embrace new ideas, which might have been proposed by others. But it showed that except for the newest scientists, young researchers far outpaced older scientists in citing new ideas in their papers, Packalen and Bhattacharya found. Because the two had no way of measuring the actual age of a researcher, they calculated 'career ages' — the number of years after a scientist's first publication.

"I really like the way they're approaching things in terms of text analysis," says Bruce Weinberg, an economist at Ohio State University in Columbus, who works with Packalen and Bhattacharya on other projects.

All is not lost for senior scientists, however. Packalen and Bhattacharya also analysed the career stages of papers' first authors (who tend to do the bulk of the research) and last authors (who tend to be supervisors), and found that the most innovative combination was an early-career first author and a mid-career last author (see 'Hot spot'). "One reading of the results is that we quantified something that a lot of people thought was true: that young guys are innovative but they also need some mentorship," says Packalen.

"One reading of the results is that young guys are innovative but they also need some mentorship."

And Weinberg previously found that the age at which scientists make Nobel-prizewinning breakthroughs is increasing (B. F. Jones and B. A. Weinberg *Proc. Natl Acad. Sci USA* **108,** 18910–18914; 2011). "I think we're learning something about what these different measures are picking up," Weinberg says.

Nonetheless, Paul Ginsparg, a physicist at Cornell University in Ithaca, New York, and the founder of the online repository arXiv.org, says that Packalen and Bhattacharya's findings make sense. "In some areas of biomedical research it might take a couple of years to learn a new set of ideas and retool a lab," he says. "Hence it wouldn't be surprising if established researchers have trouble finding the time to do so."

Ginsparg also wonders whether analysing the full text of papers might tell a different story. It could be that established researchers incorporate fresh ideas into an existing methodology and framework, and therefore mention them deeper in a paper.

Packalen, who published his first paper in 2010, knows that the findings could be tough for some older scientists to swallow. "I look at these findings and say, 'No way is this going to happen to me'," he says. "I'm going to stay innovative. I'm going to learn new ideas." ■

LINGUISTICS

Language origin debate rekindled

Eurasian steppe gains ground as Indo-European birthplace.

BY EWEN CALLAWAY

From Icelanders to Sri Lankans, some 3 billion people speak the more than 400 languages and dialects that belong to the Indo-European family. Two fresh studies — one of ancient human DNA, the other a newly constructed genealogical 'tree' of languages — point to the steppes of Ukraine and Russia as the origin of this major language family, rekindling a long-standing debate.

Scholars have long recognized an Indo-European language group that includes Germanic, Slavic and Romance languages as well as classical Sanskrit and other languages of the south Asian subcontinent. Yet the origins of this family of tongues are mired in controversy.

Some researchers hold that an early Indo-European language was spread by Middle Eastern farmers around 8,000–9,500 years ago (see 'Steppe in time'). This 'Anatolian hypothesis' is supported by well-documented migrations into Europe, where agriculturalists replaced or interbred with the existing hunter-gatherers. In 2012, a team led by evolutionary biologist Quentin Atkinson of the University of Auckland in New Zealand produced a family tree of Indo-European tongues that also pointed to an Anatolian origin more than 8,000 years ago.

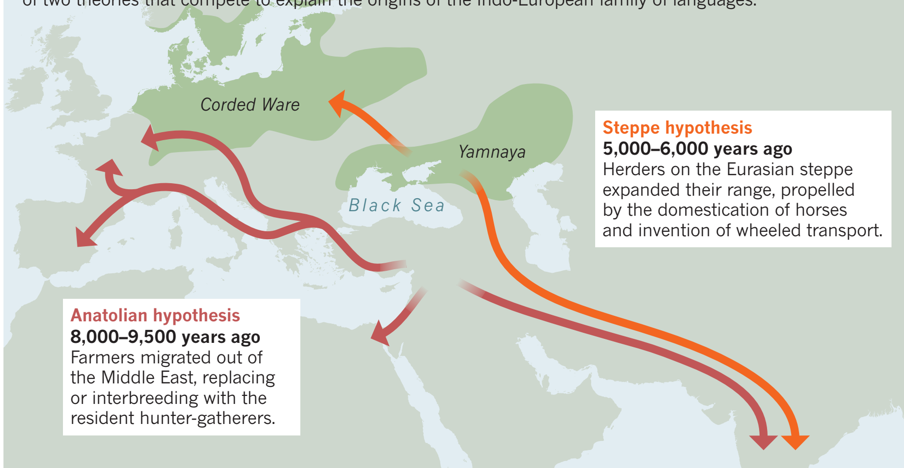
A competing theory posits that the languages emerged on the Eurasian steppe some 5,000–6,000 years ago, when the domestication of horses and invention of wheeled transport would have allowed herders there to rapidly expand their range. Proponents of the 'steppe hypothesis' note that linguistic reconstructions of a proto-Indo-European tongue include words associated with wheeled vehicles, which were not invented until long after Middle Eastern farmers had reached Europe. "Most linguists have signed up to the steppe hypothesis," says Paul Heggarty, a linguist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany.

One knock against the theory was a lack of compelling evidence for a large-scale migration from the Eurasian steppe at this time.

A study of ancient human DNA posted to the bioRxiv.org preprint server on 10 February now plugs that gap (W. Haak *et al.* http://doi.org/z9d; 2015). A team led by David Reich, an evolutionary and population geneticist at Harvard Medical School in Boston, Massachusetts, analysed DNA from the bodies of 94 individuals who lived across Europe between 8,000 and 3,000 years ago. The data confirmed the arrival of Middle Eastern farmers in Europe between 8,000 and 7,000 years ago. But they also revealed evidence for a second migration that began several thousand years later. DNA

STEPPE IN TIME

An ancient-DNA study links the Corded Ware culture of northern Europe with the Yamnaya culture of the Eurasian steppe. It points to a mass migration northwest that would support the Steppe hypothesis, one of two theories that compete to explain the origins of the Indo-European family of languages.



W. HAAK *ET AL.* HTTP://DOI.ORG/Z9D (2015) recovered from steppe herders called the Yamnaya, who lived in what are now Russia and Ukraine around 5,000 years ago, closely matched that of 4,500-year-old individuals from present-day Germany, who were part of a group known as the Corded Ware culture that encompassed most of northern Europe. The similarities suggest "a massive migration into the heartland of Europe from its eastern periphery", the team writes.

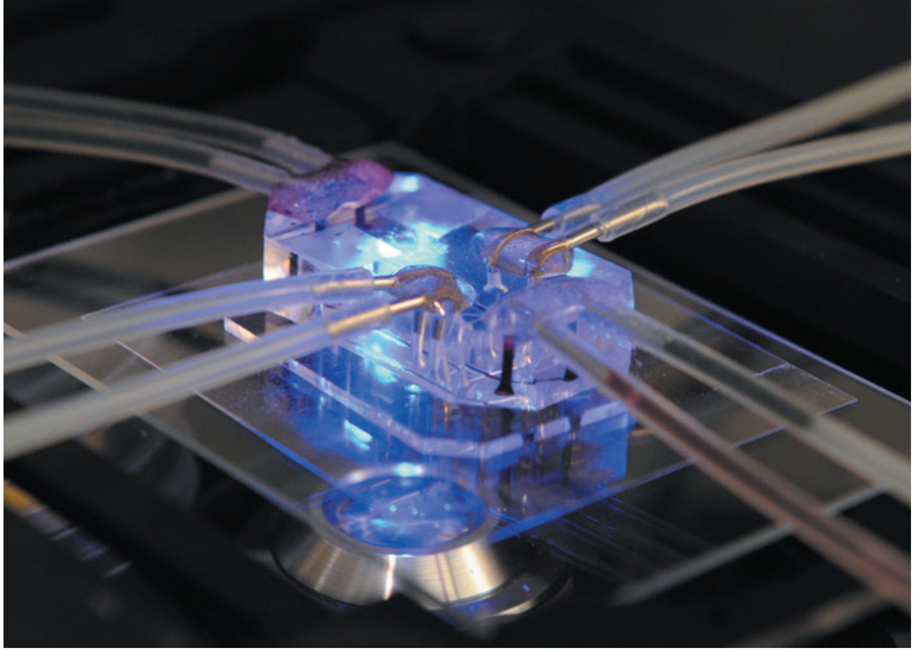
Yamnaya ancestry survives in the genomes of modern Europeans, with northerners such as Norwegians, Scots and Lithuanians maintaining the strongest link. The geographical extent of the Yamnaya migration is not clear, but the researchers note that the eastern migrants could have completely replaced existing populations, at least in what is now Germany. It is impossible to know the language these migrants spoke, but it is likely to have originated in the steppe homelands of the Yamnaya.

"This seems like very striking support for at least part of the traditional steppe model of Indo-European diversification," says Andrew Garrett, a historical linguist at the University of California, Berkeley, whose own work adds further support. When he and his team re-analysed the data from Atkinson's 2012 family tree, this time taking into account the approximate ages of ancient Indo-European languages, they dated the origin to around 6,000 years ago, in line with the steppe hypothesis (W. Chang, *et al. Language*; in the press).

Atkinson says, however, that the analysis assumes that ancient languages such as Latin and Old Irish are direct ancestors of modern languages, instead of side-branches of a common ancestor. This makes it appear that these languages evolved faster than they did, he says, and would argue incorrectly for a more-recent common tongue.

Heggarty points out that Reich's ancient DNA study is not the final word on the steppe hypothesis either. He suspects that the Yamnaya spoke a language that later developed into Slavic, Germanic and other northern European tongues, but he doubts that the group imported the predecessor of all Indo-European languages: "For me, these data look like the steppe population was speaking a branch of Indo-European."

Reich and his team acknowledge that attributing the origin of all Indo-European languages to the Yamnaya migration would require the discovery of their genetic signatures in samples from further east, such as from India and Iran. But Carles Lalueza-Fox, a palaeogeneticist at the Institute of Evolutionary Biology in Barcelona, Spain, notes that the climates of the Middle East and southern Asia do not augur well for preservation of ancient DNA: "It could be difficult to find good samples from the right time frame." ■



WYSS INSTITUTE/HARVARD

'Organs on chips', such as this simulated lung, could be used to test bodily responses to toxic chemicals.

BIOENGINEERING

Scientists seek '*Homo chippiens*'

Biodefence projects aim to mimic the human body using networks of simulated organs.

BY SARA REARDON

Each year, the US government spends hundreds of millions of dollars stockpiling countermeasures for potential biological, chemical and radiological warfare agents. For ethical reasons, many of these treatments have never been tested in humans. Now, the US military and civilian science agencies are supporting the development of the next best thing for tests: miniature human organs on plastic chips.

"It's unethical to expose humans to the kind of radiation that you'd see in a disaster like Fukushima, but you need to be prepared," says Donald Ingber, a bioengineer at Harvard University's Wyss Institute in Boston, Massachusetts. With support from the US Food and Drug Administration, he is adapting his 'bone marrow on a chip' to study the effects of harmful radiation and experimental remedies.

Other researchers working along similar lines discussed their work on model organs for biodefence applications at a meeting of the American Society for Microbiology (ASM) last week in Washington DC. The hope is that these complex three-dimensional systems will mimic human physiology better than do cells grown in a dish, or even animals.

A common way to form a model organ is to seed cells into channels in a small plastic chip and then feed them with nutrient-rich fluid that flows through the system to mimic blood. The devices can be used individually or connected to other types of organs-on-chips to approximate a biological system, or — eventually — perhaps an entire human body.

The US Environmental Protection Agency plans to announce next month an US$18-million programme to link 'livers on chips' with chips that simulate fetal membranes, mammary glands and developing limbs. The ultimate aim is to study how environmental contaminants such as dioxin and bisphenol A alter metabolism in those organs once they have been processed by the liver.

The flexibility afforded by model-organ systems is especially attractive to researchers who are investigating dangerous pathogens, given the expense of animal studies and the security restrictions required. At the ASM meeting, microbiologist Joshua Powell of the Pacific Northwest National Laboratory in Richland, Washington, presented experiments testing the ability of anthrax spores to infect a three-dimensional 'lung' grown from rabbit lung cells. The cells sit at an interface between liquid and air, much as in real lungs.

Powell says that the US Department of Homeland Security is interested in using the system to answer questions such as how many anthrax spores are necessary to cause disease in the body.

For some viruses in particular, Ingber ▶