Hands-on molecular biology techniques

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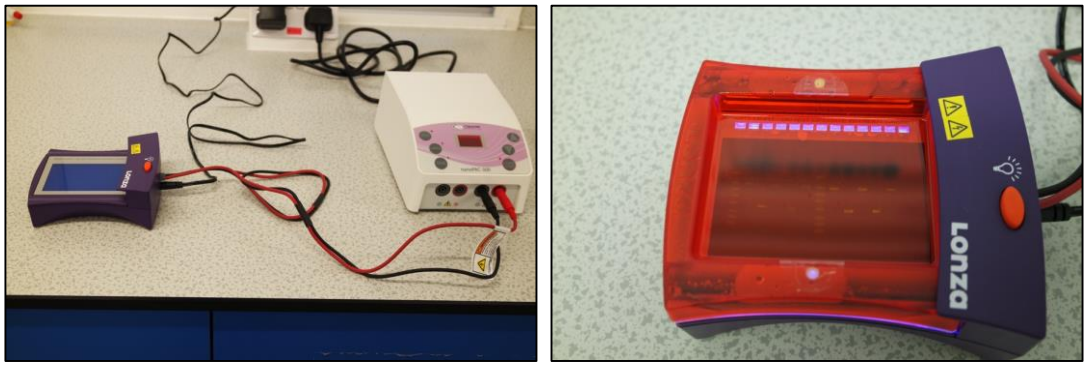
Introduction

There are a large number of scientific techniques that A-level students learn the theory of, but unfortunately due to school budget constraints students are unable to get hands-on experience of. Furthermore, many techniques involve dangerous chemicals or take a long time to carry out, which are not always feasible in a school setting.

One example of these techniques is agarose gel electrophoresis - an essential technique used in microbiology laboratories during construction of plasmids, genotyping and analysis of PCR products. Learning the theory of this technique is part of the A-level syllabus, but there are a number of challenges with carrying out this technique in classrooms, in addition to the cost. The technique usually takes at least 60 minutes, which is often not possible in lessons when added to an introduction and training. Finally, there are safety concerns as traditionally gels use ethidium bromide to stain the DNA (which is toxic), and UV light to visualise the DNA (which is harmful).

Using a grant from the Biochemical Society, I purchased a Lonza FlashGel System: a gel electrophoresis kit which has significant advances over those traditionally used. The kit is fast, allowing for separation of DNA bands in 5 – 7 minutes. It also has an integrated alternative transilluminator light (not UV) that allows students to watch DNA migrating in real-time (not usually possible with traditional methods). Furthermore, the DNA stain is not considered hazardous according to OSHA or EU hazard criteria and the gels come pre-made in a sealed cassette, meaning that students will have reduced exposure to any chemicals.

Taking this equipment into classrooms, and allowing students to use it, will provide a unique opportunity to consolidate the theory learnt in school, as well as give them a taste of what research is like.



Gel electrophoresis equipment

Aims

The target audience will be students studying A-level biology (age 16-18), but the workshop could also be adapted for other audiences such as younger secondary school students and adults. By carrying out the workshop I intended students to:

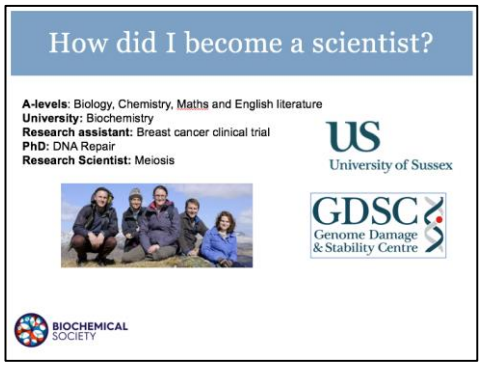
1. Gain knowledge of the theory of the technique, and understand some of the applications both in and out of the research lab
2. Learn to use micropipettes, and use them to accurately measure samples
3. Load their samples on an agarose gel and watch the DNA migrating
4. Analyse the results from their samples

The workshop

I visited BHASVIC 6th Form college (Brighton and Hove) in February 2017, and delivered a 1 hour workshop to a small group enthusiastic students who were a mix of AS and A-level students. Although the group size was small, this meant that the students got even more of a chance to use the equipment and get a feel for research. My workshop was broken down into several parts:

Introduction

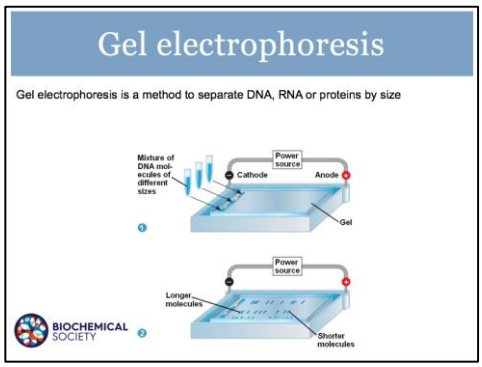
Firstly I gave a brief description of my career to date, and what I research. This will hopefully have been of an advantage to those students who are currently considering their career choices as they can gain an insight into what it is like to be a scientist. Students also had the opportunity to ask me questions.

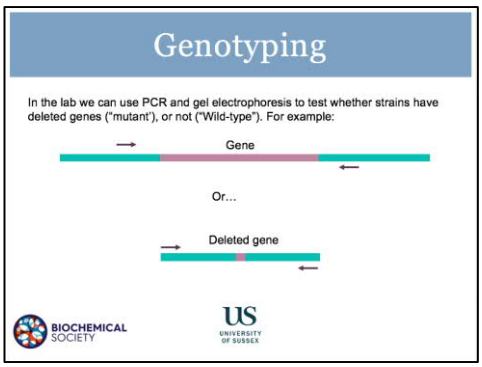


Left: Delivering the introductory talk during my workshop. Right: Example slide.

Discussion of gel electrophoresis

I assessed the student's knowledge of gel electrophoresis by asking them questions, then filling in the gaps in their knowledge to ensure that all students knew the basic background. I also took the opportunity to explain the problem which we would be addressing today: identifying whether PCR products from different strains indicate whether they are wild-type or a mutant. I discussed with them reasons for why we might want to do this in research.





Examples of slides used during my discussion of gel electrophoresis

Safety talk

In order to ensure that the students were safe, I gave a brief safety talk and ensured that all students were wearing lab coats, gloves and goggles. Once students were wearing the correct protective clothing we were ready to start with the practical section!

Safety slide

Practice using micropipettes

As none of the students had used a micropipette before, I showed them how they work and asked them to practice using them. They practiced by moving various amount of water accurately between tubes, and all enjoyed learning how to use the micropipettes. The students picked the technique up at various rates, and I made sure to support the ones who did not pick it up as quickly as the others. I also encouraged peer learning by asking those who has picked it up quickly to support their classmates.

Learning how to use micropipettes

Loading DNA and watching migration

The students then prepared their samples by mixing DNA with loading dye, and loading it onto the gels. They could then watch their DNA migrate in real time. The students were very excited by seeing their DNA, and all took many photos of their gels running, some of which they were going to enter into a biology department photography competition! Once run, the students completed a worksheet detailing the results of the experiment and I am pleased to say that they all analysed their gels correctly.

Loading agarose gels and watching the DNA migrate in real-time

Roundup

To roundup the session we had a discussion of the uses of gel electrophoresis, and I encouraged students to think about different TV shows which they have seen it used, as well as what they have covered in the classroom. I also prompted the students to think of other reasons by giving them clues as to what you can do with DNA, and this encouraged them to think outside the box. The students were all very successful in this and even came up with some examples that I wouldn't have thought of straight away.

Evaluation of the activity

There were a number of challenges that arose when delivering the session, which I was able to overcome but I will incorporate into my future sessions. The students had never used micropipettes before, and they picked up the technique at different rates. Fortunately the group size was small so I was able to support all students, but in future if I had a large group I would either take a helper with me or show the teachers how to use them beforehand, so that all students can get the support that they need. The workshop also ended up taking longer than my intended hour, as I underestimated how long the students would take to carry out the experiment. In the future I will give them fewer samples to analyse which will make the workshop quicker.

At the start of the session I spoke to the students to assess their knowledge and experience of the techniques, then I did the same at the end to assess any change in their knowledge. This was a qualitative, rather than quantitative, assessment as I did not want the students to feel like they were taking a test. At the start of the session around 25% of the students has learned the theory of the techniques, and none of them had had previous practical experience with it. By the end of the session 90% of the students were able to explain the basic principles of the technique, and all had gained practical experience in it. I also asked the teachers for feedback, who said it was a great session that added to the curriculum that they taught as well as stepping beyond it. The students really enjoyed it, with one student saying that she said she found the session "very enjoyable and that it opened her eyes to the possibilities of a career in Biology."

Hands-on molecular biology techniques: Evaluation

Kayleigh Wardell, University of Sussex

Has your activity met the aims originally set out in your application? If your aims changed during the project, please note the reason for making these changes.

The aims of my activity were to:

1. Allow A-level students to get unique hands on experience with laboratory equipment and techniques
2. Add to students' knowledge of molecular biology
3. Give students an understanding of what research is like
4. Enhance the students' problem solving and analytical abilities

I did this by using the Biochemical Society Outreach Grant to purchase a Lonza FlashGel system, a gel electrophoresis kit which I took into the classroom, allowing students to experience using this technique. I also purchased a set of micropipettes, essential equipment for this type of experiment. I successfully achieved all of my aims through a combination of presentations, practical experiments and discussions.

Referring to your original application, what objectives did you set for your activity? If these objectives changed during the project, please state the reasons for making these changes.

The objectives of my activity were to:

- Allow students to prepare a sample of DNA and use the gel electrophoresis equipment to visualise their DNA
- Discuss different techniques with the students, with a particular focus molecular biology techniques
- Discuss what it is like to be a researcher

I carried out all of these objectives during my workshop, by using a combination of presentation, discussions and practical work.

How well you think the activity went and what could be improved. Please think of this from a variety of perspectives, including the project leader, staff/volunteers delivering the project and the audience.

I feel that the activity went very well, I met all of my aims and objectives and the students were able to experience a research activity that they would normally be unable to. Furthermore, the session was enjoyable for all involved. When I asked for feedback following the sessions all students said they has enjoyed themselves, and the teachers were positive too and invited me back to deliver different workshops in the future.

Improvements that I would make for future sessions are as follows:

- The students had never used micropipettes before, and they picked up the technique at different rates. Fortunately the group size was small so I was able to support all students, but in future if I had a large group I would either take a helper with me or show the teachers how to use them beforehand so that each student would be able to get the amount of support that they need.
- The workshop ended up taking longer than my intended hour, as I underestimated how long the students would take to carry out the experiment. In the future I will give them fewer samples to process, but more to analyse in order to improve on their analytical abilities.

How did you benefit from this Outreach grant?

I benefited from the grant as I was able to gain experience and confidence in planning and organising workshops for students in schools. This gave me a chance to think about my research in a way I wouldn't normally so that I could pitch it at an appropriate level to A-level students.

Did the activity meet the criteria of the Biochemical Society Scientific Outreach Grants? If not, please state why. How did you meet these criteria?

The criteria are as follows, with details of how I met them:

- *The effectiveness of the proposal for disseminating information about (bio)sciences to young people and the general public. The effectiveness will be considered in terms of the attractiveness of the event(s) to the target audience and the soundness of the underpinning science.*

I visited a school to discuss biosciences with A-level students, allowing them to try out one of the techniques I commonly use in my research. The equipment purchased can also be used to demonstrate research and techniques with other members of the public, for example at science fairs.

- *The level of relevance to the biosciences, with particular emphasis on molecular bioscience for upper secondary school age audiences and above. For primary school age audiences, the focus can be on biology or on all sciences (for further information, please see the extract from our Education strategy below).*

I took my equipment and workshop into a school and delivered it to AS and A-level students, who are taught the theory but are often unable to perform the practical aspect due to expense of equipment.

- *The number of students/teachers/members of the public reached (N.B. This may include young people involved in developing an event or people to whom material is passed on, in addition to the number actually attending).*

I delivered my first workshop to 8 students and 2 teachers, but the workshop will be delivered to other classes. In June I will be delivering it to 16 students at another school, and in June it will be used as a demonstration at the University of Sussex Community Festival, where it is estimated 300+ members of the public (of a variety of ages) will visit the stand.

- *Consideration for widening participation: e.g. with regard to 'difficult to reach' groups.*

I took the workshop into an A-level college which takes students from all background including those from families with no history of higher education. In the future the workshop will be taken into more schools, in particular those which have a low rate of university applicants. The Public Engagement Coordinator within my department has contacts at a range of schools within the local area which we can connect with.

- *The clarity of the intended output and any performance indicators (including evidence of impact) or methods of evaluation, such as feedback forms or questionnaires.*

From my application I intended to assess the activity by giving the students a questionnaire at the beginning, and then again at the end, of the session, to see how their knowledge and perception of research has developed. I will intended to also ask teachers for feedback at the end of the event and in the week after the event when they have had a chance to discuss it with their students.

I changed this during my actual activity: as I had a small group of students I decided to use a qualitative discussion with them, rather than a paper-based assessment, as I did not want the students to feel like they were taking a test. I did ask the teachers for feedback, both straight after the session and a week later, which was positive on both accounts. In the future I would do a more quantitative assessment if I had a large group of students or was demonstrating the activity at a science fair.

- *The likelihood of delivery within the proposed timetable and within the funding requested.*

I delivered the workshop within the proposed timeframe, and it did not cost more than the funding requested.

- *The inclusion of hands-on/practical work.*

The workshop was predominantly practical, allowing students to learn how to use micropipettes and carry out agarose gel electrophoresis. None of the students had experience in these techniques prior to the workshop.

- *Long term benefits/sustainability (resource production, train the trainers, opportunities for roll out, potential for cascading the benefits).*

The students who have been engaged with the activity will, hopefully, be inspired to take up a career in a STEM subject. One student said that the workshop "opened her eyes to the possibility of a career in Biology". Furthermore, all students will have benefitted in terms of getting a deeper understanding of topics covered in the A-level Biology curriculum.

While at the school I trained the teachers in using the equipment, and offered to bring the equipment back into a school for them to use with other workshops should this fit into their curriculum. In June the equipment will be shown to teachers at the Teachers Conferences at the University of Sussex, which will allow for more teachers and schools to be aware that this workshop is available for us to deliver. I anticipate that we will make long-standing connections with these schools which will allow us to deliver the workshop annually, enabling more students to benefit from the equipment which I was able to purchase using the Biochemical Society grant.

- *Events or activities that can be re-run or organized by others.*

The equipment is reusable and is available for anyone within the School of Life Sciences at the University of Sussex to use at any time for Outreach or Public Engagement activities. I have trained our Public Engagement Coordinator in the technique, and provided her with the workshop and materials.

Will you run this activity, or a similar project to engage the public, again?

I have another workshop lined up in June, to deliver the session at another school. I have also trained our Public Engagement Coordinator in the technique, and provided her with the workshop and materials. This will allow others who work in the department to take my resources and equipment and deliver the workshop in the future. We also plan to use the equipment at science fairs for students and families, as well as demonstrate it at Teachers Conferences at the University of Sussex. For example, another research group will be using the equipment at the University of Sussex's Community Festival in June, showcasing microbiology research to members of the local community.