nature

www.nature.com/nature

Vol 464 | Issue no. 7290 | 8 April 2010

Open sesame

Government influence favouring enhanced openness is rightly diversifying practices in science publishing.

The rise of the Internet in the 1990s helped spark a radical idea for turning primary science publishing on its head. If journals charged authors a fee to publish, instead of charging readers and libraries a fee to subscribe, said the advocates, published peer-reviewed papers could be provided free to anyone in the world.

This simple-sounding notion provoked visceral debate, resulting in extensive multisided arguments and antagonism among advocates of this and other forms of 'open access' and publishers, librarians and funders. Most of that rancour has now given way to greater pragmatism, dialogue and compromise. There is a broad appreciation that change is inevitable, but that constructive change takes time, thought and experimentation.

"There is a growing demand among lawmakers and funders for greater public access to the literature."

Open-access pioneers such as the not-for-profit Public Library of Science (PLoS) and its commercial cousin BioMed Central have successfully shown that the author-pays model can be financially viable in the real world — something many had doubted. But the demonstration also offers a dose of reality. PLoS's goal when it launched in 2003 was to prove that high-impact journals could be paid for by author fees of just US$1,500 per paper. Yet author fees for its top journals have risen to $2,900 per paper, and the organization's finances are critically dependent on the high volume of papers published in its online journal *PLoS ONE*. This low-overhead journal, which charges $1,350 per paper, does not make editorial judgements about its papers' merits, it simply passes them through peer review to certify that they are technically sound.

The PLoS experience highlights the challenge in applying the author-pays model universally. Many journals, such as *Science* or *Nature* and its sibling journals, rely on their subscription fees to support the costs of high selectivity, added-value editorial content, such as reviews, and online enhancements. Such journals would need to charge fees several times that of *PLoS ONE* to cover their costs and support investment. So although author-pays could be a viable model for many lower-overhead journals, its broader uptake within the publishing industry will depend on the level of funds that research agencies are willing to make available for scientists to pay publishing fees.

One valuable and established intermediate model is the hybrid approach, in which subscription journals give authors the option to pay a fee to make their article freely available instantly. Nature Publishing Group will soon be launching its first Nature research journal of this sort, *Nature Communications*. Economists who have studied the science publishing industry argue that the sector will ultimately evolve into a mix of open-access, subscription and hybrid journals, rather than a monoculture.

In the meantime, there is a growing demand among lawmakers and funders for greater public access to the literature, in particular in fields where public interest is strong, such as biomedicine. This demand seems most likely to be met at least for the foreseeable future by a different model of openness, which was articulated in a 2007 bill requiring researchers at the US National Institutes of Health (NIH) to make authors' or publishers' versions of research papers publicly available in the PubMed Central repository within 12 months of publication. There is speculation that President Barack Obama might soon issue an executive order extending this requirement to all federal research agencies (see page 822). Legislation to that effect has also been introduced in the US Senate, and may soon be introduced in the House of Representatives.

Nature's publishers have consistently backed the NIH mandate, and support its extension to other agencies. But whatever form the extension takes, it should be flexible about the compulsory time limit within which papers must be deposited in archives following their publication in journals. The NIH initially insisted on a 6-month embargo interval, but agreed to extend this to 12 months after protests from some publishers. Governments must not impose a one-size-fits-all embargo interval. At a time when many academic libraries are facing deep budget cuts, they may be tempted to axe subscriptions to many journals on the grounds that all but the most recent content is freely available in archives such as PubMed Central. And that, in turn, could particularly hurt journals in disciplines such as the social sciences, in which researchers use older material far more frequently than do those in fast-moving fields such as molecular biology. Publishers must be able to negotiate embargo intervals that will fulfil their obligation to allow greater public access but not jeopardize their businesses. And publishers, in turn, need to recognize that science's social contract is evolving towards greater openness. ■

Learning in the wild

Much of what people know about science is learned informally. Education policy-makers should take note.

The seemingly endless debate about how to improve US science education seems to make the tacit assumption that learning happens only in the classroom. As a result, the arguments tend to focus on issues such as curricula — specifying, say, what information pre-college students should be expected to learn at each grade level — and, as in US President Barack Obama's recent proposals to reform the No Child Left Behind policy, on the best way to hold schools to rigorous standards of student achievement.

However, researchers who study learning are increasingly questioning this assumption. Their evidence strongly suggests that most of what the general public knows about science is picked up outside school, through things such as television programmes, websites,

NATURE|Vol 464|8 April 2010

magazine articles, visits to zoos and museums — and even through hobbies such as gardening and birdwatching. This process of 'informal science education' is patchy, ad hoc and at the mercy of individual whim, all of which makes it much more difficult to measure than formal instruction. But it is also pervasive, cumulative and often much more effective at getting people excited about science — and an individual's realization that he or she can work things out unaided promotes a profoundly motivating sense of empowerment.

This suggests that policy-makers who focus exclusively on the classroom are missing an opportunity: even modest investment in informal science education could help to make the very large investment in formal instruction considerably more effective. Most of the necessary infrastructure is already in place: museums and zoos, for example, have been around for generations. Likewise, government funding mechanisms — agencies such as NASA and the National Science Foundation (NSF) — have been funding science exhibits, television specials and other informal science-education projects for many years.

"The personal nature of informal science education is what makes it powerful. The question 'why is this relevant?' never even arises."

More recently, the NSF has begun supporting systematic research into how people learn in informal settings. The first attempt to integrate the findings from this research and to draw broad lessons from it was reported in a study released by the National Academies in January 2009. This was followed, last month, by a companion volume that focused on the most effective ways to apply those lessons. Since 2007, the NSF has also funded the not-for-profit Center for Advancement of Informal Science Education in Washington DC to coordinate efforts across the entire field — from film and broadcast media to botanical gardens to digital gaming.

Despite the obvious pitfalls of self-guided learning — starting with the huge amount of superficially plausible misinformation and pseudoscience available through sources such as the Internet and creationist museums — researchers have found that people are generally adept at picking up and applying information on subjects that matter to them. Someone with gallstones, for example, may well be able to discourse at length about the gall bladder; many small-town residents have no trouble figuring out why local fishing improved after a paper mill closed; and a ten-year-old who gets a pet snake is likely to end up knowing more than most about herpetology.

Indeed, researchers say, the personal and idiosyncratic nature of informal science education is precisely what makes it powerful. The question that plagues classroom science — why is this relevant? — never even arises. And, because it is not tied to school, informal learning is equally available to adults — many of whom find themselves confronting issues surrounding genetically modified crops or Internet privacy that didn't exist when they were students. If they are going to learn about these issues at all, most will have to do so outside the classroom.

There is, however, still much that researchers don't understand about informal science learning. It seems to be cumulative, but how do people integrate the disparate pieces of knowledge they acquired at different times and places? And how can anyone assess the overall outcome? In addition to measuring cognitive factors such as vocabulary gain or the ability to apply a formula, informal learning needs metrics for affective qualities such as attitudes, interests and behaviours. How well have people learned to think on their feet, for example? And how good are they at weighing-up evidence and asking critical questions?

The NSF, to its credit, is funding research into this area, and many others relating to informal learning. It should continue to do so. In the meantime, however, education authorities need to recognize the importance of informal science education and do more to promote it — if only as a way to motivate students in the classroom.

There are encouraging signs that this is beginning to happen. Since 2004, for example, the California Science Center in Los Angeles has operated an elementary school on its grounds, and the museum and its resources are integrated into the school's curriculum. In both the United States and the United Kingdom, dozens of museums and zoos are exploring variations on this theme as they build relationships with nearby schools. In addition, some research initiatives have begun building in citizen-science components. A prime example is the education component of the NSF's nascent National Ecological Observatory Network, which hopes to recruit large groups of citizen-science volunteers to monitor invasive species, the effects of climate change and other environmental issues.

Such experiments should be encouraged and expanded. Striking the right balance between formal and informal science education will never be easy, but the answer is not to focus exclusively on the small fraction of people's lives spent in school. Policy-makers need to start looking at alternative models. ■

Attention Canadian mentors

Since they were launched in 2005, *Nature*'s awards for mentoring in science have rewarded outstanding research mentors in Britain, Germany, Japan, Australia and South Africa. The competition is held within one country each year, in the belief that mentoring reflects not just notions of good scientific practice and creativity that are universal, but also scientific traditions and cultures that are, at least to a degree, national. (For details of past competitions, see go.nature.com/Rccbo4. For our guide to outstanding mentoring, see *Nature* **447,** 791–797; 2007.)

This year's competition is taking place in Canada. Two prizes of Can$10,000 (US$9,900) will be awarded, one for a mid-career mentor and one for lifetime achievement in mentoring.

Nominations are now open, with a closing date of 30 June 2010. The prizes will be awarded at the Canadian Association for Graduate Studies annual meeting in Toronto, Ontario, in November.

Contenders may nominate themselves or be nominated by colleagues and ex-colleagues. Nominations for a candidate must include independent testimonials from at least five researchers who have been mentored by the nominee, not all over the same period. Full details and nomination forms can be found at go.nature.com/CKbeC4.

We look forward to hearing about Canada's outstanding mentors. ■