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Brace for impacts

The latest instalment of the Fifth Assessment Report from the Intergovernmental Panel on Climate Change lays out the state of the world — and the challenges ahead.

When the Intergovernmental Panel on Climate Change (IPCC) released its previous report in 2007, some scientists and many environmentalists were still loath to talk about adapting to climate change. The policy focus was squarely on reducing greenhouse-gas emissions, and even talking about adaptation was often seen as defeatist. Thankfully, that sentiment has faded, and, although reducing emissions remains a paramount issue, climate-adaptation efforts are now under way in the private and public sectors in many countries. But as the latest instalment of the IPCC's Fifth Assessment Report — covering climate impacts, adaptation and vulnerability — makes all too clear, humanity has a long way to go in preparing for the effects that are already inevitable owing to our history, let alone for a future in which emissions continue to rise.

The report documents a range of potential impacts, from reduced agricultural yields to increased water shortages and often-unpredictable stresses on ecosystems around the globe. None of these comes as a surprise, and citizens and policy-makers would be wise to act sooner rather than later. There is no going back, regardless of the policies that might be enacted at the next United Nations climate summit in Paris in 2015, or at the meetings that follow. In that sense, this is not just a report about climate impacts. It is a comprehensive assessment of the state of the world in which we live and the direction in which it is inevitably headed. The alternatives to rapid, coordinated adaptation will be even more costly.

The latest assessment makes broad statements about the probable impacts of a warming climate on agriculture, but significant uncertainties remain at regional and global scales. Most model projections indicate reduced yields for major food crops such as rice, wheat and maize (corn) in many regions, but more than 25% of projections indicate that yields could rise by mid-century and beyond. Time does not stop in 2050, and the IPCC assigns a high confidence level to its statement that longer-term temperature increases in excess of 4 °C above late-twentieth-century levels, when combined with increasing demand, would pose significant risks to food security at regional and global scales.

Scientists have their work cut out. They must continue to collect data about the ever-changing world while seeking to understand how diverse landscapes — both wild and tamed — will respond to global warming. And they must drill down to the regional level to help governments and people to make good decisions. The IPCC should consider working with local experts and bodies on detailed assessments that could then be vetted by the agency itself — a process that would engage more people and counter the impression of paternalism that sometimes shades the IPCC's work, dominated as it is by Western scientists.

In addition to filling in the knowledge gaps, scientists and the IPCC must also work to communicate clearly what is not known, be it the cause of extreme weather or the relative benefits of the suite of policy options facing governments. The current report, to the IPCC's credit, casts doubt on the models that are used to estimate economic impacts, suggesting that they are based on "disputable" assumptions. Such projections are important when it comes to deciding who should pay which bills and when; researchers and economists must tackle these questions and more reliably determine the extent to which climate change will diminish wealth and economic growth in the long term.

"Policy-makers would be wise to act sooner rather than later."

There is no single approach to adaptation, and strategies range from basic economic diversification to improvements in irrigation and fertilizer use. Certain regions might pursue flood protections, early-warning systems and insurance programmes, whereas others might focus on maintenance and restoration of coastal vegetation. In the poorest countries, international financial support will be necessary. But to make it all come together, scientists and policy-makers urgently need to invest extra resources to improve environmental observations and to determine what actions make the most sense. ■

Natural decline

Few biology degrees still feature natural history. Is the naturalist a species in crisis?

What has become of the naturalists of yesteryear — the vicar with the magnifying glass and pressed flower collection, or the gentleman scientist with butterfly nets and a shotgun? Those dedicated observers of the natural world in all its complexity are still among us. But they are harder to pick out now; they are men and women, students and citizens. And they clutch not sample jars but smartphones.

In an article published late last month (J. J. Tewksbury *et al. BioScience* http://doi.org/r5g; 2014), Joshua Tewksbury, a naturalist and director of the Luc Hoffmann Institute at the conservation group WWF in Gland, Switzerland, and 16 colleagues issue a call to arms. They chronicle the dismaying diminution of support for natural history — that branch of science that encompasses the careful observation and description of organisms and their relations to their environments. Like all good scientists, they offer the data to support their assertion.

In the United States of 1950, an undergraduate degree in biology generally required two or more courses in natural history. Today, the average number of required natural-history courses for the same degree is zero. The amount of natural-history content in biology textbooks has dropped by 40% over the past six decades. PhDs granted in natural-history-related fields are becoming ever rarer. Biological collections are on the wane as well. The number of herbaria — research collections of plant specimens — in Europe and North America peaked in 1990.

Research in the life sciences is not created or destroyed: it simply shifts from one form to another. As natural history has been de-emphasized, molecular biology, genetics, experimental biology and ecological modelling have flourished. But here is the problem: many of those fields ultimately rely on data and specimens from natural history. Natural-history observations help to fight infectious diseases that cycle through different species, to identify promising leads for drug discovery, to manage fisheries and forests and other natural resources and to conserve species and ecosystems.

As Tewksbury and his colleagues write: "Direct knowledge of organisms — what they are, where they live, what they eat, why they behave the way they do, how they die — remains vital to science and society." The best algorithms in the world will fail to guide our action accurately if they are not based on a firm understanding of what is out there and what it's up to.

Revitalizing natural history will require tweaking the research incentives of grants and academic tenure. The *BioScience* article is right to call for natural historians to go out and stress the enduring importance of their craft to universities, funding agencies, foundations and the public. No biology student should get a diploma without at least a single course in identifying organisms and learning basic techniques for observing and recording data about them. Top journals should publish excellent natural history; the revived 'Natural History Miscellany' section in *American Naturalist* is a good first step.

Natural history itself can adapt to help. It should continue to expand beyond the elite, lone naturalist. New digital tools, including mobile versions of field guides (such as the Leafsnap app, which can identify tree species from photographs, and the Chirp! app, which helps users to recognize bird songs), are lowering the bar for entry for those without training. And digital data repositories — such as eBird, created by the Cornell Lab of Ornithology in Ithaca, New York, and the New York-based National Audubon Society — mean that today's naturalists can share and compare their observations. These tools can be used by the general public to build big data sets, which can feed into experiments or models.

"No biology student should get a diploma without at least a single course in identifying organisms."

As scientists from Yale University point out in a Comment piece on page 33, such data sets are also crucial for other purposes: to hold to account the official government figures that, for one reason or another, do not accurately reflect the situation on the ground, in the air or in the seas.

Natural history has never been just about the science. It is a craft and a passion with its own immediate aesthetic and visceral pleasures, the epitome of a positive relationship with nature. The smartphone, as the most ubiquitous representative of an increasingly digital culture, has often been held up as the pernicious opposite of a direct relationship with the natural world. But technology can be used as a tool to draw us closer to nature as well as a screen to block our view.

The dedicated observers are still there. They tramp through the woods on cold winter nights, their breath visible in the moonlight. They play the calls of the great horned owl on their smartphones. And the great horned owls call back. ■

Brain waves

Above the 'big neuroscience' commotion, literature plays its part.

"Literature was not born the day when a boy crying 'wolf, wolf' came running out of the Neanderthal valley with a big grey wolf at his heels," wrote novelist Vladimir Nabokov. Instead, he argued, it was born "on the day when a boy came crying 'wolf, wolf' and there was no wolf behind him".

The French consciousness-research pioneer Stanislav Dehaene uses this quote in his new book, *Consciousness and the Brain*, in which he describes his 'global neuronal workspace' theory, elaborated together with Jean-Pierre Changeux through modelling a 20-year series of daring experiments probing conscious and unconscious perception in humans. Only since brain imaging and other tools have allowed us to view the human brain at work has it become 'respectable' to try to pin down consciousness, and to debate how the human mind has allowed the development of intellectual pursuits as sophisticated as literature.

The Dehaene–Changeux theory holds that awareness moves from subconscious to conscious only when we pay attention to specific sets of information in our brains: images, memory, emotional state. These briefly come together in a limited-capacity workspace, ready to broadcast to all brain regions through axons. This theoretical workspace is where consciousness emerges; where, for example, a storyteller may invent a fictitious scene of deceit, such as the boy who cried wolf.

Dehaene quotes Nabokov often in his books, with good reason. The poetic, multilingual novelist and entomologist often pondered eloquently on the state of being conscious. Understanding consciousness and the mind may take a century, but it stands as an irresistible beacon. Other goals, such as understanding, fixing or ameliorating neurodegenerative or psychiatric diseases, may be 'only' decades away.

Many regret, but few doubt, that the long haul towards these goals requires a cultural shift in neuroscience research, from small to big science. Indeed, 'big neuroscience' has already begun. Last year, Europe formally launched its highly ambitious Human Brain Project (HBP), which aims to simulate the human brain in a supercomputer. It already has 32 partners across 13 countries. And the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, announced by US President Barack Obama on 2 April last year, will soon begin distributing money.

The privately funded Allen Institute for Brain Science in Seattle, Washington, has been doing big neuroscience for more than a decade, producing systematic anatomical and brain maps, mostly in the mouse, and is now starting to map functions of the component neurons. All of its maps are publicly available. It is a happy coincidence that *Nature* has published two brain-mapping papers from Allen scientists on the anniversary of Obama's announcement (see http://dx.doi.org/10.1038/nature13185; http://dx.doi.org/10.1038/nature13186; 2014). One of the maps is the first gene-expression atlas of the entire developing human brain. The other is a mouse 'connectome' — the first brain-wide neuronal-connectivity map for a mammalian species — that will guide the initial modelling of the HBP, which is beginning with the mouse brain.

But the path to generating and modelling the data needed to crack the codes of the brain will not be smooth. Already, the HBP has annoyed researchers by not funding the generation of data in non-human primates in its first phase, perhaps fearing a political backlash. But monkey data will be needed as a bridge between the mouse and human brain.

As big neuroscience advances, the Dehaene–Changeux theory may be proved wrong. So, too, may the more abstractly mathematical 'integrated information theory' of consciousness preferred by the Allen Institute's chief scientific officer Christof Koch. That is the process of science. Koch complains in his review of Dehaene's new book in *Science* that the workspace theory limits itself too much to the waves of electrical activity in the brain that experiments pick up, and fails to explain the 'why' of consciousness (see http://doi.org/r5q; 2014). Koch counter-quotes Nabokov: "The breaking of a wave cannot explain the whole sea."

As big-brain programmes navigate their thorny early years, it is good to be so neatly reminded of their ultimate goal. ■

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