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Understanding why loneliness can spread through society like a disease is a key question for social scientists.

RESEARCH POLICY

Social science lines up its biggest challenges

'Top ten' crucial questions set research priorities for the field.

BY JIM GILES

How can we persuade people to look after their health? Why do moods spread like a contagion? How can humanity increase its collective wisdom?

These are some of the most pressing questions that social scientists should tackle, according to a group of leading scholars in the field who hope that their 'top ten' list will help shape the thinking of researchers and funding bodies for decades to come.

In a parallel effort, the US National Science Foundation (NSF) last week unveiled the results of its own agenda-setting exercise, which asked social scientists to identify "grand challenge questions that are both foundational and transformative".

Both groups say that they ran the exercises because they wanted researchers to step back from immediate research priorities and identify the most significant problems in their field. The results demonstrate the growing ambition of the social sciences to tackle difficult issues in a quantitative way, addressing problems from equality and wages to wars and health.

The 'top ten' approach was inspired by a list of 23 major unsolved questions compiled by the mathematician David Hilbert in 1900. The Hilbert problems helped to focus the attention of mathematicians throughout the following century. "He laid out the road map for twentieth-century math," says Nick Nash, a vice-president at General Atlantic, an investment firm based in Greenwich, Connecticut. "What if we had a road map for other disciplines?"

In 2008, Nash was studying for an MBA at Harvard University in Cambridge, Massachusetts, when he proposed the road map to Stephen Kosslyn, then the university's dean of social science. Together, they organized a symposium at Harvard last April that gathered together 'big thinkers' to present unsolved questions and to vote on which were the most important. The results are due to be released this week on Harvard's website (see go.nature.com/wa1hwf; see also 'Top ten social-science questions'). The site will also include a range of questions submitted by members of the public.

At the symposium, Emily Oster, an economist at the University of Chicago, Illinois, focused on a perennial challenge for public-health experts: how to get people to adopt healthier behaviours. For instance, persuading people to eat less and exercise more — to control ballooning obesity rates — might be simple in theory; in practice it is extremely difficult.

Because the rewards of behavioural change are often not apparent for years, Oster thinks the answer lies in programmes that offer an immediate pay-off. Preliminary studies have shown, for example, that cash rewards contingent on hitting weight-loss targets can help[1]. Even if payments amount to hundreds of dollars a month and, to prevent a relapse, are continued after dieters have shed their excess pounds, the strategy might save society money by reducing future medical expenses.

The approach is not

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PRIORITY LIST

Top ten social-science questions

1. How can we induce people to look after their health?
2. How do societies create effective and resilient institutions, such as governments?
3. How can humanity increase its collective wisdom?
4. How do we reduce the 'skill gap' between black and white people in America?
5. How can we aggregate information possessed by individuals to make the best decisions?
6. How can we understand the human capacity to create and articulate knowledge?
7. Why do so many female workers still earn less than male workers?
8. How and why does the 'social' become 'biological'?
9. How can we be robust against 'black swans' — rare events that have extreme consequences?
10. Why do social processes, in particular civil violence, either persist over time or suddenly change?

foolproof, though. One recent large-scale experiment, aimed at financially rewarding low-income New York City families for keeping children in school and taking regular medical check-ups, was halted last year after it produced only limited improvements (see go.nature.com/eunolm). Oster says that researchers need to experiment with different reward systems, as it is not clear how the best system for a particular problem should be chosen.

Nick Bostrom, a philosopher at the University of Oxford, UK, who was also involved in compiling the Harvard list, wants social science to improve society's "ability to get the important things approximately right". He notes that judgements by specialists are often no better than those made by laypeople[2], and suggests that, rather than relying on individuals, society should develop and exploit new methods for aggregating knowledge.

In financial markets, for example, participants buy and sell shares on the basis of expectations about how the market will move. If enough people play the market, the price of the shares reflects traders' collective beliefs about future events. It is also possible to create artificial markets in which traders buy and sell shares related to specific events, such as a politician being elected. These markets also reflect traders' beliefs about outcomes, and can be good forecasting tools[3]. Bostrom would like to see such 'prediction markets' trialled more widely; they could assist with corporate decisions, such as whether to replace a company chief executive, he suggests.

Harvard social scientist Nicholas Christakis hopes to understand how physiological and psychological attributes, such as obesity and loneliness, can spread through a social network like a contagious disease, a phenomenon he has studied with James Fowler at the University of California, San Diego[4]. If one of your friends becomes obese, for example, your own chances of putting on weight increase. Christakis notes that there is unlikely to be a single theory that links social and biological factors. In the case of obesity, it may be that having an overweight friend somehow normalizes the idea of gaining weight. And preliminary work in poor neighbourhoods in Chicago suggests that loneliness and fear of crime can alter levels of stress hormones, which in turn can affect people's risk of cancer.

Nash and Kosslyn hope that drawing attention to difficult and important problems will motivate young researchers to work on them, just as young mathematicians were attracted to the Hilbert problems. "Nothing would make us happier than to see future grant applications that mention the 'Harvard problems'," says Nash. The similarity with the NSF's own exercise is not a bad thing, adds Myron Gutmann of the foundation's directorate for social, behavioural and economic sciences in Arlington, Virginia. "I'm delighted by [the Harvard exercise]," he says. "It allows us to look for repeated themes."

The NSF received more than 240 responses to its request for forward-looking ideas, which Gutmann plans to discuss with his advisory committee. "I can imagine that in the next two years we will identify a few ideas that seem especially important and invest in them, in the form of pilot projects and planning grants, with an idea that these investments will position us to make more significant investments 5–10 years from now," he says.

Cary Cooper, chair of the Academy of Social Sciences in London and a psychologist at Lancaster University, UK, is enthusiastic about the Harvard list. If funding were available to support work on the problems, he says, young researchers might feel confident enough to eschew simpler questions. Cooper adds that he will consider asking Britain's Economic and Social Research Council to run a similar exercise. ■

1. Volpp, K. G. *et al. J. Am. Med. Assoc.* **300,** 2631–2637 (2008).
2. Tetlock, P. E. *Expert Political Judgment: How Good Is It? How Can We Know?* (Princeton Univ. Press, 2006).
3. Berg, J. E., Nelson, F. D. & Rietz, T. A. *Int. J. Forecasting* **24,** 285–300 (2008).
4. Christakis, N. A. & Fowler, J. H. *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives* (Little, Brown, 2009).

GENOMICS

Gene reading steps up a gear

Third-generation sequencing machines promise to make their mark one molecule at a time.

BY HEIDI LEDFORD

"It's super cool, but it's never going to work," genomics guru Eric Schadt responded when a wary investor asked for his opinion about a new DNA-sequencing technology in 2003. A company was creating a machine that it claimed could revolutionize the field by reading over the shoulder of an enzyme as it copied DNA molecules.

Despite his initial scepticism, Schadt touted the method's success last weekend at the Advances in Genome Biology and Technology meeting in Marco Island, Florida. Now chief scientific officer at the company he had once doubted — Pacific Biosciences in Menlo Park, California — Schadt was one of several researchers at the meeting who provided a glimpse of how the company's first DNA-sequencing machines are performing.

All eyes are on these machines. Pacific Biosciences set a high bar for its own success in 2008, when chief technology officer Stephen Turner boasted that the instruments would be able to sequence a human genome in just 15 minutes by 2013, compared with the full month it took at that time. This year, as researchers unveiled data from the first machines to leave the company's campus, the discussion was less about revolutionizing the field and more about niche applications.

After several delays, customers have now been told to expect their machines in the second quarter of this year. The machines potentially offer advantages over the 'next-generation' sequencers currently on the market. Users of the new machines last week reported generating sequences an average of 1,500 base pairs long — about ten times the length of those currently produced by the state-of-the-art sequencers from Illumina in San Diego, California. These longer reads make it easier to stitch fragments of DNA sequences together into a coherent genome sequence.

"Single molecule is the future of sequencing, but it still has hurdles."

Pacific Biosciences' machines are also fast. In a paper published online in December, Schadt and his team used them to trace the origin of the ongoing cholera outbreak in Haiti by sequencing the genomes of five strains of *Vibrio cholerae* (C. S. Chin *et al. N. Engl. J. Med.* **364,** 33–42; 2011). The team sequenced all five strains in less than an hour. It takes about a week to complete a 150-base sequencing run on an Illumina sequencer.

IN A FLASH

New DNA sequencers watch an enzyme called DNA polymerase as it uses fluorescently tagged bases to synthesize DNA. Each base is identified by a distinguishing colour that flashes as the base is incorporated into the DNA strand.

But for many researchers, the key advance of the Pacific Biosciences machines is the ability to sequence single molecules of DNA. The instruments work by watching as an enzyme confined within a tiny compartment copies DNA, adding fluorescently labelled bases that flash with characteristic colour as they are added to the DNA strand (see 'In a flash'). Leading sequencers on the market instead report an average sequence taken from a population of molecules.

Single-molecule sequencing opens the door to analysing rare sequence variants, and frees researchers from having to amplify DNA samples before sequencing — a step that can introduce errors, and can fail altogether for certain DNA sequences. "Single molecule is the future of sequencing," says Michael Metzker, who studies sequencing technology at Baylor College of Medicine in Houston, Texas. "But it still has hurdles."

Chief among those hurdles has been high error rates. Whereas other methods on the market surpass 99% accuracy, users of the Pacific Biosciences machines last week reported an accuracy rate of about 85%. Schadt argues that this can be overcome by resequencing the same molecule repeatedly.

Nevertheless, because of the cost of its machines (US$700,000 per unit compared with less than $125,000 for the new Illumina sequencer rolling out this autumn) and limits on the number of sequences that can be read during every run, the instruments are unlikely to disrupt the sequencing market in the near future. For now, the machines are likely to be used for tackling regions of the human genome that resisted conventional sequencing. The instruments can also detect some chemical modifications to DNA, which could be useful to the burgeoning epigenetics field. Peter White, who heads the sequencing centre at Nationwide Children's Hospital in Columbus, Ohio, says he is interested in acquiring a machine, but would mainly use it to analyse microbial genomes, which tend to be much smaller than mammalian genomes.

At the meeting last week, Turner did not reiterate his pledge for a 15-minute human genome. But he did emphasize that there is still plenty of room for the current instrument to improve. "We are just at the beginning of this technology." ■

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CORRECTIONS

The News story 'Social science lines up its biggest challenges' (*Nature* **470,** 18–19; 2011) should have said that Nick Nash did his MBA at Stanford University.

The News Feature 'Exoplanets on the cheap' (*Nature* **470,** 27–29; 2011) should have said that the spectrometer on which the comb at the Hobby-Eberly Telescope was mounted came from Pennsylvania State University not the University of Pennsylvania.

The graph in the News Feature 'The End of the Wild' (*Nature* **469,** 150–152; 2011) showing a correlation between rising minimum temperatures in Wyoming and increased survival rates for mountain pine beetles should have made it clear that the beetle data were modelled not measured.