

COMMENT

A modest proposal for an outreach section in scientific publications

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Introduction

The idea for this column started with a tweet.

Both of us are active on Twitter, the social media website where users can share messages, or tweets, of 140 characters or less. While Twitter has swept around the world, a small but growing fraction of scientists are using it to establish collaborations or exchange information. More importantly, side effects of Twitter include a narrowing of the gaps between academic or industrial scientists, a burgeoning movement of science communicators, and a public very interested in science and technology.

As the saying goes: we're here to help.

We propose that scientific publications include a short section, akin to the acknowledgments at the end, which lists several outreach activities related to the paper. These could be new resources that the authors have created, or existing resources that are related to the paper's subject(s) – the goal is to reach out across that gap and help non-expert readers understand the work.

Yes, we know that writing a paper is hard enough. But if publishing scientists don't continue to help non-scientists (or even non-specialists in our areas) engage with our work, then disturbing trends will continue. Right now many of us bemoan the lack of science coverage in mainstream media – if we don't constantly work to translate our science, the coverage will continue to disappear. In addition, we will fail to give non-experts the tools and resources that will help them understand research and fact-check suspicious claims. Publishing scientists will also be increasingly unable to compete successfully against other demands for either governmental or philanthropic funds. Engagement even allows us to understand our own work better. If scientists can't summarize their work in a one-minute elevator pitch or in a phone call to their family, our experience suggests

they'll have a harder time keeping pace with their peers. Increasing numbers of grant proposals require a section on education or outreach; our proposal could help you find the materials – or inspiration – you need for your next funding application.

Finding material for this section will not be as difficult as you might think: many scientists may not be aware that the past few years have seen an explosion in high-quality, multimedia resources in science communication. Consider the 2012 Flame Challenge, hosted by the Center for Science Communication in NY, USA and the actor Alan Alda. Participants were challenged to explain with scientific accuracy, but speaking to an 11-year-old, what exactly a flame is. Entries included written text, videos, graphics and animations (viewable at <http://flamechallenge.org/>). The winning entry is definitely worth a watch and ends with a rocking chorus of “pyrolysis – chemiluminescence – oxidation – incandescence” in front of both molecular-block diagrams of the process and a guitar-playing Lucifer. Not exactly a paper in a high-profile journal, but scientifically accurate and more likely to be retained in the mind of an 11-year-old.

Methods

As a way to bridge the communication gaps we observe, we suggest that papers include a few links to resources or materials not aimed at passing peer review in the journal. Our point is not that these resources should explain all nuances of the paper; rather, we envision that the more layman-friendly elements will explain scientific concepts underlying the main themes of the paper, enabling interested parties to read the paper with increased understanding. Links could also provide context for the research in society, such as relevance to human health or to potential legislation or privacy concerns. Examples of outreach materials from our own institutes include the series of Biotech Basics articles at <http://www.hudsonalpha.org/education/outreach>, and the collection of videos on plant cell biology at <http://www.youtube.com/user/plantendomembrane>. Box 1 outlines other possible types of resources, but science and communication are both constantly evolving, and so this section should as well.

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Box 1. Possible types of resources

- References to non-scientific publications, such as popular science books and magazines.
- Links to websites, blogs and social media.
- Downloadable files, such as images, movies, artwork, audio (podcasts, songs) and slide files of public talks.
- Short reports of offline or online activities (for example, a festival stall, public lecture, webinar or webchat). What did the authors or communicators do? Who was the intended audience? What worked well? What did they learn?
- An author-created graphical abstract for the paper.

Although many papers are not freely accessible at the time of publication, we would suggest that this section be placed on the website for the paper, and be visible alongside the abstract even to those without a subscription. We do recognize that this would require journals to link to outside resources and even other brands. Despite the concerns over permanency and ownership of links, we believe the effort in creating this section would be worth it.

Should this section be peer-reviewed? Logic would suggest that someone check the links pre-publication to make sure they are working and suitable. Journals can decide if this should be done by peer reviewers (thus educating even more potential authors about the resources out there), or by editors or subeditors as part of the proof process. Ideally, this section would also contain keywords, tags and integration of social media (such as share buttons) to show up in internet searches and to interlink with the online community.

We further suggest this section allow comments, to contribute to the quite small but growing movement for post-peer-review. Educators or students could convey their experiences using the suggested outreach activities, or could share links to new activities created based on the work. Beyond the traditional links and videos we point to heavily here, there are many avenues for new resources: hands-on activities for children, a talk at a Cafe Scientifique or Science Tavern-type setting for adults, workshops for high-school or A-level students, creating a short movie with a tour around the lab or demonstrating a particular technique, or interviews with lab members in any medium.

Results

To demonstrate the feasibility of this section, we asked the editors to select three articles in this issue of *Genome Biology*, and we searched for appropriate resources. We ran into no shortage of possibilities; the problem was rather in selecting only a few for each article. First was Wong K *et al.* [1], “Sequencing and characterization of the FVB/NJ mouse genome.” Here the main concepts

include genome sequencing, particularly next-generation sequencing, and the use and history of mice and model organisms in genetics research. Thus the outreach section could include:

- <http://www.sanger.ac.uk/about/engagement/>.

The Wellcome Trust Sanger Institute’s own public engagement website, with links to quite a number of different activities relevant to genomics.

- <http://www.nature.com/nature/mousegenome/timeline/index.html>.

An interactive, freely-available timeline made by *Nature* to accompany the first mouse genome paper.

- http://en.wikipedia.org/wiki/Next-generation_sequencing#High-throughput_sequencing.

The Wikipedia entry on sequencing, and particularly high-throughput technologies. We suggest this due to the changing nature of the field and the ability for the entry to reflect context over time.

Our second assigned paper was Palmer N *et al.* [2], “A gene expression profile of stem cell pluripotentiality and differentiation is conserved across diverse solid and hematopoietic cancers.” Obviously this covers the high-interest topics of both stem cells and cancer, enabling a section with:

- http://outreach.mcb.harvard.edu/animations_S03.htm.

Part of a large resource for teachers with animations on multiple topics, including cancer.

- <http://www.youtube.com/watch?v=Sjcn2ZAJ5sc>.

A student-produced, class assignment video called “Determination of *Mus musculus* Hematopoietic Stem Cells by DNA Methylation.” The hematopoietic cell pathway, chromosomes, and methylation are illustrated using clay.

- http://www.stemcellresources.org/mm_podcasts.html.

A long list of podcasts and audio lectures covering the science of stem cells, maintained by Bioscience Network in NJ, USA.

The above selection doesn’t even include the last author Isaac Kohane’s own blog at <http://hmscountway.blogspot.co.uk/>, or any of the countless explainers of microarray technologies.

Finally, we were given Brunner AL *et al.* [3], “Transcriptional profiling of lncRNAs and novel transcribed regions across a diverse panel of archived human cancers.” The authors surveyed long non-coding RNAs in a panel of solid tumor samples, and find potential tumor-specific biomarkers. While many of us who live and breathe genomics may be used to reading about lncRNAs, the concept involves multiple layers of explanation for those not in the field. We’d suggest building layers as in this outreach section:

- <http://www.dnalc.org/resources/3d/central-dogma.html>.

A basic animation of the central dogma in biology, produced by the CSHL DNA Learning Center, or

- <http://www.dnalc.org/view/15889-RNA-polymerase-game-interactive-2D-animation.html>.
A game where you drag the correct RNA bases to the RNA polymerase, to understand transcription.
- <http://www.youtube.com/watch?v=eL9FKdAtU7c>.
A video lecture by Melissa Moore of the University of Massachusetts and Howard Hughes Medical Institute, going through transcription and splicing.
- <http://vimeo.com/29823316>.
A video of an overview slide session on non-coding RNAs at a conference, by Jens Kortmann, Ruhr-University Bochum.
- <http://mcmanuslab.ucsf.edu/node/251>.
An explainer website specifically for lncRNAs, the so-called dark matter of the genome, by the laboratory of Michael McManus at University of California, San Francisco.

Discussion

Biology is one of the most tangible, and easily understandable, areas of science, but biologists cannot afford to look only inward and not at the relationship between their work and our world. Our proposed section aims to crystallize outreach as a part of academic publication. Over time, this section can serve as a list for outreach projects outlined in grant proposals to funding bodies and implemented during the project. The added transparency would enable grant officers and reviewers to more easily confirm that grant money directed to outreach was spent appropriately. Perhaps this could even have the benefit of increasing public trust in science and scientists.

In the course of writing this column and selecting examples for three papers, we each found resources we had not seen before. Even though websites with lists of resources exist (see Box 2), a significant increase in new resources might require new ways of tagging or indexing to increase their visibility and citability. We are aware that the challenges here mirror general challenges in open science and online science, and we have faith that new movements in both areas will bring about exciting developments to facilitate interaction.

Biologists should take a moment and look at space sciences, with their intense focus and success in capturing the imagination of millions. For many, the excitement of the moon landing sparked a life-long interest in space science and even served as the stepping stone into a scientific career. Would the Apollo 11 mission have had a similar impact if it had happened without the live TV transmission and if NASA had just published the results of the expedition in scientific papers? Witness the recent landing of the Mars Curiosity rover – people all over the world stayed up late or got up early to follow along in real time. Twitter was ablaze. Museums and theaters showed

Box 2. A few of the many sites with collections of activities suitable or created for outreach

<http://collectivememory.britishtscienceassociation.org/>
<http://www.genome.gov/Education/>
<http://saps.org.uk/>
<http://www.letstalkscience.ca/>
<http://www.schoolscience.co.uk/>
<http://learn.genetics.utah.edu/>
<http://stemnet.org.uk/>
<http://www.molecularmovies.com/>
<http://www.dnatube.com/>

the landing on giant screens to packed crowds. Times Square in New York City was full of people watching on the Jumbotron and chanting “Science! Science!” NASA’s website was stocked with lovely multimedia explainers of the “seven minutes of terror” and these were downloaded millions of times.

Clearly, space science is doing well with outreach – what about molecular sciences? Cell biology? Genetics? Our fields may have a higher barrier to entry, meaning that there will be more work involved to create resources – but that makes it even more important. People refer to the Human Genome Project as the “moonshot” of genetics; we need a life science Mars landing now and then, too. And we also need to communicate the everyday wow! moments in what we do. It’s easy to be jaded and view some of our achievements as clichés (see the genomics conference bingo card at <https://docs.google.com/spreadsheet/ccc?key=0AkNPpmDaw5GhdFUyRFJ5TDd2b2l6Wlg3TnJKTl9ySGc#gid=0>) – but they are achievements and they do capture the imagination of budding scientists of all ages. Generating a human genome sequence has progressed from a multi-year, multi-billion-dollar endeavor to one that happens so often we think of it as just the first step in a publication. We may even be able to sequence genomes on a USB stick soon, due to improvements in sequencing technology that put Moore’s law to shame. We can use microscopy to see single proteins shuttling in and out of a nucleus in real time. We are slowly but steadily unraveling how plants, animals and humans function, from the smallest scale inside the cell to whole-organism level. Key findings of a single paper might seem like a small victory compared to what we don’t know yet. But if we put together all the small pieces, they form an amazing big picture.

The purpose of outreach extends beyond explaining the pure facts of research. Science does not happen in a sterile lab environment but is carried out by humans, is part of our everyday life, and impacts humanity. Small

steps or big leaps have the power to inspire, and we need to continue to strive to make those leaps accessible to everyone – especially in disciplines where results are more abstract and less tangible than the picture of a footprint on the moon. In the daily grind of publishing our work, it's easy to lose sight of these important principles, and our section is one way to recapture the feeling that led many of us to become scientists in the first place.

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Outreach Resources

Twitter: @girlscientist and @AnneOsterrieder
<http://www.publicengagement.ac.uk/>
<http://blogs.nature.com/soapboxscience/2012/06/07/reaching-out-so-you-want-to-communicate-science-online-the-flowchart>

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