Neil deGrasse Tyson

WHY EXPLORATION MATTERS — AND WHY THE GOVERNMENT SHOULD PAY FOR IT

Giant research efforts like the one that put a man on the moon produce the kinds of technology that can lift an economy and protect citizens in times of war or disaster. It takes a government-size budget to fund those efforts, but the payback can be enormous.

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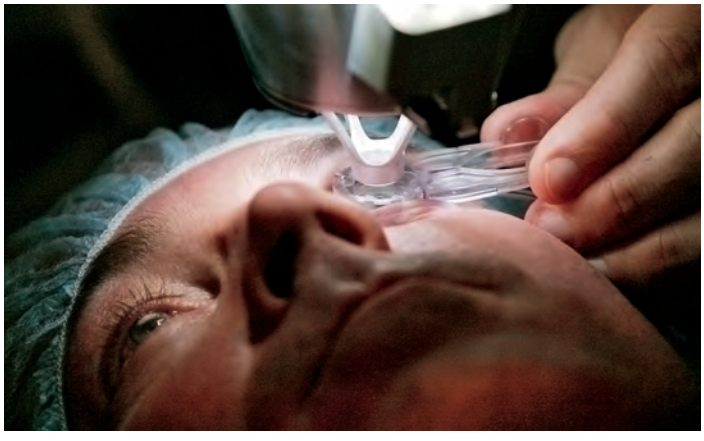
Twentieth-century America owed much of its security and economic strength to national support for science and technology. Some of the most revolutionary (and marketable) technologies of the past decades have been spun off research done under the banner of US space exploration: kidney-dialysis machines, implantable pacemakers, affordable and accurate LASIK surgery, global-positioning satellites, corrosion-resistant coatings for bridges and monuments (including the Statue of Liberty), hydroponic systems for growing plants, collision-avoidance systems on aircraft, digital imaging, infrared handheld cameras, cordless power tools, athletic shoes, scratch-resistant sunglasses, virtual reality. And that list doesn't even include Tang.

Although solutions to a problem are often the fruit of direct investment in targeted



TO THE GALAXY AND BEYOND! Research for space missions like Apollo 14, above, has led to important technologies, including LASIK eye surgery.

research, the most revolutionary solutions tend to emerge from cross-pollination with other disciplines. Medical investigators might never have known of X-rays, since they do not occur naturally in biological systems. It took a physicist, Wilhelm Conrad Röntgen, to discover light rays that could probe the body's interior with nary a cut from a surgeon.

Why not ask investigators to take direct aim at a challenge? My answer may not be politically correct, but it's the truth: when you organize large-scale, extraordinary, inspiring missions, you attract people of extraordinary talent who might not happen to have been inspired by, or attracted to, the goal of saving the world from cancer or hunger or pestilence.

Today, cross-pollination between science and society comes about when you have ample funding for ambitious long-term projects. America has profited immensely from a generation of scientists and engineers who, instead of becoming lawyers or investment bankers, responded to a challenging vision posed in 1961 by President John F. Kennedy. Proclaiming the intention to land a man on the moon, Kennedy welcomed the citizenry to aid in the effort. That generation, and the one that followed, was the same generation of technologists who invented the personal computer. Bill Gates, cofounder of Microsoft, was 13 years old when the United States landed an astronaut on the moon; Steve Jobs, cofounder of Apple, was 14. The PC did not arise from the mind of a banker or artist or professional athlete. It was invented and developed by a technically trained workforce that responded to the dream unfurled before them; they were thrilled to become scientists and engineers.

Yes, the world needs bankers and artists and even professional athletes. They, among countless others, create the breadth of society and culture. But if you want tomorrow to come—if you want to spawn entire economic sectors that didn't exist yesterday—those are not the people you turn to. It is technologists who create that kind of future. And it is visionary steps into space that create that kind of technologist. I look forward to the day when the solar system becomes our collective backyard—explored not only with robots but also with the mind, body, and soul of our species.

When I stand in front of eighth graders, I suppose I could say to them, "Become an aerospace engineer so that you can build an airplane that's 20 percent more fuel efficient than the ones your parents flew on." But imagine if instead I said, "Become an aero-

space engineer so that you can design the airfoil that will be the first piloted craft in the rarefied atmosphere of Mars." "Become a biologist because we need people to look for life, not only on Mars but also on Europa and elsewhere in the galaxy." "Become a chemist because we want to understand more about the elements on the moon and the molecules in space." When you put that kind of vision out there, my job as science educator becomes easy, because I just have to point them to it and the ambition rises up in the students. The flame gets lit, and they're self-guided on the path.

NASA's current budget sits just below $20 billion—sounds large. But the National Institutes of Health has a $30 billion budget. That's fine. They ought to have a big budget, because health matters and everyone wants to live a long and healthy life. But most high-tech medical equipment and procedures—EEGs, EKGs, MRIs, PET scans, ultrasound, X-rays—work on principles discovered by physicists and are based on designs developed by engineers. So you can't just fund medicine; you have to fund the rest of what's going on. Cross-pollination is fundamental to the enterprise.

What happens if you double NASA's budget? The vision becomes big—it becomes real. You attract an entire generation, and generations to follow, to science and engineering. Nowadays, everyone who spends even a minute thinking about the next few decades knows that all emergent markets in the 21st century will be driven by science and technology. The foundations of every future economy will require this. And what happens when you stop innovating? Everyone else catches up, your jobs go overseas, and then you cry foul: they're paying them less over there, and they're giving huge subsidies to new industries, and the playing field is not level. Well, it's time to stop whining and start innovating.

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Let's not just talk about inspiration. Let's talk about true innovation. People often ask, "If you like spinoff products, why not just invest in those technologies straightaway, instead of waiting for them to happen as a secondary or tertiary benefit?" The answer: it just doesn't work that way. Let's say you're a thermodynamicist, the world's expert on heat, and you're asked to build a better oven. You might invent a convection oven or an oven that's better insulated or one that permits easier access to its contents. But no matter how much money I give you, you will not invent a microwave oven, because that came from another place. It came from investments in communications, in radar. The microwave oven is traceable to the war effort, not to a thermodynamicist.

That's the kind of cross-pollination that goes on all the time, and yes, it's wacky. It's surprising. There's no reason it should happen. But it does. And that's why futurists get it wrong more often than not—they observe current trends and just extrapolate. They don't see surprises. So they get the picture right for about five years into the future, and they're hopeless after ten.

If you double NASA's budget, whole legions of students will fill the pipeline. Even if they don't become aerospace engineers, scientifically literate people will rise up through the ranks—people who might invent stuff and create the foundations of tomorrow's economy. But that's not all. Suppose the next terrorist attack is in the form of biological warfare. Who are we going to call?

Not the Marines. We want the best biologists in the world. If there's chemical warfare, we want the best chemists. And we would have them, because they'd be working on problems relating to Mars, problems relating to Jupiter's ice moon, Europa. We would have attracted those people because the vision was in place. They wouldn't have become lawyers or investment bankers, which is what happened in the 1980s and 1990s.

So this $40 billion starts looking pretty cheap. It becomes not only an investment in tomorrow's economy but also an investment in our security and in our dreams. Our most precious asset is our enthusiasm for what we do as a nation. Marshal it. Cherish it. ■