THIS WEEK

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Prepare farms for the future

Scientists must work closely with farmers to ensure that agriculture can stand up to the ravages of climate change.

Ignore the climate sceptics who set up a straw man of the need for 'settled science' and then burn it to the ground. Ambiguity is the acknowledged refrain of the climate-change symphony. From storms to sea-level rise, all projections of future change are surrounded by a residual uncertainty that will not go away, no matter how sophisticated our climate (and climate-impact) models may become.

The future of global agriculture is one of the most urgent issues in a warming world. Farmers must prepare for, and adapt to, a changed climate that is likely to feature more erratic rainfall, temperature extremes, drought, soil erosion, invasive weeds and durable pests. Science, error bars included, has much to offer these efforts. But if adaptation is to work, climate scientists, agricultural researchers, farmers and government officials must work closely together.

As a reminder of how sensitive farming is to extremes, consider the record-breaking 2003 European heatwave, which caused more than €13 billion (US$14 billion) in damage to agriculture and forests. In less-developed parts of the world, prolonged drought and other extremes come with even more direct social costs, in the guise of increased hunger and risk of violent unrest.

Reliable climate services, such as those being established around the globe under the auspices of the World Meteorological Organization, can provide valuable early seasonal forecasts to farmers and governments. Their accuracy and coverage must improve in the face of the coming climate crisis. But the strategic decision-making that climate change will increasingly force on the farming sector requires forecasts that look further ahead. And climate change is far from the only uncertain outcome that farmers must grapple with as they prepare for the future. Trade, technology and socio-economic change can affect agriculture just as profoundly as changes in rainfall and temperature.

Farmers are natural adaptors. They have been tweaking and changing their practices since humans first began to grow food, and most today have a keen sense of what works best on their fields. But climate change may require drastic measures beyond the capability of individual farmers, from expensive irrigation schemes to the transformation of farming systems. These may not materialize through economic growth alone. And specific needs and adaptation options will substantially differ from region to region — or perhaps from village to village — depending on farm types, soils, local climate and topography. There are as many different ways for agriculture to adapt to climate change as there are different types of agriculture.

Models of different scenarios concerning crops, climate and economics can help, but only up to a point. Agriculture is an early adopter when it comes to using science to inform and guide adaptation. However, this use of science does not rely only on the scale of models and the skills of modellers: trust, intuition and cultural empathy are just as important.

Developing an improved crop variety in the lab is a very different thing from convincing farmers to adopt conservation agriculture, switch to semi-arid farming systems or do anything else that may not come with an immediate, tangible benefit. To produce any 'actionable' outcomes, the science of climate-change adaptation must therefore engage and listen to the people it is supposed to serve.

As we discuss in a News Feature on page 396, adaptation researchers are increasingly aware of this communication challenge. Science-led initiatives, such as Modelling European Agriculture with Climate Change for Food Security and the Agricultural Model Intercomparison and Improvement Project (AgMIP), are being pursued in close consultation with local experts and farming communities. Such programmes are a valuable step beyond coarse academic projections of climate impacts such as changes in global crop yields, which lack regional specificity.

> ***"The science of climate-change adaptation must engage and listen to the people it is supposed to serve."***

Regional studies suffer from the inevitable uncertainty over the magnitude and manifestations of climate change, and perhaps even more over the course of socio-economic and technological development. But carefully crafted regional case studies, informed by locally sourced data, can produce plausible future scenarios from which local planners can draw a range of tailored adaptation options.

AgMIP aims to produce a standard experimental protocol to study climate impacts on farming, which will help adaptation efforts even further. If it succeeds, the programme should solidify adaptation research, in the same way that model comparisons have improved the consistency of the physical climate sciences. The future is uncertain, but that cannot be used as an excuse to fail to plan for it. ■

Timeless advice

The best guidance on how to get ahead in science stands the test of time.

How can a young researcher get ahead in science? They need perseverance: "You do experiments and 90% of them aren't going to work. Nobody warned me about that." Boldness: "People don't ask enough questions. They're embarrassed." Mastery of the basics: "I didn't even know where the pipettes were." And perhaps a dose of reality: "Rejection is an ever present companion in science."

Those quotes, all from researchers interviewed for a Careers Feature on page 491, demonstrate that there is more to a successful scientific career than being good at science. And although opportunities for paid positions in research have flourished in recent years, so has the competition. The message has yet to filter down to schools and university undergraduates, but professional science has become one of those careers that teachers and lecturers could euphemistically describe as 'popular' and 'competitive'.

This is good for science overall. The global talent pool is well-stocked and the number of proficiently trained apprentices eager to take their chances is healthy. It is less promising for the scientists themselves: too many are chasing too few positions.

In such a climate, providing careers advice for scientists has become a career in itself. Yet, as the researchers highlighted in the feature make clear, many of the questions and anxieties that trouble early-career scientists also crop up in other careers. And the useful skills that ambitious researchers are urged to develop are hardly unique to science either: confidence, communication skills, networking abilities and persistence will help to propel people up the ranks in most professional fields.

Not everyone is suited to a career in science — nor is there space for them. So how can the community identify and help those young researchers who have the best chances of success? Senior and established scientists can help through formal mechanisms such as mentoring schemes and more informal routes, including workshops and blogs. Universities and other institutions should recognize that these contributions are valuable, and assess and reward them appropriately.

Amid all this advice, how should young scientists judge which guidance to listen to? *Nature*'s advice to these young scientists is to read *Advice to a Young Scientist* by Peter Medawar (Harper and Row, 1979), which celebrates its 36th birthday this year. Back when it was published, digital science meant little more than measuring fingers, and to modern readers the book may look as if it belongs to another age, but almost all of its content remains startling relevant. Furthermore, it is warm, witty and written in a welcoming way that, at the very least, shows scientists that scientists can (a) communicate and (b) do so as well as anybody else.

Here is Medawar, for example, demolishing the platitude that science is based on mere curiosity. "Curiosity is a nursery word," he writes. "Most able scientists I know have something for which 'exploratory impulsion' is not too grand a description … A strong sense of unease and dissatisfaction always goes with lack of comprehension."

"How can the community identify and help those young researchers who have the best chances of success?"

But he is not always correct. On scientists who find that the job is not for them and opt out of research, Medawar claims that "the qualifications required of scientists are so specialized and time-consuming that they do not qualify him to take up any other occupation". In fact, as *Nature* has argued before, a solid grounding in science and the skills of research offer a strong platform for many alternative careers.

Lest anyone jump on the "him" in the above sentence and assume that this is a book 'of its time' that paints a male-dominated picture of science, Medawar is frequently at pains to stress the benefits of and the need for greater equality — for better and for worse. "Men or women who go to the extreme length of marrying scientists should be clearly aware beforehand, instead of learning the hard way, that their spouses are in the grip of a powerful obsession that is likely to take the first place in their lives."

And on the original point, on how young scientists can get ahead, he writes: "A novice must stick it out until he discovers whether the rewards and compensations of a scientific life are for him commensurate with the disappointments and the toil." Indeed. ■

It's good to talk

Help for those struggling to reproduce results could be just a phone call away.

Survey results released last week by the American Society for Cell Biology (ASCB) included an interesting nugget. Some 72% of respondents said that they had been unable to replicate a published experimental result. Yet a higher proportion (77%) said that they had never been told that their work could not be replicated.

There could be many reasons for the difference. The most obvious would be that no one actually tried to replicate the research in question (or that they did not try very hard). When survey participants were asked how they responded to such problems, 55% said that they did not bother resolving the replication issue because they did not think the research was important enough to pursue. For others, the survey results suggest that if and when they did try to replicate, and failed, then they also failed to flag the problem with the original researchers. And it means that they did not ask the people who are best placed to help answer the most obvious question: what am I doing differently to you?

That is not always easy, but it should be the first response. And those on the receiving end of such enquiries should be open to them, not defensive or hostile. As this journal has pointed out before, there is often an art to science. The methods sections of papers, as rigorous as authors and journals try to make them, do not always tell the full story. They cannot pass on tacit knowledge — just as someone cannot be taught adequately from a book how to ride a bicycle.

More than 800 of the ASCB's 9,000 or so members answered the survey. They reported that the most common way to resolve problems with failed replication attempts was through collegial consultation with the lab that did the original experiments. In an era of huge competition in biomedicine — when some researchers might fear hostility or even retaliation from senior colleagues when questioning the reproducibility of their work — the survey shows that amicable collaborations, including reagent sharing and open communication, can improve science and make the work of scientists more efficient.

The 'replication crisis' in science, and in biological research in particular, is a serious and complex problem that will not be solved by better communication alone. This journal and others have launched initiatives that aim to address many suggested and suspected problems in reproducing results. The ASCB survey results again highlighted some of the issues: respondents rated the push to publish in high-profile journals and poor methodological training as the biggest factors.

The ASCB published a report alongside the survey results, which made some further recommendations for change (see go.nature.com/uh1wsu). These include improvements in statistics training and standardizing the way that experiments are performed.

Even if systemic problems are tackled successfully, some problems of irreproducibility will remain. Biological systems are complex and finicky, and there will always be new experiments, equipment and techniques that take time to master. That one scientist cannot repeat the work of a second does not mean that the first is unskilled or the second sloppy. Although much of the broader media attention on the replication crisis focuses on deliberate misrepresentation and research fraud, scientists and journals know that the reality is more complex, and less nefarious. Good science is often difficult science. And good scientists should not make it more difficult than it needs to be. So ask for help — pick up the phone. ■

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