

Science AMA Series: Hi, we're Josh Shiode and Matt Hourihan. We help scientists and engineers understand the federal R&D budget and engage with their legislators on funding issues. Ask us anything!

AAAS-AMA<sup>1</sup> and r/Science AMAs<sup>1</sup>

<sup>1</sup>Affiliation not available

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Hi and thank you for doing this AMA!

Can you talk a bit about how US spending on R&D compares to other nations?

Further, when determining how to spend R&D dollars, what are the key metrics that politicians consider (return on investment, portfolio diversification etc)?

[SirT6](#)

Matt Hourihan (MH): OECD maintains some very useful country profiles that put national S&T metrics in international context - [here's the U.S. one](#). In a nutshell, we're at or near the top on several metrics like total dollars spent, number of elite universities, high-impact papers, triadic patents, etc; but a lot of this is due to our size. On some science-relevant metrics we're closer to the OECD median (which is not a bad place to be, though we can also do better). One of our bigger strengths, besides size, is an innovative and dynamic business sector. On R&D/GDP overall we're 10th in the world, with investment ramping up in the Far East in recent years. But that OECD link has a lot more really interesting data comparisons.

Why does NASA not have double the funding from Obama era? I did an EPQ dissertation on whether NASA was worth the cost, and found that, holy shit yes it was. Instead of having an army three times as big as the next biggest and twelve times as big as the next, why not divert funding to education and science?

[CMDR-FusionCor3](#)

JS: If return on investment were the only, or even the primary, metric by which we decided where to spend tax dollars, NASA, science and engineering across the board really, early childhood education, and infrastructure would probably be the best funded parts of the government. Clearly that is not the case. There are A LOT of factors that go into policymaking, but to quote Judy Schneider, long time Congressional Research Service Specialist on Congress, there are three Ps to policymaking: policy, politics, and process; all three have to be done right for a bill to become a law. Bad politics and getting

the procedural moves wrong can quickly kill a bill, so often the first P to go is policy.

The question of why NASA's budget isn't bigger, or why any science or education funding line isn't, is largely about the overall size of the budget pie Congress has to split up. The history of R&D funding shows that it is basically a [fixed fraction \(~ 11%\)](#) of the total discretionary funding level. Discretionary funding is the part that Congress debates every year, as opposed to Mandatory programs like Medicare, Medicaid, and Social Security, which are funded automatically year to year based on formulas. When there's more funding in general, more tends to flow to R&D. The exception is the Space Race, of course, but as many others can argue much more eloquently than me, that was chiefly about international competition and national security rather than science (see e.g., John Logsdon).

One other important point here is that there have been huge dividends in terms of technological advances out of the Defense Department, especially the Defense Advanced Research Projects Agency (DARPA). Here's just [one piece](#) exploring how (and in part why) DoD research laid the foundation for a lot of modern technology. It's an interesting story. I personally am hoping to read [Sharon Weinberger's \*The Imagineers of War\*](#) soon.

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[CMDR-FusionCor3](#)

MH: Adding to what Josh said, and to try to bring this down to the point at which Congress has to actually decide: agencies are divvied up in spending bills, and if you're an appropriator and you want to (say) double NASA: either you need a much bigger spending bill, or you need to find that money by cutting something else currently in your bill. Well, in the current process NASA is in the same bill as NSF and the Commerce and Justice departments. If you don't have a bigger bill, what do you cut to grow the NASA budget? FBI? The Weather Service? The National Marine Fisheries Service? Most things in most bills have supporters that will put up a fight, even if they support your ultimate goal of growing NASA. These are the kinds of trade-offs appropriators have to grapple with.

How much do we actually see research in hard sciences influencing legislation/budgetary decision making? I have worked in mental health/social justice advocacy and we use research to back legislative testimony in support/opposition but, it never seems to make much of a difference? How can we best use empirical evidence to put together compelling testimony which could sway votes or at least gather more awareness?

[Tyler53121](#)

JS: It's hard to answer your first question in a comprehensive way, but I would say, recognizing that science will *always* be just one input in the process of policymaking, it definitely does have an impact. And I really applaud you and your colleagues for taking the time to translate the results of your work into legislative testimony and other direct inputs to policy. I think too often researchers publish their work and expect it be taken up, but it really requires active engagement on the part of researchers.

I think this is the key to increasing influence: active engagement. That means both talking (e.g., through testimony) and listening. One thing you might do, which you may already be doing, is engaging with policymakers and the public earlier in the process to develop the questions you are asking and the answers you are delivering. I saw a great talk recently about work on sea level rise. The researchers originally planned on projecting a range 100 years off, but they spoke with policymakers (legislators,

city planners, and others) and realized that really what was *needed* on the ground was projections on a mortgage timeframe of 20-30 years -- **that** would be useful.

The other advice I would give is that you need to tell a story that demonstrates impact. Data is important, but stories resonate. Focus on local impacts that speak to the audience. Whatever policy your talking about, make the importance of the science locally relevant. How many people would that help here in this state or district? And know what the person you're speaking to values? Are they a small government conservative, for instance? How can what you propose resonate, or at least not offend, those values? And one last thing, consider that you as the researcher might not be the right messenger. Maybe there's someone you worked with in the research who would have more credibility with your audience than you, arm them to be an advocate.

Thanks for doing this AMA!

Personally, I am (like most redditors I think), in favor of a vastly increased budget for science-- both basic research and applied science.

Still, I'm nagged by this question: What can be done to ensure that we get the most "bang for our buck" or, in other words, to make sure that the money is used for actually performing research and not pointless red tape?

Related question: how can the process be improved so that research priorities more closely align with majoritarian priorities (treating and curing pervasive diseases) and not weird agendas (e.g., personally I'm annoyed by social psychology that looks like sociology of dubious merit).

Thanks!

[ban condoms](#)

JS: Well we can definitely agree on that! And we're in good company, CEOs from nine leading companies and over 500 groups recently [called](#) for increasing basic research funding by 4 percent above inflation per year, along with a number of other pro-innovation policies. And some, like Norm Augustine have [called](#) for as much as tripling energy R&D in particular.

Recently passed bipartisan legislation called the [American Innovation and Competitiveness Act](#) mandated that the White House set up a task force to streamline the amount of red tape involved in research, something many in the science community have been advocating for for a long time (e.g., the [Association of American Universities \(AAU\)](#)). This task force would look at ways to reduce the estimated 40 percent or so of researchers' time they report having to spend on compliance tasks and other non-research. The National Academies of Sciences, Engineering, and Medicine has a [report](#) with recommendations for this that came out last year, and many in Congress are very interested in seeing regulations streamlined.

In terms of aligning research priorities, in part the Congress serves the function of alignment with what society wants. There's also a lot to be said for funding research broadly, especially fundamental science, because we rarely can predict where insights from science will end up being applied. The [Golden Goose Award](#) is one effort to tell the stories behind how even silly sounding, federally funded science can have major societal impacts. In terms of social science, consider for example the [obscure economic research](#) that has been applied to kidney transplant programs and saved thousands of lives and many millions of taxpayer dollars.

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Thanks!

[ban\\_condoms](#)

MH: tacking on to Josh's reply: [here's what the current federal research distribution looks like](#).

You may be the wrong people to ask, but given that the science funding in the US is probably being cut, how do you see universities (which rely on funding for operations and for tenure decisions) adjusting?

[andural](#)

MH: I'm actually not so sure about your starting assumption that research will be cut. I won't lay odds, but there's good reason to believe much of the federal science portfolio will look fine in a year. Whatever the Trump Administration is proposing, it's up to Congress to actually make funding decisions, and they've historically been supportive of S&T funding. [Here's what they just did a month ago, for example](#). In particular, NIH is very popular. Other funders of university research also have their supporters.

That said, universities have increasingly been using their own funds to support their own R&D activities ([see page 8, figure 14](#)) in recent years. Basically, demand for research dollars have been outstripping federal supply for a while.

Can you give me a short run-down of the newly released budget? Where is funding going, and where is it being cut?

[xXKSXx](#)

MH: Here's a [short summary](#), and we've got other info on [website](#). Short version is, the Administration is proposing the largest set of research cuts in at least 40 years. Most science agencies would see double-digit reductions - i.e. a 22% cut to NIH. Many programs and projects would be facing elimination. There are rather few places that would see any increase: DARPA, NASA's Planetary Science program, exascale computing R&D in the Energy Dept. Perhaps a few others I'm missing. It's a very tough budget for science and technology.

All that said: odds are pretty good that most of this won't happen.

How much tax dollar R&D is used for private business?

[schtickybunz](#)

MH: About 35% - 40% of federal R&D funding goes to industry. The vast majority of that is going to be

defense contractors doing development and engineering work on new weapons, comms tech, and other things for DOD. A big chunk also goes to NASA contractors for things like [SLS development](#). Those two account for something like 90% of industry R&D directly funded by government.

Thank you for your work! I don't know if you have any inside knowledge of the workings of NSF, but as a researcher who submitted a proposal in fall of 2016, when can I expect to hear from them? Based on previous experience, I have been expecting a reply for about two months, and it is driving me crazy. I thought that when the 2017 budget went through they would be able to make decisions, so do you know what they are waiting for now?

A more general question: to what extent does Congress and/or the administration make science funding decisions (at the program level) based on specific research content vs general budget considerations? I know political science at NSF was targeted in recent years, and renewable energy at DOE in the current administration. Has this always been happening or is it something new?

[jkga](#)

MH: Can't provide any help on NSF, unfortunately! Best bet is probably to contact your program officer. It's only been about a month since the omnibus was signed into law, so things might be hectic. Hopefully your PO would know more.

On your general question: it's a little of both, really. Both branches of government have to weigh their S&T priorities against broader fiscal realities; and differences in science funding preferences are also very real. You might have one president or legislator who's a big believer in space flight; another whose biggest thing is cancer research; another whose main priority is low-carbon energy technology. And they'll make funding decisions, or otherwise try to influence the process, in ways that reflect those priorities. That's always been the case. In the case of social science, for example, the explicit belief from some members of Congress is that returns on investment are greater in, say, computer science than in social science, so we should fund marginally more of the former, and marginally less of the latter. Others disagree. The system allows people with different ideas to (eventually, amid much gnashing of teeth) come up with a final compromise that everyone can live with.

What actions can the "average" person do to help strengthen our country's scientific sector? I know this is a broad question, but I would like to hear your opinions. For example should we rely on gov't monies for our scientific preservation? Thanks!

[Hipsterdoucher](#)

JS: It kind of depends on the position you're in. I think engaging with science and scientists in your community is a great piece. Understanding what they do and why it's important and then connecting that with policymakers. Depending on your job and your personal affiliations (local hiking clubs, rotary clubs, school boards, etc.) you may be a great messenger for policymakers to say, "science is important, and I want to see you supporting it with your votes." One of, if not THE, most important motivations for members of Congress is getting re-elected, so if they know that your vote may turn on their positions on science, that will affect their decision-making.

Of course, supporting science education, e.g., if/when initiatives show up for votes on local ballots, is important to ensuring future generations value science.

If you are in a position to donate money, you might look at various [crowdfunding platforms for science](#) to help researchers struggling to get grants, or support things like the [Golden Goose Award](#) that help tell the stories of how science impacts society.

The truth is, there is no private entity waiting in the wings to take up science research, especially the most fundamental work, if the government pulls back significantly. Economic research has tended to show that government investment brings more money to the table rather than "crowding it out."

What has been the rate of increase in nsf and nih funding over the last ten years?

[mracidglee](#)

MH: If we go back to 2007, they've fared pretty differently, actually.

Congress doubled NIH's budget in the late 1990s, but then let it erode for several years thereafter. NIH has been recovering since sequestration in 2013, and it's gotten billion-dollar increases the last couple years (Congress is very supportive, along bipartisan lines, of biomedical science). But because of that earlier erosion, it's pretty close today to where it was in 2007.

NSF, on the other hand, benefited from the [Rising Above the Gathering Storm report from the Academies](#), which called for a doubling of federal physical sciences research, and the corresponding [America COMPETES Act](#) which tried to put that recommendation into practice. Didn't fully work as NSF never doubled, but Congress *did* give NSF some pretty generous plus-ups for several years. As a result, NSF's budget is close to 10% larger now than it was, even after sequestration and all that.

How much control does Trump have over specific projects at NASA? He has stated that he wants to send people to mars while he's president, but has he put in the funding to make that actually possible? And is that money only for NASA or does some of it go to third party groups like SpaceX?

[TheGreenGuy91](#)

MH: Typically, budgeting is basically a big negotiation: between the White House, the agency, and Congress. The White House has its priorities and is final arbiter of what NASA can ask Congress to fund, but NASA has a say in this as well. And they both have to be responsive to Congressional preferences too, since it's Congress that has the final say anyway.

If we're talking Mars, well that is definitely a goal that has Congressional support. [Trump signed an authorization bill with that goal earlier this year](#). NASA's proposed funding on this (including for both future robotic missions and an eventual crewed mission) is not as large as many would like, but it is in there. And that is one area you might see Congress plus-up this summer.

\*ETA a word

Hey! Thanks for doing this AMA. I did my thesis on the creation of a specific NASA program that ended up being a long series of satellites. It seemed like there wasn't much in the way of talking to the Executive branch (aka White House) about the ins-and-outs of developing programs. How much do researchers and scientists need to convince the White House to support any particular program? Is there any particular process for doing so? For example, when the project passes Phase B and is ready for conversion to Phase C, a report must be sent to the White House...or something like that.

[shittyroomiethrowawy](#)

MH: There isn't a fixed process; these kinds of discussions might happen at the Program Examiner level - that's the staff in the White House budget office, OMB; or at the interagency level, or through the White House science advisory panel, PCAST; or with other White House science policy staff. Good administrations will take good ideas from anywhere.



Having worked in this field and seen what you've seen, what do you think the government needs to improve on with regards to funding and transparency?

[Kliapatra](#)

MH: How so, re: transparency? You mean how Congress provides funding, or what agencies actually fund, for instance? There are tools like [grants.gov](#) or [NIH Reporter](#) that provide grant info and the like.

Ok, we know overall that almost everything gets hit. But let's say you had a specific area of particular concern about it. What is the best (most effective) way to influence that? I mean, who do you even target?

[mem\\_somerville](#)

JS: True, there are cuts pretty much across the board proposed in the budget request. Also true is that most areas of research got an increase in the most recent appropriations bill passed in May.

For a particular area, you would want to identify where that is funded in congress. Say, the U.S. Geological Survey, for instance. That is part of the Dept. of the Interior, which is funded through the Interior and Environment subcommittee ([House](#), [Senate](#)). Take a look at the members of these subcommittees and where they represent and think through how that funding impacts those Members' states and/or districts. Then think about who the right messenger for those messages are. If it affects watersheds in one district, maybe you need to connect with hydrologists or city planners there, for example.

Hi There!

I was looking at your link for federal R&D budget and noticed that the department of defence has a ridiculously portion of the R&D budget. What's the deal with that? Is this good or bad? I work in Italy in healthcare and I see lots of calls for applications for grants given by the US DoD where my hospital can apply. Why is the U.S. army funding diabetes research in Italy? That's not really what you'd think that an american army would be spending money in... Where does this huge amount of money end up, generally?

[lucaxx85](#)

MH: Yes, DOD is huge! About half of all federal R&D. Mostly it goes to defense contractors for development of new vehicles, weapons, and other tech. They do have a pretty large research enterprise as well, including around \$2 billion a year in assorted biomedical research on an array of topics - a lot of cancer research, traumatic brain injury, etc. Some of it is extramural, some intramural.

Do organizations that seek federal grants lobby for those grants or do they just fill out a bunch of forms, submit them and wait to hear back? It would seem that with millions of dollars of grant money available that universities, for example, would be lobbying the NIH, etc., to get that money. If lobbying in the grant world goes on, how big of an effort is it and does everybody do it?

[Boothecus](#)

JS: Since most federal research grant programs are awarded based on merit review of proposals by the researcher's scientific peers, there's not really lobbying on specific proposals. What savvy



researchers will do is talk with the program officer, federal agency staffer who is overseeing the program requesting proposals, to understand the agency's priorities so that they can craft the most competitive possible proposal.

That said, well in advance of proposal requests going out, colleges and universities, science societies, and others, will engage in advocacy and lobbying about what priorities the agency should focus on. They'll often do this by engaging with the federal agency's staff, the White House, and the Congress to talk about what they particularly excel at and how that kind of research would benefit the local area, the country, etc. and how it fits into the agency's particular mission (e.g., [biological research is important for the Department of Energy \(DOE\)](#) in part because the DOE is interested in things like biofuels.)

As a student who is going to be majoring in physics this year, and hoping to go into photonics later on, this does not help me feel comfortable with the inevitable funding that I'll need for research opportunities. Is my major in danger?

[DeliveryBoyNumber5](#)

JS: While the President's Budget states his priorities for the budget, it is the Congress that controls the power of the purse. And in the most recent bill passed for funding the government in May, they boosted R&D by about 5%. So don't go too quickly to fear. That said, we can't be complacent. Talk to your members of Congress about your passion for physics and interest in photonics and urge them to support funding for research at the agencies you think might fund you (Dept. of Energy and NSF come immediately to mind, as do the Department of Defense Science & Technology programs). Talk about the importance of photonics to our economy and why your work is important beyond just your own interest. You can be a great messenger!

What percentage of scientific funding comes from the government? What other sources are available for scientists to fund their research?

[Leocor8](#)

MH: [Latest data](#). If we're talking strictly about basic research, the feds account for about 44%, which is down some from recent years. Business accounts for about half of the rest, though that's mostly in-house or contracted with other firms, rather than universities. There's often talk of universities finding more biz partners for R&D, but that doesn't seem to show up in the data just yet. Philanthropic sources definitely seem to be of rising prominence.

Most of my research is ecological, i.e. more likely funded by NSF than NIH. How will NSF fair? Should I start re-thinking research to appeal more to DOE or NIH?

[forever\\_erratic](#)

JS: It's hard to say with any certainty how NSF or any other specific agency will fare after the [whole complicated budget process](#) is complete, but NSF is facing a tough road. In particular, this has to do with the parts of the budget it is in direct competition with during the appropriations process.

NSF is funded through the Commerce, Justice, Science and Related Agencies subcommittee ([House, Senate](#)), which also has NASA and the entire Commerce and Justice Departments under its jurisdiction. So in Congress, it competes directly with these other parts of the government for part of the same slice of the overall budget pie. That subcommittee has largely prioritized NASA in terms of science funding recently, and of course has major national priorities in Justice and Commerce that it

must fund.

**It's critical that folks like you and others funded by the NSF work to advocate for that funding with your Members of Congress, especially if they are on those subcommittees.** And when you do, be sure to demonstrate that this funding is an investment that returns benefits to the nation at large and the local area that the Member of Congress represents. How does what you do impact the broader society? How does better understanding ecology help the world? Why are you passionate about this topic? Those are the kinds of questions to think about in advocating.

In terms of the DOE and NIH, the DOE is facing [even steeper cuts](#) to the non-nuclear security parts of the agency, and NIH is as well. That said, both agencies have tended to have stronger, more bipartisan support in Congress than NSF -- NIH especially. Diversifying is always good, but it's also really important that you speak up to advocate for why NSF is important! Here are [some resources](#) we've got here at AAAS.

The general consensus seems to be that the Trump administration's budget proposal is farfetched and unlikely to be supported by most of Congress. Unless something crazy happens, it seems likely that Congress will devise a budget much more similar to what we're operating on right now.

What are the most effective ways for individual citizens to help influence this decision-making process (besides voting)? Do you have any useful facts/metrics about the return-on-investment for government funded research?

[shiruken](#)

JS: You're right, largely the reaction from Congress has been, "thanks for your input, but we control the checkbook," and regardless of Administration, last year's appropriations tend to be better correlated with the following year's than the President's budget. The request has influence, especially down below the levels that Congress specifies, and in signaling to those in the President's party where he would like the party to go. The latter seems even less relevant this year though, thus far.

The most effective ways to advocate with sitting members of Congress is to connect with them and/or their staff directly, especially face-to-face, and talk about the importance of science to their local area and the nation. This is born out by [surveys of senior staff members](#) who are in the room with their bosses when they make decisions on how to vote. The report based on that survey has a lot of useful advice, but those are the key points.

Here's an example: this [op-ed](#) by a [Golden Goose Awardee](#) Al Roth and University of Alabama Birmingham (UAB) School of Medicine Professor Dr. Jayme Locke talks about how obscure economic research has led to the way that UAB does live donor kidney transplants, helping hundreds of local residents and potentially impacting tens of thousands locally who need transplants. The piece also talks about how each transplant has been shown to save the government \$250,000 in the first five years since Medicare would have been paying for dialysis instead. Local, personal stories are what resonate.

How should early career scientists, primarily funded by NSF, navigate these times? How will Earth and Planetary sciences and Climate Science budgeting decisions be affected by the proposed budget?

[tit-for-tat](#)

JS: It is probably the case that some earth and climate science research will end up being cut in the final budget. However, planetary science at NASA is a favorite not just of this administration, but also with powerful members of the congressional committee that funds NASA. Planetary Science funding

has been on the upswing of late, and I expect that will continue. Overall, research and development was boosted by 5% in the last appropriations bill the Congress passed for the remainder of FY 2017.

I would strongly recommend learning about the policy process and engaging with your members of Congress and your local communities to talk about why the work you do is important to society and why you care about it. We have some resources [here](#) and [here](#) (and our inboxes are open!). Sometimes people underestimate the power of a passionate advocate. As an early career scientist, you are also an embodiment of concerns about the need for more STEM talent in the U.S. Talk about your desire to work in the U.S. on problems that are important to the country (and the world).

Also, I would say you should develop a relationship with your program officers at NSF to know where the agency might be headed in terms of priorities, and engage with us here at AAAS, as well as other societies like AGU, GSA, and AGI, depending on the type of science you do of course.

When discussing R & D with republican senators (not in regards to environment) is their any enthusiasm in regards to funding progress in research involving biology and medicine? has the well been poisoned by partisan politics involving scientific policy?

[modestmeeee91](#)

MH: Biomedical research most definitely has bipartisan support, and has for many years. Republicans were in the front lines during the push to double NIH in the 1990s.

[Here's an interview with Tom Cole of Oklahoma](#), Republican who runs the House appropriations panel responsible for NIH funding, and who loves him some NIH.

And [here's an item](#) on Cole's counterpart in the Senate, Missouri's Roy Blunt, among others. Another big NIH supporter.

Do you think the 2018 Budget cuts for science agencies will get approved? or there is a hope that it will get knocked down like 2017 budget proposal.

[ayush\\_ranawade](#)

JS: It's pretty unlikely, as we've said above. The response from Congress has largely been to thank the President for his suggestions and reassert they have the power of the purse. That said, we can't be complacent. Researchers need to engage with policymakers and the public to talk about why science is important to society.