

Informing the general public about cell migration - a public engagement resource

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Abstract

Outreach activities become an increasingly important part of a researcher's life, out of social responsibility as well as to meet expectations by research funding institutions. Yet, outreach activities are little supported by resources which provide guidance, strategies, examples and materials, and researchers are widely left alone with the task of re-inventing the wheel when starting to engage with the public. Whilst public platforms are slowly starting to be developed which provide support and resources for educational activities, initiative can also be taken at the grass root level to improve this situation. Here we show how final year undergraduate student projects can be used to deliver freely available outreach resources. Thus, the Faculty of Life Sciences at The University of Manchester runs projects on public engagement where students develop outreach exhibitions which they personally display on an open day at the Manchester Museum. We capitalised on this by using the subsequent project evaluation phase to further improve the content and design of the resource, guided by the practical experience made on the open day. As proof-of-concept we publish here the resource on the topic of cell migration together with the thoughts, rationale and strategies that have underpinned its development. We discuss the win-win situation this strategy provides for both students and researchers and how this approach can be further developed in the future, but also what grant-giving institutions can do to improve the status quo.

This publication its reference and supplementary materials can be downloaded from
dx.doi.org/10.6084/m9.figshare.741264

Introduction

Outreach activities become an increasingly important part of a researcher's life based on simple arguments: responsibility and transparency. Thus, the general public has a right to be informed about the science which is, in its majority, tax or charity funded (see [Jai Ranganathan blog](#)), and public opinion is likely to increasingly impact on political funding decisions [1]. Outreach paves the way to greater acceptance and it provides an opportunity to enthuse the next generation of researchers and to encounter their potential role models at arm length. At the same time, outreach activities are a fantastic opportunity for researchers to focus their minds on the fundamental aspects of their work and find the phrases, terms and images that convey their science from the ivory tower of science to the housing estate next door. Once these fundamental aspects have been identified they can be of enormous benefit also to the researcher, since they tend to impact positively on the style of scientific presentations as well as grant and manuscript writing. Even for those who do not want to engage in public outreach there will be less and less space for manoeuvre, since grant giving institutions worldwide demand increasingly that the researchers they fund actively contribute.

However, this trend is not well matched by the resources available to drive these activities and to help us improve the ways in which we translate a conference poster into a presentation which appeals to the general public. First, much is still to be learned about the actual requirements. The Wellcome Trust clearly has identified this problem and carried out a [public survey](#) interrogating what is understood about science by the general public and what is needed to improve the *status quo*. This information is now (hopefully) being used by experts to extract the kind of information we require to develop effective outreach strategies and designs. Second, we need simple and easily accessible instructions that help us to improve our activities. Good examples are the Wellcome Trust's blog collection "[Science writing tips](#)" (where public science writers share their tricks and thoughts), the Wellcome Trust's "[Education Resource](#)", as well as the web sites of the [National Co-ordination Centre for Public Engagement](#), the [University of Bristol Centre for Public Engagement](#), [The Science Museum](#) and the [British Science Association](#). Third, we need freely available archives and depositories that provide access to examples of successful outreach activities as adaptable prototypes and sources for ideas and inspiration - let alone materials that can be directly used or incorporated to improve quality and appeal of presentations without having to invest too much time and effort. A good example of a resource collection is the [National STEM Centre](#) and a good example for a centralised archive is [resources4schools](#), both of which provide centralised support and resources for the teaching at schools and could be similarly adapted also for the wider scope of public engagement activities (see Discussion).

In this publication, we address the point of resource building and provide an example of how publicly available materials for public engagement activities can be generated within the realm of our daily teaching activities. The essential basis for this strategy is a programme of final year projects on public engagement instated by the Faculty of Life Sciences at The University of Manchester. On these projects, the students develop an outreach display for an open day at the Manchester Museum which is then evaluated for its success and quality. The students' physical presence on the open day provides a strong incentive to develop and implement a presentable display. The current weakness of these projects is the subsequent phase where the resource is being evaluated and tested only to turn it into a scientific write-up, whereas the actual resource usually never sees the light of day again. Here we experimented with this second project phase and used the experiences from the museum event as an ideal guidepost to reflect on weaknesses and strengths of the display retrospectively, and improved it by deleting, replacing, toning down or improving respective components. To drive these improvements with rigour we aimed for publication of the project on a citable and metricised platform, which provided a strong incentive to deliver a high quality and freely available resource that can be of use to others and can even be listed as an item on her future CV.

Project work

Choice of topic and key objectives

We decided to choose cell migration as the topic for this project. Cell migration is a fundamental and important biological phenomenon. It is the process where cells or groups of cells detach from their cellular or environmental contexts to move to another location. Migration is essential for single cell organisms to explore their environment or respond to environmental changes. It is pivotal within multicellular organisms for their development (e.g. in gastrulation, germ cell migration, neural crest cell migration, the formation of muscles and skeleton and brain development) [2], for their maintenance (e.g. in immune response, tissue repair and wound healing) [3,4], and it is closely linked to diseases (e.g. cancer, immune diseases such as [Wiscott-Aldrich syndrome](#), cleft lip and palate, brain disorders such as [lissencephaly](#), neural crest cell migration defects such as in [DiGeorge syndrome](#), or absence of gut ganglia in [Hirschsprung disease](#)). However, the public is not necessarily aware of the cell migration phenomenon, of its importance and its direct relation to our daily life. Furthermore, researchers tend to be more fascinated by the essential mechanisms which underpin cell migration (i.e. cell polarity, cell adhesion, cytoskeletal dynamics, as well as the chemical and physical communication with the cell environment), and this is usually the level at which we teach our students. However, the bigger picture of cell migration and its importance at the systemic level is often sidelined, and developmental biology lectures are perhaps the only spaces where these fundamental concepts are taught. Clearly, there is scope for improvement, and developing a public outreach resource for cell migration should help to identify its most essential, understandable and exciting aspects. Therefore, we decided as the key objective for this project to inform lay audiences about the existence of the phenomenon of cell migration, and bring across its importance to aspects of our daily life.

Choice of strategies and materials

This resource has been designed for a public exhibition day and the choice of content, media and activities was based on a number of general considerations:

- 1) Public events tend to be crowded and the items on display need to be attractive enough so that people stop and look, get involved and listen.
- 2) Time per visitor and the number of presenters are usually limited, so items on display need to be carefully chosen and, without exception, they need to serve a clear purpose towards the key objective.
- 3) Written background information on display should be limited to the most important statements, be clear and self-explanatory so that people can understand information even when un-attended.
- 4) Images should complement and support the written information and carry clear self-explanatory messages whilst also being helpful when actively explaining the exhibition to visitors.
- 5) At least some of the pictures should engage visitors emotionally, so that people get curious and stop.
- 6) Hands-on activities are ideal to engage the audience, enhance the overall experience and attract children together with their parents, thus providing opportunities to involve them in discussion [5]. However, activities must be good enough to justify the time spent on their supervision, which will not be available for explaining other parts of the exhibition.
- 7) The full learning objective is often impossible to achieve on the event itself, due to the limitation of time and distractive atmosphere of crowded spaces. So it is helpful to provide visitors with complementary materials to take home – but these materials should have elements that protect them from being thrown away at first opportunity.

On the basis of these considerations, a number of display items and materials were chosen. (1) The centrepiece was decided to be a self-explanatory poster informing about cell migration in simple terms and containing carefully chosen and relevant examples, ideally with images that attract the attention of visitors. (2) It was decided to capitalise on the topic of cell migration by showing a catchy movie with different sequences of moving cells, ideally shown on a large screen to serve as a powerful magnet for visitors passing by. (3) Different hands-on activities were considered. For example, there was the idea of a game in which children stand on a large panel showing a human body and throw or move melanocytes from their place of origin (dorsal neural tube) to different body parts to give their skin colour. However, the idea was technically too difficult to implement as a fun game, and it was deemed unlikely to convey a strong enough message. Instead it was decided to show real migrating cells live under a microscope, since this would be a way to bring the laboratory experience closer to the visitor. (4) It was decided to provide hand-outs with activities around cell migration, in particular a word search and maze, to be taken home as carriers of complementary information (Trojan horse strategy). In the following we will explain rationale and background information of the various resources that were initially tested on a public museum event and then further improved based on that experience.

The poster (Suppl. Mat. 1)

The overarching aim of the poster is to inform in simple terms about cell migration and its relevance, to have elements that make passers-by curious and attract them, and be self-explanatory whilst delivering useful illustrations that can be used to discuss the topic with visitors. For this, the poster has a simple title "What's moving in you - Cells!", hopefully addressing the passer-by directly ('you') and raising curiosity. The title is followed by a general text box with four bullet point explanations of what cells are, what they are good for and why their migration is important. Four separate boxes provide different examples of cell migration to illustrate these points. Firstly, we chose white blood cells as an example because people are usually familiar with the concept of infection and immune responses, and it seems intuitive that immune cells have to actively move towards sites of infection. By focussing on the example of extravasation (i.e. the process where white blood cells migrate through the blood vessel wall) this example also illustrates the principal complexity of migratory processes. Secondly, cleft lip and palate as a migratory deficit during development is familiar to most people and provides a very different example of cell migration. Thirdly, melanocyte migration illustrated with the white bellied black cat is an easy to understand example of cell migration and the consequence of potential aberrations. Finally, the example of cancer clearly concerns everyone and it also allows talking about some principle mechanisms, in particular cell adhesion, as an important regulator of cell migration.

Box 1. Examples of films available in the internet:

- films illustrating mechanisms of cell migration - http://www.mit.edu/~kardar/research/seminars/motility/Videotour/video_tour.html
- zebrafish lateral line migration - <http://www.youtube.com/watch?v=CT12utYICs8>
- single green fluorescent cell - <http://www.youtube.com/watch?v=sHFN48il9YY>
- single migrating cell - <http://www.reading.ac.uk/cellmigration/migration.htm>
- transmigration of white blood cell - <http://www.youtube.com/watch?v=slDzIEY0Pac>
- Neural crest cell migration - <http://embryology.med.unsw.edu.au/Movies/neuralcrest/nc2.htm>
- *D.discoideum* migration - <http://www.youtube.com/watch?v=Ak9S4aRD9W4>

Each of these themed boxes is highlighted with a distinct vivid colour, has a short title, a sub-heading (conveying a short self-explanatory key message that hopefully raises curiosity), some further bullet points with simple information for those who want to delve a bit deeper, as well as one image plate with illustrations that help explain the topic but also raise curiosity. For example, the cleft palate image attracted some visitors who were personally affected, the white bellied black cat attracted people for various reasons, and spider man escaping from a blood vessel certainly attracted young boys. Importantly, the images ideally complement the text and

were very helpful to explain the topic during the event. Overall the poster provided a helpful and informative source of information.

The film (Suppl. Mat. 2)

Films are almost indispensable to illustrate the topic of cell migration, and they are very helpful when talking to visitors at the exhibition. They are extremely well suited to attract passers-by, especially when colourful and projected onto a larger screen. Numerous films are available online (Box 1), and they should ideally be edited into a vivid sequence. Furthermore, to make them self-explanatory, little informative headings can be added at the start of each new sequence, which often stimulate visitors to ask questions and get involved. To avoid copyright issues, we can not distribute the film we have used ourselves, but provide a shorter example movie with sequences of *Dictyostelium discoideum* and *Drosophila* which were kindly given to us for this purpose (Suppl. Mat. 2).

Microscope activities

Microscopes are key instruments for the study of cell migration and should ideally be present at the exhibition to provide a look-and-feel of how research in this area is done. However, high quality microscopes are expensive and indispensable for the work in laboratories. Bringing them to public events is of considerable risk, since they are usually not insured. This problem is less pressing for lower end teaching microscopes, yet these microscopes often lack the high quality optics and the right accessories such as camera adaptors, fluorescence light sources and filters, or even simple DIC or phase contrast optics. Therefore, any decision about the use of microscopes will have to consider these restrictions.

Also the choice of specimens needs careful consideration. We tried to use *Dictyostelium discoideum* to demonstrate cell migration live under the microscope. But without experience it is not trivial to have *Dictyostelium* at a suitable motile stage, and the movement that can be seen is not necessarily impressive, especially under a low end microscope. Alternatives are not easy to find. For example, many mammalian cell lines are of good size (40-50 μm) but they are not well suited since they require temperature-controlled microscopes. Cell migration can be observed live in embryos of fish or fruit flies following published protocols [6,7], but this requires easy access to suitable fish or fruit fly strains as well as to high end microscopes. Therefore, demonstrating live movement under the microscope is not an easy task and the degree of movement seen is not necessarily too impressive. It might be a realistic option only for those who have sufficient experience with suitable models in their own laboratories.

The best alternative option is the use of fixed cells, such as fibroblasts. Fixed cells can be stained for migration-relevant sub-cellular components, such as F-actin, microtubules or focal adhesion proteins (e.g. [Martin Humphries Lab](#) site), and they provide stunning images that ideally complement the movies that are in parallel on display (see above). Importantly, cell staining does not have to be carried out with fluorescent markers but can be done with enzymatic staining procedures, such as horseradish peroxidase-, alkaline phosphatase- or β -galactosidase-based methods, or with histological dyes. Such specimens are visible under standard microscopes and can be reused on other occasions.

The hand-outs (Suppl. Mat. 3)

Hand-outs are a very powerful strategy to extend the outreach experience beyond the realms of the exhibition hall, ideally into the visitors' homes tempting them to explore the topic further. We experimented with this idea and designed hand-outs to be taken home by visitors. To prevent them from being thrown away, they carry some activities (a maze or a word search) which relate to the cell migration topic and which children may want to keep for a while. They carry links to web resources, hopefully tempting people to have a look and explore further. This "Trojan horse" strategy can therefore be a good way to engage people beyond the exhibition. However, a current downside of this strategy is that exciting online resources for lay audiences that can be

linked to are still rare and hard to find, crying out for more support platforms for outreach activities (see Discussion).

Discussion

What has been achieved on this project and how does it help?

This project produced three main outcomes. Firstly, we have demonstrated how short student projects can be used to generate outreach resources. Secondly, we have provided this resource and made it publicly available. Thirdly, we have laid out our thoughts, rationale and strategies that have underpinned the process of resource development.

With respect to the first outcome, we feel that the design of outreach resources is an ideal objective for short final year projects and provides students with transferable skills that can be adapted to many other tasks in their later life, an opportunity in particular for those students that do not aspire to a career at the bench. More could have been achieved on the project published here, but it became clear that the objectives of outreach activities are difficult to grasp for beginners and substantial time was needed to agree on and clarify the key objectives. Through the prototype project published here, the next generation of students should be able to focus their project work from early on and therefore make better use of the time available. Through capitalising on this strategy it should be possible to build a rich resource for public outreach activities that covers a wide range of scientific topics. Even more, projects can build on one another by taking existing materials and improving, refining and extending their contents and designs, and this strategy can therefore be used to improve the resource pool not only quantitatively but also qualitatively.

The second outcome, i.e. the resource itself, has been described in great detail here and clearly illustrates the proof-of-concept of how student projects can be used to deliver outreach resources. However, there is of course scope for further improvements. For example, we could have added further examples of cell migration. Our likely choice would have been a brain-related topic, such as lissencephalies which are a group of brain disorder where neuronal migration is affected [8]. Another attractive addition would have been a module on the cellular mechanisms that underpin and regulate cell migration [9-11], certainly a challenging but also most interesting task. A strategically interesting idea would have been to design a website in which visitors of the exhibition can re-visit the exhibited materials spiced up by further information and links, such as links to charity sites explaining some of the diseases mentioned on the poster. This website could be listed on the hand-outs, thus carrying the Trojan horse strategy one step further. Finally, it should be mentioned that we chose the figshare.com server to publish this resource for several reasons: its service is free and unlimited, it provides a digital object identifier (DOI) which makes this publication and resource citable (also on the student's CV), and it provides metrics which may help to enhance its status on the CV. Using the option of publication as an incentive whilst realising this step only with the best projects, should help us build a strong pool of outreach resources.

The third outcome, i.e. the thoughts and rationale used to develop this resource, are certainly commonsense and not new to those who are experienced with outreach activities. However, for those new to these activities they may be inspiring and help set realistic objectives from start. Certainly, they will help the next generation of project students here at Manchester to start with a clearer idea when developing further outreach resources on their topics of choice.

The bigger picture of outreach activities and how to improve them

As explained in the introduction, outreach activities are becoming more important in a scientist's life. However, we need to see this development with caution, and also grant giving institutions need to consider their positions. Thus, the main work load and the development of outreach activities is mainly left to the researchers, and this is problematic in times of increasing time constraints. It does not necessarily lead to the high standard science exhibitions as hosted by the [Royal Society](https://royalsocietypublishing.org/), but is more likely to produce quantity for quality where many activities are rather mediocre in their design and do not achieve the effects we wish for. This certainly is not

the fault of the scientist and presenters, but it is the result of insufficient support, leading to a situation in which the wheel has to be re-invented by each and every contributor again and again. Certainly, helpful information is out there. However, it is only beginning to be collected in public platforms (see introduction), whereas many gems remain dispersed on web sites or platforms such as YouTube (see for example "[Stated Clearly](#)"), and finding them requires too much time and effort or word of mouth. Even if found, this information is often not provided in a user-friendly way. If grant-giving institutions demand outreach activities, they need to invest in supportive resources. Good attempts in this direction are platforms for school teachers like [resources4schools](#) which archive and organise available materials across platforms, and comparable platforms could be developed for the wider range of public engagement activities. In our view the current attempts (see Introduction) are promising, but more dedicated projects are required in which outreach specialists put together much needed web resources and turn the current patch work of didactic ideas, explanations, tips and examples into a well-digested, focussed and time-saving tool, easy to browse and absorb, as well as providing archives and collections of helpful and concisely explained links to other resources. This will help to raise exhibition standards and provide the kind of materials that can be used to extend the experiences of science open days or school visits right into people's homes.

An important further consideration is the general effectiveness of different learning strategies. What are the true switches that recruit new scientists and that generate public understanding and acceptance of science? For example, how do we need to adapt strategies when targeting different audiences [12], or which are the most efficient venues and locations where to engage with the public - our laboratories, exhibition halls, schools or even theatres [13]? A recent [Wellcome blog](#) has argued that the experience at schools is far more essential than any public events. Hence, should we invest our overstretched time on open days and their likes, or would it not be far more effective to closely collaborate with schools as our main strategy? For the latter, what are the activities that meet curricular requirements and provide resources for teachers that can be used beyond a single extra-curricular school event? We need time-saving guidance on these formal aspects. In conclusion, any strategic decisions should be made on an informed basis, and grant giving institutions should invest in projects that can lay the foundations on which we can then build our activities.

Acknowledgements

We would like to thank Suzanna Battom (FLS, Manchester) for help with generating the Dictyostelium movies, Tom Millard (FLS Manchester) for providing *Drosophila* movies, and Chloe Sheppard from the Wellcome Trust for making me aware of some of the links on public engagement support.

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Supplementary materials

Supplementary materials can be downloaded from [dx.doi.org/10.6084/m9.figshare.741264](https://doi.org/10.6084/m9.figshare.741264)

Suppl. Mat. 1. The poster "What's moving in you?" in PDF format (can be opened and modified in Adobe Illustrator). Images were taken / modified with permission from the following sources: the tumour image from [CancerHelp UK](#); the pigment cell migration image from [Catherine McMillan](#); the cleft and palate images from [Centers for Disease Control and Prevention](#). The spiderman images were generated by [Loston Wallace](#).

Suppl. Mat. 2. A short edited film sequence showing dorsal closure in *Drosophila* (a paradigm for wound healing), the migration of *Dictyostelium discoideum* and in vivo migration of blood cells (haemocytes) of *Drosophila*. The movie illustrates the use of headlines and is in Windows AVI format. The *Drosophila* films were kindly donated by Tom Millard, *Dictyostelium* movies were generated in collaboration with Suzanna Battom.

Suppl. Mat. 3. Two "trojan horse" hand-outs with some activities designed to be taken home and providing links for further study.