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ORION OPEN SCIENCE FACTSHEETS

Brief, informative, and easy-to-understand one-page factsheets on Open Science topics

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 741527 and runs from May 2017 to April 2021.

CONTENTS

FACTSHEET: BIOHACKING AND DIYBIO RESEARCH

Definition: DIYbio/Biohacking: 'is a growing biotechnological social movement in which individuals, communities, and small organizations study biology and life science using the same methods as traditional research institutions'.[1] **Keywords:** Citizen science, crowd science, open source

SUMMARY

Biohacking is related to both Citizen Science and Open Source in that it is a community in which research non-professionals work with qualified scientists in a collaborative environment on scientific problems. However, biohacking is focused on 'hacking' in biology, particularly gene editing technology. The movement is growing in both the US and Europe.

KEY CONCEPTS

1. The majority of biohacking (92%) is conducted in 'Wetlabs',[2] like Biocurious. These are communal spaces in which equipment for gene editing and other experiments have been acquired, usually through crowd funding or other donations. Despite concerns, almost all these community labs have strict ethical and safety protocols. Many of these labs are co-run by professional scientists. There are also starter kits available and some biohackers have created labs in their own homess.
2. Biohacking has been applied to healthcare with both positive and negative outcomes. One example of a positive outcome is Matt Might's investigation of the genetic mechanisms responsible for his son's rare disease. A more controversial and less successful instance of health biohacking is Tristan Robert's injection of unapproved experimental gene therapy to treat his HIV.
3. Despite the independent and community-based nature of DIYbio there have been some moves in Europe to legitimise and even fund biohacking projects. The H2020 'Doing It Together Science' project have made 'recommendations to the European Commission as to how it can integrate DIYBio into existing science funding mechanisms and regulatory directives, thereby maximising benefits for European stakeholders'.[3]

RELEVANCE TO OPEN SCIENCE

DIYbio is in keeping with the ethos of Open Science, 'these science enthusiasts meet in McGuyvered laboratories for a common goal: democratize science and innovation'.[4] Open Science seeks to enhance scientific literacy and enthusiasm for science, biohacking provides another opportunity to do that and a way for both ameteur and professional scientists to create new ideas and solutions.

HELPFUL LINKS AND FURTHER INFORMATION

- Seven Myths & Realities about Do-It-Yourself Biology (https://goo.gl/NbHei)
- Scientific American article on the 'Rise of Citizen Bioscience' (https://goo.gl/76fcdn)
- Discussion of whether biohacking democratises science (https://goo.gl/bSwVG8)
- Ellen Jorgensen's famous TED talk on biohacking (https://goo.gl/4zSDnh)

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1 https://en.wikipedia.org/wiki/Do-it-yourself_biology
2 http://www.synbioproject.org/site/assets/files/1278/7_myths_final.pdf
3 https://ecsa.citizen-science.net/sites/default/files/ditos-policybrief2-20171004-diybio.pdf
4 https://labiotech.eu/biohacking-democratisation-science-hobby/

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FACTSHEET: CAREER BENEFITS OF OPEN SCIENCE

Definition: A career benefit or incentive is a positive outcome as the result of a particular behaviour (in this case Open Science). This can be a small, private gain such as saving time or it can be a large, public reward such as research funding. In all cases it helps advance career goals or increases opportunities. **Keywords:** Public engagement, collaboration, funding, skills, research integrity

SUMMARY

Open Science is often seen as beneficial to scientific processes and society, improving reproducibility and accessibility for instance. However, there are also potential benefits for individual researchers. Increased visibility, potential collaborations, specialised funding, more citations, faster discoveries, and broader professional skills can all be gained from Open Science practices.

KEY CONCEPTS

1. Open Science methods such as Open Access publishing, Open Data repositories, Open Software sharing, and Public Engagement can increase the visibility of researchers. This visibility can translate into an increase in citations[1] (which may become the new metric upon which the impact of article is based) because the manuscript is more accessible. It could mean that there are more chances of collaborations or collaborative projects e.g. Nipype. There may also be new or faster discoveries because of interactions with different peers or with citizen experts e.g. Polymath.
2. The skills that engaging in Open Science requires also improves the employability of researchers.[2] For example, archiving and sharing data correctly is a skill that many specialised roles require. Additionally, outreach work with the public could be helpful in changing careers to communications or entrepreneurial work.
3. There are a range of funding schemes that actively support Open Science.[3] In addition, EC funded projects have to meet a number of Open Science practices such as Open Access publishing and Data sharing plans.[4] Other funders are also encouraging Open Science, for example a number of funders now accept pre-prints in funding applications.

RELEVANCE TO OPEN SCIENCE

While there are still barriers to doing Open Science, the motivation for engaging in the movement need not be entirely based on altruism. There are a range of practical career benefits of doing Open Science.

HELPFUL LINKS AND FURTHER INFORMATION

- Journal article on 'How open science helps researchers succeed' (https://goo.gl/NvEFqY)

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1 Eysenbach G. Citation advantage of open access articles. PLoS Biology. 2006;4:e157. doi: 10.1371/journal.pbio.0040157. [PMC free article] [PubMed] [Cross Ref]
2 https://ec.europa.eu/research/openscience/pdf/os_rewards_wgreport_final.pdf
3 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4973366/table/tbl2/
4 http://ec.europa.eu/research/openscience/index. cfm?pg=openaccess

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FACTSHEET: CITIZEN SCIENCE

Definition: Citizen Science is the systematic collection and analysis of data; development of technology; testing of natural phenomena; and the dissemination of these activities by researchers on a primarily avocational basis.[1]
Keywords: Crowd Science, public engagement, biohacking

SUMMARY

Citizen science projects are different from studies which use human subjects or data as part of the research. The fundamental aspect of Citizen Science is that members of the public who are not working as active researchers can be involved and participate in a research project. This can range from projects in which large scale data reporting and analysis is undertaken (Crowd Science) or smaller projects in which specific members of the public contribute information or solutions e.g. identifying research priorities or inventing healthcare solutions.

KEY CONCEPTS

1. One common misunderstanding about Citizen Science is that it is restricted to a certain group of people e.g. retirees or students, or that contributors will have no scientific knowledge. Citizen science projects involve a huge range of people, who are often experts in their own area, for instance a professor in Art History might play the protein pattern game Fold-it or an IT professional might also be a patient who invents a healthcare solution.
2. Digital technology is key to the increase of Citizen Science in society. The majority of Citizen Science projects either directly involve working online e.g. NASA's observation and analysis projects or the use of online systems for reporting data e.g. the numbers of animals observed at certain times. Smartphones and body monitoring gadgets are also facilitating active participation in science.
3. Some have criticised Citizen Science for being patronising or for exploiting people to reduce research costs. However, when Citizen Science projects are organised well and aim to encourage and involve non-professional scientists in the research process the effect has been a positive one which enhances the enthusiasm for science. These principles help to ensure Citizen Science is done well.

RELEVANCE TO OPEN SCIENCE

'Public participation enables investigations that would not otherwise be possible, ones that push new frontiers in our understanding of our world.[2] Citizen science encourages people to take a stake in the world around them'. These outcomes mesh exactly with the aims of Open Science and as such Citizen Science is key part of the Open Science agenda.

HELPFUL LINKS AND FURTHER INFORMATION

- TED Talk: Citizen Science: Everybody Counts by Caren Cooper (https://www.youtube.com/watch?v=G7cQHSqfSzI)
- Blog about Citizen Science with some information on funding sources (http://www.openscientist.org/)
- EU project on Citizen Science: Doing It Together Science (DITOs) (https://goo.gl/YAaurw)
- Journal article about 'Citizen science or scientific citizenship? Disentangling the uses of public engagement rhetoric in national research initiatives' (https://goo.gl/2oYrtx)

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1 http://www.openscientist.org/p/citizen-science-thoughts-and-opinions.html
2 https://scistarter.com/citizenscience.html

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FACTSHEET: COMMERCIALISATION OF RESEARCH

Definition: 'Research commercialisation refers to the process through which ideas or research are transformed into marketable products, capital gains, income from licences and/or revenue from the sale of new product.'[1] **Keywords:** Data management, open research data, Open Source/Software

SUMMARY

Research commercialisation can happen in a number of ways: licensing, spin-out companies, royalties, incubation, and in-house development. In some cases commercialisation leads to actual financial gain, in others it increases the reputation and recognition of the researcher who originated it (and sometimes it results in neither!).

KEY CONCEPTS

1. There are two key aspects to research commercialisation: Intellectual Property (IP) and patents. IP is a creation of the mind (intellect) that has value as an asset (like any property). IP is more than just a theoretical idea or discovery, it is the practical manifestations and associated applications of your research. IP that can be protected in law, normally by copyright or patents, potentially becomes much more valuable. However, a patent is not an essential requirement for commercialisation, and equally filing a patent application does not automatically mean successful commercialisation will follow.[2]
2. It is very important for researchers considering commercialisation to know what rights they have and to ensure that any relationship with the private sector does not impinge their academic freedom. In addition, in big collaborative projects decisions about IP should be made very early on to avoid disputes later. Most institutions have a Tech Transfer department or a commercialisation department who should be consulted.
3. 'The significance of recent scientific results differs widely across technologies. Scientific publications are a major source for patents in biotechnology, pharmaceuticals, digital and basic communication, food or organic chemistry, while they play little role in other technological fields, such as transport, machine tools or civil engineering.'[3]

RELEVANCE TO OPEN SCIENCE

Some advocates of Open Science are broadly against research commercialisation because it requires the results of research (e.g. datasets) to be restricted and not made available to the public (at least in the short term). However, it can also be argued that the fundamental principle of Open Science is that science should benefit society and as such commercialisation that leads to practical improvements for society should be encouraged.

HELPFUL LINKS AND FURTHER INFORMATION

- Ten Simple Rules To Commercialize Scientific Research (https://goo.gl/JpqkPY)
- Guide on Commercialisation of Research from Sheffield University, UK
- (https://goo.gl/PajGWJ)
- Journal article on the issue of 'Patents Do Not Block the Progress of Science' (https://goo.gl/8KciZy)

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1 https://sourceable.net/what-is-research-commercialisation/

2 https://www.sheffield.ac.uk/polopoly_fs/1.205420!/file/commercialisation1.pdf

3 https://ec.europa.eu/research/openvision/pdf/rise/sachwald-twin_deficits.pdf

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FACTSHEET: COMMUNICATING ANIMAL RESEARCH

Definition: Animal Research/Testing/Experimentation in the Life Sciences is the use of non-human animals in experiments and development projects that seek to control the variables that affect the behaviour or biological system under study. Animal Research Communication is the manner in which citizens not directly involved in such research are informed about the processes and issues involved. **Keywords:** Science communication, public engagement, ethics and integrity

SUMMARY

Animal Research is a very controversial topic with strong advocates on both sides of the debate. Unfortunately, due to the threatening and even violent actions of a minority of Animal Rights Activists some research institutions and individuals are reluctant to communicate with the public about animal research. This has led to a widespread lack of understanding of the details of the ethics of animal research. Communication with the public on animal research can include age-appropriate workshops at schools, tours of animal facilities, factsheets or other online resources, articles in popular science publications, and public engagement or full public dialogues events. A Nature survey found that a majority of scientists feel there needs to be more discussion within the scientific community and with the public about the ethics of animal research.

KEY CONCEPTS

1. Public dialogues (such as the one listed below) repeatedly find that the public is generally opposed to animal research but that this is because of a number of widespread misconceptions. These include; cosmetic testing is still done on animals (this was banned in Europe nearly a decade ago), animal research subjects are mainly dogs and apes whereas in reality rodents are most commonly used, animals and humans are too different for drug tests to be effective whereas humans share a huge amount of similarities with other mammals, animals are tested on because it is cheaper than alternative methods such as computer modeling when in fact animal testing is very expensive and is only used when there is no other alternative.
2. The strict ethical principles that govern animal research are also not broadly known or understood by the general public. For instance, the 3Rs: Reduce, Replace, and Refine[1] or the oversight of vets and the strict guidelines on animal welfare in terms of care and housing.
3. The public dialogues have frequently found that when members of the public are presented with this information they often shift their opinion to support for animal research. Animal rights activists are also usually willing to listen and engage in productive discussions with scientists.

RELEVANCE TO OPEN SCIENCE

The need for openness and communication regarding the realities of animal research is very great. Open Science advocates that researchers engage directly with the public about the nature of their work. Animal Research is one of topics which would benefit most from this culture shift.

HELPFUL LINKS AND FURTHER INFORMATION

- FAQs about Animal Research from Understanding Animal Research (https://goo.gl/E6c7ht)
- Report on Public Dialogues on Animal Research done in the UK (https://goo.gl/Lqp1zG)

[1] http://www.bbc.co.uk/ethics/animals/using/experiments_1.shtml

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FACTSHEET: CROWD SCIENCE

Definition: Crowd Science is a process that involves outsourcing research tasks to a distributed group of people (usually data analysis). These tasks could be online or offline, paid or for free, and they are outsourced to an undefined public. It can also include, the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists. **Keywords:** Citizen science, crowdsourcing, public engagement, Community-based production, Problem solving, Open innovation

SUMMARY

Citizen Science often involves crowdsourcing research problems that require huge amounts of information processing. These problems are opened to the public so that a large number of people with a variety of approaches can contribute. These projects frequently utilise 'gamification', they make the problems an online game or competition. The most famous example of this is probably Foldit, which makes variations in protein folding into a computer game.

KEY CONCEPTS

1. The three main advantages of crowd science are that it is relatively low-cost (much less than using an algorithm on a supercomputer), it makes use of human ingenuity, imagination, and intuition in problem-solving, and it actively involves the public in scientific research.
2. There is great variety in crowd science projects, disciplines including astronomy, archaeology, mathematics, and biochemistry. There is also a wide range of people involved from Field Medalist winners to those with no formal science education. Some projects require specialisation but some, such as GalaxyZoo and Foldit, are completely open.
3. 3. In order for crowd science projects to be successful it is necessary for the scientific problem to be translated into a set of challenges that a large group of people (anything between 50 to 250,000) can work on. This can be pattern spotting in images or data, design of structures, or observing information in nature, records, or their own body. Scientists need to have a clear long-term goal, sufficient funding, and the ability to support the project over time.

RELEVANCE TO OPEN SCIENCE

Crowd science combines public engagement with truly open science. The results of the research are open, the findings are usually made available to everyone. Crowd science has also shown that the involvement of the public leads to scientific advancement. Several projects have lead to well-regarded publications, which have collectively listed the citizen scientists or players as authors.

HELPFUL LINKS AND FURTHER INFORMATION

- Journal article on 'Crowd science: The organization of scientific research in open collaborative projects' (https://goo.gl/XrM9wh)
- Blog article on Yale Scientific about crowdsourcing in science (https://goo.gl/8eAhWX)
- Journal article on 'Online citizen science games: Opportunities for the biological sciences' (https://goo.gl/BHEFxc)

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FACTSHEET: RESEARCH DATA MANAGEMENT

Definition: 'Research data management concerns the organisation of data, from its production, entry to the research cycle through to the dissemination and archiving of valuable results. It aims to ensure reliable verification of results, and permits new and innovative research built on existing information'.[1] **Keywords:** Open research data, reproducibility, Commercialisation of Research, open access, ethics

SUMMARY

Research data management involves creating a data management plan, decisions on securely storing data both during and after the research project, organising and structuring the data, curating the data by creating metadata, and ethical and commercial considerations regarding acquiring and sharing data.

KEY CONCEPTS

1. The European Commision and a number of national funders now ask for a Data Management Plan (DMP) as part of either the funding application or the grant agreement. A 'DMP should describe the data your research will generate, how you will ensure its curation, preservation and sustainability, what parts of that data will be open and how you plan to achieve this. One DMP should be prepared to cover all datasets'.[2] Practical assistance in creating at DMP online.
2. One of the considerations regarding research data needs to be balancing commercial opportunities with making research data open and accessible. In the Life Sciences there can be opportunities to work with industry to develop products or objectives which have a direct impact on society. It is wise for researchers to consider which approach, commercialisation or open data, will have the most benefit for society.
3. Another important aspect of research data management is data ethics and security. Any data that contains sensitive and/or personal information e.g. identities of participants, patient data, etc. should be stored as securely as possible during the project and only be shared with care and consideration afterwards.

RELEVANCE TO OPEN SCIENCE

The European Commision states that sharing data should not necessarily mean opening up all your research data. Rather, they follow the principle of "as open as possible, as closed as necessary" and focus on encouraging sound data management as an essential part of research best practice.[3]

HELPFUL LINKS AND FURTHER INFORMATION

- Guide to 'Research Data Management: Open Research Data in Horizon 2020' from UCD (http://libguides.ucd.ie/data/H2020)
- Journal Article on 'Open Data for Healthcare' (https://goo.gl/rDTWgR)
- Journal Article on 'Open science versus commercialization: a modern research conflict?' (https://goo.gl/xjqHxx)

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1 http://www.dcc.ac.uk/resources/briefing-papers/making-case-rdm
2 http://libguides.ucd.ie/data/H2020
3 https://goo.gl/Hghgvn

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FACTSHEET: OPEN ACCESS

Definition: 'Open access refers to the practice of making peer-reviewed scholarly research and literature freely available online to anyone interested in reading it'.[1] **Keywords:** Publishing, reproducibility, pre-prints, predatory journals, preregistration

SUMMARY

Open Access is an alternative method of publishing and sharing research findings, it seeks to overcome the limitations of traditional publishing which can prohibit people who are outside the scientific community in the developed Western countries from accessing this information.

KEY CONCEPTS

1. There are two methods of publishing Open Access: either publication in an open access journal (Gold) or as a second publication (Green) via a repository (usually institutional). A Gold publication is immediately accessible, but mostly paid. Green is free but means the publication is usually only available after an embargo period. Policies vary between publishers and journals. The Sherpa/Romeo directory lists the OA restrictions of almost all journals.
2. Proponents of Open Access argue that it 'has the potential to maximize research investments, increase the exposure and use of published research, facilitate the ability to conduct research across available literature, and enhance the overall advancement of scholarship'.[2] In addition, European Commision funding and an increasing number of other funders now actively expect publication of the results of research projects to be Open Access.
3. Author copyright and attribution still apply in Open Access publishing, but can be much less restrictive than traditional publishing. For instance, the BMJ do not ask authors to assign them copyright at all whereas Springer ask for a CTA (Copyright Transfer Agreement) but allow self-archiving within that.

RELEVANCE TO OPEN SCIENCE

Open Access is the most well-developed element of the Open Science movement, although the traditional publishing route is still common practice. Most of the major academic publishers now have Open Access options for some of their journals. Funders and institutions actively encourage or even insist upon research being published Open Access. The principle of Open Access is the one that underpins all of Open Science: research should be freely available and accessible to everyone.

HELPFUL LINKS AND FURTHER INFORMATION

- Fact sheet: Open Access in Horizon 2020 from the EC (https://goo.gl/NCcXfr)
- Open Access Explained video from PhD Comics (https://www.youtube.com/watch?v=L5rVH1KGBCY)
- Discussion of arguments for and against Open Access (https://goo.gl/tY4RVG)
- Article on 'From Open Access to Open Science from the viewpoint of a scholarly publisher' (https://riojournal.com/article/12265/)
- Article on 'Open access, copyright and licensing: basics for open access publishers' (https://goo.gl/Yb99WZ)

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1 https://opensource.com/resources/what-open-access
2 http://www.openaccessweek.org/page/about

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FACTSHEET: OPEN RESEARCH DATA

Definition: Open research data refers to the data underpinning scientific research results that have no restrictions on their access, enabling anyone to access them through the internet.

Keywords: Data management, Commercialisation of Research, reproducibility, open access, ethics

SUMMARY

Open research data involves making the data that supports research findings fully available to anyone. This usually involves putting full datasets in an online repository (e.g. NeuroMorpho, GenBank, or figshare). While there is a movement for all data to be made accessible in this way it should be noted that good data management also requires considerations of commercialisation and ethics. However, there are many advantages to making research data open, such as higher citations, potential collaborations, and increased reproducibility/decreased wasted research resources.

KEY CONCEPTS

1. Open research data should be governed by the FAIR principles: Findable, Accessible, Interoperable, Re-usable.
2. It is essential that open research data has metadata and Digital Object Identifiers (DOIs) and the correct licensing. Metadata is data that describes data, it accompanies the research data which makes it discoverable and usable over time.[1] DOIs can be given to datasets and are a unique alphanumeric string assigned to identify content and provide a persistent link to its location on the Internet[2] (i.e. it can't be removed or be inaccessible if the website is removed). Licensing may be assigned by repositories but they are usually variations of Creative Commons (CC) licences.
3. Data needs to be stored in a suitable institutional or discipline specific repository. The Registry of Research Data Repositories (Re3data) can help identify one. If there is no suitable resource then Zenodo is a good alternative.

RELEVANCE TO OPEN SCIENCE

Open research data is one of the three major pillars of the Open Science movement (Open Access and Public Engagement being the other two). The European Commision and other funders actively support making data as accessible as possible, where appropriate.

HELPFUL LINKS AND FURTHER INFORMATION

- Guide to 'Research Data Management: Open Research Data in Horizon 2020' from UCD (http://libguides.ucd.ie/data/H2020)
- Nature article on 'Data sharing: An open mind on open data' (https://goo.gl/9bzw65)
- Guide to Open Data on FOSTER project (https://goo.gl/cWX7sp)
- Nature article on 'The FAIR Guiding Principles for scientific data management and
- stewardship' (https://www.nature.com/articles/sdata201618)

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1 http://guides.library.uwa.edu.au/c.php?g=325196&p=2178564

2 http://www.apastyle.org/learn/faqs/what-is-doi.aspx

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FACTSHEET: OPEN SOURCE AND SOFTWARE

Definition: Open Source – A software for which the original source code is made freely available and may be redistributed and modified according to the requirement of the user.[1]

Keywords: Data management, Open Research Data, Commercialisation of Research, Reproducibility

SUMMARY

'There are two kinds of software. One is open source software and the other is proprietary software or closed source software. As the source code of an open source program can be modified by anyone without any licence to do the same, this is also free to download. The terms of use are often defined by the General Public Licence, which serves as the Software Licence Agreement (SLA) for many open source programs. [...] Generally programmers can't charge money for the open source software they create or to which they contribute. Many open source software programmers find that charging users money for software services and support rather than for the software itself is more profitable' (see reference 1).

KEY CONCEPTS

1. Open Source software communities are seen by some as the ideal which science should follow. 'Free and open source software communities have demonstrated that actually practicing the norms of openness and information sharing in a peer-production setting can result in the creation of complex technological products that approach, and sometimes rival, the scope and quality of similar products produced by proprietary efforts'.[2]
2. There is also a study which found that opening science in a similar way to the open source community allowed solutions from unconnected disciplines to emerge: 'In a four-week period of time, over 574 scientists investigated the problem statement and forty-two of them submitted potential solutions for considerations. The winning solution was proposed by a scientist from Finland who did not work in this field.'[3] However, some obstacles to this approach are concerns regarding risks to career advancement, commercialisation and IP, and publications.
3. One example of the crossover between the Open Source approach and science is that currently NASA has all its research as Open Source. For example, all physical experiments done on the ISS are now available for data mining.

RELEVANCE TO OPEN SCIENCE

Open Source is in some ways the model upon which Open Science is based and a working demonstration that complex problems can be freely shared and collaborated on. While there are still risks and obstacles in adopting such an approach in all scientific fields it can offer possible solutions.

HELPFUL LINKS AND FURTHER INFORMATION

- Journal of Open Research Software (JORS) (https://openresearchsoftware.metajnl.com/)
- Collection of Open-source Scientific Tools on Thingiverse (https://goo.gl/X1uZQG)

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1 https://economictimes.indiatimes.com/definition/open-source

2 http://www.hbs.edu/faculty/Publication%20Files/07-050.pdf

3 https://hbswk.hbs.edu/item/open-source-science-a-new-model-for-innovation

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FACTSHEET: PRE-REGISTRATION

Definition: Pre-registration – pre-registering research means committing to a plan in advance, before data is gathered. Pre-registration separates hypothesis-generating (exploratory) from hypothesis-testing (confirmatory) research. Both are important, but the same data cannot be used to generate and test a hypothesis, which can happen unintentionally and reduce the clarity and quality of results. **Keywords:** Reproducibility, open access, pre-prints, open research data

SUMMARY

Pre-registration is closely linked with the Reproducibility or Replication Crisis. The concept is that if researchers have to state their hypothesis and their plan for testing it before they do the experiment then this will reduce the risk of interpreting or 'cherry-picking' the data in such a way that it supports the hypothesis regardless of how the experiments have gone.

KEY CONCEPTS

1. A survey in Nature revealed that selective reporting was the number one reason for irreproducible research.[1] One aspect of research that pre-registration is designed to prevent is so-called 'p-value fishing'. The p-value is a measure of statistical significance (evidence against a null hypothesis), but this significance can be exaggerated by including large amounts of variables or a larger number of subjects (while not disclosing the effect size). Pre-registration of hypothesis and methods tries to ensure that these manipulations can not happen.
2. Some have raised concerns that pre-registration is too rigid and it will restrict creativity and exploration in fundamental research. The fear is that in order to avoid the falsification of data any later stage improvement or alteration to experiments will also be prevented.
3. Several journals, such as, the BMJ and nearly 100 others ask for registered reports now. It may become a common aspect of science publishing in years to come. There is also a journal that publishes protocols: Bio-protocol.

RELEVANCE TO OPEN SCIENCE

Pre-registration is one specific method for enhancing the openness of the scientific process and possibly enhancing public trust in it. However, it may not be suitable for all types of research or publications.

HELPFUL LINKS AND FURTHER INFORMATION

- Article on Wiley: '8 Answers About Pre-registered Reports' (https://goo.gl/pXvJv8)
- Article on 'The Preregistration Revolution' (https://goo.gl/Fwpgah)
- Article on The Guardian on how pre-registration improves trust in science (https://goo.gl/FSLL6F)
- Blog article on the pros and cons of pre-registration (https://goo.gl/kwpq9J)

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[1] Baker M. 1,500 scientists lift the lid on reproducibility. Nature. 2016;533:452–454. [PubMed]

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FACTSHEET: PREDATORY JOURNALS

Definition: Predatory open-access publishing is an exploitative open-access publishing business model that involves charging publication fees to authors without providing the editorial and publishing services associated with legitimate journals (open access or not).[1]

Keywords: Publishing, open access, pre-prints, research misconduct

SUMMARY

Predatory journals emerged about a decade ago as a way to take advantage of the Open Access publishing model. Open Access publishing requires a publication fee so that the final content (the article) can be made freely available. However, a large number of companies now pretend to be academic publishers and ask for large fees, but do not offer the peer review process or editorial oversight that legitimate Open Access journals do.

KEY CONCEPTS

1. The danger for researchers is that articles published in predatory journals are worthless in terms of career progression or professional reputation. In addition, once the predatory journal has published the article on their website very few legitimate journals will accept it. Often predatory journals ask for binding copyright agreements (which is a warning sign, see list below). Researchers should follow the Think. Check. Submit protocol.
2. The risk for the public or students is that predatory journals will publish anything, there is no scientific scrutiny at all. This means that pseudoscience and 'fake news' can be disseminated through these journals and accepted by those not familiar with the subject area as real science.
3. There have been a number of attempts to compile checklists for spotting predatory journals and to find ways to better prevent these journals from functioning effectively. Most famously, Jeffery Beall created his blog 'Beall's List', a blacklist of predatory journals. However, a number of issues have been raised regarding his criteria and conduct. Several associations have created whitelist of legitimate Open Access journals.

RELEVANCE TO OPEN SCIENCE

Predatory journals have taken advantage of the positive principles behind the Open Access movement to make money and in doing so undermine scientific publishing. These journals thrive on the desperation that overly competitive research environments create, as well as the lack of wider knowledge and access the public has to research. Open Science principles that support collaboration, public engagement, and publishing literacy for early career researchers all help combat these problems.

HELPFUL LINKS AND FURTHER INFORMATION

- Article on '8 ways to identify questionable open access journals' (https://goo.gl/ pNR4wj)
- Opinion Piece: 'Why I Published in a Predatory Journal' (https://goo.gl/PekPQh)

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[1] https://en.wikipedia.org/wiki/Predatory_open_access_publishing

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FACTSHEET: PREPRINTS

Definition: A manuscript (final or draft) made publicly accessible without formal peer review. Preprints are frequently also submitted for peer review and publication in a journal.

Keywords: Publishing, open access, peer review

SUMMARY

Academic publishing is a very lengthy process, as such a number of disciplines have started uploading articles on to preprint platforms. The physics community developed preprints over 20 years ago but it has only started to be accepted in the life sciences relatively recently. The idea of preprints is that manuscripts are made publicly available so that the author can receive informed comments and the research can be more widely disseminated.

KEY CONCEPTS

1. Proponents argue that preprints improve the visibility of the research, establish a record of priority, improve accessibility, do not prevent later formal publication, and do not lead to scooping.[1]
2. Critics caution that preprints may allow others to steal research ideas, diminish the overall quality of scientific publishing, create an overload of information, and could lead to the spread of misinformation or pseudoscience through unverified results, especially in the field of biomedicine.[2]
3. A number of funders now accept preprints in applications e.g. the NIH, The Wellcome Trust, the Simons Foundation, the Human Frontiers Science Program, Medical Research Council (MRC UK), the Helmsley Charitable Trust, and the Canadian Institutes for Health Research.
4. There are a number of different platforms that publish life sciences preprints, these vary in terms of what type of manuscript they will accept (draft, final) and what type of research they will publish e.g. bioRxiv does not accept any clinical research except epidemiology and certain trial results.

RELEVANCE TO OPEN SCIENCE

Preprints are linked to Open Science because they are Open Access publications, freely accessible to everyone. They are also, potentially, a way of making research more open to comment and input from citizen scientists, patient advocates, or the public in general.

HELPFUL LINKS AND FURTHER INFORMATION

- List of preprint servers currently available 'Research Preprints: Server List' (https://goo.gl/bsQDGH)
- Open Science Framework (OSF) FAQs on Preprints (https://goo.gl/rZLnJh)
- In-depth article on the future of Preprints in Biology (https://goo.gl/vz5Syy)
- Article on Ten Rules Regarding Preprints (https://goo.gl/FR6NwV)

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1 http://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1005473

2 http://www.sciencemag.org/news/2017/09/are-preprints-future-biology-survival-guide-scientists

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FACTSHEET: PUBLIC ENGAGEMENT

Definition: 'Public engagement describes the myriad of ways in which the activity and benefits of higher education and research can be shared with the public. Engagement is by definition a two-way process, involving interaction and listening, with the goal of generating mutual benefit'[1] **Keywords:** Science communication, citizen science, communicating animal research

SUMMARY

Public engagement encompasses a wide variety of interactions between the scientific community and the public. While a talk or lecture can be a great way of communicating the results of research the goal of public engagement is more interactive and reflexive. Engagement can come in many forms, for example a public dialogue about a contentious scientific topic e.g. animal research, a citizen science project where researchers and citizens work on a research project together, or a blend of participatory arts and sciences.

KEY CONCEPTS

1. Research projects, even on controversial topics, often do not consider the opinions of the public or the impact on society. This can lead to widespread misunderstanding of research fields e.g. GM crops, or to a feeling that science is not connected to the realities of peoples' lives.
2. The European Commision are actively supportive of Public Engagement, stating that it 'leads to multiple benefits: it contributes to building a more scientifically literate society able to actively participate in and support democratic processes, and science and technology developments, it injects differing perspectives and creativity in research design and results, and it contributes to fostering more societally relevant and desirable research and innovation outcomes to help us tackle societal challenges'.[2]
3. The RCUK (Research Councils UK) have created a pack of mulitple case studies called 'What's in it for me?'[3] which show how different scientists have felt their work and career has directly benefited from public engagement activities.

RELEVANCE TO OPEN SCIENCE

Public engagement is the form in which science can directly connect with the public, this increases accessibility and the openness of science in society. Debates on 'open science' frequently focus on the public accessibility of the products of scientific and academic work. In contrast, public engagement is about 'opening' the ongoing work of science.

HELPFUL LINKS AND FURTHER INFORMATION

- Guidance on Public Engagement from the RRI Tools project (https://goo.gl/3kcwQU)
- Video Guide to Planning Public Engagment from University of Oxford, UK (https://goo.gl/LSYcWv)
- Blog article on how to move towards true public engagement in science (https://goo.gl/cuHrCh)
- Journal article on 'Open Science, Public Engagement and the University' (https://arxiv.org/pdf/1702.04855.pdf)

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1 https://www.publicengagement.ac.uk/about-engagement/what-public-engagement

2 https://ec.europa.eu/programmes/horizon2020/en/h2020-section/public-engagement-responsible-research-and-innovation

3 http://www.rcuk.ac.uk/documents/scisoc/rcukbenefitsofpe-pdf/

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FACTSHEET: REPRODUCIBILITY

Definition: Reproducibility is when an experiment or data analysis can be reliably repeated, the challenge is that large percentages of studies cannot be replicated successfully.

Keywords: Open research data, data management, open access, pre-registration, predatory journals, analysis, access, funding

SUMMARY

The issues related to reproducibility (sometimes called replication) started in the social sciences with Psychology. However, studies in an increasing number of disciplines have failed to be replicated, including the life sciences. According to a 2016 poll of 1,500 scientists reported in the journal Nature, 70% of them had failed to reproduce at least one other scientist's experiment (50% had failed to reproduce one of their own experiments).[1] These numbers differ among disciplines of course.

KEY CONCEPTS

1. Failure to replicate an experiment does not necessarily mean that the hypothesis or original findings are flawed, reasons such as mutated cell lines that could be the cause.
2. There is debate as to whether there is truly a reproducibility crisis which threatens scientific practice or whether failure to replicate experiments is simply part of the scientific process.[2]
3. The lack of access to the underlying data and analysis scripts is exacerbating the failures to replicate studies, without the raw data it is more difficult to replicate the experiments accurately.
4. Pre-registration of the experiment design reduces the chances of bias and individual interpretation during the analysis of data.

RELEVANCE TO OPEN SCIENCE

The reproducibility challenges are linked to the Open Science movement because a more responsible use of data would make studies easier to replicate. Science that cannot be replicated either from flawed experiments or lack of clarity regarding the methodology requires further research, this is seen as a waste of funding which often public money.

HELPFUL LINKS AND FURTHER INFORMATION

- Slate Opinion Piece by Dan Engber (OOS Podcast Guest) for Slate on the Replication Crisis in Biomedicine, 2016. (https://goo.gl/jSFQDS)
- Journal Article by Marcus Manafo, et al, on Improving the Reproducibility of Research, 2017 (https://www.nature.com/articles/s41562-016-0021)

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1 Baker, Monya (26 May 2016). "1,500 scientists lift the lid on reproducibility". Nature. 533 (7604): 452–454.

2 The reproducibility "crisis" Reaction to replication crisis should not stifle innovation, Philip Hunter, DOI 10.15252/embr.201744876 | Published online 09.08.2017, EMBO reports (2017) e201744876.

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