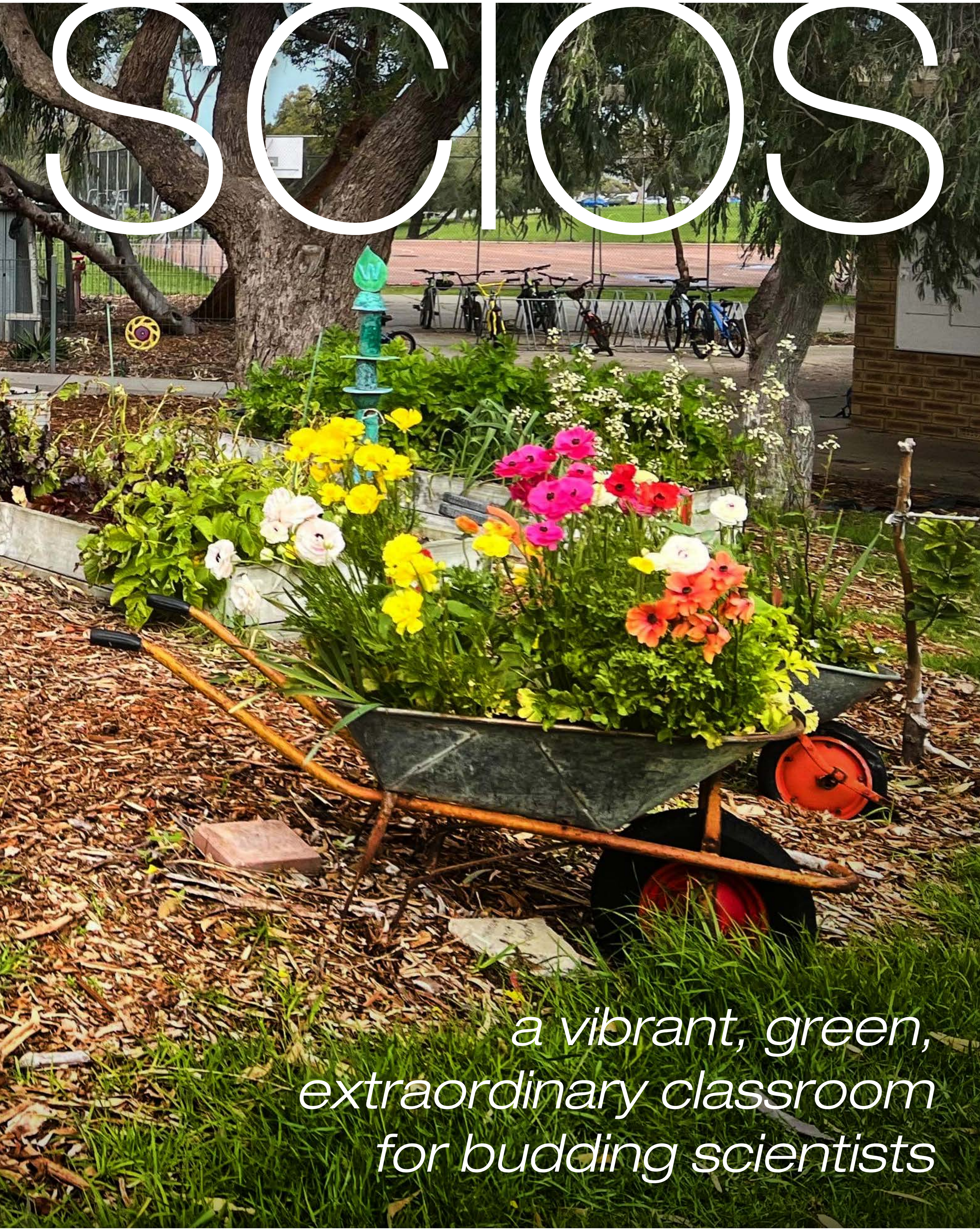
JOURNAL OF THE SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

# SCIOS



a vibrant, green, extraordinary classroom for budding scientists

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## SCIOS: To Know

This journal aims to promote the teaching of science with a focus on classroom practice. It provides a means of communication between teachers, consultants and other science educators. Opinions expressed in this publication are those of the various authors and do not necessarily represent those of The Science Teachers' Association of Western Australia (STAWA), the editorial committee or the publisher.

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# DNA'BLING THE NEXT GENERATION

Dr Siew Fong Yap

**About the Author**

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**DNA BioBarcode Club - A Citizen Science Project**

Research has shown that citizen science can foster an understanding of engagement with science as well as the perception of the relevance of scientific topics (Lusse et. al, 2022). Among potential learning outcomes identified, citizen science can enhance aspects including students' motivation, interest and knowledge and their scientific communication skills. Project designs with high level of student participation are found to contribute towards high level of student achievement of the learning outcomes (Phillips, et. al, 2018). With the increased availability of gene technology kits, citizen science is gaining popularity in the context of global biodiversity and environmental issues that require the use of biotechnological skills that are increasingly incorporated as part of STEM education.

This article presents some perspectives of the usefulness of citizen science in the application of DNA bio-barcoding technology to facilitate secondary students' understanding of molecular biology, in particular, DNA structure, biotechnology tools and their applications to study the biodiversity in their school ground and their community.

Under the auspices of BioBarcode Australia and the Australian Barcode for Life Project and in partnership with Harry Butler Institute at the Murdoch University, Kingsway Christian College secondary students started their inaugural DNA BioBarcode Club with a group of eighteen 15-year-old Year 10 science students.

Under the instruction of Pauline Charman, Director of BioBarcode Australia and a group of ambassadors (post-doctoral and masters students), the students met for two hours every week after school to run their club activities for a term of ten weeks.

## Program

| Week | |
|---|---|
| 1 | Introduction – Overview of the project, DNA structure and the gene code, introduction to pipetting mastery, introduction to science ambassadors. |
| 2 | Micropipette mastery – learning to use micropipettes like a research scientist |
| 3 | Extraction and amplifying DNA from specimens (PCR) polymerase chain reaction |
| 4 | Visualising DNA using gel electrophoresis |
| 5 | Off-site visit to the Gene Sequencing Facility (Murdoch University where samples are sequenced) |
| 6 | Introduction to DNA and computer science, Bioinformatics (use of laptops) |
| 7 | Bioinformatic analysis of samples / log data into Bio-collect Application |
| 8 | Choose locations and samples for future species (identifying specimens) |
| 9 | Introduction to Fungi Barcoding – joint study with Dr Sarah Sapsford (Murdoch University) |
| 10 | Showcase/Guest artists |

*Source: Phillips et. al. (2018).*

## Club Learning Outcomes

The learning outcomes for the club activities included:

| NSF Framework Category | DNA BioBarcode Club Learning Objectives |
|---|---|
| **KNOWLEDGE**<br>Awareness, understanding: Measurable demonstration of assessment of, change in, or exercise of awareness, knowledge, understanding of a particular scientific topic, concept, phenomena theory, or careers central to the project. | Australian Science Curriculum<br>Year 10 Science Understanding - Biological Science<br>Use of models and diagrams to represent the relationship between genes, chromosomes and DNA of an organism's genome.<br>Transmission of heritable characteristics from one generation to another involves DNA and genes (ACSSU184)<br>Year 10 Science as a Human Endeavour<br>Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries. (ACSHE160/194) |
| **ENGAGEMENT**<br>Interest or motivation in science: Measurable demonstration of assessment of, change in, or exercise of engagement/interest in a particular scientific topic, concept, phenomena, theory or careers central to the project. | Interest and motivation: Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.<br><br>This is observed in the type and quantity of questions posed during the activities, as well as the weekly tasks and reflection notes by students. |

| NSF Framework Category | DNA BioBarcode Club Learning Objectives |
|---|---|
| **SKILLS**<br>Skills related to science inquiry – measurable demonstration of the development and/or reinforcement of skills, either entirely new ones or the reinforcement, even practice, of developing skills. | Year 10 Science Inquiry Skills<br>*Questioning and Predicting* (ACSIS163/198)<br>*Planning and conducting* (ACSIS165/199)<br>*Processing and analysing data and information* (ACSIS170/204)<br>*Evaluating* (ACSIS171/205)<br>*Communicating* (ACSIS 174/208)<br>Make sense of the natural and physical world from the data collected.<br>Skills of collecting biological specimens, extracting DNA, gel electrophoresis, micro-pipetting, polymerase chain reaction and gene sequencing.<br>Data interpretation and analysis – genome annotation and analysis |
| **ATTITUDES**<br>Attitude towards science – refers to changes in relative stable, more intractable constructs such as empathy for the specimens collected, plants and animals and their habitats, appreciation for the role of scientists in society or attitudes towards the research in genetics. | Students appreciate the role of molecular biologists in the various fields in contributing towards biodiversity, environment care and diseases in plants, animals and humans.<br>Students appreciate the potency of the scientific enterprise for making a real difference, and the ethic of integrity and the values of perseverance and hard work in the face of potential multiple failures before a successful outcome. |
| **BEHAVIOUR**<br>Measurable demonstration of assessment of, change in, or exercise of behaviour related to a STEM topic. Behavioural impacts are particularly relevant to projects that are environmental in nature since action is a desired outcome. | Students work with scientists and researchers, understand the nature of their research and the implications for the environment.<br>For example, studying the ticks from WA Canning River brings about an awareness of the gene diversity; coding the DNA of a dandelion brings an awareness of the intricacy of the genes and how this situates in a phylogenetic tree. Understanding brings about a different thinking and action when students recognise the role and function of species in its ecological niche and system. |

*Note: While the framework was used to map out learning outcomes, no quantitative analysis was conducted so the outcomes are not stated in measurable terms here.*

Using the Shirk et al. (2012) category of citizen science projects based on degree of participation of public and students with scientists, our college has adopted the *contributory project* model. Such a model is generally designed by scientists and for which members of the public and students primarily contribute data.

At this college, this citizen science model is based on an extra-curricular program where an external educational agency such as the BioBarcode Australia


and the Australian Barcode for Life Project work closely with the science educators of the college. The sessions were also run with the support of ambassadors who were science researchers in the field of molecular biology. The science educators also worked closely with one of the university research scientists who brought their expertise on how gene technology was currently used in problem-solving and helped students value the importance of communicating science. With the use of information technology, students gained new understandings on mobile applications and online programs in the context of environmental education to address socio-ecological challenges. Contact with researchers and scientists also opened a world of possible career pathways in STEM, a bonus that the students cherished.

These students have been privileged to play a pioneering role in working with scientists to carry out gene sequencing of ticks (from Canning River and South of the River) to understand how these ticks can bring about diseases in cattle and local produce. Students carefully extracted the DNA and amplified these using mini-polymerase reaction thermocyclers (PCR machines) specially designed to run in school labs. Using an innovative dipstick technology, students were able to extract enough (in a school setting) for gene sequencing in the university lab.

Collection of real data utilised applications such as the *iNaturalist* and *SEEK* including the BLAST (Basic Local Alignment Search Tool) gene sequencing techniques allow students to see the relevance and appreciate the power of such knowledge applications in daily science, and the potential contributions these data would help improve the local environment and community.

**Students' reflection notes**

(selected from different workshop sessions)

*"I really like walking around the school grounds and finding out about all the different native and non-native plants that has been planted around the school. We were able to see and hear different species of birds around the school and the different types of plants they eat. It was also interesting learning how to use the SEEK and iNaturalist apps and allow our observations to be uploaded so that professionals in the field can see these and investigate these further. I really want to learn about the different species in our school. It was such an eye-opening experience."* I.S.

*"This session, we got to perform DNA extraction by following a protocol. The DNA extracted was from a blade of grass and a Canning River tick. Through this experience, I learned the technique of sterilisation and the importance of doing it thoroughly. I am excited to see the*

*PCR results from the DNA extracted and want to learn more about the optimisation of such a process."* B. W.

*"For our session today, we got to the results of DNA extracted from ticks and grass (school ground). The gel electrophoresis machine has a gel called "agarose" to collect the DNA. We can see the "ladders" of the DNA. At first, we used silicon to learn how to pipette the correct amount of DNA sample into the wells. I found the machine quite interesting as it is used to separate the DNA according to different charges. I am curious to see the results of the tick from Canning River. I was surprised to learn that the word `agar' came from the word `algae'. Overall, I thoroughly enjoyed today's lesson and the concepts we explored about DNA and the techniques we can use to find information."* S.T.

*"Today's session was about bioinformatics. We used genetic code to compare different species and see which ones are closely related. First, we used the NCGI website and when copying and pasting different base sequences into the application, we came upon a family tree or a phylogenetic tree from the genome net. We also coded the DNA of a dandelion. We also carried out gel electrophoresis of the tick we prepared the week before. One key take-away from today' session is that we can do bioinformatics as a job. I am excited about going to Murdoch University next week to see how the sequencing is done. This is so exciting."* B. L.

*"I have come to realise that coding is relatively easy, and I can copy and paste the base sequences on the Genome net. I was really surprised by how we can access information of DNA from around the world. I can see from the phylogenetic tree how closely certain species are to each other. I want to see the process in which DNA code is created. I also want to find out more about how similar species can be."* R. R.

**Teacher's reflection notes**

*"There was a good balance of theory and practical. The students were clearly engaged and enjoyed the lessons. Students have found it helpful to hear from the post-graduate students with diverse backgrounds, following different pathways in the field of the sciences. Technology not usually used in school lab was made accessible to students, and it is an eye-opener as they explored the possibilities where their data can take them."* S. L.

*"Kingsway Christian College students 10-week involvement in the BioBarcode Club helped pioneer a new citizen science project aimed at helping genetically identify species found in our urban landscapes using the engaging, accessible technique of DNA barcoding. BioBarcode Australia's Australian Barcode for Life Project hopes to engage and empower school students and community members to join race to genetically catalogue our precious Australian biodiversity before we lose it to climate change. The Kingsway students spent their sessions being introduced to research grade equipment that enabled them to process tiny samples of locally sourced plants that were then genetically sequenced and compared to established data bases. It's possible that new species can be revealed with this accessible, fast, and efficient technique, and students have the opportunity to contribute to the genome bank of local species."* Director of BioBarcode, Pauline Charman

**Program Review**

As DNA Biobarcode Club progressed over the ten weeks into the final phase of gene technology applications, the students were led through the process of DNA extraction and profiling (gel electrophoresis) using specially designed school lab protocol. The instruction sequence and teaching practices involved were also carefully documented by a teaching staff as biotechnology applications are currently being developed to integrate citizen science as such into a formal science curriculum – an initiative that this college has been privileged to be the first independent school to implement in Western Australia.

The DNA Biobarcode Club thus provides an authentic opportunity for students to apply their scientific knowledge, to practise a range of skills and to use equipment that professional scientists would recognise from their own day-to-day work (Dillon, 2011). However, as the program contains more than just the curriculum content, the focus also works towards a consideration of what it means to learn about the nature and processes of science inasmuch the *practice* of science.

In highlighting some of the positives of such an initiative, it is also important to note, as with all new endeavours, there are factors such as time and timetabling, staffing and equipment cost that should be taken into consideration in the overall equation. Certainly, as we face a future where STEM skills are essential in the workforce, the benefits outlined here far outweigh the constraints presented. It is with much anticipation that we look forward to more schools running clubs such as these in our aspiration towards growing our future scientists.

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**References**

1. Dillon, J. (2011). Teaching science outside the classroom. In *How Science Works – Exploring effective pedagogy and practice*. R. Toplis (Ed.) New York: Routledge, 134 -147.
2. Lusse, Mientje, Brockhage, F. Beeken, M. & Pietzner (2022). Citizen science and its potential for science education. *International Journal of Science Education* 44 (7), 1120 - 1142.
3. Phillips, T., Porticella, N., Constas, M. & Bonney, R. (2018). *A framework for articulating and measuring individual learning outcomes from participation in citizen science. Citizen Science: Theory and Practice*, 3 (2), 3.
4. Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E. [Ellen], Minarchek, M., Lewenstein, B. V. [Bruce V.], Krasny, M. E., & Bonney, R. (2012). Public Participation in Scientific Research: A Framework for Deliberate Design. *Ecology and Society*, 17(2), Article 29. https://doi.org/10.5751/ES-04705-170229.