protein, CCR5, that gives the virus a toehold as it establishes an infection.

But those are complex and risky interventions. Doctors must remove stem cells from the body, add or modify their genes, and then reinfuse the cells back into the body after using chemotherapy to wipe out a patient's original stem cells. In sub-Saharan Africa, where medical infrastructure is limited, those procedures are largely out of reach. Yet the region is home to more than 12 million people with sickle cell disease and 25 million living with HIV—two-thirds of the world's total for both diseases.

The new collaboration will instead seek to put gene therapy or gene editing into a one-time infusion. The strategy would enlist a harmless virus or nanoparticles to ferry sophisticated molecular tools into the body. "The potential beauty of in vivo gene editing is that it might be given ultimately as a single shot, curing everyone in a scalable manner," says Steven Deeks, a leading HIV cure researcher at the University of California, San Francisco (UCSF).

Although several labs are working on such in vivo gene therapy or editing to modify blood stem cells in animals, "A major challenge is modifying enough cells," says Harvard University stem cell scientist Stuart Orkin. He estimates that at a minimum 20% of a patient's blood stem cells within the bone marrow would have to be modified to cure sickle cell, which would be "a real stretch."

Mike McCune, an immunologist who has long worked on HIV/AIDS at UCSF and recently joined the Gates Foundation, came up with the idea for the collaboration and approached NIH. McCune, who has worked with Deeks, says he realized existing strategies won't be enough to defeat HIV in Africa. "Antiretroviral treatment alone is not going to cut it," he says. The foundation was already talking about investing in in vivo gene editing for sickle cell. Merging the two disease efforts made sense, McCune says.

Collins met in December 2018 with Bill Gates, co-chair of the foundation, to hash out details. Each institution will fund its own grants, but they will share information about proposals each is considering so they can identify redundancies and gaps. The Gates Foundation can act more quickly and is freer to collaborate with industry if it wants. NIH, for its part, has a vast clinical trials network throughout sub-Saharan Africa, where the collaboration aims to launch trials in 7 to 10 years. "I don't think this is traditionally something the foundation or the NIH would do on its own," McCune says.

Hematologist Alexis Thompson of the Northwestern University Feinberg School of Medicine in Chicago, Illinois, who is working on sickle cell gene therapy trials, calls the NIH-Gates collaboration "phenomenal." But she says a low-tech need is more urgent: expanded screening of newborns in Africa for sickle cell so those afflicted can receive antibiotics. Many die before age 5 from bacterial infections because the sickled cells impair the spleen's immunological function. "It's almost being able to crawl or walk before you sprint," Thompson says. Gates and NIH say that outside the collaboration, they plan to support screening efforts.

The new effort also hopes to develop other genome-based strategies to cure these diseases, including cutting-edge approaches such as excising HIV from genomes. "This might be science fiction now, but one day may be a real possibility," Deeks says. ■

PHOTO: JUNIOR D. KANNAH/AFP/GETTY IMAGES

Some 12 million people in sub-Saharan Africa have sickle cell disease, and many die in childhood, from infections.

ARTIFICIAL INTELLIGENCE

DOE readies multibillion-dollar AI push

U.S. supercomputing leader is the latest big backer in a globally crowded field

By **Robert F. Service**, *in Washington, D.C.*

The U.S. Department of Energy (DOE) is planning a major initiative to use artificial intelligence (AI) to speed up scientific discoveries. At a meeting here last week, DOE officials said they will likely ask Congress for between $3 billion and $4 billion over 10 years, roughly the amount the agency is spending to build next-generation "exascale" supercomputers.

"That's a good starting point," says Earl Joseph, CEO of Hyperion Research, a high-performance computing analysis firm in St. Paul that tracks AI research funding. He notes, though, that DOE's planned spending is modest compared with the feverish investment in AI by China and industry.

But DOE has a big asset: torrents of data. The agency funds atom smashers, surveys of the universe, and the sequencing of thousands of genomes. "We generate almost unimaginable amounts of data, petabytes per day," Chris Fall, who directs DOE's Office of Science, said at the last of four town halls DOE has held here to build support for the AI initiative. Algorithms trained with these data could help discover new materials or spot signs of new physics. "It's going to impact everything we do," Fall says.

DOE is joining a global rush to fund AI. Worldwide corporate AI funding is expected to hit $35.8 billion this year, up 44% from 2018, according to IDC, a market analysis firm. Companies see commercial advantages in AI. It helps banks detect and prevent credit card fraud, and oil and gas companies use it to pinpoint productive drilling sites in mounds of geological data.

Governments are also jumping in, with goals as diverse as improving traffic flow and detecting early-stage cancers. In February, President Donald Trump signed an executive order launching the American AI Initiative, and the administration requested nearly $1 billion for AI and ma-

chine learning research in fiscal year 2020 across all civilian agencies, according to the U.S. Office of Science and Technology Policy. The U.S. Department of Defense is seeking a similar level of funding for unclassified military AI programs.

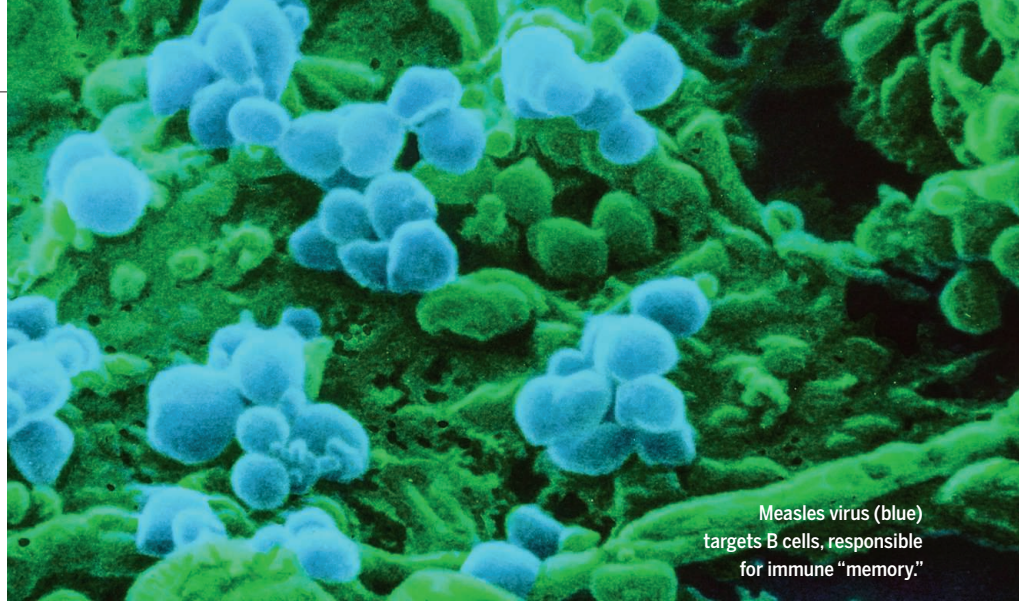
Definitive numbers are harder to come by for other countries. But in 2017, China announced a national AI plan that aims for global leadership, and a projected commercial AI market worth 1 trillion yuan ($140 billion) by 2030. And the European Union has committed to spending €20 billion through 2020. "Just as with the race to create the first exascale computer, the AI world is getting really competitive," Joseph says.

Just who is leading the race depends on what you measure. According to Hyperion Research, China accounted for 60% of all investments in AI from 2013 to 2018. U.S. investments were about 30% of the global total. China dominates the number of AI publications, whereas the European Union has the most AI researchers, Joseph says. But U.S. researchers in AI get the most citations per paper, he says, suggesting their research has the most impact.

DOE officials say the AI initiative will help keep U.S. researchers at the forefront. Though DOE has yet to detail its program, it's likely to include funding for national labs to optimize existing supercomputers for AI, and external funding for academic research into AI computer architectures, says Rick Stevens, associate laboratory director for computing, environment, and life sciences at Argonne National Laboratory in Lemont, Illinois.

Not only is the initiative likely to speed up data analysis, but it could also boost the pace of data collection, by using AI to come up with hypotheses and design new experiments. "AI won't replace scientists," says Jeff Nichols, associate laboratory director for computing and computational science at Oak Ridge National Laboratory in Tennessee. "But scientists who use AI will replace scientists who don't." Battery researchers, for example, could use these tools to test the properties of thousands of materials in days.

Nichols acknowledges that DOE's push for AI lags efforts at the U.S. National Science Foundation (NSF), which has spent roughly $4.5 billion over the past decade on research to improve AI algorithms and software. Nevertheless, Erwin Gianchandani, NSF's acting assistant director for computer and information science and engineering, says that given DOE's role in funding major user facilities such as supercomputers, the agency's AI push "would dovetail well" with NSF's programs. ■



Measles virus (blue) targets B cells, responsible for immune "memory."

IMAGE: NIBSC/SCIENCE SOURCE

IMMUNOLOGY

How measles causes the body to 'forget' past infections

With cases rising around the world, studies underscore the importance of widespread vaccination

By **Eva Frederick**

One of the most contagious human pathogens, the measles virus is dangerous enough by itself, with sometimes-fatal complications including pneumonia and brain inflammation. Two detailed studies of blood from unvaccinated Dutch children who contracted measles now reveal how such infections can also compromise the immune system for months or years afterward, causing the body to "forget" immunity it had developed to other pathogens in the past.

To what extent this "immune amnesia" increases illness and deaths from other infections isn't clear. But the results are another good reason to immunize children against the virus, the studies' authors and other infectious disease experts say. The findings are particularly sobering now that measles cases are increasing sharply—by more than 30% globally from 2017 to 2018—because of undervaccination and misguided vaccine safety concerns. "If we allow [measles] outbreaks to happen, we are knowingly creating pockets of people who are susceptible to other diseases as well," says Velislava Petrova at the Wellcome Sanger Institute in Hinxton, U.K., who led one study.

"These two studies provide further strong evidence for the highly immunosuppressive effects of measles infection and the power of measles vaccination to counter it," adds population biologist Bryan Grenfell of Princeton University, whose group in 2015 reported early evidence for the effect.

That finding was based on population data showing that mortality from other pathogens increases after a measles outbreak. Experiments in animals have also suggested the measles virus impairs immunity. So Petrova's group and another, headed by Stephen Elledge of Harvard University, decided to explore this phenomenon more closely in people. Both teams chose a well-known cohort of children from an Orthodox Protestant community in the Netherlands whose parents had opted out of all vaccines for their children for religious reasons.

Michael Mina, a Harvard virologist who also worked on the population study, teamed up with Elledge to analyze blood samples from 77 of the children before and after they became infected during a 2013 measles outbreak in the Netherlands. Tomasz Kula, a postdoc in Elledge's lab, had developed a technology called VirScan that enabled the team to test the antibodies in the infected children's blood against antibody targets representing most known human pathogenic viruses.

Before the children contracted measles, their blood contained antibodies to many common pathogens. "These were really healthy kids," Mina says. After the disease, the children lost, on average, about 20% of their antibody repertoire. Some fared much worse, losing more than 70% of their immunity to viral pathogens, the research-

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