Twitter during a TEDMED conference in 2009, as a tool to gauge reactions to his talk. Now, he starts his workday browsing through his Twitter feed for news and noteworthy research in his field. During the day, he checks Twitter several times and spends another 10 to 20 minutes on an evening roundup. "It actually may be the most valuable time [I spend] in terms of learning things that are going on in the world of science and medicine," says Topol, who reciprocates by daily tweeting papers, presentations, and more to his followers.

Psychologist Daniel Gilbert of Harvard University (36th; 15,500 followers) views Twitter as a natural extension of his public outreach efforts, which include hosting the PBS science documentary, *This Emotional Life*. "It's another teaching tool," he says.

Jonathan Eisen of the University of California, Davis (25th; 24,900 followers), says that consistently tweeting ongoing research at his lab has helped attract graduate students as well as two grants for science communication. He suggests an active social media presence might even aid applications for research funding, as it demonstrates a commitment to public outreach. But the spontaneity of Twitter can backfire, too. Eisen, for one, has live-tweeted brusque criticism at academic conferences that came back to bite him. "You can seem like a jerk, an idiot, or both," he says.

The K-index gets it wrong by suggesting that science communication and research productivity are incompatible, says Albert-László Barabási, a network theorist at Northeastern University in Boston who studies social media. Research on altmetrics—alternative metrics for measuring scientific impact—has found no link between social media metrics such as number of tweets and traditional impact metrics such as citations, he says. "We should really not mix the two … because they really probe different aspects of a scientist's personality."

For his part, Hall says others have read too much into his satire, which originated after seeing conference organizers factor Twitter follower numbers into speaker considerations. "I don't mean to criticize anyone for having a lot of Twitter followers," he says. "My criticism is only of using it as a metric on research scientists."

It might be premature, in any case, for the scientific community to worry about "Science Kardashians" when it faces a more pressing challenge of staying relevant in public discussions. Even Tyson's Twitter popularity is dwarfed by that of the real Kim Kardashian, who boasts 10 times as many followers. ■

PHOTO: LOREDANA SIANI/OKAIROS

Okairos uses a "wave bag" to shake up cells and produce small lots of vaccine.

INFECTIOUS DISEASE

Ebola vaccine: Little and late

Scaling up production of Ebola vaccines and treatments will take many months

By **Jon Cohen**

As the Ebola outbreak in West Africa accelerates, the containment measures that worked in the past, such as isolating those who are infected and tracing their contacts, clearly have failed. This has spurred hopes that biomedical countermeasures, such as monoclonal antibodies and vaccines, can help save lives and slow spread. But as President Barack Obama calls for an aggressive ramp up of the U.S. government's response (see p. 1434), resolve is colliding with a grim reality: The epidemic is outpacing the speed with which drugs and vaccines can be produced.

Administration officials have begun working with industry to speed manufacturing of experimental drugs and vaccines. "We're trying to do everything we can to scale up product," says Nicole Lurie, assistant secretary for preparedness and response at the U.S. Department of Health and Human Services (HHS). But the logistical obstacles are huge, and makers are getting a late start.

An Ebola vaccine made by GlaxoSmithKline (GSK) in Rixensart, Belgium, is the furthest along, having entered phase I human trials on 2 September. GSK has committed to manufacturing up to 10,000 doses of the vaccine, which consists of an Ebola surface protein stitched into a weakened chimpanzee adenovirus, by the end of the year. If it passes muster in the early studies, it could be given to health workers as soon as November. But hundreds of thousands of doses would be needed to slow the outbreak. That "would take one-and-a-half years at the scale we're working at," says Ripley Ballou, who heads the Ebola vaccine program for GSK.

The scientific hurdles are not particularly high. Companies have made similar vaccines at high volume, and animal studies have shown that Ebola virus is fairly easy to defeat with the proper immune response. "Although Ebola is a very scary, hemorrhagic virus, all you need is fairly modest neutralizing antibody response and you're protected," says John Eldridge, chief scientific officer at Profectus BioSciences, a Maryland and New York–based company making an Ebola vaccine that has struggled to attract funding.

Ballou says GSK is considering several options for speeding production. But first the company wants to be sure that there's a market for the vaccine. He says when the company contacted the World Health Organization at the start of this outbreak in March, no one showed much interest. "The answer was, 'Thanks, we'll get back to you.' "

NewLink Genetics of Ames, Iowa, has a second vaccine in a phase I trial that consists of a crippled vesicular stomatitis virus (VSV), which infects livestock, with the gene for the Ebola virus surface protein. Only 1500 doses exist. Profectus makes a similar vaccine that should be ready for human testing next June. Like GSK, Profectus needs a commitment from a funder before it can scale up production from the planned 5000 to 20,000 doses, Eldridge says.

In principle, vaccine production is

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straightforward: Grow a "master seed" strain of virus on a large scale, then harvest and process it. Okairos, a small company that produces the GSK vaccine at a facility near Rome, grows its virus in a human cell line in up to 200-liter wave bags, so-called because they rock back and forth on a platform. It will take about 2 months to grow, harvest, and prepare the promised doses.

Company founder Riccardo Cortese says with an investment of about $10 million, they could convert their facility to process several 400-liter bags simultaneously in as little as 3 months. At that scale, he says, "I calculated we could make 100,000 doses per month."

GSK's Ballou is more circumspect. First, they need more master seed. "There were only so many vials made, and we're depleting them," he says. And mass production, he says, would work best in huge bioreactors, stainless steel tanks that hold 1000 liters or more. But the cell lines that produce the vaccine virus are finicky. "The driver is really the productivity of the cell line," Ballou says. He puts the most optimistic timeline for 100,000 to 500,000 doses at 9 months—and the cost at $25 million.

Treatment is stuck in a similar rut. A cocktail of Ebola antibodies called ZMapp has shown remarkable efficacy in monkey experiments and has been given to seven people. But there's less than one dose left. Made by Mapp Biopharmaceutical of San Diego, California, ZMapp contains three monoclonal antibodies produced in tobacco plants. The process from plants to product takes a few months and now yields just tens of doses.

HHS's Biomedical Advanced Research and Development Authority (BARDA), which was established to speed development of treatments and vaccines for emergencies, has contacted two other outfits that can make the antibodies in tobacco plants. But this will boost production to only hundreds of doses per month. BARDA is now exploring the possibility of producing the antibodies in Chinese hamster ovary (CHO) cells—the standard system for making monoclonals. But a 2012 study suggested that the antibodies would have reduced potency if made in CHO cells. "You're not going to make 100,000 doses anytime in the near future," says someone familiar with the discussions who did not want to be named.

A bill now moving through the U.S. Congress would give BARDA $58 million for Ebola vaccines and treatments. That's sure to help, but not soon enough. "I don't know that we're going to have these countermeasures in time to make a big dent now," says HHS's Lurie. "But hopefully we'll have the countermeasures by the next time there's an outbreak so this never, ever happens again." ■

SCIENCE POLICY

Play it again, Uncle Sam

Prominent academics recommend growth in federal basic research budget that matches previous golden era

By **Jeffrey Mervis**

A report out this week urges the U.S. government to lift spending on basic research to historically high levels as a way to ensure prosperity and preserve American preeminence in science and technology.

The recommendations include boosting real spending on basic research by more than 4% annually, making multiyear funding commitments, streamlining regulations on academic research, and creating an optimal biomedical research workforce. The proposals echo those in a half-dozen other reports in the past decade from similarly high-level panels. Coming from the American Academy of Arts & Sciences in Cambridge, Massachusetts, the advice may also seem self-serving. But panel co-chair Neal Lane, former director of the National Science Foundation and presidential science adviser, says the message bears repeating as tight overall federal budgets have put the squeeze on research.

"The response from policymakers to date has been disappointing," admits Lane, a physics professor at Rice University in Houston, Texas. (The panel's co-chair is Norman Augustine, who also led the influential 2005 National Academies' report, *Rising Above the Gathering Storm*.) "But you can't give up on the political process. We hope that this report will help start a conversation about the things that really matter."

The panel's first suggestion is to return to the annual rate of growth in federal funding for basic research that occurred between 1975 and 1992 (see graph). Funding for the biomedical sciences has stalled since the end of a 5-year doubling of the National Institutes of Health's budget in 2003 except for a spike in 2009 to 2010, for example, and Lane says that boom-and-bust cycle has been devastating to the community. At the same time, a budget doubling for agencies funding basic research in the physical sciences, proposed in the 2005 National Academies' report and embraced by Congress and the White House, never materialized.

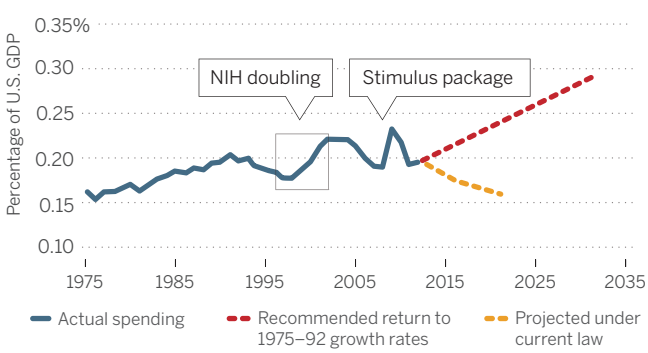
The new report calls for federal spending on basic research, now $32.3 billion, to reach 0.3% of the nation's gross domestic product by 2032. Such a leap "is rather ambitious," Lane admits. That ratio has hovered around its current level of 0.19% for the past 2 decades. But he says it's needed at a time when "science and engineering have become even more important as drivers of economic growth."

The report also proposes that the White House issue a biennial report on the "state of American science and engineering," that research universities strengthen ties with industry, and that professional and scientific organizations speak with one voice about how research has created jobs and improved public health and welfare. Even then it's going to be an uphill battle, says panel member James Duderstadt, an engineer and president emeritus of the University of Michigan. "Sometimes I feel that we're plowing the ocean," says Duderstadt, who also served on a 2012 National Academies' committee that suggested ways to improve the health of U.S. research universities.

Duderstadt cites last week's triple announcement by Apple of a new smart watch, iPhone, and banking app as evidence for the need for a continued federal investment in research. "They are doing wonderful things with basic research from 30 years ago," he remarks. ■

A boost for basic research?

U.S. government spending has been inconsistent and is headed down.



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