The Living Lab

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

A SCIENTIST'S JOURNEY: LEARNING TO COMMUNICATE SCIENCE FOR IMPROVED NATURE CONNECTEDNESS

Kara McHugh

Doctoral Research Student, James Hutton Institute, Invergowrie, Dundee, DD2 5DA, Scotland, UK.

Correspondence:

Email: k.mchugh@dundee.ac.uk

ORCID

https://orcid.org/0000-0002-2629-986X

ABSTRACT

With continuing concerns over the future of the natural world in the face of climate change, it is becoming increasingly important that people feel a sense of caring for, and responsibility towards, the environment. A feeling of 'nature connectedness' can be a useful means of predicting an individual's likelihood of making more sustainable life choices and is an area of great interest to researchers. Unfortunately, many people today struggle with so-called 'plant blindness' and low levels of nature connectedness. Through science communication, scientists can attempt to improve public knowledge and understanding of the natural world, thereby increasing individuals' appreciation for, and sense of connection to, nature. As a doctoral student at the early stages of my scientific research career, I had not had a great deal of experience with science communication for a public audience. However, as part of my doctoral training programme, I had the opportunity to undertake a professional internship to explore career options out with the university lab environment. During this internship, working within a university botanic garden in the East of Scotland, I had the opportunity to experience science communication for a variety of audiences including school pupils, school teachers and the general public. The intention was to use my

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

molecular biology and protein biochemistry knowledge to produce a new educational and recreational resource highlighting plants with medicinal properties. The aim of the new resource was to inform and entertain visitors to the botanic garden in a manner that would improve these individuals' sense of nature connectedness.

Keywords: Nature connectedness; Interpretation, Medicinal plants, Botanic Garden

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

INTRODUCTION

As part of my doctoral training programme, I undertook a three-month professional internship working within a university botanic garden in the East of Scotland. The internship was an opportunity to explore career options out with the area of academic scientific research. I was eager to discover the realities of working at the public-facing front of science, having spent the first two years of my doctoral training in a lab conducting molecular biology and protein biochemistry experiments, and the botanic garden provided an ideal environment for this. During initial discussions with my supervisor, we agreed that during the internship I would work to produce a new educational and entertainment resource highlighting plants with medicinal properties. The target audience of the medicinal plants trail was to be secondary school pupils (education) and members of the general public (entertainment). As I had little experience of communicating science to a public audience, I began work on the project by considering a simple question—what is science communication?

LITERATURE REVIEW

What is science communication?

According to the Oxford Reference definitions, science is "the systematic study of the structure and behaviour of the physical and natural world through observation, experimentation, and the testing of theories against the evidence obtained" (Oxford Reference 2017) and communication is "a process of interaction through messages or signals" (Oxford Reference 2020). Taken in combination, science communication can therefore be considered the use of speaking, writing or other tools to provide information which explains our understanding of the physical or natural world. Science communication can take many different formats depending on the subject matter and the intended audience.

The importance of science communication

In a 1998 article, Jane Lubchenco considered the role of science within society at the dawn of a new millennium. Lubchenco posited that public funding for science is provided in exchange for knowledge or technological contributions to society (Lubchenco, 1998). Indeed, for the current generation of early-career researchers, it is challenging to fully comprehend the extent to which the technologies that developed within their lifetimes have revolutionised both the possibilities and expectations of science. In the last 20 years, computational and technological advances have

enabled progression from the enormous effort and expense of the Human Genome Project (>90% sequencing of the human genetic code, completed after 13 years in 2003, at an estimated cost of around $3 billion) (The National Human Genome Research Institute 2022) to the Oxford Nanopore MinION (a pocket-sized portable sequencer, capable of whole genome sequencing, available for $1000) (Oxford Nanopore Technologies 2023). As highlighted by Lubchenco, it is clearly important to ensure such scientific advances are communicated to the public to secure future funding for research. However, I believe it is also relevant to consider the importance of science communication as a means of providing individuals with a greater sense of nature connectedness.

A relatively new term, nature connectedness can be considered a measure of an individual's attitudes towards the natural environment. Chen-Hsuan Cheng and Monroe (2012) suggested four key areas which contribute towards an individual's sense of nature connectedness:

1. Enjoyment of nature.
2. Empathy for creatures.
3. Sense of oneness with nature.
4. Sense of responsibility for the environment.

In the face of ongoing issues such as climate change and loss of biodiversity, it is important that people feel a strong sense of nature connectedness as this increases the likelihood of an individual valuing, respecting and protecting the environment (Whitburn *et al*. 2018). Additionally, increased nature connectedness is not only beneficial for the environment but is good for people too. In a survey for 2021 Mental Health Awareness week, 73 per cent of UK adults reported that connecting with nature was important for managing their mental health during the COVID-19 pandemic (Mental Health Foundation, 2021). Furthermore, researchers in Japan were able to measure the physiological health benefits of spending time in forest environments, so called *Shinrin-yoku* or forest bathing, in reductions in cortisol levels, pulse rate and blood pressure (Park *et al*, 2010).

The aims of science communication

The aims of a piece of science communication are dependent on the research area, target audience and format of the specific work. Despite the customised needs of individual projects, some core, shared objectives of science communication have been identified. One influential report by Burns *et al.* (2003) identified the five aims of science communication as:

1. Increased awareness.
2. Enjoyment.
3. Interest.

4. Opinion-forming.
5. Understanding.

Sanchez-Mora (2016) suggested the major outcomes of public engagement of science were:

1. Recognition that science exists.
2. Recognition that science is attractive.
3. Recognition that science is interesting.
4. Awareness that science is part of one's identity.

As a final example, in 2017 the National Academies of Sciences, Engineering and Medicine published a report listing the following as potential goals of science communication:

1. Sharing recent findings and excitement for science.
2. Increasing public appreciation of science.
3. Increasing knowledge and understanding of science.
4. Influencing opinions, policy, preferences, or behaviour.

Aims of the botanic garden

Historically, botanic gardens have predominantly served as conservation sites for rare or endangered plant species. However, in the 21st century botanic gardens have the potential to, and indeed must, serve new broader roles within their communities. In the botanic garden where this internship was completed, the curator recognises the identity of the garden "as a visitor attraction and centre for human well-being, in addition to traditional functions in research and education" (Frediani, 2021). Furthermore, the botanic garden also houses the Living Lab, a new doctoral training programme which promotes multi-disciplinary collaboration between the STEAM subjects (traditionally STEM; Science, Technology, Engineering and Maths, now with the additional inclusion of Art) working in the areas of education, sustainability and nature connectedness.

Aims of the medicinal plants science communication resource

It was with the above information in mind that the goals of the new medicinal plants science communication resource were considered. The resource was intended to be informative and entertaining, with a target audience of educational and recreational visitors to the botanic garden. By highlighting plants with medicinal uses and their intersections with human history, the resource was also intended to create a greater sense of nature connectedness for botanic garden visitors. It was agreed that the internship would work to create:

1. A trail of interpretive panels to be stationed next to the plants throughout the garden.

2. An accompanying guidebook with additional information.
3. Animated videos explaining some of the relevant molecular biology concepts.

METHODS

Part one – selecting medicinal plants

Work for the internship began with establishing which plants would be included in the medicinal plants trail. During discussions with the botanic garden education officer and curator it was agreed that a total of ten plants would be featured in the medicinal plants trail. The botanic garden includes areas dedicated to specific plants from different continents and climates, varying from Asia to the Mediterranean, as well as both tropical and arid glasshouses, providing a diverse range of plant species. One consideration for the selection of plants in the medicinal plants trail was to sample a diverse selection of plant species, spanning the physical and botanical range available in the botanic garden. A second consideration was to include plants with different growing seasons to ensure continuous points of visual interest for visitors to the botanic garden throughout the year.

It was next considered how to bring the medicinal plants trail together into a cohesive narrative. To help the medicinal plants trail improve the sense of nature connectedness felt by the botanic garden visitors, the decision was made to highlight the human stories associated with the discovery and use of medicinal plants. Documents existing from Ancient Egypt and Ancient Greece, the Ebers Papyrus and De Materia Medica respectively, describe the use of plants in a medicinal context, highlighting the extent of medicinal plants' involvement in human health throughout history (Bryan 1930, Gunther 1934, Magdalen College, University of Oxford 2014 & Metwaly *et al.* 2021). As human medical and scientific knowledge advanced, the stories of medicinal plants intersected with those of the scientists and doctors who studied them. As early as 1858, experiments conducted by 'the father of immunology' Louis Pasteur were able to reveal the antibacterial properties of garlic (Rupp 2014, Wong 2019). Research into the medicinal properties of plants continues today with scientists such as Dr Martha Yahimbu, whose work aims to identify new treatments for neglected tropical diseases (WIPO 2021).

Finally, the medicinal plants trail was also intended to function as an educational resource. To achieve this goal, it was decided to produce molecular biology animations for a subset of the medicinal plants in the trail. The animations would be used to explain the biology underlying how the plants help to treat different medical issues. In order for plants with reputed medicinal properties to be accepted for use in the 21st century, they require scientific validation. Regulations surrounding medicinal plants vary between different countries, but some fundamental requirements

include meeting safety and efficacy measurements (Bhosale & Banerjee 2019). Alternatively, sometimes a specific chemical can be identified as being responsible for a plant's medicinal properties, and this active molecule can be extracted or reproduced synthetically for use as a medicine. As defined by the European Patients Academy on Therapeutic Intervention (EUPATI 2020) "an active molecule is a chemical compound that has pharmacological or biological activity likely to be therapeutically useful".

With these considerations in mind, a literature review helped to identify potential plants to include in the medicinal plants trail. The ten selected plants were as follows:

1. Willow tree (*Salix alba*)
   Produces the active molecule salicylic acid, which is used to produce the painkiller aspirin (Desborough & Keeling 2017)
2. Foxgloves (*Digitalis purpurea*)
   Produces the active molecule digoxin, which is used as a medicine to treat heart failure (Edwards 2012).
3. Tea plant (*Camellia sinensis*)
   Produces the active molecule theophylline, which is used as a medicine to treat asthma (Ito *et al*. 1997).
4. Yew tree (*Taxus baccata*)
   Produces an active molecule which is used to make the chemotherapy medicine Taxol (Foa *et al*. 1994).
5. Snowdrops (*Galanthus spp*.)
   Produces the active molecule galantamine which is used as a medicine to help manage Alzheimer's disease symptoms (Royal College of Physicians 2017).
6. Autumn crocuses (*Colchicum autumnale*)
   Produces the active molecule colchicine which is used as a medicine to treat gout (Dasgeb *et al*. 2018).
7. Lesser periwinkle (*Vinca minor*)
   Produces the active molecule vincamine which benefits brain health (Farahanikia *et al*. 2011).
8. Garlic (*Allium sativum*)
   Produces the active molecule allicin which has antibacterial properties (Bayan *et al*. 2014).
9. Heather (*Calluna vulgaris*)

Is under active investigation, results show potential antibacterial properties (Vučić *et al*. 2014).

10. Juniper (*Juniperus communis*)

    Is currently under investigation for potential liver-protective effects that could benefit fatty-liver disease patients (Raina *et al*. 2019).

Part two – creation of pilot interpretive panels

As early research and medicinal plant selections were concluded, work turned towards the creation of a pilot interpretive panel. The interpretive panels were to be a central element of the medicinal plants trail, to be positioned next to the plants, around the garden. It was therefore a priority to ensure that the interpretive panels were well designed and appealing to botanic garden visitors. At this early stage of the project, it was unclear exactly what the content of the interpretive panels should be, so the decision was made to create a pilot interpretive panel to trial with members of the public.

A pilot interpretive panel was created for foxgloves (*D. purpurea*) and is represented in Fig. 1 below. Briefly, the pilot interpretive panel contained the following information:

1. The traditional medicine history of the plant.
2. The doctor involved in validating the medical properties of the plant.
3. The active molecule responsible for the plant's therapeutic benefit.

A chance to gather public feedback on the pilot interpretive panel was presented by an open day at the botanic garden during October 2022. Opportunist, informal conversations were had with members of the public who had attended the botanic garden open day, by approaching people as they neared the garden exit. Members of the public who agreed to provide informal feedback included the parents/grandparents of both pre-school and primary school aged children and adults without children (of various ages) including a teacher and a children's Brownie Guide leader. The following list of questions was pre-prepared for the open day:

1. Have you visited the botanic garden before?
2. Would you be interested in finding out more about medicinal plants?
3. Do you think a medicinal plants trail would improve visitor experience of the botanic garden?
4. What do you think of the pilot interpretive panel?

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

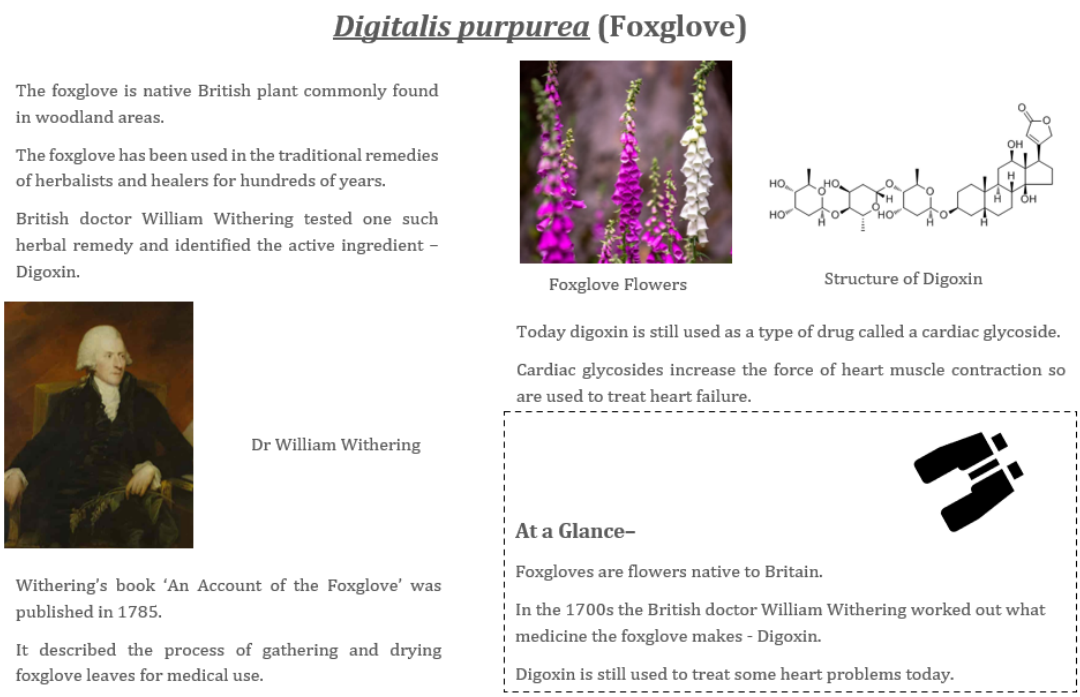


Figure 1. The pilot interpretive panel for *Digitalis purpurea* (foxglove)

The pilot interpretive panel created for *D. purpurea* as part of the medicinal plants trail, as shown to members of the public at the botanic garden open day in October 2022.

Most of the participants were repeat visitors to the botanic garden, while a small number were making their first visit due to the open day. All of the participants reported being interested in learning more about the medicinal properties of plants. Most of the participants had noticed examples of the other plants featured in the current trails present in the garden such as 'Plants for People' which highlights plants such as the rubber tree (*Hevea brasiliensis*) which produces latex (Rainforest Alliance 2012), and the paper reed (Cyperus papyrus) used to produce the ancient writing material papyrus (Beaulieu 2023). The participants were in agreement that resources such as plant trails were informative and interesting, and welcomed the idea of a new trail highlighting medicinal plants. However, the participants had a few criticisms of the pilot interpretive panel, primarily that it contained excessive text which may deter people from engaging with the resource. Evidence in the literature supports the idea that simple signage is a more effective means of communicating information to the public. In a study conducted at a national park in the United States of America, simple educational signs were installed to encourage members of the public to stay on designated trails, no participants spent longer than eight seconds reading the signs (Park *et*

al. 2008). Such findings suggest that it will be important for the interpretive panels in the medicinal plants trail to convey information quickly and effectively.

Despite gaining public insight into opinions of the new medicinal plants trail, the usefulness of the feedback was limited by the informal nature of the conversations with participants. More formal questions and data collection would have allowed for proper conclusions to be drawn. Nonetheless, I reconsidered my design ideas for the interpretive panels during the next meeting with my internship supervisor and the garden curator. The garden curator reiterated the public feedback that interpretive panels are most effective as signposts, serving to introduce a resource and direct those interested in learning more to additional information. It was therefore decided to swap to an image-based design for the interpretive panels. This presented an exciting new opportunity to collaborate with a medical and scientific illustrator to create original artwork that would form the basis of the interpretive panels.

Part three – revision of interpretive panels, working with a medical illustrator

During an initial consultation meeting with the illustrator, different design possibilities for the medicinal plants trail interpretive panels were considered. After reviewing the pilot interpretive panel, it was decided to aim for a very simple design to quickly capture the attention of botanic garden visitors. The first design element to be included was each plant's common name along with a complementary adjective indicating the medical usefulness of the plant. For examples, please refer to Table 1 below. Highlighting the connection between the medicinal plants and human health was considered a potentially effective means of helping to achieve the goal of enhancing botanic garden visitors' sense of nature connectedness.

Table 1. Descriptive titles for plants in the medicinal plants trail

Scientific Name	**Medicinal Plants Trail Title**
Allium sativum	Great Garlic
Calluna vulgaris	Helpful Heather
Camellia sinensis	Terrific Tea
Colchicum autumnale	Awesome Autumn Crocus
Digitalis purpurea	Fantastic Foxgloves
Galanthus spp.	Super Snowdrops
Juniperus communis	Generous Juniper
Salix alba	Wonderful Willow
Taxus baccata	Useful Yew

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

Vinca minor	Practical Periwinkle

Next, focus turned towards the major focus of the interpretive panel design, the illustrations. It was decided to keep the interpretive panels focused on the plants they would be representing, through the creation of modernised botanical illustrations. Botanical illustrations are scientific artworks that depict the stages of growth and key features of plant species (Botanical Art and Artists 2022). Botanical illustrations were considered a useful design idea as they highlight the different features and life stages of plants, allowing garden visitors to recognise the medicinal plants during all seasons of the year. However, traditional botanical illustrations served an exclusively scientific purpose (Rix 2012), and therefore are often subtly coloured and extensively detailed. In order to be in-keeping with the public engagement goals of the medicinal plants trail, the new illustrations (Fig. 2) focused on simpler, brighter images.

(A) **(B)**

Figure 2. Examples of botanical illustrations

(A) A traditional botanical illustration of *Taxus baccata* (common yew) (free use via Rawpixel).

(B) Modernised botanical illustration of *Taxus baccata* (common yew) as produced for the medicinal plants trail.

Part 4 – Planning of the accompanying guidebook

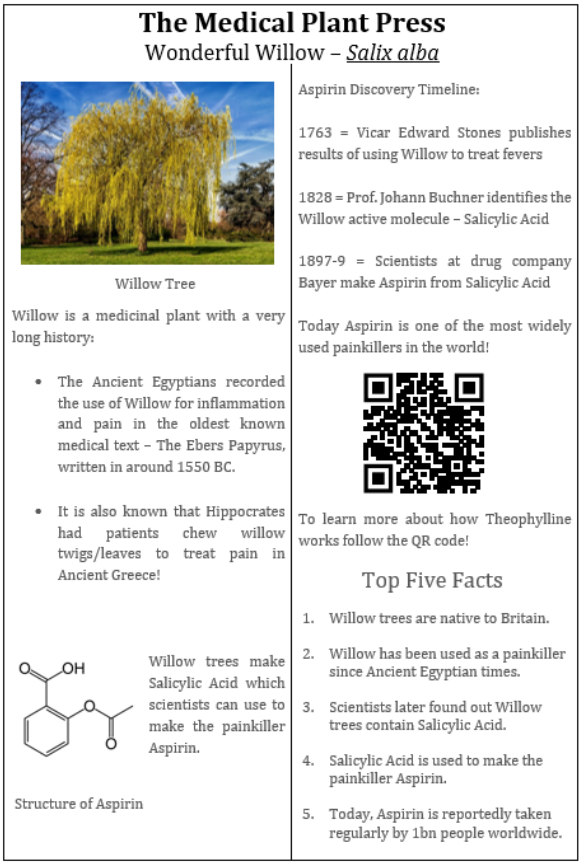
Work was then carried out to produce a pilot version of the accompanying guidebook for the medicinal plants trail. The first draft was reviewed by two members of the university public engagement team for design assistance. In coordination with the re-configured illustrated interpretive panels, the guidebook was now going to be the primary source of written information for the medicinal plants trail. To contribute to the medicinal plants trail's goal of improving nature connectedness, focus was again placed on highlighting links to human health and the individuals who contributed to the scientific understanding of each medicinal plant. The following pieces of information were provided for each medicinal plant:

1. The interpretive panel title, including the plant's scientific and common name.
2. Information about the plant's growth habit.
3. The active molecule responsible for the plant's medicinal effect (if known).
4. The scientists or doctors involved in the research process of the medicinal plant.

The public engagement team were able to provide several points of feedback that helped to improve the initial guidebook design. Firstly, the design was swapped to a landscape orientation for more instinctive flow across the page for readers, and the background set to off-white to reduce contrast. Secondly, it was recommended to use a suitable font size and style to further increase reading ease. Additionally, it was advised to limit text to bullet points wherever possible to improve the speed with which readers can find information. This idea was also supported in the literature, "In today's fast-paced world, people are looking for information that is easy to digest and bullet points provide that by breaking down complex ideas into simple, bite-sized chunks" (Raitaluoto 2023) The medicinal plants trail accompanying guidebook design process is shown in Fig. 3 below.

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

(A)



The Medical Plant Press

Wonderful Willow – *Salix alba*

Willow Tree

Willow is a medicinal plant with a very long history:

- The Ancient Egyptians recorded the use of Willow for inflammation and pain in the oldest known medical text – The Ebers Papyrus, written in around 1550 BC.
- It is also known that Hippocrates had patients chew willow twigs/leaves to treat pain in Ancient Greece!

Willow trees make Salicylic Acid which scientists can use to make the painkiller Aspirin.

Structure of Aspirin

Aspirin Discovery Timeline:

1763 = Vicar Edward Stones publishes results of using Willow to treat fevers

1828 = Prof. Johann Buchner identifies the Willow active molecule – Salicylic Acid

1897-9 = Scientists at drug company Bayer make Aspirin from Salicylic Acid

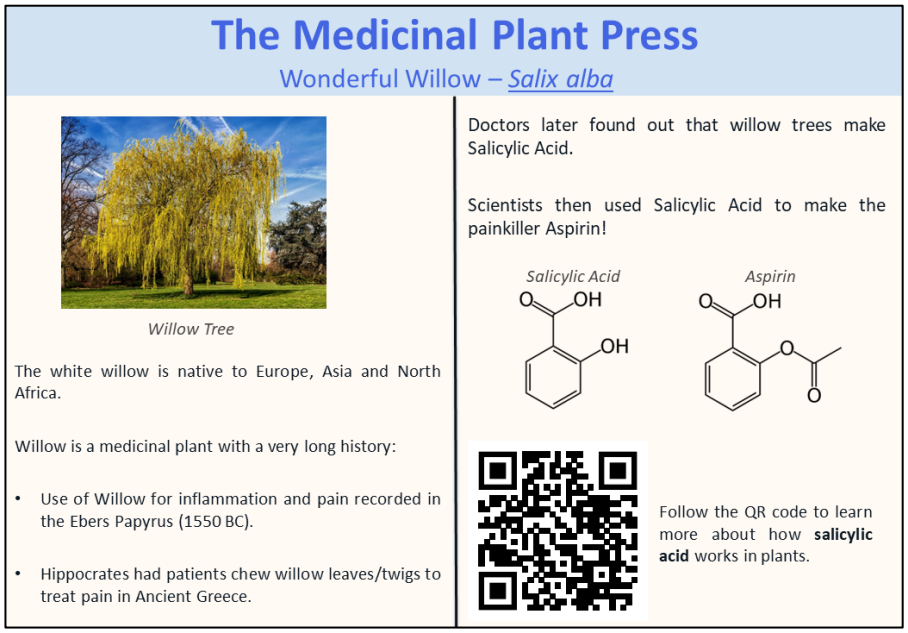
Today Aspirin is one of the most widely used painkillers in the world!

To learn more about how Theophylline works follow the QR code!

Top Five Facts

1. Willow trees are native to Britain.
2. Willow has been used as a painkiller since Ancient Egyptian times.
3. Scientists later found out Willow trees contain Salicylic Acid.
4. Salicylic Acid is used to make the painkiller Aspirin.
5. Today, Aspirin is reportedly taken regularly by 1bn people worldwide.

(B)



The Medicinal Plant Press

Wonderful Willow – *Salix alba*

Willow Tree

The white willow is native to Europe, Asia and North Africa.

Willow is a medicinal plant with a very long history:

- Use of Willow for inflammation and pain recorded in the Ebers Papyrus (1550 BC).
- Hippocrates had patients chew willow leaves/twigs to treat pain in Ancient Greece.

Doctors later found out that willow trees make Salicylic Acid.

Scientists then used Salicylic Acid to make the painkiller Aspirin!

Salicylic Acid *Aspirin*

Follow the QR code to learn more about how **salicylic acid** works in plants.

Figure 3. Medicinal plants trail accompanying guidebook design process

(A) Initial accompanying guidebook design idea.

(B) Re-drafted accompanying guidebook design.

Part 5 – Molecular biology animations

Another goal of the new medicinal plants trail was to serve as an educational resource, by including some more detailed molecular biology information. Information in the literature suggests that animations are becoming an increasingly popular method of communicating information in the modern age, as their use of both audio and visuals suit individuals with different learning styles (Prior 2023). Simple computer animations were therefore considered a suitable means of explaining some of the more complex scientific processes that underly the therapeutic benefits of medicinal plants.

Work in this area led to a collaboration with a local secondary school. Through discussions with a high school biology teacher, it was possible to assess the appropriate level of biological detail to include for a target audience ranging from secondary school pupils to the general public. Consistent with the earlier work on the interpretive panels and accompanying guidebook for the medicinal plants trail, the molecular biology animation designs focused on simple, clear images to communicate information. Metaphors and analogies relating the molecular biology processes to everyday items were also included in the animations, as these are often found to be useful communication tools (Thibodeau *et al*. 2019).

The analogy for use of digoxin as a treatment for heart failure is provided as an example (Fig. 4). The sodium/potassium pump can be thought of as a revolving door, controlling the flow of sodium and potassium across cell membranes. Digoxin can be thought of as a door wedge, it can be used to block the sodium/potassium pump, which increases the force of heart muscle contraction helping treat heart failure. The molecular biology animations will be hosted online, with QR code links provided in the medicinal plants trail accompanying guidebook.

2024, VOL. 1. NO. 1. 86-107
https://doi.org/10.20933/40000104 **The Living Lab ISSN: 3033-3989**

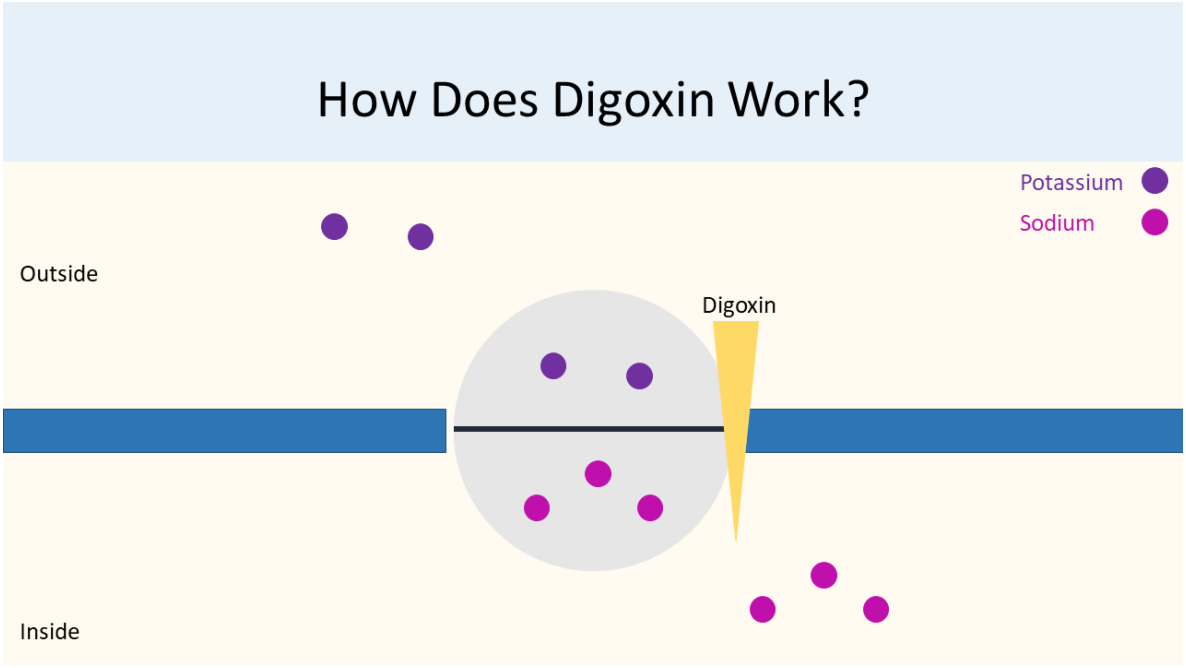


Figure 4. Still from the foxglove (*Digitalis purpurea*) molecular biology animation.
Example analogy used in the molecular biology animations to help explain scientific concepts, here the sodium/potassium pump is compared to a revolving door (grey circle) which can be blocked by digoxin, which acts like a door-wedge (yellow triangle).

DISCUSSION

Production of the new medicinal plants trail is now nearly complete. It will be interesting to monitor the public response to the new resource once it is installed in the botanic garden, and to discover the impact it may have on the sense of nature connectedness that visitors feel. It is hoped that by highlighting the unique and useful properties of the featured plants, the medicinal plants trail may serve to increase individuals' enjoyment of nature during their visit to the botanic garden, educate individuals about the plants around them and emphasise the importance of looking after the natural world, which harbours so many important plants that have been shaping the human journey since the dawn of civilisation.

Unfortunately, it has not yet been possible to collect formal feedback on the medicinal plant trail, making it impossible to draw any official conclusions about the success of the resource at improving botanic garden visitors' sense of nature connectedness. However, after installation and official launch, the intention is to run a survey or questionnaire to collect public feedback. This will allow proper analysis to be conducted.

The medicinal plants trail will also be used during a Royal Society Partnership Grant Project that has been developed as a spin-off of this internship project. During this new project, a local high school will conduct their own research project investigating plants with anti-microbial properties. As part of the anti-microbial plants research project, the pupils will visit the botanic garden and complete the medicinal plants trail, presenting another opportunity to collect formal feedback about the resource.

My time working on the production of a new medicinal plants trail for the botanic garden was an outstanding means of developing my public engagement and scientific communication skills. Throughout the process I had the opportunity to experience working with a wide range of different professionals including teachers, artists and graphic designers. I learned how to clearly and concisely present complex scientific concepts for non-experts, and some important design principles for making useful visual aids.

An unexpected outcome of my work on the medicinal plants trail was the positive impact the project had on my own sense of nature connectedness. Despite working towards a doctorate in the field of plant sciences, I found that in the process of taking a step back from the lab-bench and a look out at the wider context of plant sciences I reignited my own sense of wonder at, and oneness with, the natural world around me. Additionally, I found the process of scientific communication to a public audience very rewarding, reminding me of what first inspired my own childhood interest in plants.

In addition to the skills I developed and the things I learned while completing work on the medicinal plants science communication project, I also had the opportunity to work with some wonderful people in a variety of roles, and I am extremely grateful for the colleagues and friends that I met. I hope that the new medicinal plants trail will be a force for greater nature connectedness that is enjoyed by many botanic garden visitors for years to come.

CONCLUSION

In the modern world, it is important that people feel a strong sense of nature-connectedness to help ensure that plant and animal life is respected and protected in the face of climate change. Botanic gardens are one place interested members of the public can visit to spend time with nature and learn about plants. It is therefore useful to have interesting and informative resources available to engage and inform botanic garden visitors. This internship worked to produce one new resource about medicinal plants. By highlighting examples of plants which have had important roles in human health throughout history, and which continue to provide a source of new medicines today, it is hoped that the medicinal plants trail will improve garden visitors' sense of nature connectedness. As the project has not yet been installed in the botanic garden, it is not possible to confirm whether the

medicinal plants trail has achieved its aim, however this will be investigated upon the official launch in 2024.

ACKNOWLEDGEMENTS

A most heartfelt and emphatic thank you goes to all of the people who provided assistance to this project, without you the medicinal plants trail would not have been possible.

Dr Elizabeth Lakin

Kevin Frediani

Jenna Foster

Sarah Carlton

Ali Floyd

Ailsa Black

Dr Kirsteen Mustard

REFERENCES

Bayan, L., Koulivand, P.H., Gorji, A. (2014) 'Garlic: A Review of Potential Therapeutic Effects', *Avicenna Journal of Phytomedicine*, 4(1), pp. 1-14.

Beaulieu, D. (2023) *How to Grow and Care for Papyrus Plants*. Available at: https://www.thespruce.com/papyrus-plants-for-water-gardens-4125678 (Accessed: 15 November 2023).

Bhosale, V.V. and Banerjee, D. (2019) 'Scientific Validation of Herbal Medicine', in: S. Sen and R. Chakraborty (eds) Herbal Medicine in India. Singapore: Springer, pp. 573-579.

Botanical Art and Artists (2022) *What is Botanical Illustration?*. Available at: https://www.botanicalartandartists.com/what-is-botanical-illustration.html (Accessed: 17 November 2023).

Bryan, C.P. (1930) *The Papyrus Ebers: Translated from the German Version*. London: Geoffrey Bles.

Burns, T.W., O'Connor, D.J., Stocklmayer, S.M. (2003) 'Science Communication: A Contemporary Definition', *Public Understanding of Science*, 12(2), pp. 183-202.

Chen-Hsuan Cheng, J. and Monroe, M. C. (2012) 'Connection to Nature: Children's Affective Attitude Toward Nature', *Environment and Behaviour*, 44(1), pp. 31–49.

Dasgeb, B., Kornreich, D., McGuinn, K., Okon, L., Brownell, I., Sackett, D.L. (2018) 'Colchicine: An Ancient Drug with Novel Applications', *British Journal of Dermatology*, 178(2), pp. 350-356.

Desborough, M.J.R. and Keeling, D.M. (2017) 'The Aspirin Story – From Willow to Wonder Drug', *British Journal of Haematology*, 177(5), pp. 674-683.

Edwards, S.A. (2012) *Digitalis: The Flower, The Drug, The Poison*. Available at: https://www.aaas.org/digitalis-flower-drug-poison (Accessed: 17 November 2023).

European Patients Academy on Therapeutic Intervention. (2020) *Active Molecule*. Available at: https://toolbox.eupati.eu/glossary/active-molecule/ (Accessed: 14 November 2023).

Farahanikia, B., Akbarzadeh, T., Jahangirzadeh, A., Yassa, N., Ardekani, M.R.S., Mirnezami, T., *et al*. (2011) 'Phytochemical Investigation of *Vinca minor* Cultivated in Iran', *Iranian Journal of Pharmaceutical Research*, 10(4), pp. 777-785.

Foa, R., Norton, L., Seidman, A.D. (1994) 'Taxol (Paclitaxel): A Novel Anti-Microtubule Agent with Remarkable Anti-Neoplastic Activity', *International Journal of Clinical & Laboratory Research*, 24(1), pp. 6-14.

Frediani, K. (2021) *Botanic Garden and Grounds Strategy.* Available at: https://www.dundee.ac.uk/corporate-information/botanic-garden-and-grounds-strategy (Accessed 21 July 2023)

Gunther, R.T. (1934) *The Greek Herbal of Dioscorides*. Oxford: Oxford University Press.

Ito, E., Crozier, A., Ashihara, H. (1997) 'Theophylline Metabolism in Higher Plants', *Biochimica et Biophysica Acta*, 1336(2), pp. 323-330.

Lubchenco, J. (1998) 'Entering the Century pf the Environment: A New Social Contract for Science', *Science*, 279(5350), pp. 491-497.

Magdalen College, University of Oxford. (2014) *The John Goodyear Collection of Botanical Books*. Available at: https://www.magd.ox.ac.uk/blog/the-john-goodyer-collection-of-botanical-books/ (Accessed: 14 November 2023).

Metwaly, A.M., Ghoneim, M.M., Eissa, I.H., Elsehemy, I.A., Mostafa, A.E., Hegazy, M.M., *et al*. (2021) 'Traditional Ancient Egyptian Medicine: A Review', *Saudi Journal of Biological Sciences*, 28(10), pp. 5823-5832.

National Academies of Sciences, Engineering, and Medicine (2017) *Communicating Science Effectively: A Research Agenda*. Washington, DC: National Academies Press.

Oxford Nanopore Technologies. (2023) *MinION*. Available at: https://store.nanoporetech.com/uk/minion.html (Accessed: 20 November 2023).

Oxford Reference. (2017) *Science and Technology*. Available at: https://www.oxfordreference.com/page/134 (Accessed: 20 November 2023).

Oxford Reference. (2020) *Communication*. Available at: https://www.oxfordreference.com/display/10.1093/acref/9780198841838.001.0001/acref-9780198841838-e-413 (Accessed: 20 November 2023).

Park, B.J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., Miyazaki, Y. (2010) 'The Physiological Effects of Shinrin-yoku (Taking in the Forest Atmosphere or Forest Bathing): Evidence from Field Experiments in 24 Forests Across Japan', *Environmental Health and Preventative Medicine*, 15, pp. 18-26.

Park, L.O., Manning, R.E., Marion, J.L., Lawson, S.R., Jacobi, C. (2008) 'Managing Visitor Impacts in Parks: A Multi-Method Study of the Effectiveness of Alternative Management Practices', *Journal of Park and Recreation Administration*, 26(1), pp. 97-121.

Prior, M. (2023) *Benefits of Using Animation as a Learning Tool*. Available at: https://www.rawpictures.co.uk/blog/benefits-of-using-animation-as-a-learning-tool (Accessed: 17 November 2023)

Raina, R., Verma, P.K., Peshin, R., Kour, H. (2019) 'Potential of *Juniperus communis* L as a Nutraceutical in Human and Veterinary Medicine', *Heliyon*, 5(8), e02376.

Rainforest Alliance. (2012) *Species Profile Rubber Tree Hevea brasiliensis*. Available at: https://www.rainforest-alliance.org/species/rubber-tree/ (Accessed: 15 November 2023).

Raitaluoto, T. (2023) *The Importance of Clear and Concise Bullet Points on a Landing Page*. Available at: https://markettailor.io/blog/importance-of-clear-and-concise-bullet-points-on-landing-page (Accessed 17 November 2023)

Rix, M. (2012) *The Golden Age of Botanical Art*. London: Andre Deutsch Carlton Publishing Group.

Royal College of Physicians. (2017) *White Here, White Now: The Medicinal Power of the Dainty Snowdrop*. Available at: https://www.rcplondon.ac.uk/news/white-here-white-now-medicinal-power-dainty-snowdrop (Accessed: 17 November 2023).

Rupp, R. (2014) *How Garlic May Save the World*. Available at: https://www.nationalgeographic.com/culture/article/how-garlic-may-save-the-world (Accessed: 14 November 2023).

Sanchez-Mora, M.C. (2016) 'Towards a Taxonomy for Public Communication of Science Activities', Journal of Science Communication, 15(2).

The Mental Health Foundation (2021) *How Connecting with Nature Benefits Our Mental Health*. Available at: https://www.mentalhealth.org.uk/sites/default/files/2022-06/MHAW21-Nature-research-report.pdf (Accessed: 21 July 2023).

The National Human Genome Research Institute (2022) *Human Genome Project Fact Sheet*. Available at: https://www.genome.gov/about-genomics/educational-resources/fact-sheets/human-genome-project (Accessed: 21 July 2023).

Thibodeau, P.H., Matlock, T., Flusberg, S.J. (2019) 'The Role of Metaphor in Communication and Thought', *Language and Linguistics Compass*, 13(e12327), pp. 1-18.

Vučić, D.M., Petković, M.R., Rodić-Grabovac, B.B., Stefanović, O.D., Vasić, S.M., Čomić, L.R. (2014) 'In Vitro Activity of Heather [*Calluna vulgaris* (L.) Hull] Extracts on Selected Urinary Tract Pathogens', *Bosnian Journal of Basic Medical Sciences*, 14(4), pp. 234-238.

Whitburn, J., Linklater, W.L., Milfont, T.L. (2018) 'Exposure to Urban Nature and Tree Planting Are Related to Pro-Environmental Behaviour Via Connection to Nature, the Use of Nature for Physiological Restoration, and Environmental Attitudes', *Environment and Behaviour*, 51(7), pp. 787-810.

Wong, S. (2019) *Louis Pasteur*. Available at: https://www.newscientist.com/people/louis-pasteur/ (Accessed: 14 November 2023).

World Intellectual Property Organisation. (2021) *Women in Research: Educating Drug Development Scientists in Papua New Guinea*. Available at: https://www.wipo.int/policy/en/news/global_health/2021/news_0110.html (Accessed: 14 November 2023).