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Science

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Faraday's First Motor

AGM 2019

Plant Power 'at the National Botanic Gardens

Pioneer of Science Education - James Dominic Burke

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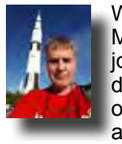
In this issue of SCIENCE



Welcome to a packed March issue of your ISTA journal. In this issue we are delighted to bring you lots of very interesting articles and while its impossible to single out any articles in particular I must mention a few. I know that those of us teaching physics will find Geoff Auty's piece on Faraday's first successful electric motor interesting. Geoff shared his wonderful expertise in practical physics at last years AGM in Athlone and a number of you asked him at the time if he could share more of his knowledge with us. His article in this issue is a timely one as it hints at ideas and at the type of work that could one day form part of the proposed new Leaving Certificate project work which is envisioned by the Minister to contain a "high proportion of practical work". So thanks to Geoff for sharing this article with us.

Cover Photo: Timelapse showing the Moon during the eclipse on the morning of the 21st of January. Passing mist during the timelapse does not hide the changes in brightness as the moon passes in and out of the penumbral and umbral shadows.

STEM features strongly again in this issue and there are ideas and information on how it might be implemented in the classroom. Thanks again to Dr. Maeve Liston for her continued series on how to implement STEM lessons into the classroom. Thanks also to Dr Cordula Weiss of 'Calmast' who tells us of a pilot 'STEMreach' STEM project between a post primary and a primary school. This project could be the spark to inspire some of us to try a similar link between our own school and a local primary school. Cordula will have another piece for us next month.

A must read in this issue is the article on the life and times of science educator, Br James Dominic Burke. In the 6th of his series on Pioneers of Science Education Dr Peter Childs, University of Limerick, brings us yet another excellent piece on a man who was well ahead of his time when it came to teaching, especially in the area of technical education. I will say

Continued on page 48.

President's Reflection

Gerald Fleming

As I write this we are less than four weeks away from a Brexit that may or may not happen as scheduled, or that may be postponed, or that may even be abandoned – all depending on games of brinksmanship being played out in Westminster and elsewhere. One of the more troublesome lessons of Brexit, and indeed of many other political happenings of recent and not-so-recent years, is the degree to which misinformation, demonstrably inaccurate information, or just plain nonsense can become accepted by many as established "fact".

We see this also in many areas which are – or should be – informed primarily by science. Think of the many years it took to gain acceptance that smoking was a significant causative factor in many illnesses. Think of the active community of "climate deniers" who cannot accept the clear evidence linking increases in Carbon Dioxide (and other atmospheric constituents) to measured changes in the global climate. Think of the "anti-vaxxers" who cannot accept overwhelming evidence that vaccination of children reduces health risks to a significant degree.

What is certain is that when uncomfortable scientific facts come up against strong vested interests, be they informed by commercial considerations, religious beliefs or just conspiracy theory, the scientific facts frequently come out of the contest looking decidedly the worse for wear.

Why is this? How can experimental evidence, often obtained through painstaking, rigorous effort, be so easily countered or neutralised by "common sense" or simplistic "facts"?

For a species that has achieved the mastery of our globe primarily through our ability to think, it may seem odd that the practice of thinking, and how we go about it, was ignored for many decades – indeed centuries – since the Renaissance and the "scientific revolution". We simply did not know a lot about how our minds work. It was only in the last decades of the 20th century that two Israeli psychologists, Daniel Kahneman and Amos Tversky, published papers with fascinating insights into how our brains work. For these, Kahneman was ultimately awarded the Nobel Prize (for Economics) and he popularised their work in the best-selling book "Thinking, Fast and Slow".

With some words of apology to those already familiar with the work of Kahneman and Tversky, allow me to give a brief overview (but get the book and read it if at all possible). Their theory centered around the idea that our brains have two distinct modes of operation, which they named System One and System Two.

To start with the latter, System Two represents deep concentration and study, using our brains in their most "rational" modes. Reading a scientific paper, marking exam scripts, developing lesson plans – these are all activities of the System Two mode. One of the early results was that System Two work was really difficult – it burned a lot of energy and the brain tried to avoid it where possible. System Two is painstaking, but slow.

System One, on the other hand, is where all of our "automatic reflexes" reside. System One delivers answers very quickly. It can be related to our primeval instincts around safety – those "fight or flight" split-second decisions. System One is a repository of our experiences of the world around us, so it is responsible both for "intuition" and "jumping to conclusions". It is where our biases live, conditioning our thoughts without us even knowing it.

System One is very useful, even essential. We simply could not live our day-to-day lives if we subjected every decision to the deep and rational mode of thinking exemplified by System Two. We would be permanently exhausted. Take driving a car; when we learn we have to think about everything – when to put our foot on the clutch, what gear to change into, how to lift the clutch and depress the accelerator in a synchronised manner. All System Two work. In time, however, we find we can do all of these without conscious effort; the tasks have become routine and have been transferred to System One. We sometimes call it "muscle memory" but it is more that our brains remember what our muscles should do and should feel like, and issue the commands accordingly.

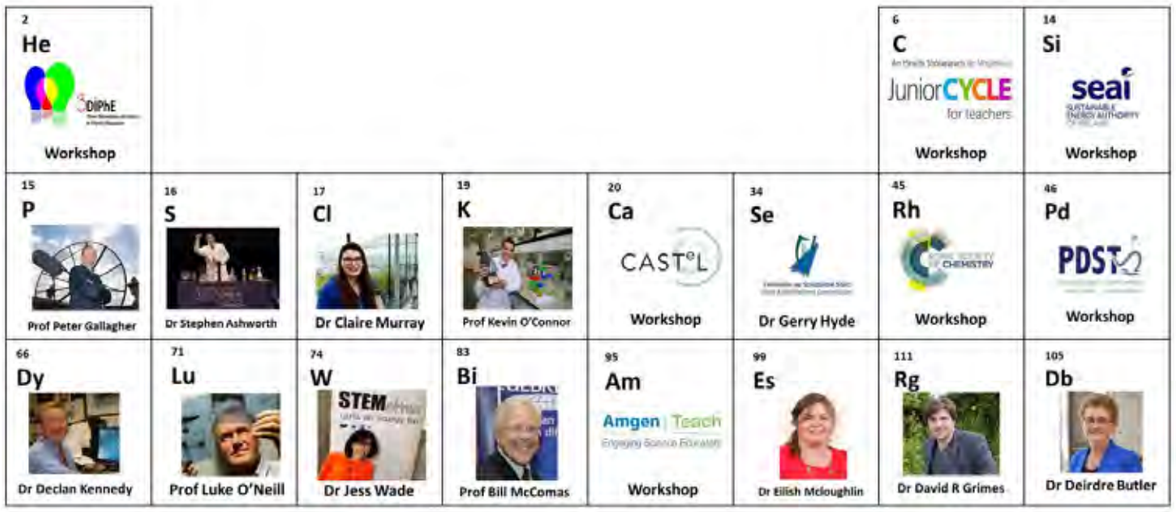
This understanding of System One and System Two helps to explain why humans are notoriously poor at estimations of risk, for example. For most activities, a statistical analysis will reveal the real risk of failure, injury or death. We almost never assess risk through that approach. Commercial aviation is statistically the safest method of travel around, but there are still many people who are afraid to fly. We tend to assess risk through emotive imagery we create for ourselves – thus the road safety advertisements that focus on stories of loss and grief. The hope is that these stories lodge in our "System One" and are quickly recalled whenever we are contemplating a potentially dangerous manoeuvre. This approach is much more effective at modifying our behaviour than feeding us with statistics.

In essence, humans are lazy thinkers. Rather than focus and concentrate on a difficult problem, which would engage our System Two, we often swop the difficult problem for a similar, but simpler, problem which we can deal with through System One. Of course then all of our biases are applied and influence the "result" which our brain passes back to us.

The upshot of all this for those who try to communicate scientifically-based messages to the public is sobering. There is almost no point in presenting rigorously-derived results, in explaining complex theories, in complex linking of cause and effect. These just expect too much effort of our audience. Rather we have to turn to story-telling, or the use of pictures or graphics, or other methods which our listeners and viewers can grasp through the easy application of their System One processes. But then we run up against their biases, their pre-conceived notions, maybe their religious and/or cultural beliefs, and the going can get tough.

It is ironic - but perhaps not surprising - that these great insights into how the human minds work has been primarily taken on board by the advertising industry and by propagandists, who have in social media an almost perfect tool for spreading misinformation (or true information framed in a heavily biased context). Like many advances in science and technology, it will take some further time and maturity before we figure out how to use these insights for the benefit of greater society rather than the benefit of the few.

Embracing the Elements of Change



SKYLON HOTEL DUBLIN

https://www.istaconference.com/
www.ista.ie

Chairman's Report

John Loughlin

A chomhghleacaithe, a chairde,

I hope you all have had a restful February break. It has been a busy time for science teachers up and down the country, what with CBAs, CPD events, mock exams and science competitions. The coming months should hopefully be a little less hectic and allow us the opportunity to look forward to our 57th annual ISTA national conference to be held April 12th to 14th, 2019. In recognition of The International Year of the Periodic Table of Chemical Elements, the theme will be 'Embracing the Elements of Change'.

Annual ISTA Conference 2019
Conference Theme:
Embracing the Elements of Change
#ISTAcon2019

The opening will take place on Friday 12th April in DCU St. Patrick's Campus Drumcondra at 7:30 pm with the eminent Prof. Peter Gallagher of DIAS giving the opening talk. This will be followed by a hot buffet in The Skylon Hotel at 9pm. Our main conference will be held at St Patrick's Institute of Education, DCU on the Saturday from 9am to 5pm and will play host to some of Ireland's leading science researchers, communicators and educators. The day will conclude with our gala dinner at The Skylon Hotel at 7:30pm. You can find more information and booking details on the dedicated conference website www.istaconference.com

Many science and education events have taken place since our last edition of Science.

Senior Cycle Review

The senior cycle review by the NCCA continues with phase 2. This involves further consultation with the 41 selected pilot schools around the country, as well as the parents and students of the schools and has also seen a number of additional seminars being held recently. I was in attendance at the seminar held in Galway last November as part of phase 1 of the review. A major theme of the senior cycle review seems to be the bringing of the student voice to the fore in shaping the future of the Leaving Cert. A report/bulletin on phase 1 is available on the NCCA website: https://www.ncca.ie/media/3878/ncca_sc_single_pages_en.pdf with a phase 2 report due in the near future. A public consultation will begin in March. Science teachers are encouraged to send in their thoughts and feedback to the following email address: seniorcycle@ncca.ie

BT Young Scientist and Technology Exhibition.

Congratulations to Adam Kelly on becoming BT Young Scientist 2019 and to Niamh Doherty for winning the ISTA

Special Award and thanks again to our ISTA President Gerald Fleming for presenting the award.

ESA Robotics workshop, Belgium.

I was fortunate enough to be able to attend this workshop. It ran from Monday 7th to Wednesday 9th January. The programme was a very interesting series of workshops on Lego Mindstorm, Scratch, Arduino, and the programming languages C++ and Python. It was useful to see the ways these resources can be incorporated into teaching and learning – with them being particularly useful for after-school/lunchtime clubs/events and would also be a very interesting module for transition year science. For any science teachers interested in attending the workshops there is another robotics workshop due to be run at the end of March. ESA are also planning other STEM-related workshops in the summer and autumn. Check out their website for further information.

Junior Cycle Science Survey

James Stephens, our Junior Cycle Science committee convenor and Galway branch member very kindly put together a short survey of science teachers to gauge their opinions on their experiences of the new Junior Cycle Science course. He will be presenting the results of this survey at the national conference in April. Thanks to James and all involved in compiling the survey.

Classroom-based assessments for JC science

Most third year Junior Cycle Science students would now be finished their SSI and AT. We are looking forward to liaising with science teachers and getting feedback through our JC survey on their experiences of the SSI and AT. Second year science students will also be busy in the coming weeks with their CBA-1/EEI. Good luck to all involved.

JCT Science

The JCT Science team continue to work hard on their excellent CPD provision and now have a YouTube channel where you can access many videos on planning your teaching and unpacking learning outcomes. Information on conducting the assessment tasks, CBAs and SLARS is also available.

ISTA National CPD Seminars – sponsored by Lennox Laboratory Supplies

Our very own CPD events are coming to an end soon. They have run nationwide since September with Rory Geoghegan having given his talk on the 'Physics and Maths for Earth and Space at Junior Cycle Science'. Declan Kennedy continues to give his talk on 'Ideas and Experiments for teaching Rates of Reactions to Junior Cycle Science students'. It will run until March. A sincere thank you to Rory and Declan for keeping the ISTA flag flying around the country; to Lennox Laboratory Supplies for sponsoring the talks; and to all the local branches and their representatives for the great work they do in welcoming Rory and Declan every year.

SciFest 2019

SciFest 2019 has been launched by the Minister for Education and Skills Joe McHugh T.D. Second-level students across the island of Ireland are being encouraged to put their skills in science, technology, engineering and maths (STEM) to the test as SciFest launches a call for entries for its 12th annual SciFest@College competition. SciFest is the largest and most inclusive second-level STEM fair initiative on the island of Ireland. Since launching in 2008, more than 60,000 students have participated in the competition. SciFest is funded primarily by Science Foundation Ireland, Boston Scientific, Intel Ireland and Specsavers. Good luck to all involved.

ISTA Junior Science Quiz

The ISTA Junior Science Quiz quiz will be held in various location all around the country in April. Please remember to have your ISTA membership up to date as only students whose teacher is an ISTA member can enter. A huge thank you to all the quiz coordinators, quiz venues, teachers and parents around the country for the hard work involved in running the quiz. Good luck to everyone.

ASE conference Birmingham, UK

I attended the ASE conference in the University of Birmingham, UK on January 10th, 11th and 12th. There were some excellent talks, seminars and workshops. There seems to be a big push in the UK at the current time for a knowledge-rich curriculum with detailed specifications. This is somewhat at odds with the direction the Irish science curriculum is taking and it will be interesting in the years ahead to see the effects of the different directions the two systems are taking. There were many leading international scientists, educators and science communicators in attendance and we are hoping to bring some of them to an Irish audience at next year's ISTA annual conference in Galway – attracted, of course, by Galway being the European Capital of Culture for 2020.

And finally, as I mention in each of my reports, I would like to ask all ISTA members to encourage any science teachers in your schools/colleges/universities, who are not members yet, to join us in the ISTA. The ISTA is a great community of science educators from many different backgrounds. The educational landscape in Ireland is changing very quickly and together we can shape that change to ensure the best possible outcomes for all of our students. If you have any questions related to our organisation or you would like to get involved, please do not hesitate to contact me.

Is mise le meas,

John Loughlin
Chair, ISTA

News & Views

Mary Mullaghy

Ireland's Yearbook of Education

Minister of Education and Skills, Joe McHugh, T.D., launched the 12th Education Matters - Ireland's Yearbook of Education in the National University of Ireland on Merrion Square. It is a record and think-tank on education policy, practice and innovation. The current editor is Guidance Counsellor, columnist and broadcaster, Brian Mooney. It is also available to read online https://educationmatters.ie

New Science Technology in Action

The 14th edition of Science Technology in Action was launched and hard copies were delivered to all schools. There are PDFs of all lessons along with PowerPoint presentations available on line. Many lessons are suitable for TY and might inspire project ideas for SciFest, BT Young Scientist Exhibition and other competitions. www.sta.ie

The Irish Lab Awards

The Irish Laboratory Awards recognise excellence and achievement in the laboratory environment, covering management, innovation, collaboration, personnel development and laboratory equipment supply. Just making the shortlist for the Irish Laboratory Awards ensures that the scientists involved receive national recognition for their achievements. A full list of this year's winners on www.labawards.ie

Laboratory Apprenticeships

The Minister for Communications, Climate Action and the Environment, Richard Bruton T.D. launched two new apprenticeship schemes for BioPharmaChem Ireland, the IBEC group that represents the biopharma and chemical sectors, along with their industry led consortium and lead academic provider, Institute of Technology Tallaght. The apprenticeships form part of the government's wider national strategy and is in direct response to the Expert Group on Future Skills Needs report published in 2016. The report recommended the development of new apprenticeship programmes for the biopharma industry with the aim of opening a vocational route into careers within the industry and thus bridging the identified skills shortages across the sector. www.laboratoryapprenticeships.ie

BT Young Scientist & Technology Exhibition 2019

Thanks to all the teachers who helped out with the ISTA stand at the BT YSTE this year. They were in alphabetical order: Brian Clarke (Limerick/Clare), Rory Geoghegan (Dublin), Elaine Howlin (North Midlands), Sharon Magner (Carlow/ Kilkenny), Ann Molloy (North Midlands), Triona Mulcahy (Kerry), Mary Mullaghy (Dublin), Aodhagan O'Suillivan (Carlow/Kilkenny), Crena Shelvin (Dublin) and John Sims (Limerick/Clare). A special thanks to Rory & Aodhagan. Volunteering and sharing best practice is a key component of our Association and should be embraced. We welcomed famous guests such as Dame Jocelyn Bell Burnell (right), Dr. John Monahan (inaugural winner of the Young Scientist Exhibition in 1965) (photo below), James Soper (the juggling scientist), Paul Nugent (Institute of Physics) to name a few. Congratulations to all the winners especially the overall winner Adam Kelly from Skerries Community College, Co Dublin for his project "Optimizing The Simulation Of General Quantum Circuits" in the Chemical, Physical & Mathematical Sciences Senior Individual Category. He received a Perpetual Trophy, a cheque for €7500 and will represent Ireland at the 31st European Union Contest for Young Scientists in Sofia, Bulgaria in September. Thanks to Gerald Fleming, our Honorary President, for presenting the ISTA special award to Niamh Doherty, St. Joseph's College, Lucan, for her project entitled "Natural Geometry – An extension of Alfred Meyer's 1878 'Floating Magnets' experiment". She

also won 1st place in the category (Intermediate Individual Chemical, Physical & Mathematical Sciences).

Angel City Flyers STEM Competition

In collaboration with ISTA, Seosamh Somers former Wexford man and owner of Angel City Flyers Inc, Los Angeles California, is providing two fully paid scholarships for two young Irish people to attain their private pilot license with them in Los Angeles. The selection of candidates will be based on a competition to encourage STEM education and showcase the sciences through their practical application in aviation. The scholarship winners will train with them in LA over the summer vacation for 7 weeks (minimum 16 years to start training and 17 to get their license). It is proposed that this competition would run every two years. The competition will be launched at the opening of the Annual Conference The teams will be mentored by science teachers who are ISTA members. More details will be available on www.aerprize.com

Institute of Physics in Ireland

Best wishes to Dr. Sheila Gilheany who was the Policy Officer for the Institute of Physics in Ireland. She now works with Alcohol Action Ireland - the national charity for alcohol-related issues. Also best wishes to her colleague Dr. Liz Conlon who was the Education & Promotions Advisor for Institute of Physics in Ireland, who has also moved on to new adventures.

ISTA Annual Conference 2019

The ISTA Annual Conference for 2019 will take place in DCU St. Patrick's Campus, Drumcondra over the weekend of April 12-14th – Embracing the Elements of Change!

Prof Bill McComas - Keynote speaker from the USA

McComas is the recipient of many prestigious awards and was recently elected a Fellow of the American Association for the Advancement of Science (AAAS). He was a Fulbright Fellow at CASTeL in DCU and is currently the editor of The American Biology Teacher, the world's largest circulation journal for biology teachers. He has written and edited several books including The Nature of Science in Science Education: Rationales and Strategies, The Language of Science Education. He will give two talks at this year's conference: The 8 C's of Science: Supporting and Defending the Teaching of Science and What's Wrong with STEM Education? Nothing or Everything?

The conference will open on Friday 12th April in the Skylon Hotel. Our Honorary President, Gerald Fleming, will launch of the Report on the Junior Cycle Science. Prof. Peter Gallagher, Head of Astrophysics in DIAS will give the plenary talk entitled "Tuning in to the Radio Universe from Birr Castle". Some more talks not to miss are "Bio-obased and Biodegradable Plastics for a Greener Society" by the talented Dr. Kevin O'Connor from UCD, Top 10 Resources for a Chemistry Teacher by Brendan Duane, "Humanology: A Scientist's Guide to our Amazing Existence" by the omnipotent Prof Luke O'Neill from TCD and "Do we need to mind the gap?" by Dr. Declan Kennedy to mention but a few. There is also a Primary Science Programme. All the main science education exhibitors will also be in attendance.

Early bird booking for March available on the www.istaconference.com

European Cancer League Video/Poster Competition

Ahead of the European Immunisation Week from 24 to 30 April, ECL is organising a Youth Competition for Schools, as part of the EU Joint Action on Vaccinations, and under the work package being led by France.

This School Competition aims to raise awareness among schoolaged populations across Europe. Schools offer unique settings to promote vaccine uptake while reaching out to parents. In addition, games provide a unique way to engage and motivate young individuals, enabling them to gain knowledge and understand the evidence. The competition encourages students to work in groups of 3 to create Public Service Announcements targeting their own age group. Shortlisted posters and videos will be disseminated during the EU Immunization Week end of April.

All posters and videos must be in line with information on vaccinating against Hepatitis B and HPV as provided by WHO. Full competition details at https://www.europeancancerleagues.org/schoolcompetition/

SciFest 2019 - 3 new Awards.

1. SciFest STEM School Award: This award recognises the support and commitment of school principals, teachers and leadership teams in second-level schools who in collaboration with SciFest have implemented the SciFest@School STEM fair programme. Schools qualifying for the award receive a framed certificate and an official SciFest STEM School Award digital badge which can be posted on the school website. To qualify for the award a school must be registered with SciFest and have hosted five SciFest@School STEM fairs. External judges should be employed and the fairs must operate under the SciFest Guidelines.

2. Specsavers Making a Difference Award: This award will be presented at each of the 16 regional SciFest@College STEM fairs.

3. Institute of Physics Award: This award will be presented at each of the 16 regionalSciFest@College STEM fairs.

Keep up-to-date

A comprehensive list of all competitions, news and events is available on our website. www.ista.ie You can also keep up-to-date with our Facebook and Twitter @IrishSciTeach

Dates For Your Diary

ISTA Annual Conference
12th - 14th April 2019 DCU St Patrick's Campus
www.istaconference.com

PDST:
Chemistry teams are on the road with Resource Workshops www.pdst.ie
Due to GDPR you also need to re-register for PDST and www.iChemistry.ie in order to receive updates!

IOP Ireland Spring Meeting
A Climate of Change
30th March in Athlone Sheraton www.iopconferences.org/iop

SciFest Regional STEM Fairs
A list of dates, venues and contacts available on www.scifest.ie

Physics Busking
Bloom June 3rd 10am - 4pm Phoenix Park Dublin
www.physicsbusking.ie

Tech Week
11th - 18th May
www.techweek.ie

RDS ESB Science Blast
March 6th - 7th Dublin
May 21st - 23rd Limerick
June 5th - 6th Belfast
www.rds.ie

Robert Boyle Summer School
20th – 23rd June – Lismore
www.robertboyle.ie

8th Annual BASF Summer School
25th & 26th June - Eureka Centre UCC

Féilte: Lifelong learning: Making a difference!
FÉILTE 2019 will take place on 27th -28th September in NUI Galway.
www.teachingcouncil.ie

ResearchEd Dublin
5th October - St Columba's College Dublin

Teacher Professional Network (TPN)

Assistant National Treasurer Mr Brian Smyth

I have just taken over as Assistant National Treasurer from Joe Griffin. First, I would like to thank Joe for all his work over the last number of years. Thank you to the branches that have submitted proposals to me in early January. These have been submitted to the Blackrock Education Centre.

Branch officers should familiarize themselves with the content of the TPN website and perhaps appoint somebody within the branch to deal with TPN. I have taken some of the content relating to local activities from the website and this is summarised below.

It is really important to generate a paper trail of receipts and attendance records for all TPN events. It is also very important to advertise these events and to say that they are open to everyone and TPN funded.

I will take other aspects of TPN and updates in future issues of 'Science'

- DEADLINE: a maximum of thirty days after the activity's completion.
- Use the same reference number as in the *Summary proposal* (Branch/Ref, i.e. Tipp A2).
- Activities with fewer than ten teacher attendees will not receive TPN funding; this may be reconsidered in the case of smaller TGAs, where evidence of registered participants is provided or due to other operational issues.
- The use of Education Centres as first option venues is encouraged; otherwise TPN will fund a maximum of €75 for each group of up to 30 participants, between 31 and 60 attendees €150 and €225 for over 60 attendees. In exceptional circumstances a business case can be made.
- Where there is a CPD element for Friday evening conference events, the maximum payable is €2.86 for catering per participant; attendance rolls should be signed and dated for each day of attendance.
- Support will be provided for the administration of the conference in the granting of a maximum of €200/€400/€800, depending on TGA level of funding, towards expenses such as programme design/printing, conference folders, lanyards, banners, mailshot, etc.; receipts must be provided for all administration costs incurred.
- No claims, whether lecturers' or activities', will be considered without a copy of a signed attendance list; all invoices and receipts must also be included.
- Lecturers' claim forms must be included with the claim; they will be paid by the nominated Education Centre in order to deduct the appropriate taxes; TES rates and regulations apply.
- All claims, either from lecturers or participants, must include both school and home address; TPN funds can only be used to pay participants' claims of post-primary teachers.
- In order to assess TGAs' activity levels, please present *Local Activity Reports* even if the event did not incur any cost.
- Evaluation forms for each event are required and can be included with your claim or kept by the TGA (see *Appendix 5*).

Senior Science Quiz National Final

St. Eunan's, Letterkenny, Co. Donegal overall winners for 2018.
Gerry Murphy, RTÉ & Met Eireann, (Quizmaster), Conal Bonar, Ben Harkin, Liam Keane. Mr. Enda Dempsey (BPCI) & Ms. Mary Mullaghy (National Quiz Coordinator).

The National Finals of the annual ISTA Senior Science Quiz took place in the Tercentenary Hall in Trinity Biomedical Sciences Institute on Saturday 24th November. It was full to capacity with 50 teams of Leaving Certificate science students representing 20 counties from all around Ireland and their teachers. Almost 1100 Leaving Certificate students took part in the Regional Finals held during Science Week and the top 150 LC students were invited to the BioPharmaChemical Ireland sponsored National Final.

The charity associated with the quiz this year was the Irish Kidney Association highlighting organ donation. All attendees received a pen and an organ donor card. Thanks to Colin White IKA National Projects Manager for attending the quiz and accepting a small donation. Thanks also to Enda Dempsey who represented BioPharmaChemical Ireland.

Thanks to all the local coordinators and their teams in the 14 Branches of ISTA who facilitated the Regionals Rounds during Science Week. (Sarah Brusey, Maura Conneally, Brendan Duane, Gary Galvin, Maireád Donnelly, Michelle Lyons, Mary McDonagh, Siobhán Mc Cormack, Tríona Mulcahy, Sam Pearson, Seamus O'Donghaile, Aodhagan O'Suilleabhain, Seán Reidy, Maria Sheehan & Brian Smyth). Thanks also to the Dublin Branch of ISTA who organised the Final. A special thanks to Prof Luke O'Neill who welcomed us to Trinity College and also presented copies of his book 'Humanology' as spot prizes for the teachers. Thanks to John Loughlin, current Chairperson of ISTA and Gerry Murphy, RTÉ & Met Éireann who acted as guest quizmaster, BioPharmaChemical Ireland main sponsor, Trinity College who provided the venue. Also, thanks to CJ Fallon, Folens, ICI, IoP Ireland, SEAI, StudyClix & TIMSTAR who provided spot prizes and last but not least the students and their teachers who attended.

Congratulations and well done to ALL who participated. The top 10 teams this year were:

- **St. Eunan's, Letterkenny, Co. Donegal**
- **St. Louis C.S., Kiltimagh, Co. Mayo**
- **St Columba's, Stranorlar, Co. Donegal**
- **Ardscoil Rís, Limerick**
- **CBS High School, Clonmel, Co Tipperary**
- **St. Mary's CBS Enniscorthy, Co. Wexford**
- **Ardscoil na Trionoide, Athy, Co. Kildare**
- **St Mary's College, Galway**
- **Summerhill College, Sligo**
- **St Gerard's, Bray, Co. Wicklow**

Sky & Space

Seosamh Ó Braonáin

In the last issue of Science, Declan Kennedy and Sean Finn described a number of excellent demonstrations using dry ice. Here is one more activity I have done with my students that helps them to understand what a comet is and how it is different from an asteroid (see Earth and Space LO 1). We take our comet on a tour of "the Solar System" I.e. our other Science classes, as it only last about a day!

Comet recipe: Water (about half the volume of dry ice), thick black bin liners, dry Ice (about 2-3 x 500ml beakers) one spoonful of sand or soil one spoonful of charcoal a few ml of soy sauce (organic component) mixing bowl, wooden spoon

SAFETY - Thick rubber gloves (never touch dry ice!)

- The dry ice usually comes in pellets, first put these in a bin liner and crush into pieces of a few mm long with a mallet
- Now take a bin liner and use it to line the bowl.
- Mix together all the ingredients other than the dry ice in the bowl using the wooden spoon.
- Finally add the dry ice. Wearing the rubber gloves, lift the bin liner up and around the ingredients and apply some pressure.
- This should cause the ingredients to form into a solid lump: the comet core.
- Take the core out of the bag and display it on a heat proof mat.

I have found that as it warms up and the carbon dioxide sublimates, the comet makes an audible fizzing/ crackling sound and vapour and droplets can be seen to be given off.

This is what happens as a real comet comes closer to the Sun in its orbit. Gas and dust stream out of the core, pushed out into a tail by the charged particles that constantly stream out from the Sun (the solar wind) . It is this frozen ice/dry ice content that distinguishes comets from

the rockier/more metallic asteroids (plus the fact that comet orbits tend to bring them from far out beyond Neptune to closer the Sun where the tails develop)

For fantastic videos of real comets, go to the Solar and Heliospheric Observatory website at https://sohowww.nascom.nasa.gov/

References:

Science November 2018 p 14 (also has information on how to source dry ice)

Useful Websites

You may find the following websites useful when teaching Earth & Space topics.

1. https://eyes.nasa.gov/

this website has a welth of interactive material on all NASA planetery missions allowing you to present simulations of many famous missions and look at where spacecraft are now. It requires you to download an app and you will need to spend a bit of time getting familiar with this but its well worth it.

2.http://thinkzone.wlonk.com/SS/SolarSystemModel.php

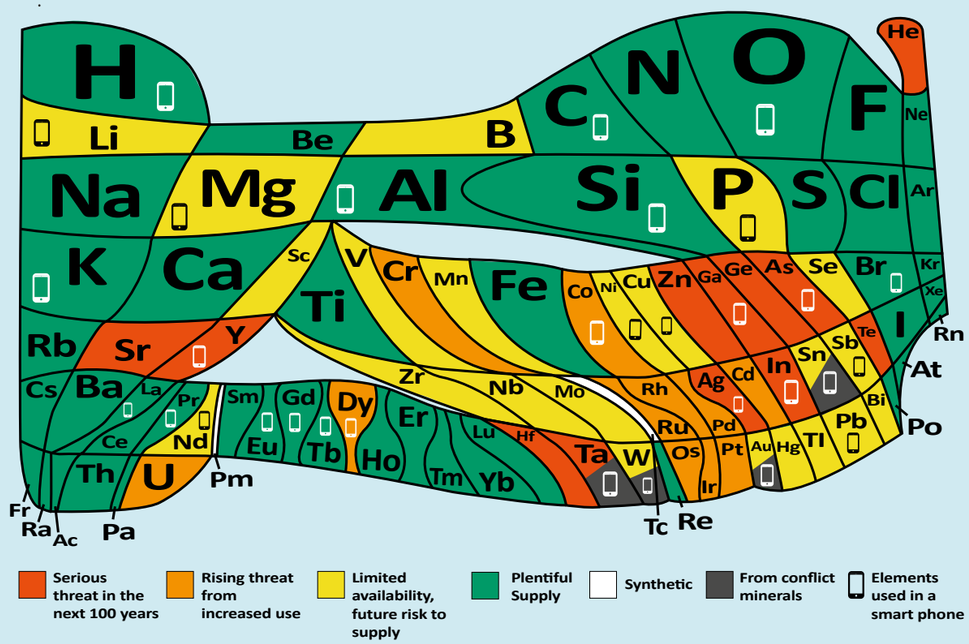
This site allows you to enter the diameter you decide to use for your model of the sun when building a solar system model and then tells you the size your planets should be and the distance they should be apart, also, at the bottom, it has an option that allows you to put in your location which it uses to plot the positions of the orbits of the planets around your school, house etc on a map based on the scaled models you have made. Its very useful to help students appreciate the vastness of the solar system by linking to the models they have constructed.

150 years of the Periodic Table

Peter E. Childs Emeritus Senior Lecturer, University of Limerick

United Nations Educational, Scientific and Cultural Organization

2019 IYPT International Year of the Periodic Table of Chemical Elements



Inspired by WF Sheehan's 'A Periodic Table with Emphasis' published in Chemistry, 1976, 49, 17-18'

Everyone who has done science at school will remember the Periodic Table wall chart in the school laboratory. 2019 marks the 150th anniversary of the invention of the periodic law and the accompanying table of elements by the Russian Chemist Dimitri Mendeleev. The UN through UNESCO, and in conjunction with the international scientific bodies for chemistry, physics, astronomy, and history and philosophy of science and technology, have designated 2019 as the International Year of the Periodic Table (IYPT). (https://www.iypt2019.org/)

A number of international events are planned for the year starting with the launch in the UNESCO headquarters in Paris on January 29th followed by another launch in Russia on February 8th. In February there will be a symposium on "Women and the Periodic Table of Elements" in Spain. A book is in preparation titled Women in their element, which will feature the contributions of women to the Periodic Table and the study of the elements. In July an international conference will be held in St. Petersburg, Mendeleev's old university. Many national events will be happening around the world – competitions, special stamps and a special Periodic Table (above) showing the scarcity of chemical elements used in everyday life, including mobile phones. This has been produced by EuCheMS, the European body representing chemists, and they would like to get copies into every school in Europe. It is available for free download at https://www.euchems.eu/euchems-periodic-table/.

In Ireland the annual ChemEd-Ireland conference for chemistry teachers in October will focus on teaching about the periodic table.

The periodic table is probably the single most important unifying idea in chemistry and one that is recognisable in every country and language. In 2016 four new elements were named and added to the PT, completing the row. All the elements beyond no. 84 , Polonium, are radioactive and those beyond uranium do not occur in nature but have been made in laboratories using nuclear reactions. The PT is still not complete and scientists are still looking for superheavy elements beyond no. 118.

I hope that every science teacher in the country will take up the idea and celebrate the International year of the Periodic Table in their schools.

Faraday's rotating wire,

the homopolar motor - time to update?

Geoff Auty

A fresh look at creating demonstrations to illustrate the Michael Faraday's first success in producing a continuously running electric motor.

Abstract

Answering some of the questions raised in the production of a previous article led to the development of a simple alternative design for the rotating wire demonstration, significantly avoiding the use of mercury as a conducting liquid. The attempt to explain variations in performance of another model and seeking the best performance for a new one became a catalogue of theoretical and practical activity which illustrates "How Science Works". Much modern science often requires the investment of extensive research facilities and involves large teams of people. Yet as in Faraday's time, the work described here could be done in a school laboratory or a garden shed. To see only the successful outcome, look at figure 3 and the description linked to it.

Introduction

Consideration of the possibility of updating an instructive demonstration, which had become defunct due to health and safety issues, occurred when I was asked questions about understanding a modern alternative. The subsequent thinking processes, the investigations and the eventual building of a viable demonstration became a convincing example of how science works. I believe that the final result is worth recording, although a simple description of what worked would take up much less space. It is tempting to do just that, and to pretend I got it all right first time. However I admit to a number of ill-considered theories and false trails which I believe truly record the path of progress in demonstrating How Science Works.

The story of this development began when Alan Goodwin sent a proposal for a science note in School Science Review (Goodwin, 2009). After trying to explain some investigations into the performance of his method which involved a rotating magnet, he felt that several features were unclear. In my capacity as editor of SSR, I discussed a number of points with him in theory, but eventually it all had to be put to the test. It would help to look at that method in order to understand the reasons behind some of the discussions which follow in the appendix.

The route to success in that rotating-magnet method, powered by only a 1.5 V cell, came from the strength of a modern neodymium magnet, not available in Michael Faraday's time. I went on to use the same magnet to adapt Faraday's design. I found success more quickly than I had dared hope. Whether this was luck or judgement, I felt that many things had to be checked and justified in order to claim that the design was reproducible.

History

In the past, physics teachers may have demonstrated the Faraday rotating wire experiment (e.g. Abbott, 1977, Licker 2003). An important part of the original method was the use of mercury as a conductor (figure 1), allowing motion without loss of electrical contact.

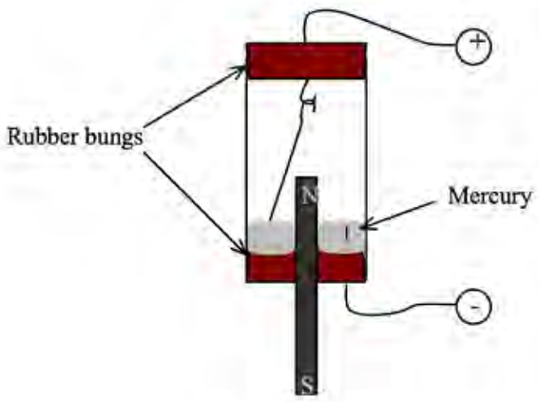


Figure 1. Wire loosely suspended in a glass tube and dipping into mercury

Physics teachers may also have demonstrated setting up a mercury barometer and coped with broken mercury thermometers numerous times, and it was quite common to pass a bottle of mercury around the class so that students could feel how heavy it is. We are all still here to tell the tale. But fears about the toxicity of mercury have caused it to be withdrawn from use in schools, and these opportunities are no longer available. Students no longer have the chance to see globules of this fascinating liquid metal run across a glass sheet.

The logic is that the wire suspended from another in a glass tube is just dipping into the mercury, but is free to move. When the current is switched on, this wire rotates around the magnet.

The basic explanation found by considering the view at the level of the top of the magnet, north pole in this case, as in figure 2.

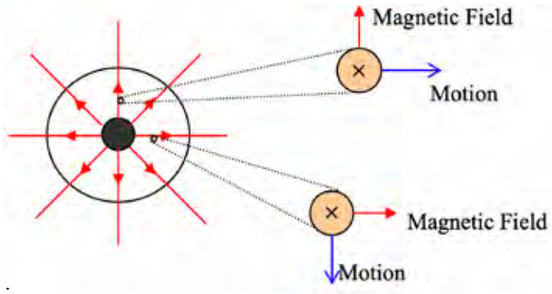


Figure 2. Cross section view at the top of the magnet. Two positions for the wire are shown, with enlargements illustrating the direction of motion (x symbol in the wire means current into diagram). Asking students to consider the wire in other places around the magnet will establish the explanation of a circular motion.

Seen in this top view, the flux lines (which represent the direction of the magnetic field) are away from the north pole and are hence radially outwards. The flux lines eventually go to the south pole of the magnet, but that is a long distance behind the plane of this diagram. This is why Faraday chose a long slim magnet.

Considering two of many possible positions for a wire carrying current downwards (which means into the plane of this diagram), the application of Fleming's left hand rule shows that the movement of the wire at any point is in a tangential direction. Hence it moves in a circle, clockwise in this case, but reverse either the field or the current and it will move anticlockwise.

The two wires hooked together at the top allow free movement but retain electrical contact. The bottom of the loose wire moves in the mercury, the liquid metal enabling good conduction to the wire which provides the negative connection to a wire through the bung at the bottom of the tube.

This arrangement was the simplest observation of continuous rotation available using the electric motor effect, but of no commercial value. It is sometimes called the homopolar motor because the free wire always moves around just one pole. Once mercury was removed from the school environment, this demonstration was abandoned, until now.

For further information on Michael Faraday and this historic demonstration, see references.

In this proposed method, the availability of the very strong neodymium magnet means that a demonstration using the same principle as Faraday's rotating wire is possible without the use of mercury. However in the method described in Alan Goodwin's note, it is the magnet which rotates rather than the wire. In correspondence, Alan asked several questions about clarifying the explanation of his demonstration and making it successful. Answers to these enhance the understanding of the viability of electromotive demonstrations and are given in the appendix.

Recreating the Faraday style

The basic apparatus to recreate the an alternative to the Faraday design is illustrated in figure 3.

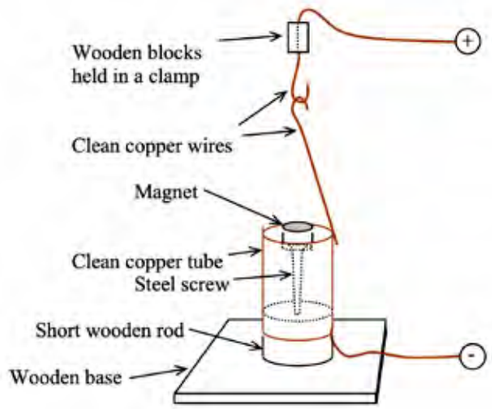


Figure 3. Apparatus to create the layout of a mercury-free version of Faraday's rotating wire.

A short wooden rod was made to fit tightly inside a piece of copper tube (scrap remaining from a plumbing project). The rod was fixed to a baseboard.

A steel screw was fixed into the centre of the top of the rod. The neodymium magnet was placed on the head of the screw.

A piece of copper tubing was pushed onto the rod, trapping a piece of wire. The top of the tube was approximately level with the top of the magnet. This is not critical, but preferably, the top of the tube should not be below the centre of the magnet.

Two pieces of wire each had one end made into open hook shapes. One became the rotatable wire to hang from the other. The second (supporting) wire was held in a clamp. Apart from the curve for the hook, the suspended wire should be as straight as possible.

The free ends of the wires were connected to a DC power supply via an ammeter (not essential, but I found it useful to monitor current).

Once the apparatus was assembled and connected, the suspended wire began to rotate immediately. The very strong magnet now available meant that using a long slim magnet as usually illustrated in the Faraday method was not essential, but more important, it operates without mercury.

I was so excited by this instant success and as I was working at home, I called for my wife to come to the shed to witness the observation. Cooking the Saturday evening meal made her reluctant, but I recounted reports that according to legend, Michael Faraday had first called his wife from preparing the Christmas dinner to see a similar discovery. So there was a precedent.

Was this a lucky accident? Could it be done better? More research was needed to ensure this success was reproducible.

Researching the design

2 copper tubes (15 mm and 22 mm diameter) and 3 suspended wires were tried. Supporting wires of the same type were also tested.

Wire type	Description	Length of suspended wire
Stiff single	A piece of copper wire 1.8 mm diameter. No plastic sleeve	9 cm
Multistrand	A section of flexible cable with 14 strands of wire 0.2 mm diameter, making an overall diameter of	15 cm

Table 1. Types of wire used in tests

I thought it worth testing whether the demonstration appeared easier to observe with a 22 mm diameter tube compared with the 15 mm tube used in the first attempt. I also decided that I should take some measurements of current and p.d. These are not extensive, but give sufficient detail to understand the performance. As contact was not always consistent, the ammeter readings were often an estimate of an average value.

Other observations are not described with consistency, because the performance was so varied. In fact the limits of success are as important as success itself. To assess the rate of rotation, I timed 10 revolutions for each successful operation. In the tables, the columns headed T/s indicate the time taken for 10 revolutions when running successfully.

Results

Support wire - 3 strand			
Suspended wire	Meter readings	T/s	Observation.
3 strand	3 V 2.4A	8	It works
	6 V 2.4A	-	Wire swings out, ammeter fluctuates. Runs but liable to stick
Stiff single	3 V 2 to 3 A	-	Sticks a lot
	6 V 2 to 3 A	-	Reasonably successful, not consistent
Multistrand	3 V 0.3 A	8	Runs around steadily, slight swing-out*
	6 V 0.4 A	8	Runs around steadily, more swing-out

Support wire - Stiff single			
Suspended wire	Meter readings	T/s	Observation.
3 strand	3 V 0.4 A	7	Runs quite smoothly
	6 V 0.4 A	7	Runs quite smoothly
	10 V 1.3 A	8	Runs but scrapes noisily
Stiff single	3 V 2.2 A	-	Sticks
	6 V 2.0 A	-	Sticks at times
Multistrand	3 V 0.2 A	-	Runs only if suspension carefully centred
	6 V 0.2 A	-	Runs easily but bounces.

Support wire - Multistrand			
Suspended wire	Meter readings	T/s	Observation.
3 strand	3 V 7 A	-	Poor - sticks, current inconsistent
	6 V 0.6 A	6	Runs quite well
Stiff single	3 V 0.4 A	-	Not successful
	6 V 0.6 A	-	Reasonable rotation but current shoots up if it sticks
Multistrand	3 V 0.3 A	7	Swings out somewhat but smooth. Runs successfully, if well centred
	6 V 0.4 A	7	Very stable rotation

* "swing-out" means that the wire swings away from the copper tube noticeably, then drops back and touches again enabling motion to continue.

Tables 2. Observations with a 22mm diameter tube

Support wire - 3 strand			
Suspended wire	Meter readings	T/s	Observation.
3 strand	3 V 0.4 A	7	Steady rotation (some ammeter fluctuation)
	6 V 0.6 A	7	Swings out more
Stiff single	3 V		Sticks
	6 V		Sticks
Multistrand	3 V 0.2 A	8	Reasonable rotation
	6 V 0.2 A	8	Swings out much more, hardly seems to touch tube, only about twice per revolution. Looks almost like if "floats" without contact

Support wire - Stiff single			
Suspended wire	Meter readings	T/s	Observation.
3 strand	3 V 0.2 A	7	Consistent rotation
	6 V 0.1 A	7	Swings out as it rotates
Stiff single	3 V 0.5 A	6	Fairly stable rotation swings out slightly
	6 V 0.1 A	6	Good rotation again
	10 V 0.16 A	5	Good rotation (no swing)
Multistrand	3 V 0.2 A*	-	In both cases, swings out so much that the wire hardly touches the tube, looks like magic, defeats the reason for doing it
	6 V 0.2 A*	-	

* best estimate – fluctuating wildly

Support wire - Multistrand			
Suspended wire	Meter readings	T/s	Observation.
3 strand	3 V 0.2 A	8	Rotates easily, ~ one touch per rev
	6 V 0.3 A	7	Jumpy, ~ one touch per rev
Stiff single	1.5 V 1.6 A	-	It sticks
	3 V .6 to 1 A	7	Long contacts, large jumps
	6 V .6 to 8 A	7	Big swings
Multistrand	1.5 V 0.04 A	8	Decent rotation
	3 V <0.1 A	7	Only about one touch per revolution
	6 V 0.14 A	-	Swings wildly, but keeps going

Tables 3. Observations with a 15mm diameter tube

It will be apparent that having pushed this to various limits, I might seem to be playing with too many variables, and much more research could be done.

One point to note is that even for steady rotations using the same set-up, current and p.d. are not proportional. The reason is that an increase of current brings an increase of force, producing a faster rotation. In turn, this produces a back e.m.f restricting the current. So the consequence is only a small increase in current and the rate of rotation for a substantial increase in p.d. The effect of back e.m.f. is also especially noticeable if the wire "sticks" (stops moving and remains in contact with the tube). The current then increases considerably because there is no significant resistance in the circuit.

Enhancing the design

As shown by figure 4 (which is similar to figure 2) application of

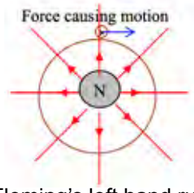


Figure 4. Cross section view where the moveable wire touched the tube. x symbol in the wire means current into diagram.

Fleming's left hand rule shows that the force on the movable wire is tangential to the copper tube wherever it makes contact.

When the current is switched on, the tangential direction of the force causes the wire to move away from the surface of the copper tube. If it succeeds, the current stops and the force reduces to zero. Then the wire will fall back to the copper tube making contact in a different place. In this way the wire can move in a series of bounces, repeatedly touching and leaving the tube.

The weight of the moveable wire as it leans on the tube tends to make it stay in contact. Hence for some of the arrangements described in the tables smooth motion is obtained with small current but the movement becomes erratic if the current is increased.

So is it possible to obtain an increased speed and a smooth movement?

In an attempt to prevent the wire swinging away from the tube 15 mm and 22 mm tubes were arranged concentrically (figure 5). The suspended wire was arranged to run in the gap between the tubes. The tubes were electrically connected so that current would flow when the wire touched either of them. The logic considered for this extra connection was that the effect of briefly touching the inside surface of the outer tube would be to help the circular motion to continue.

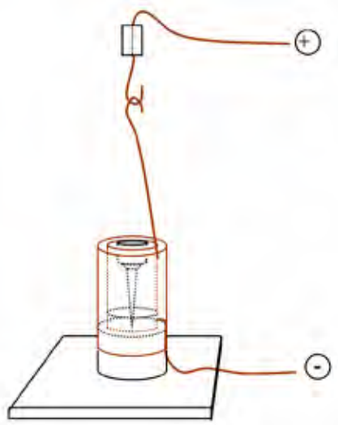


Figure 5. Assembly of apparatus with concentric tubes.

I obtained some movement with this design, but it was not particularly successful.

There were two problems. The gap was too narrow for my wires. They fit into the space available, but kept jamming during movement. Secondly, the tangential force encourages the wire to press against the inner surface of the outer tube, and this effect possibly inhibits free movement.

With a slim wire of suitable flexibility, I believe this method could be more successful, but I did not pursue it further.

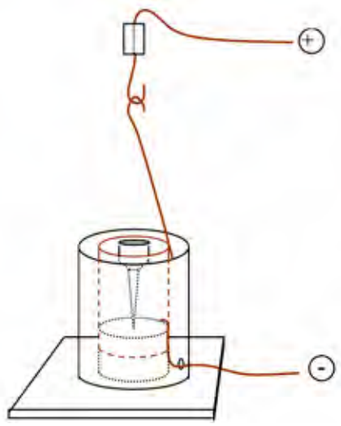


Figure 6. Assembly of apparatus producing concentric tubes from 22 mm copper tubing and a plastic film carton.

As explained, the gap between the tubes was too narrow to allow all the wire types to run freely. Also, having the electrical connection to the outer tube is probably not significant. For wires travelling around the outside of a single piece of tube, observations show that the 15 mm tube is slightly more reliable, but motion around the 22 mm tube is easier to see, and with the wider angle, the whole effect its more convincing.

Hence another option was to use the 22 mm tube with a plastic outer tube to contain any "bounce" but not contribute to providing the transverse force.

Although any plastic tubing of similar diameter (30-35 mm) would suffice, I tried an empty carton as used to contain 35 mm film cassettes. I cut a large hole in the bottom of

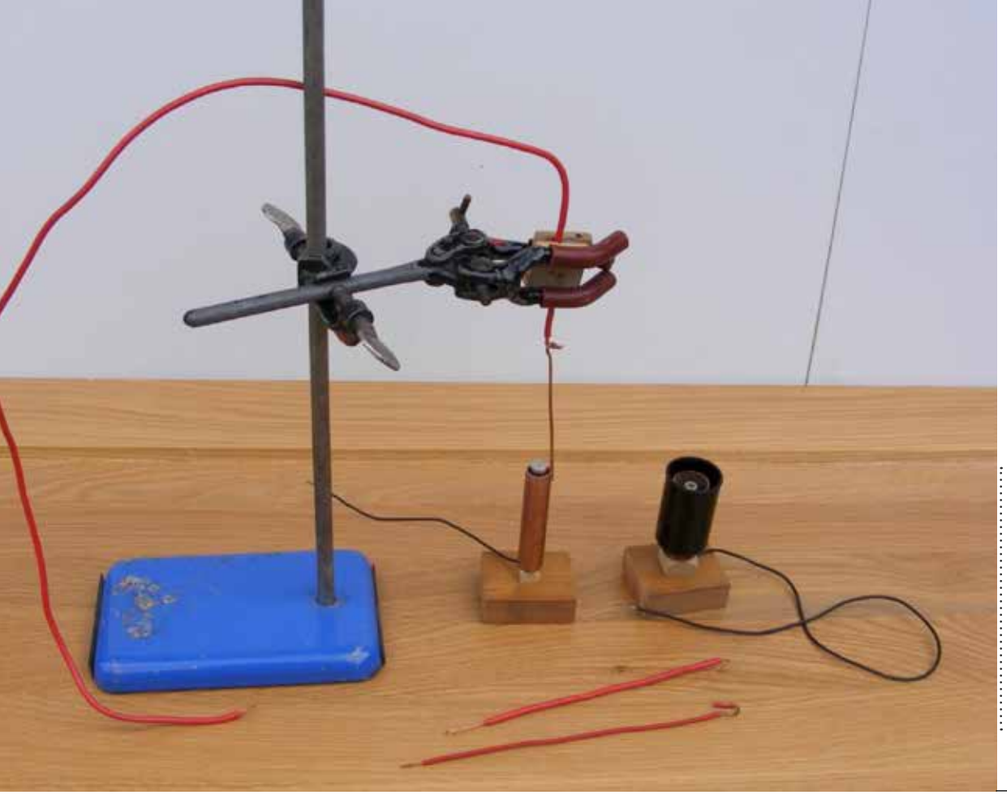


Figure 7. Apparatus as set up with 15 mm copper tube and single 1.8 mm suspended wire. A 22 mm tube inside a film carton, and the other wires used in tests are also shown.

the film-carton to make a push-fit onto the 22 mm copper tube, but it would perhaps be as easy to start again, drilling a small hole in the bottom of the carton, provided that the length of copper tube makes for a compatible height.

However an extra hole would be needed for the electrical connection to the copper tube. This arrangement is illustrated in figure 6, with results in tables 4.

Figure 7 shows the assembled apparatus with a 15 mm tube, and other parts used for different tests

Support wire - 3 strand				
Suspended wire	Meter readings		T/s	Observation.
3 strand	6 V	0.6 A	7	Runs successfully
	10 V	2.4 A	9	Sticks slightly at times, scraping audible
Stiff single	3 V	0.4 A	9	Reasonable rotation
	6 V	0.6 A	9	Reasonable rotation
Multistrand	3 V	0.4 A	9	Reasonable rotation
	6 V	0.6 A	9	Reasonable rotation
	10 V	0.4 A	-	More likely to stick, jump and spark

Support wire - Stiff single				
Suspended wire	Meter readings		T/s	Observation.
3 strand	3 V		-	Unsuccessful
	6 V	~2 A	12	Goes reasonably but can stick
	10 V	~2 A	12	Goes better but not perfect
Stiff single	3 V		-	Unsuccessful
	6 V	~2 A	-	Goes inconsistently (sticking often)
	10 V	~2 A	12	Runs adequately scrapes audibly
Multistrand	3 V		-	Unsuccessful
	6 V	0.6 A	7	Runs well
	10 V	0.6 A	8	Better, slower but a more consistent movement

Support wire - Multistrand				
Suspended wire	Meter readings		T/s	Observation.
3 strand	3 V		-	Unsuccessful
	6 V	2.2 A	-	Poor, sticks yet conducts
	10 V	0.6 A	-	Poor, sticks yet conducts
Stiff single	3 V	2.2 A	-	Tends to stick
	6 V	1.6 A	12	Runs successfully
	10 V	0.6 A	12	Runs but sticks occasionally
Multistrand	3 V	~0.8 A	-	Rotates inconsistently, Current jumps
	6 V	0.6 A	7	Runs successfully
	10 V	0.6 A	6	Runs successfully

Tables 4. Observations with a 22 mm diameter copper tube inside a 30 mm diameter plastic tube

Illustrating the field pattern and "strength" of the magnet

Illustration of the magnetic field pattern around the magnet (particularly the radial field away from the top surface) using iron filings is another idea explore. I would certainly do so to emphasise the shape of the field in three dimensions and hopefully increase the understanding to be derived using two-dimensional diagrams in books and in this article. It is quite spectacular with these strong magnets, but take care to find a method which ensures that iron filings do not get onto the magnet itself. They will be very difficult to remove.

In previous articles, I have for suggested methods for displaying magnetic fields (Auty 1968, 1994). In this case, I found a rectangular plastic tray 24 cm by 18 cm. A piece of A5 paper fitted nicely in the base. I placed a short plastic tube of 30 mm diameter on the paper and sprinkled iron filings into the tube. The iron filings remained in a circular heap when the tube was lifted away. Holding the tray carefully in one hand, I used the other hand to place the magnet beneath the tray. When it was underneath the iron filings, they produced that appropriate field pattern in 3 dimensions (figure 8), and the strong attractive force caused the magnet to cling to the underside. For viewing, the tray could then be placed on a bench (on small wooden blocks).

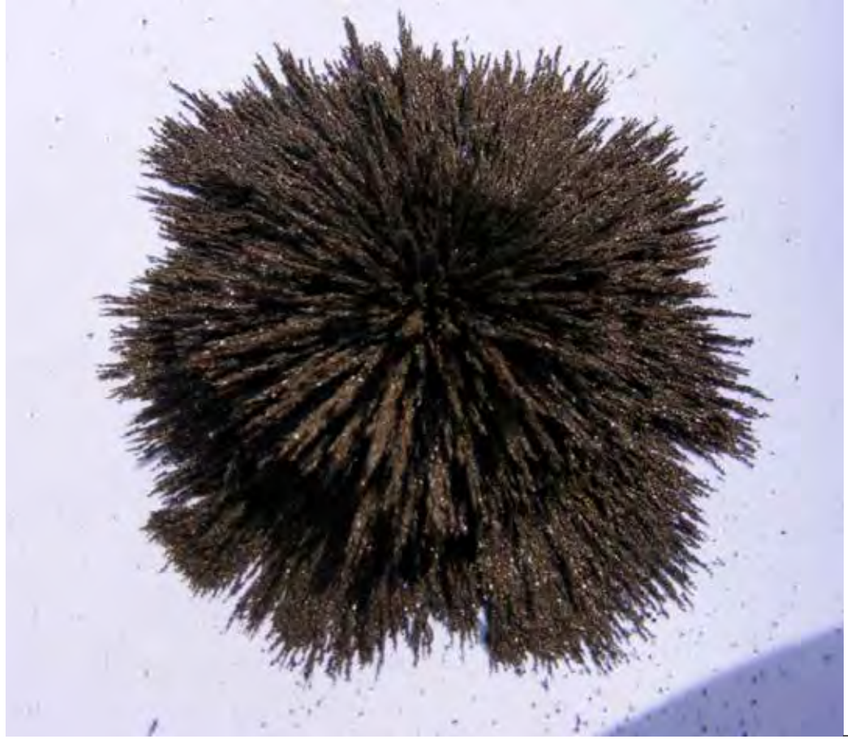


Figure 8. Radial Magnetic field pattern obtained with the north pole of a neodymium magnet just beneath a plastic tray (about 2mm thick) holding the iron filings, illustrating flux lines outwards and upwards away from the pole.

To obtain a 2-dimensional pattern, I placed the magnet beneath a piece of plywood about 5 mm thick. I sprinkled iron filings very thinly onto the paper in the tray. Then I carefully lowered the tray into position above the magnet. Very gentle tapping of the paper achieved the pattern shown in figure 9. Without the plywood spacer, the iron filings are pulled too strongly towards the magnet across the paper (resulting in a smaller version of the pattern in figure 8) and the extent of the field pattern away from the magnet is not so easy to see.

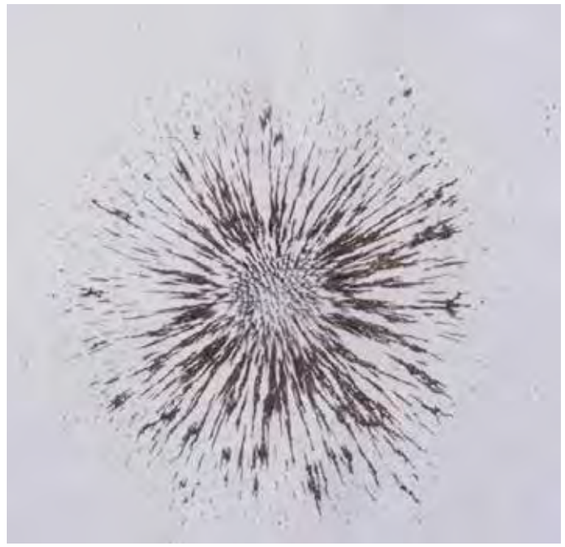


Figure 9. Radial magnetic field pattern obtained with the north pole of a neodymium magnet held by a wooden spacer about 7mm beneath the plastic tray holding the iron filings, illustrating flux lines outwards from the pole.

Conclusion

I have not tried every combination, just sufficient to see that the effect can be demonstrated. I have only recorded observations which seem relevant and there are many other possible variations, not one "right answer".

My observations show that "simplest seems best". Success will depend on the mass of and length of the moving wire and its flexibility, and on the "strength" of the magnet. So there is no definite recipe, but it's worth trying.

A challenge could be to show that it can be done; then set students an investigation to see if they can improve on the basic design using the techniques I have begun to pursue or any others you or they might think of. Further questions might be considered concerning Faraday's initial design. Why did he choose a long magnet? Without the guidance of a solid surface, how did the wire move in a circular path, and what determined the radius of the path?

Considering that I started by being asked questions about understanding an existing science topic, thought of possible theories to explain behaviour beyond what was published, performed experiments to put theories to the test, produced a successful technical outcome to overcome health concerns, and tested limitations on apparatus design, I think process recorded here offers a valid example of how science works.

Using Excel to Draw Graphs.

Hilary Rimbi

Using Excel to draw graphs and insert error bars.

The last article included details on how to present data in tables using Excel. This article looks at how to present data in the form of graphs. There are many types of graphs, but the most commonly used are bar graphs and line graphs.

Bar graphs can be used where the independent variable is non-numerical, while a line graph is usually used for a numerical independent variable.

Using the data table from the last issue, here are instructions on how to develop a bar graph using Excel.

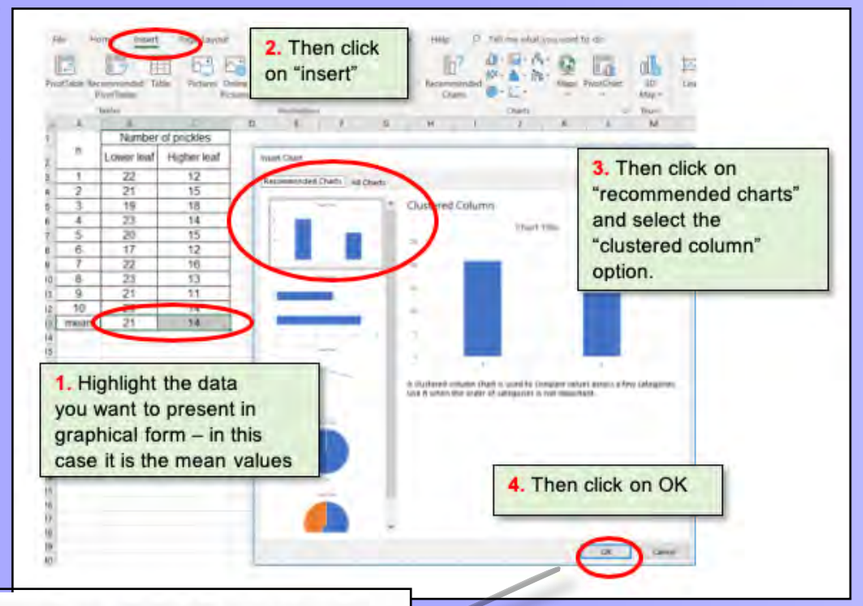
n	Number of prickles	
	Lower leaf	Higher leaf
1	22	12
2	21	15
3	19	18
4	23	14
5	20	15
6	17	12
7	22	16
8	23	13
9	21	11
10	20	14
mean	21	14

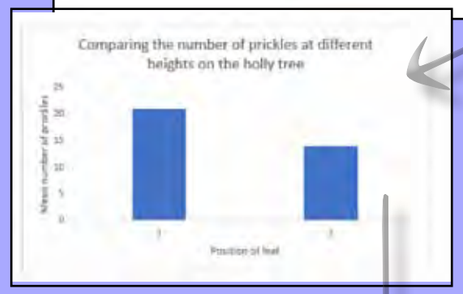
The graph appears on the Excel sheet as shown. You will then need to edit it to add a title, axis labels and error bars.

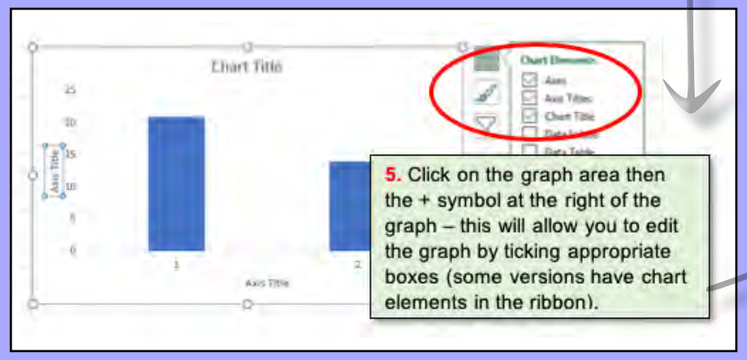
You can then type in the appropriate title and axes labels, including units if relevant.

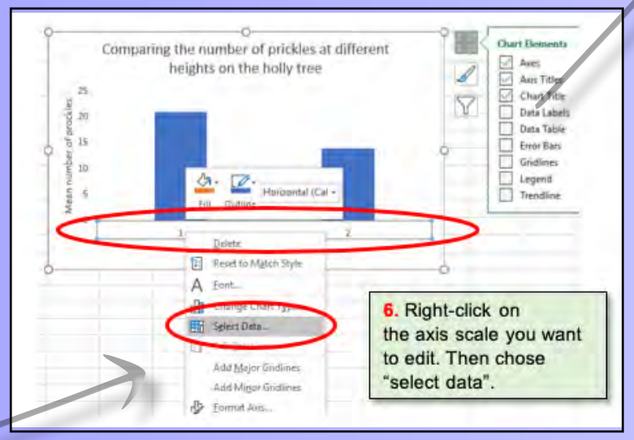
The scale can also be changed – in this example the numbers 1 and 2 on the x-axis would be better as "lower" and "higher".

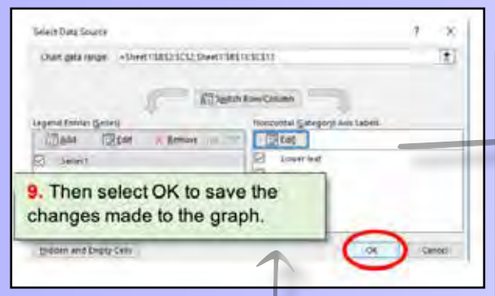
Error bars can be added to show the variation of values at each height. Range of values is a simple measure of variation for students. Values for the range can be added to the data table as shown.

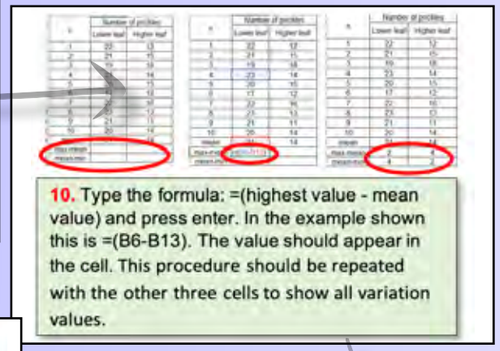


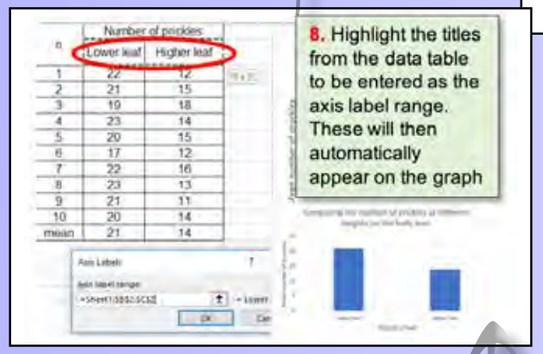


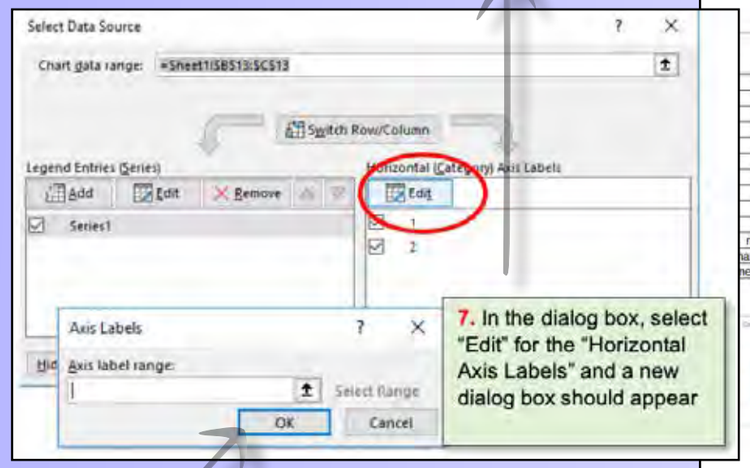


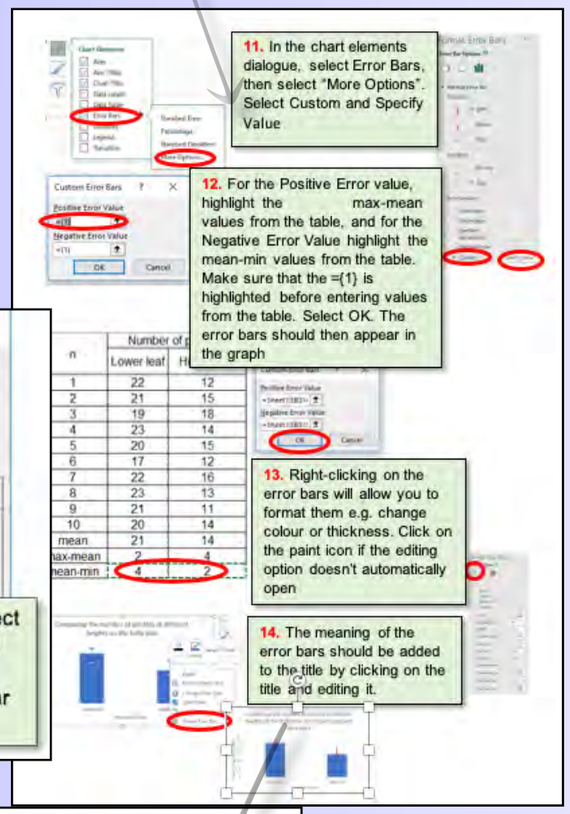


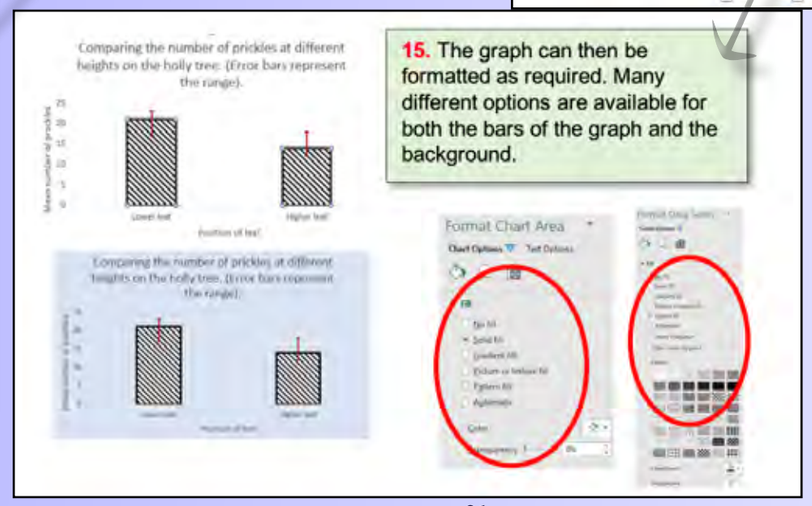












Similar formatting steps can be taken with line graphs. Hopefully this article will help your students to produce clear graphs. An article on statistical analysis will appear in the next issue.

Schrödinger at 75 - The Future of Biology

Siobhan Sweeney & Carolyn Cavey

It was a great pleasure and privilege to be able to attend the 'Schrodinger 75 Conference' in the National Concert Hall on the 5th and 6th of September. This was organised under the direction of Professor Luke O'Neill FRS and a team from Trinity College Dublin. In his opening remarks Prof O'Neill told us how, when he was involved in organising the 50th anniversary conference, there wasn't a single female speaker, and rather tellingly, that that didn't seem that odd at the time! Happily, the gender balance was somewhat restored this time, with 40% of the speakers being women.

The conference commemorated the 75th anniversary of the 'What is Life?' lectures given by Erwin Schrodinger at Trinity College Dublin in February 1943. At the time Schrodinger was the Director of the Dublin Institute of Advanced Studies.

Delegates came from all over the world as did speakers and included six Nobel Laureates. The conference was opened by Mary Robinson, former President of Ireland and Chancellor of the University of Dublin, Trinity College. She said that 'Schrodinger 75 aspires to look into the future of various aspects of biology through the eyes of the distinguished speakers here today who have already made a significant impact on science and technology.'

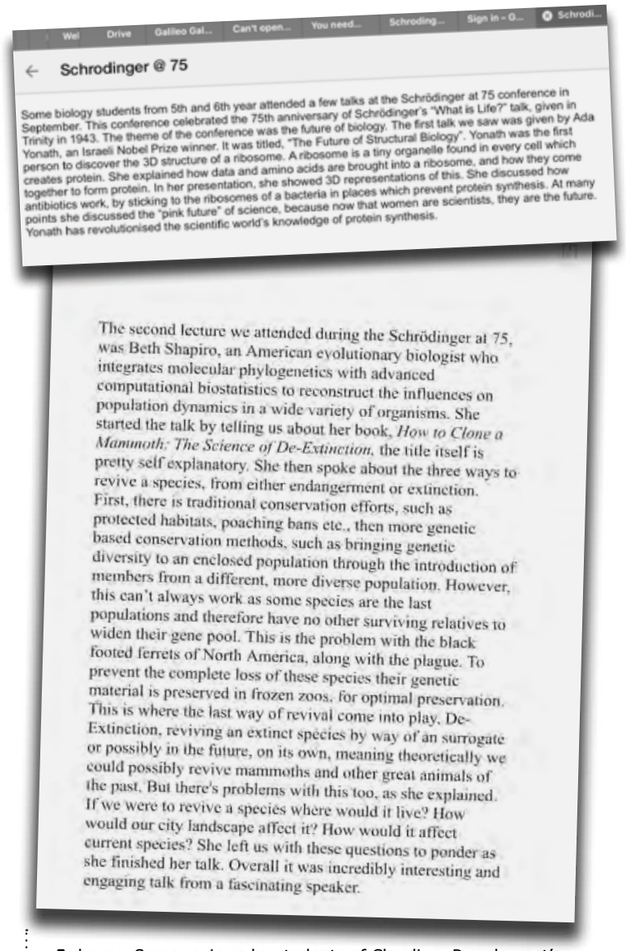
Irish speakers included Professor Emma Teeling of University College Dublin and Professor Lydia Lynch of Trinity College Dublin and Harvard Medical school. The chairs of all sessions were Irish and included Professor Luke O'Neill, Professor Aoife McLysaght and Professor Eucharia Meehan who is CEO of the Dublin Institute of Advanced Studies. Werner Nahm, who now has Schrodinger's position in DIAS chaired the final session.

Roger Penrose claims that Erwin Schrodinger's book What is Life? is one of the great science classics of the twentieth century. The book was written for the layman but became one of the spurs for the development of molecular biology and the subsequent discovery of the structure of DNA. In a letter from Francis Crick (12th August 1953) to Erwin Schrodinger he states 'Watson and I were once discussing how we came to enter the field of molecular biology and we discovered that we had both been influenced by your little book, "What is Life". James Watson, now 90 years of age, was one of the delegates to the conference in Dublin.

At first glance the programme for the conference looked very ambitious, with 12 thirty minute talks each day, laid out in four sessions, followed by a keynote lecture. However, despite this we came away each evening 'buzzing' from the variety of topics covered and in most cases by excellent presentations. Having been involved in running three ISTA annual meetings over the years, I was in awe at how smoothly the line up ran.

If I (Siobhán) were to pick two talks from each day that inspired me the most they would be

1. Leroy Hood who spoke passionately about The Future of Medicine. His early work in developing DNA and peptide synthesisers contributed as an enabling technology for the Human Genome Project. Hood is credited with introducing the term 'systems biology' and more recently is the driving force in the P4 Healthcare project which advocates medicine that is 'predictive, personalised, preventative and participatory'. This approach to medicine is, I believe, the future of successful medical care.https://systemsbiology.org/research/p4-medicine/.
2. The Israeli protein crystallographer, Ada Yonath who spoke on The Future of Structural Biology. Prof Yonath is famous for her ground breaking work on the structure of the ribosome, for which she was awarded the Nobel Prize for Chemistry in 2009. Her more recent work has centered on the modes of action of many different antibiotics targeting the ribosome and the elucidation of the structural basis for antibiotic sensitivity which has led to an understanding of how it plays a key role in therapeutic effectiveness. Leaving Cert students who have covered DNA/RNA and Protein synthesis would have found this talk very accessible (see more on this talk in Carolyn Cavey's report below).
3. Bernard Feringa who lit up the hall with his dynamic and engaging presentation entitled, The Future of Chemistry. Prof Feringa is a Dutch synthetic organic chemist at the University of Groningen, who won the Nobel Prize for Chemistry in 2016. In brief his work has centered on his development of molecular nano motors which can transport medicines to the exact place in the body where they are needed, thus reducing greatly the many problems of drug side effects.
4. Finally, for me, Prof. Ottoline Leyser, from Cambridge University in the UK who gave a wonderful presentation of her work on plant developmental biology. From experience, teaching 'plants' to students is not always the easiest thing to do, but this speaker drew her audience in, in a most engaging way. She spoke of her work on the roles and mechanisms of plant hormones, auxins, in particular, and how plants are able to adjust their growth and development to suit the environmental conditions in which they are growing. Although not mentioned on the day, it is interesting that Prof. Leyser, who is the recipient of the Royal Society Rosalind Franklin (The Dark Lady of DNA) Award, used the award to publish a book entitled 'Mothers in Science, 64 ways to have it all, 2008'. Concerned about the under-representation of women in academia, Prof. Leyser gathered family and career stories of 64 women to illustrate this point. The aim of the book is therefore, to show that it is possible for a woman to combine a career in scientific research with motherhood. (Available from royalsociety.org)



Schrodinger @ 75

Some biology students from 5th and 6th year attended a few talks at the Schrödinger at 75 conference in September. This conference celebrated the 75th anniversary of Schrödinger's "What is Life?" talk, given in Trinity in 1943. The theme of the conference was the future of biology. The first talk we saw was given by Ada Yonath, an Israeli Nobel Prize winner. It was titled, "The Future of Structural Biology". Yonath was the first person to discover the 3D structure of a ribosome. A ribosome is a tiny organelle found in every cell which creates protein. She explained how data and amino acids are brought into a ribosome, and how they come together to form protein. In her presentation, she showed 3D representations of this. She discussed how antibiotics work, by sticking to the ribosomes of a bacteria in places which prevent protein synthesis. At many points she discussed the "pink future" of science, because now that women are scientists, they are the future. Yonath has revolutionised the scientific world's knowledge of protein synthesis.

The second lecture we attended during the Schrödinger at 75, was Beth Shapiro, an American evolutionary biologist who integrates molecular phylogenetics with advanced computational biostatistics to reconstruct the influences on population dynamics in a wide variety of organisms. She started the talk by telling us about her book, *How to Clone a Mammoth: The Science of De-Extinction*, the title itself is pretty self explanatory. She then spoke about the three ways to revive a species, from either endangerment or extinction. First, there is traditional conservation efforts, such as protected habitats, poaching bans etc., then more genetic based conservation methods, such as bringing genetic diversity to an enclosed population through the introduction of members from a different, more diverse population. However, this can't always work as some species are the last populations and therefore have no other surviving relatives to widen their gene pool. This is the problem with the black footed ferrets of North America, along with the plague. To prevent the complete loss of these species their genetic material is preserved in frozen zoos, for optimal preservation. This is where the last way of revival come into play, De-Extinction, reviving an extinct species by way of an surrogate or possibly in the future, on its own, meaning theoretically we could possibly revive mammoths and other great animals of the past. But there's problems with this too, as she explained. If we were to revive a species where would it live? How would our city landscape affect it? How would it affect current species? She left us with these questions to ponder as she finished her talk. Overall it was incredibly interesting and engaging talk from a fascinating speaker.

Above: Some reviews by students of Claudine Prendergast's class from Loreto, St Stephens Green, who also attended the conference.

Report from Carolyn Cavey St David's Holy Faith, Secondary School, Greystones, Co. Wicklow who accompanied a group of her students to one of the sessions.

On Wednesday September 5th, a group of Fifth years from St.Davids Holy Faith were privileged to attend the National Concert Hall for a Session with three lectures. The group on arrival were delighted to see their posters displayed digitally in the foyer based on the theme " The Future of Biology" not to mention the free coffee!!

The first lecture by Dr. Ada Yonath from the Weizmann Institute of Science, was on " The future of molecular Biology' .

She started by explaining how the paper clip represents a correctly folded protein, the exact structure means function. From this analogy she expanded on the enormous work her team has done on the ribosome.

There are 4/5 million ribosomes in each cell, which are continuously creating proteins, up to 40 peptide bonds per second! The detailed structure of the ribosome unit has been studied so thoroughly that the intention is to create drugs (antibiotics) which will cause modification to the ribosomal function in pathogenic bacteria. This new form of antibiotic could not be resisted by the bacteria as they don't have the ability to alter the RNA/ DNA sequence that codes for a Ribosome, so plasmid resistance technique currently used by bacteria wouldn't be possible.

As we have a crisis in exponential antibiotic resistance and a decline in drug creation in the market, this new approach to combating bacterial disease through Ribosome modification could be transforming to humanity!! It is worth noting that at the end of her lecture she showed a ribosome birthday cake she was given and herself dressed up as a ribosome for Halloween, good idea!!

The Fifth years now feel the Chapter in the book is a doddle after that lecture!!

Following that Dr.Beth Shapiro from the University of California talked about ' The future of Extinction' She opened on the frightening fact that we are currently experiencing the Sixth Extinction, 50% of species have fallen away. There are three paths to preserve Biodiversity, which include Status Quo, Genetic Rescue and De- Extinction. The latter is a Jurassic Park method but her studies have concentrated on Genetic Rescue.

This term means that when a population of a species has fallen to a critical level ' inbreeding depression' occurs leading to body function and organ decline. Beth explained that by introducing new males to a group new DNA is injected into declining the group which can bring back its strength to grow in numbers again. This has been demonstrated to be successful with Florida panthers, wolves, ferrets, coral reefs and so on. So great information for the Conservation section of the Syllabus.

Finally Dr.Svarr Paabo talked about " The future of Ancient DNA" . This study discussed how modern humans have evolved from Neanderthal man. By using techniques of DNA extraction from bones, a library of genomes is produced. This means that any bones found in the field can have their DNA extracted to figure out the era and type of prehistoric human, be it Denisovan or Neanderthal. This type of information allows Archeological scientists to map movements of these groups through the continents among other things.

A nice example of how Genetics is a fundamental part of so many studies.

The Fifth years felt quite tired by the end and that was only 11.25 to 1pm. A nice taster of the real world of Science Research. So if anyone attended the entire event I am sure they are buzzing with exciting information!!

ISTA 57th ANNUAL CONFERENCE - Draft Programme
12th – 14th April 2019
"Embracing the Elements of Change"

Friday 12th April 2019

Venue: – The Skylon Hotel, Drumcondra

18.00 - 19.30	**Registration**
19.00 – 19.30	Refreshments
19.30 –19.50	**Welcome and official opening**
19.50 –20.00	**Launch of findings of ISTA Junior Cycle Science survey**
20.00 – 21.00	**Prof Peter Gallagher**
	Tuning in to the Radio Universe from Birr Castle
21.00 – 00.00	Hot buffet (in *The Skylon Hotel*)

Saturday 13th April 2019

Venue: DCU, St Patrick's Campus, Drumcondra

08.30 – 9.15 **Registration**

09.15 – 10.15 *Plenary Lecture (Primary and Secondary)*

- **Dr Deirdre Butler**
  Lego, Minecraft and STEM Education

10.15 – 11.00 *Concurrent Sessions*

- **Dr David R. Grimes**
  Fake Science?
- **Prof Kevin O'Connor**
  Biobased and Biodegradable Plastics for a Greener Society
- **Dr Claire Murray**
  Breaking Bias: Gender Representation in Chemistry Textbooks
- **Dr Eilish McLoughlin and Dr James Lovatt**
  Developing an Inquiry Stance – An overview of the Three Dimensions of Practitioner Inquiry in Physics Education Project (3DIPhE)
- **Dr John O'Donoghue**
  RSC Primary Workshop

11.15 – 11.45 ***Tea/Coffee in the Exhibition Area***

11.45 – 12.45 *Concurrent Sessions*

- **Prof Bill McComas**
  The 8 C's of Science
- **JCT Workshop**
- **PDST Chemistry Workshop**
  Top 10 Resources for Teaching Leaving Certificate Chemistry
- **Dr Eilish McLoughlin** *Open Schools for Open Societies (OSOS)*
- **Dr Cliona Murphy**:
  Primary: What is this thing called science?

12.30 – 14.00 ***Lunch break and exhibitions***
Drop-in workshops: – Go Fly Your Kite and *SEAI*

14.00 – 14.45 *Workshops*

- **Dr Jess Wade**
  Conjugated molecules, chirality and changing the world
- **Dr Declan Cathcart**
  Amgen Teach Workshop: Biotechnology through Inquiry
- **Dr John O'Donoghue** *RSC Second Level Workshop: Instrumentation and Analytical Chemistry for Leaving Cert*
- **Dr Eilish McLoughlin and Deirdre O'Neill**
  Improving gender balance in Ireland
- **Dr Orla Kelly**
  Primary: Creative science - Art and Science not such strange bedfellows!

15.00 – 15.45

Prof. Luke O'Neill
Humanology: A Scientist's Guide to our Amazing Existence

Paul Nugent, Jane Shimizu, Dr Jitka Houfková
"Lilu's House"- A New Primary Science on Stage Workshop

16.00 – 16.15 **Stephanie O'Neill,** Science Foundation Ireland
16.15 – 17.00 **Dr Stephen Ashworth**
Kitchen Chemistry
17.00– 17.30 **ISTA Annual Business Meeting**
17.30 –18.00 **Summary of findings of ISTA survey on Junior Cycle Science**

Venue: – The Skylon Hotel, Drumcondra
19.30 – 20.00 **ISTA President's reception**

20.00 – 22.30 Conference Banquet & President's Address

23.00 – 01.00 Entertainment

Sunday 14th April 2019

Venue: – The Skylon Hotel, Drumcondra

10.00 – 10.45 **Prof Bill McComas**
STEM Education
10.45– 11.30 **Dr Gerry Hyde**
What makes a good exam question?
10.45 – 11.15 Break, *Tea/Coffee*
11.45 – 12.30 **Dr Declan Kennedy**
Do we need to mind the Gap? (The leap from JC to LC)

Science Day for Primary Teachers

Saturday, 13th April, 2019

DCU Institute of Education, DCU St Patrick's Campus, Drumcondra

Organised by the Irish Science Teachers' Association as part of their annual conference, this event will be an opportunity to bring together primary teachers who are interested in developing the teaching of science within their schools.

Attending this event will help you to:

- build on your own knowledge and confidence in the teaching of science
- meet like-minded teachers who share a similar interest in Primary Science
- gain ideas to inspire children and colleagues to enjoy science
- become more aware of resources and programmes available to support you in the teaching of Primary Science

What is this thing called science? Helping children to understand science and inspiring them to work like scientists	**Creative science - Art and Science not such strange bedfellows!** Exploring the powerful connection between art, science and creativity
Kitchen Chemistry Using your kitchen as a laboratory to explore the principals of chemistry.	**Lilu's House - Primary Science on Stage** Explore a resource that shows how to promote language skills through science experiments
Other talks include: Lego, Mindcraft & STEM Education; Royal Society of Chemistry Primary Workshop—bringing everyday chemistry into the classroom; Bill McComas STEM Education; Jess Wade—Making Physics fun and more	

A fee of €30 will cover registration for primary teachers, entry to all talks and lunch. Access to the exhibit area is also included, where science resources companies, publishers and national science programmes will have a variety of stands, as well as access to all second level science talks.

Registration is online at **www.istaconference.com**

(Under 'Select Tickets' Scroll down — 'Primary Science €30' is the last choice)

The ISTA Science Day for Primary Teachers will run on Saturday 13th April 2019 as part of the ISTA Annual Conference for Second Level Science Teachers.

Primary teachers also welcome to attend all sessions from Friday 12th to Sunday 14th April 2019

The ISTA is a voluntary organisation run for teachers by teachers.

Science Day for Primary Teachers

Saturday 13th April 2019, 9am—5pm, DCU St Patrick's Campus, Drumcondra

Speakers	Session Descriptions
	**What is this thing called science? Cliona Murphy** This interactive session will introduce you to innovative pedagogies that are specifically designed to support the development of children's scientific inquiry skills and their understanding and appreciation of science. You will engage with hands-on inquiries that will challenge children's stereotypical views of science and focus on inquiries that illustrate how scientists; work, interpret scientific evidence, and, use models to explain scientific concepts.
	**Creative science - Art and Science not such strange bedfellows! Orla Kelly** In this hands on session, the powerful connection between science and art will be explored through the lens of creativity. Creativity is essential for the development of scientific ideas and goes hand in hand with scientific skills and scientific attitudes. By integrating science and art we can enhance science thinking and learning. Participants will experience a number of activities designed to foster creativity in science by drawing from elements across visual arts and drama.
	**Lilu's House Primary Science on Stage/IOP Workshop Paul Nugent, Jane Shimizu, Jitka Houflková** This hand-on workshop will explore many of the experiments featured in the new resource "Lilu's House Language Skills through Experiments" which shows how to promote language skills through natural science experiments in primary school. Fictional characters Lilu and her friend Alina go on a scientific discovery tour from bathroom, living room to kitchen. They need to solve tasks and to reflect on these verbally. Different levels of difficulty in texts and tasks suit mixed-ability classes and help to create inclusive lessons. Copy of resources for all participants.
	Popping good chemistry - Royal Society of Chemistry Primary Workshop Bring everyday chemistry into the classroom with this simple investigation. Cover the skills needed for a science investigations such as reliability, prediction, and fair testing. Your pupils will be amazed at the science they already know from their observations of the world around them. By bringing the everyday into the science lesson the pupils will be able to understand that chemistry is something they already know. All materials needed can be bought in their local area. Come along and you will be bursting to try this investigation with your class.
	**Kitchen Chemistry Stephen Ashworth** This science show uses readily available materials to illustrate some of the principles of chemistry. Acids, bases, catalysts and indicators are all part of this exploration of some of the chemicals that are all around us. Dr Stephen H. Ashworth of the School of Chemistry at the University of East Anglia has been giving demonstration lectures to audiences from the Women's Institute to primary school children for nearly twenty years.

Primary teachers are welcome to attend all second level and joint/plenary sessions on the conference programme. Other talks include: Dr Deirdre Butler DCU—Lego, Mindcraft & STEM Education; Bill McComas-STEM Education; Jess Wade—Making Physics Fun, Stephanie O'Neill SFI and lots more.....

McCulloch's Musings

Ian McCulloch

February 2019 Musings

I was gratified when I received my Autumn issue of SCIENCE that Seán Fogarty is now at the helm. It looked terrific and, given that Seán is a sound man who has the best interests of the ISTA uppermost in his mind, I felt that he deserved some encouragement. Whether reversing my decision to discontinue my "Musings" and reactivate my quill counts as support is moot. Whatever, the following is, I fear, a fairly predictable dose of déjà-vu.

I continue to while away some of my time in front of the telly. BBC4's science output is an attraction. Recently, I have enjoyed Zoe Laughlin's "Secret Story of Stuff" and Brian Cox's "Human Universe". Zoe Laughlin is an occasional collaborator with Mark Miodownik. Mark has featured in quite a few programmes of this genre. He also writes books - "Stuff Matters" and "Liquids", both of which I recommend. If you heed my advice, you will be treated to lots of interesting information that may be familiar to the more erudite among you (not me!). Did you know that we produce between 0.75 and 1 litre of saliva per day? I assumed that aeroplanes were made out of aluminium but, of course, nowadays, carbon fibre is used. It has many advantages but one shortcoming is its inability to act as a Faraday cage in the event of a lightning strike. To rectify that lacuna, conductive metal fibres are included in the carbon fibre weave. Incidentally, in 1999 Mark was awarded the Materials Ireland Newman Fellowship in Mechanical Engineering and spent some time in UCD. Another of his pearls of wisdom involved our perception of red and white wine. A panel of fifty-four tasters was asked to judge the bouquet of two wines. Both were Bordeaux. One was a white made from Semillon and Sauvignon grapes. The other was a "red" from Cabernet Sauvignon and Merlot grapes. Unbeknownst to the participants a flavourless red dye had been added to the "white". The colour completely dominated their appreciation of the wines. Both were described as "spicy", "intense" and "blackcurranty" which are flavour profiles exclusive to red wine.

I was reminded by this perception paradox of one of Paul Nugent's "tricks" at the AGM in Maynooth and set about recreating it. The dupe picks up all three decks of cards at once, puts them down and picks up just the top deck. Counterintuitively, it feels heavier than did all three together. Even when you know what the "trick" is, the experience remains the same. The three boxes don't have decks of cards in them at all. The bottom two have foam rubber so as to maintain their shape. The top one has some foam plus 300 g of lead. (An average deck of cards have a mass of about 100 g).

In the garden, the summer drought inspired me, at long last, to install the water butts I had purchased in ALDI about three years ago. Despite watching lots of YOU TUBE videos, and following the advice contained therein, they do overflow. I suspect describing this as a hydraulic issue is a bit pretentious. However you might refer to it, I still find the deficiency irritating. I would be receptive to advice as to how to rectify the issue!

Still in the garden, this visitor appeared in September. It is quite difficult to make out but we think it is a sparrowhawk. A few days later we saw him (it could have been a "her") and a friend having a tiff over a goldfinch that, to our delight, managed to escape their clutches as they squabbled.

We invested in a couple of new bird feeders during the summer. This model comes apart straightforwardly and one is thus more inclined to clean it regularly. This transaction also included a bag of sunflower seeds. Our brother-in-law in the UK is an avian aficionado. He recommended that we purchase the sunflower kernels, which we did, in the hope that the husk mounds beneath the feeders would contract. As you can see, the birds seem to be as carelessly cavalier in their feeding habits as heretofore and we have a budding "meadow" of sunflowers on our coal bunker lid.

I enjoyed my usual annual involvement in the Science Quiz. The Regional Round in UCD featured fewer teams than last year. The consensus was that the increasingly demanding administrative chores being visited upon teachers this year makes them less inclined to volunteer for events like this. There's an element of déjà-vu as reservations are shared vis-à-vis the contents and the implementation of the latest Junior Cert. science "syllabus".

While waiting for answer sheets to correct, there was a discussion about Nail Varnish Remover, which can be a useful solvent for other purposes. Mary Sheridan recommended LIDL's acetone free CIEN product. I think this is because it is so potent that it can cause carpet burns or coffee table blemishes. On the other hand, it may be that it doesn't display disagreeable side-effects.

The final in Trinity afforded me the opportunity to meet Luke O'Neill. So impressed was I with him that I resolved to read his recently published "Humanology" tome. So being the thrifty (mean) guy that I am, I put in a request to Rathmines library. The opening sentence "For some people it began with two hippies and a talking snake" saw me favourably disposed from the outset. It isn't all biology - he addresses a diverse range of science related topics. So good was the read that I actually bought a copy to add to our home collection. This is an exclusive conglomeration that includes titles such as "Noddy meets Father Christmas" by Enid Blyton. Despite my biological ignorance that the book remedied to a small extent (my ineptitude - not the book's), I found it informative and entertaining. I would recommend it wholeheartedly.

The Quiz was part of Science Week during which I went to a lecture in Rathfarnham Castle on Earthquakes. I learned that Irishman Robert Mallett (1810-81) was a pioneer in this branch of science and, indeed, coined the term "Seismology". He worked for the family iron foundry business. This was responsible for, amongst other things, the Fastnet Rock lighthouse, and a swing bridge over the River Shannon at Athlone. He also helped manufacture the characteristic iron railings that surround Trinity College and which bear his family name at the base.

On then to the Irish Times. A feature has appeared in the Tuesday Health supplement on FOOD LABELS by Rose Costello which I enjoy. She seems to me to have a good understanding of how to interpret these properly. For instance, your ready meal "Chicken Kiev" may be 'MADE IN IRELAND" but it could very likely consist of chicken bits from Brazil which are augmented and assembled in Ireland.

I read recently that rice paddies are a source of a considerable amount of atmospheric methane. I wondered how this might compare with the quantity generated by cattle. Incidentally, the climate-change "good news" that methane "decays" over a period of 10 years is rather debunked as this "decay" involves the production of carbon dioxide.

I have a seven year-old grandson who is "into" space. The perils of the religious aspect of primary education became apparent when he asked, "Is the asteroid belt God's belt?" He also wondered where exactly heaven was located in the universe!

There are only 10 types of people in the world - those who understand binary and those who don't.

I couldn't finish without a "grumpy old man" observation. An Irish Times letter writer in November remarked on the folly of three waste disposal companies servicing her estate. Our ghetto is the same, Greyhound, Citybin and Keywaste being the perpetrators. How can this make any sort of sense - ecological or otherwise?

Dr. Noeleen Smyth (OPW) displays herbarium plant specimens to students at the Herbarium in the NBG

'Plant Power' at the National Botanic Gardens for Science Week 2018

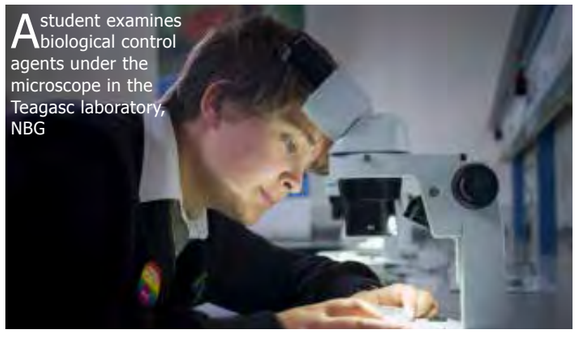
Dorothy Hayden PhD

The vast array of scientific research behind sustainable food production in Ireland is sometimes not fully appreciated by the general public. 'Plant Power' the Teagasc / OPW event held at the National Botanic Gardens, Glasnevin, for Science Week 2018, sought to address this issue by focusing on some of the important aspects of science that underpin successful crop production, in association with due regard for the environment. The Teagasc theme for the day focused on the importance of plant breeding in horticulture. Dr. Matthew Jebb, Director of the gardens, introduced the topic with a fascinating account of the evolution of plant life and man's dependence on these plants, through to early crop production and how through selection and breeding man improved these food crops for the betterment of humanity.

In today's world, there is an increasing emphasis on the inclusion of fruit and vegetables as part of a healthy diet. An impressive array of sustainably produced fruit, vegetables and salad crops by local producers was staged at the event, highlighting the importance of locally sourced seasonal produce for greater food security and environmental benefits. Additionally, Teagasc's role in the promotion of healthy eating through its involvement with initiatives such as 'Safe Food' and 'Healthy Food For All , targeting secondary school students in particular, serves to reinforce the positive imaging around the consumption of fruit and vegetables. Recently, Teagasc researchers carried out investigations on phytochemical (naturally occurring plant compounds) content in several varieties of carrot, broccoli and onion as part of the Irish Phytochemical Food Network (IPFN). The results indicated that there is indeed variation across commercial varieties and processing methods regarding the content of specific bioactive compounds. This may enable producers of the future to choose varieties for specific phytochemical content. This research offers exciting new possibilities to the industry, given the fact that many studies have shown that phytochemicals can be responsible for considerable health benefits to those consuming them. Extraction of these phytochemicals for inclusion in other foods more regularly eaten by Irish consumers, who typically do not consume the daily recommended portions of fresh fruit and vegetables, could be a way of increasing the amount of these chemicals in a person's diet.

Teagasc has been to the forefront in plant breeding, particularly in potato research, where it has a comprehensive breeding programme producing new varieties for home and export. This will help decrease the reliance on a single variety. Currently, Teagasc cultivars dominate the market. Ireland has been awarded the EU designation 'High Grade Region for Seed Potatoes' in recognition of the quality of seed potatoes being produced by our growers.

Current plant breeding and selection trials by the forestry division of Teagasc is focusing on identifying strains of our native ash that are resistant to the much publicised and devastating ash dieback disease, which is now present in every county of Ireland. Preliminary results offer encouragement in the quest to find tolerance to this serious disease, which threatens to change the characteristic nature of our rural landscape and diminish production from ash forestry plantations. Teagasc, in collaboration with COFORD and Coillte are involved in the 'British and Irish Hardwood Improvement Programme' (BIHIP), with the ob-



A student examines biological control agents under the microscope in the Teagasc laboratory, NBG

Stephen McCormack of McCormack's Family Farm demonstrates a range of locally produced fresh herbs and salads to students

jective of breeding and selecting improved lines of hardwood forestry trees such as sycamore, birch and alder.

Plant pathology is another area of research that Teagasc is involved with, dealing with research on diseases of mushrooms, vegetables , fruit, protected crops and cut- foliage. The plant pathology laboratory in Ashtown, Dublin has facilitated student research from PhD level to school students in its outreach programme over the years. In 2012, Kevin Howlett from Killester College of Further Education won an innovation award for his research on Eucalyptus Diseases. In 2014, Anna McEvoy from Greenhills College, Drogheda researched her project for the BT Young Scientist of the Year at the laboratory, and her entry ' The Aetiology of Bleeding Canker Disease in Horse Chestnut Trees' won the Elan Student Award for Excellence that year. She also went on to represent Ireland at the 2015 Intel International Science and Engineering Fair (ISEF) in Pittsburg, where she won a further award.

Horticulture has been transformed by technological advances in recent decades, such as micro-propagation techniques for new plant introductions in for example the nursery and cut foliage trade. This involves the production of genetically identical plants using plant tissue culture with high light intensity, controlled temperature and a predetermined nutrient content in a gel growing medium. This enables large numbers of plants to be propagated quickly, a useful tool to get new or improved selections of plants to market, and for bulking up numbers of those plants showing tolerances to diseases or pests, thus helping to decrease the reliance on pesticides. The demand for decorative cut-foliage to enhance floral bouquets is expanding in developing countries, and Ireland with its relatively benign climate, is well placed to service that demand to our colder European neighbours. Once innovative plants have been identified for the cut-foliage trade, Teagasc staff research production blueprints for the new plant species in order to fine tune crop management to ensure produce can meet strict market requirements in terms of quality e.g. stem length, leaf colour, freedom from pests and diseases, pattern and number of branches etc. This information is then made available to producers through practical workshops, open days and seminars.

The strawberry industry in Ireland has expanded dramatically over the last 20 years, with production now extending from March until November as a result of new technology. Prior to recent Teagasc research, which has pioneered a new tray production system, Irish growers relied on imported plants to meet the increased demand for out of season plants, risking disease transmission, compromising quality and incurring substantial costs. The new production system now enables Irish propagators to satisfy demand at half the original cost, reducing the reliance on imports, improving biosecurity as well as opening up a possible export opportunity.

An interactive laboratory session, demonstrating the array of biological control agents (natural enemies) that are currently deployed in sustainable pest control in Ireland, was available to students and teachers in the Teagasc laboratories on the day of the science event. Many of these useful insects are currently used by the OPW staff for sustainable pest control on plants at the National Botanic Gardens . Teagasc is involved in on-going research in Integrate Pest Management (IPM), in an effort to offer a sustainable and environmentally friendly approach to managing troublesome pests and diseases on crops. Recent Teagasc work in conjunction with University College Dublin (UCD) confirmed an efficient biological control agent (a tiny parasitic wasp) for an invasive leaf beetle on Eucalyptus foliage and forestry crops, while additional research investigates natural enemies for other crops. On-going monitoring programmes in conjunction with fresh produce producers for significant new pests such as the 'Spotted Wing Drysophylla' on soft and stone fruit, as well as tortrix moth, thrips and capsid bugs on cherry laurel for cut-foliage are taking place. These are aimed at early detection, observing the rate of spread and phenological patterns associated with these pest populations at various locations throughout specific cropping areas, with the objective of informing sustainable control solutions.

Pauline Murray (OPW) takes students on tour of the Palm House, NBG

A group of students and teachers from Fingal Community College', Seatown, Swords being guided around the grounds of the NBG by Dorothy Hayden (Teagasc)

However state funded horticultural research is not new to Ireland, and modern scientific trials date from the mid 1950's. Throughout the years, valuable research was carried out at research stations such as Kinsealy, Co. Dublin, Clonroche, Co. Wexford and Ballygagin, Co. Waterford. Today, most of the horticultural research takes place at Teagasc's Technology Centre at Ashtown, Dublin with foliage trials conducted at Kildalton College, Co. Kilkenny.

Participants at the Science Week event were treated to tours of the National Herbarium (not normally open to the public) on the day and these tied in nicely with the main theme, whereby preserved specimens of key plants in our food history, in addition to important landscape introductions from around the world were on display. The role of the early plant hunters / explorers in sourcing useful plants from around the globe was communicated to the students. The plant hunter's historic legacy now lives on in the herbarium, which is testament to their endeavours, where often life and limb were sacrificed in order to collect and dispatch seeds back to their plant nursery sponsors and donate preserved herbarium specimens for museum collections at home.

A range of full time degree L7 and QQI L5 & L6 courses in horticulture offered by Teagasc, are conducted at the College of Horticulture, National Botanic Gardens, Glasnevin and Kildalton College, with part time courses QQI L5 & L6 also delivered at the (NBG). So do come along to our open day at the Botanic Gardens on the 7th March 2019 between 12.00 – 3.00pm to talk to our horticultural professionals about our courses. In terms of horticultural career choices for prospective school leavers, the recent Plant Power event showcased the myriad of possibilities within the industry for the science focused student. This ranges from production horticulture where the deployment of modern scientific technology is paramount for successful crop production, to research possibilities in food science, farmland ecology, plant breeding, entomology, plant pathology and soil science. Landscape design, garden maintenance and turf grass specialisations also require environmental awareness and sustainable approaches to construction and landscape management.

The 'Plant Power' event 2018 at the National Botanic Gardens was a first for the 'Festival of Farming and Food' – SFI Science Week at Teagasc. Given the excellent turnout and interest shown in the science of horticulture, Teagasc looks forward to staging future Science Week events to showcase the relevant cutting edge science being conducted across the various strands of the organisation.

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SciFest: A teacher's perspective.

Hugo Rowsome

After four years of teaching Biology at second level, I have recently had the privilege of joining the SciFest team as its Project Manager. Since my appointment, I have been struck by the merits and benefits to co-curricular programmes such as SciFest, in assisting the holistic development of our students. Furthermore, the framework of SciFest, amongst other initiatives supports teachers to do what they do best: Ignite a passion for the STEM subjects. The relationship between SciFest and Science teachers is, of course, a symbiotic one. Without the engagement of teachers, SciFest would cease to exist. Having visited a variety of different schools across the country, my observation is that each is radically different from the other. Something, I believe that should be celebrated. A school's ethos, size, locality, community, and management are variables that may distil entirely different schooling experiences. In my opinion, SciFest's flexibility is key here. Teachers and our regional partners in the third-level colleges are afforded autonomy in the direction and scale of a SciFest fair. SciFest is there to support. The result is a rich blend of experiences for students throughout the country. Each of the now nearly 100 fairs across the island of Ireland, represents a unique strand in the colourful tapestry that is the SciFest story to date. A story that affirms the passion, industry, and drive of our teachers, the creativity and imagination of our students and the inspiration that the programme ignites in youths and adults alike.

SciFest is Ireland's largest STEM Fair programme. The operative word, for me being programme. The competition exists at four distinct levels; Local (SciFest@School), Regional (SciFest@College), the National Final, and International, comprising now of the Intel Science and Engineering Fair, Broadcom MASTERS Programme and the Berlin Long Night of Science. SciFest is not one event but many, spread across the year, throughout our island and indeed,

Above: Minister for Education and Skills Joe McHugh T.D. with students from the Donahies Community School, Aaron Byrne, Kaya Carroll and Pedro Lucas at the SciFest 2019 Launch.

beyond our shores. From the teacher's perspective, this offers a framework for students to develop their ideas over the year and to showcase them not just at one event, but at least two. SciFest is free to host and to participate in. Every student's project is accepted if at all possible. There is no barrier to participation. Whilst failure and rejection are a part of life, not being even given the chance to try was simply inadequate to our founder, Sheila Porter, when she established SciFest in 2008.

Science is a cycle of transition. As our understanding grows, the facts of yesterday are supplanted by the facts of today. Who knows what tomorrow brings? And that is a core concept that transcends all STEM subjects. More so than any other subject, the Science classroom can be the front line of discovery for students. Science is dynamic and fluid. Evolution doesn't halt. Life evolves and adapts and so must we all. Our Science education system is in transition. The reform of the Junior Cycle Profile of Achievement is coming to fruition in this academic year. We have moved past the maiden voyage of the Extended Experimental Investigation (EEI) and are now moving through the second classroom-based assessment, the Science in Society Investigation (SSI). Long before the JCPA, SciFest was encouraging inquiry-based learning in the classroom. Indeed, hosting a SciFest at school in advance of the EEI can help develop and refine the skills required by second years completing the CBA in May every year. Like every good lesson, ideas need time to grow and concepts need to be staged gradually. Hosting a SciFest fair for 1st years, plants the seed of what is meant by 'in line with expectations', that will hopefully grow and blossom to 'above expectations' or even 'exceptional' in the following years.

However, the discourse around STEM education has perhaps been dominated by the Junior Cycle over the past two years. SciFest has huge relevance beyond the Junior Cycle and indeed it is ideal for enhancing any TY programme. As of 2017, SciFest is a Gaisce partner. Students may participate in a SciFest@School fair and use this as the 'Personal Skill' element of their Gaisce Award. Furthermore, TYs may assist a teacher in running a SciFest@School and use this experience towards meeting their community involvement-element of the Gaisce Award.

Adam Kelly, from Skerries Community College is crowned SciFest 2018 winner for his project, 'An Open Source Solution to Simulating Quantum Computers Using Hardware Acceleration.'

The Leaving Certificate is frequently in the crosshairs for encouraging rote learning, thus being deficient in the promotion of critical thinking. Undoubtedly, the Leaving Cert needs reform, to address the skills gap that is growing. A recent report by Dell Technologies predicts that 85% of jobs that will exist in 2030 do not exist today. Many current 1st years students in our second-level schools will be graduating from a four-year primary degree at third level in 2028. We are teaching this generation now. We owe it to our students to push them not just within the confined structures of state examinations, but also in additional opportunities beyond the classroom. SciFest offers a platform for all students to embrace the 'softer skills' of creativity, innovation, leadership and collaboration so that students may be prepared for all eventualities in their future employment. Future employers will look less into the individual candidate's exam results as validation and look more into the evidence of an individual candidate being adaptable and well-rounded. We need to offer our students as many chances to develop beyond the classroom as possible.

In conclusion, curriculum reform is a necessity. However, there is only so much it may accomplish before its partial obsolescence. In addition, teachers are stretched and can only do so much. That is why in the STEM Policy Statement 2017-2026, former Minister of Education Richard Bruton outlined that STEM education is part of an extended ecosystem, including Primary and Post-Primary, families, business in the community and out of school programmes. It is time for society, to take a greater claim in addressing the skills gap that has grown. It is vital that programmes such as SciFest, in tandem with industry, offer support to teachers, schools and students. SciFest is grateful to be supported by Science Foundation Ireland, Boston Scientific, Intel and Specsavers amongst many others. This is further evidence that industry is awakening to the idea of good corporate citizenship and is understanding its responsibility in being a role model in the education system. Corporations want to help more than ever. SciFest therefore offers a platform for continuous education reform by joining together all aforementioned stakeholders. To that end, we are all simply functioning cogs in the machinery of STEM education, that drives the change forward and allows that cycle of transition to continue.

Éabha Kenny, from Scoil Muire gan Smál, Convent of Mercy, in Roscommon wins the inaugral Broadcom MASTERS Award.

SciFest 2019

SciFest 2019 was launched by the Minister for Education and Skills, Joe McHugh TD on 6 February. At the launch the Minister called on all second-level students across the island of Ireland to put their skills in science, technology, engineering, and maths (STEM) to the test and enter SciFest. The competition is free to enter. SciFest aims to give students of all abilities the opportunity to develop research, problem solving, critical thinking, and presentation skills.

Last year's overall national final winner was Adam Kelly, a fifth-year student from Skerries Community College, for his open source solution to simulating quantum computing. Adam will represent Ireland at the Intel International Science and Engineering Fair (ISEF) 2019 in Phoenix, Arizona in May.

SciFest@College 2019

TU Dublin Kevin St	5 Apr	TU Dublin – Tallaght	2 May
Cork IT	5 Apr	DCU	3 May
SciFest@NorthWest (NI)	8 Apr	Dundalk IT	7 May
Athlone IT	12 Apr	IT Sligo	8 May
Limerick IT Moylish	30 Apr	TU Dublin Blanchardstown	8 May
Waterford IT	1 May	IT Tralee	8 May
Galway-Mayo IT	2 May	Letterkenny IT	16 May
Limerick IT Thurles	2 May	IT Carlow	23 May

SciFest 2019 will mark the second year of the Broadcom MASTERS Award. This new award saw five junior cycle students, ranging in age from 12 to 14, compete at the 2018 national final for the opportunity to participate in the Broadcom MASTERS International Programme which includes attendance at the Intel ISEF. The five students were previously winners of the ISTA award at regional SciFest@College fairs. The inaugural award was won by Éabha Kenny, from Scoil Muire gan Smál, Convent of Mercy, Roscommon Town, Roscommon. Éabha will be one of 28 delegates representing 25 countries attending the Broadcom MASTERS International programme in May.

The opportunities for those that compete in SciFest are limitless, all it takes is to make that first step on the journey of scientific discovery. Registration is available on the website, www.scifest.ie and the closing date for registration for SciFest@College 2019 is Friday March 8th.

Naughton Foundation Awards 2018

Thirty-six students from all around the country were presented with the Naughton Awards in the Trinity Biomedical Sciences Institute. They recognise the ambition and talent of students in science, engineering, technology, and maths. They are due to the generosity and vision of the Naughton family, who have been instrumental in enabling increased focus on STEM.

The Naughton scholarships were initiated in 2008 in response to universities reporting that they were not getting enough good applicants to the STEM subjects and employers reporting that there were insufficient talented applicants for jobs in engineering, technology, science, and computer science.

In the same year that the Naughton scholarships were launched, the Science Gallery in Trinity College was opened, which is also supported by the Naughton Family. Both the Science Gallery and the Naughton Scholarships are about encouraging and enabling young people's passion for STEM.

Applications for 2019 Scholarships for interested Leaving Certificate students can be made online at thenaughton-foundation.com. Closing date: 18th May 2019.

County Carlow
Clíodhna Ní Shé, Gaelcholáiste Cheatharlach
Mathematics, Trinity College Dublin

County Cavan
Francis Fitzpatrick, St. Mogue's College
Mathematics, Trinity College Dublin
County Clare
Róisín McAteer, Coláiste Muire, Ennis
Science, University College Dublin

County Cork
Dara Costello, Coláiste an Spioraid Naoimh
Engineering, University College Cork
Matthew Gibson, Christian Brothers College
Mathematical Sciences, University College Cork

County Donegal
Caitlin McColgan, Scoil Mhuire Buncrana
Aerospace Engineering, Queens University Belfast

Dublin City
Sarah Lavelle, Alexandra College
Engineering, Trinity College Dublin
Stephen Cushen, St. Declan's College, Cabra
Engineering, Trinity College Dublin

Dublin Dun Laoghaire / Rathdown
Cathy Culligan, Loreto College Foxrock
Engineering, University College Dublin
Alison Maguire, Holy Child Killiney
Engineering, University College Dublin

Dublin Fingal
Heather Murphy, Sutton Park School
Engineering, Trinity College Dublin

Dublin South County
Aoibheann Murray, Loreto High School Beaufort
Theoretical Physics, Trinity College Dublin

County Galway
Maitias Ó Gríofa, Scoil Chuimsitheach Chiaráin
Energy Systems Engineering, National University of Ireland,

Galway
Orla Sealy Phelan, Clifden Community College
Engineering, National University of Ireland, Galway
Jamie Merrins Pryce, Clifden Community College
Chemical Sciences, Trinity College Dublin

County Kerry
Lucy Walsh, Meán Scoil Nua an Leith Triúigh
Engineering, University College Dublin

County Kildare
Matthew Martin, Clongowes Wood College
Engineering, Trinity College Dublin

County Kilkenny
David O'Carroll, St. Kieran's College
Engineering, University College Dublin

County Laois
Luan Fletcher, St. Mary's CBS
Mathematics, Trinity College Dublin

County Leitrim
Aisling O'Connor, Carrick-on-Shannon Community School
Engineering, University College Dublin

County Limerick
Cian McDonnell, Crescent College Comprehensive S.J
Mathematical Sciences, University College Cork

County Longford
Andrew Gallagher, St. Mel's College
Pharmaceutical & Biomedical Chemistry, NUI Maynooth

County Louth
Loui Byrne, De La Salle College, Dundalk
Engineering, University College Dublin

County Mayo
Thomas McCarthy, St. Gerald's College, Castlebar
Physical Sciences, Trinity College Dublin

County Meath
Colum Flynn, St Patrick's Classical School, Navan
Theoretical Physics, Trinity College Dublin
Sadhbh Leahy, O'Carolan College, Nobber
Physical Sciences, Trinity College Dublin

County Monaghan
Rhaínna Mc Entee, St Louis Secondary School, Monaghan
Chemical Sciences, Trinity College Dublin

County Offaly
Dylan Cuskelly, Tullamore College
Physical Sciences, Trinity College Dublin

County Roscommon
Oisín Stephens, CBS Roscommon
Physical Sciences, Trinity College Dublin

County Sligo
Liam Doheny, Sligo Grammer School
Engineering, University College Dublin

County Tipperary
Jake Flannery, Rockwell College
Chemical & Biochemical Engineering, University of Limerick

County Waterford
Mick Devine, St Augustine's College, Dungarvan
Engineering, University College Cork

County Westmeath
James Drumm, Coláiste Mhuire Mullingar
Engineering, University College Dublin

County Wexford
Cian Fitzhenry, FCJ Secondary School, Bunclody
Science, Dublin City University
Eoin Pinaqui, St. Peter's College, Wexford
Computer Science, Trinity College Dublin

County Wicklow
Nicolas Pochinkov, St. Gerard's, Bray
Theoretical Physics, Trinity College Dublin

Tools and templates for designing integrated STEM lessons

Dr. Maeve Liston

Introduction

In previous articles in Science I discussed the following: what is STEM education? characteristics of STEM literacy, characteristics of true authentic STEM activities and lessons, attributes of a STEM classroom and the Engineering Design Process (EDP) (Liston 2018a,b). Now that we have explored the background to STEM education and its key components, in particular, the EDP. We are now going to examine checklists, tools and templates for designing integrated STEM lessons.

Science	Engineering	Technology	Mathematics
Ask questions	Define problems	Become aware of the web of technological systems on which society depends.	Make sense of problems and persevere in solving them
Develop and use models.	Develop and use models		Model with mathematics
Plan and carry out investigations.	Plan and carry out investigations	Learn how to use new technologies as they become available.	Use appropriate tolls strategically.
Analyse and interpret data.	Analyse and interpret data.		Attend to precision
Use mathematics and computational thinking.	Use mathematics and computational thinking.	Recognise the role that technology plays in the advancement of science and engineering.	Reason abstractly and quantitatively.
Construct explanations.	Design solutions.		Look for and make use of structure.
Engage in argument from evidence.	Engage in argument from evidence.	Make informed decisions about technology, given its relationship to society and the environment.	Construct viable arguments and critique the reasoning of others.
Obtain, evaluate and communicate information	Obtain, evaluate and communicate information		Look for and express regularity in repeated reasoning

Fig. 1. Connections between skills in Science, Technology, Engineering and Mathematics (Vasquez, Comer & Sneider, 2013, p.38).

Designing integrated STEM lessons

Jolly (2017) in her book *STEM by Design: Strategies and Activities for Grades 4-8*, sets out a very useful list of considerations that you could use when designing truly authentic integrated STEM lessons:

- Be thoroughly familiar with the content and concepts you will cover in your lesson.
- Research the topic.
- Include the components of the EDP (Liston, 2018b).
- Estimate the amount of time needed to complete each stage of the lesson and EDP.
- Engage students' interest in the challenge using a creative introduction to the problem and challenge.
- Make explicit connections between concepts in maths and science.
- Identify how technology is used or created in the lesson.
- Make explicit connections between skills in Science, Technology, Engineering and Mathematics (Fig. 1).
- Make connections with other subject disciplines also.
- Include specifications for STEM lessons from Jolly's STEM Design Tool (Fig. 2).
- Try out the lesson before teaching it to you students.

Specifications for STEM lessons

1. Presents a real problem (an engineering challenge).
2. Students will relate to the problem.
3. Allows for multiple acceptable and creative solutions to the problem.
4. Integrate and apply important science and math grade-level content.
5. Uses the engineering design process as the approach to solve problems.
6. Uses a student-centred, hands-on teaching and learning approach.
7. Leads to the design and development of a technology or model or prototype.
8. The role of technology is clear to the students in the lesson.
9. Successfully engages students in purposeful teamwork.
10. Includes testing the solution, evaluating the results, and redesign.
11. Involves students in communicating their design and results.

Fig. 2. Specifications for STEM lessons (adapted from Jolly's STEM Design tool (Jolly 2017).

The W.H.E.R.E. Model

Vasquez, Comer & Villegas (2017) in their book entitled: *STEM Lesson Guideposts. Creating STEM Lessons for Your Curriculum*, introduce the W.H.E.R.E. model for planning STEM lessons and units, which I found to be very useful.

The W.H.E.R.E. model provides a framework for planning STEM units by identifying strategic guiding questions when planning STEM lessons.

STEM

Science • Technology • Engineering • Math

The model includes the following 5 key elements:

W: what and why: what needs to be learned and why?

H: How: how do you plan to get there? Experiences, activities etc.?

E: Evidence and Evaluation: what evidence of learning will be used and how will you evaluate the final product?

R: Rigor and relevance: How will you provide opportunities to increase the rigor of students' thinking and the relevance to studnets' experiences in the real world?

E: Excite, engage and explore: how do you engage and excite the children with the topic, developing cognitive understanding of key concepts and skills?

This STEM lesson Guidepost Planning Template can be used to record your ideas while brainstorming as you are planning and designing a STEM activity or unit of activities. Vasquez, Comer & Villegas (2017) recommend that you consider the template as a whole rather than just focusing in on one section at a time.

W: what and why: what needs to be learned and why?

W	WHAT are the desired results, including big ideas, content, knowledge and skills? *List the content and what the students will know and be able to do*	WHY would the students care about this knowledge and skills? *Write the driving question that will lead to the development of the integrated tasks that provide for the application of the content, knowledge and skills.* *List the essential questions that can be answered as a result of the learning.*

H: How: how do you plan to meet this goal?

H	HOW do I plan to meet this goal? *Identify the pathway, including major tasks and milestones that result in answering the driving question.*

E: Evidence and Evaluation: what evidence of learning will be used and how will you evaluate the final product?

E	EVIDENCE and EVALUATION: what evidence of learning will be used and how will you evaluate the final product? *PRE-ASSESSMENT: what prior knowledge is needed for this task?* *Identify the pre-requisite skills and understandings.*	FORMATIVE: how will I measure student progress toward understanding? *Establish the assessment tools you will use to monitor progress and inform instruction.*	SUMMATIVE: what criteria are needed for students to demonstrate understanding of the content and skills? Create a checklist of criteria for use in a rubric.

Egg Drop Challange - a classic STEM activity.

R: Rigor and relevance: How will you provide opportunities to increase the rigor of students' thinking and the relevance to studnets' experiences in the real world?

R	RIGOR: how can I increase student's cognitive thinking? *Identify tasks that can elevate student thinking, improve inquiry, and increase conceptual understanding.*	RELEVANCE: does the learning experience provide for relevant and real-world experiences? *Identify current topics and local issues that can make the tasks more engaging.*

E: Excite, engage and explore: what exploration activities will excite the students and engage them in STEM practices?

E	EXCITE: what is the hook to excite the learner? *Create the scenario to engage the learner.*	ENGAGE: how will the students be cognitively engaged throughout the lesson/unit? *List the STEM practices that will be used as evidence.*	EXPLORE: what activities will help students address the driving question? *List questions for students to investigate that will lead them to a deeper understanding of the content and skills.*

I would highly recommend Vasquez, Comer & Villegas' book where the authors describe and explain the 5 key elements of the W.H.E.R.E framework in detail. It also provides many different specific examples of STEM activities designed using the W.H.E.R.E framework. For example projects such as Engineering Hat, Wind Turbines etc.

I hope this article was useful to you if you are considering developing a more integrated approach to your science lessons. I finished my last article in Science with this comment and I will finish again with the following: '*it's ok to go slowly at first. Don't feel that you need to embrace STEM-mania too quickly. But when you do, you may wonder, 'why haven't I been teaching this way all along?'* (Vasque, 2015).

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STEMreach STEAM Project:

Plastics: The Good, The Bad & The Ugly

Dr Cordula Weiss, Calmast

Coordinated by Calmast, Waterford Institute of Technology's STEM Engagement Centre, with support from Creative Ireland (Waterford) and local artist Rachel Smith, primary and post-primary pupils from two all-girls schools in Waterford participated in a pilot STEMreach STEAM project. Together, the post-primary and primary pupils explored plastics and created an exceptional art exhibition that discusses plastic pollution, a very current subject that is making the news on a daily basis.

The post-primary students were challenged to research key issues such as microplastics, single-use plastics and single-use plastics ban, ocean clean-up, fossil fuels, sustainable resources biodegradability and more. They looked at the good, the bad and the ugly of plastics including environmental issues around the world and the measures in place or under development to recycle, reuse, reduce and replace plastics. Through an initial discussion with local environmentalists and scientists from Waterford Institute of Technology, post-primary students were encouraged to find out more about the topic. Working with experts in the area who could draw on personal experience regarding environmental issues and challenges inspired a curiosity in all things plastic in the students who then went on to process their findings and developed and delivered a lesson to primary pupils.

Wanting to share what they've learned with the general public, both groups together created an art installation (see photos) that visualised all aspects of plastics – the good, the bad and the ugly. They made colourful mosaics from single-use plastic toys and bottle tops, imaginative and thought-provoking messages written to a future generation and pieces that encourage the visitor to reflect on plastics in our environment. Posters and a short video presented the scientific facts and gave a glimpse into the pupils' efforts and works. The complete video is available on www.calmast.ie

The key concept of the STEMreach STEAM Project is peer learning. Learning from and with older peers is a very effective method to introduce pupils to new concepts. The post-primary students, acting as teachers, must first development an in-depth understanding of the topic and discuss ways to teach their younger peers. They are required to process their knowledge and make it accessible to pupils about five years their juniors. The teaching experience itself allows the post-primary students to gain more confidence in their own abilities, an important asset for girls in their teens. A significant change was observed in the post-primary students' attitude towards plastics and the environment with many students agreeing that it was the combination of art and science that "made issues easier to understand" and "give everyone an idea of what is happening".

	TY STUDENTS			PRIMARY PUPILS		
	Before [%]	After [%]	Change [%]	Before [%]	After [%]	Change [%]
Do you know much about the history of plastics?	0	54	+54	-	-	-
Do you know much about the science of plastics	0	38	+38	-	-	-
Do you know much about plastic waste management and recycling	0	31	+31	-	-	-
Do you know much about environmental issues caused by plastics?	23	69	+46	-	-	-
Do you know much about the alternatives that can be used instead of plastics?	0	38	+38	-	-	-
Do you know much about plastics?	-	-	-	15	32	+17
Do you know much about what plastic waste does to the environment?	-	-	-	26	58	+33
Do you know much about what plastic waste does to the ocean and the animals living in the ocean?	-	-	-	58	66	+8

Table 1. Post-primary students' and primary pupils' knowledge about plastics before and after the project.

The STEMreach STEAM Project on plastic further added to the environmental awareness of the primary pupils who developed a thorough understanding of the impact of our generation's actions on the environment. On completion of the STEMreach STEAM Project, the primary pupils knew a lot more about plastics and showed a very concerned attitude towards the environment.

	TY STUDENTS			PRIMARY PUPILS		
	Agree [%]	Disagree [%]	Don't know [%]	Agree [%]	Disagree [%]	Don't know [%]
All plastics should be banned.	16	46	23	47	19	32
We should reduce the amount of single-use plastics.	69	0	15	74	2	25
There should be heavy fines for littering.	46	0	38	83	9	8
Everyone should be aware of the problems plastics cause in the environment.	77	0	8	96	0	4
Fish could soon be extinct if we don't do something about this problem.	77	0	8	91	4	6
Microplastics can be eaten by fish and other animals.	54	0	31	79	2	19
I am willing to pay more for products packed in plastics.	15	54	15	28	47	25
People should be educated more about littering.	69	0	15	85	4	9

Table 2. Post-primary students' and primary pupils' attitude towards the environment after the project.

Through creativity the STEMreach STEM Project inspired curiosity in science and promoted a strong interest in the future of the environment and our planet. The participants' creativity developed over the course of the project and their imagination, ingenuity and insightfulness became obvious in the final product, the art installation, which attracted more than 500 visitors in only three days.

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About Calmast

Calmast is Waterford Institute of Technology's STEM Engagement Centre. Calmast was founded in 2003 and runs several festival and a myriad of activities in all areas of STEM. Calmast's events engaged more than 20,000 participants in 2018 in the region. The guiding spirit is "STEM for all" with particular efforts to ensure inclusion regardless of gender, socio-economic background, ability or location. In addition Maths Week Ireland was founded and is run by Calmast engages over 400,000 in Ireland and Northern Ireland annually.

About STEMreach

The Calmast STEMreach model is an effective way of engaging learners with all areas of STEM where younger pupils learn from and with their older peers. The programme started with a pilot programme in 2017, and due to its success, has now grown to include six different modules with several thousand students and pupils involved. The programme is coordinated by Calmast and is supported by local industry both financially and through volunteer mentors.

Pioneers of Science Education #6 James Dominic Burke:

Pioneer of technical education (1833-1904)

Dr. Peter E. Childs

In this series I will look at some of the pioneers of science education, either in terms of pedagogy, curriculum development or science education research. Some of them have an Irish connection, but all have had an influence on the teaching and learning of science in Ireland. In PoSE #1 we looked at Maria Edgeworth, who was a friend of Jane Marcet (PoSE #3), and in PoSE #2 at Richard Dawes, a pioneer of child-centred science in context. In PoSE #3 we looked at the life of Mrs Jane Marcet, one of the earliest popularisers of science, especially for women. PoSE #4 looked at J.M. Wilson, who served on a Royal Commission with Thomas Huxley (PoSE #5), who also promoted technical education as Br. James Dominic Burke, the subject of this article, did in Cork.

Introduction

The subject of this article is Br. James Dominic Burke (1833-1904), a science teacher in the North Monastery in Cork, who pioneered technical education in Ireland and elsewhere. He is probably not as well known internationally as our previous subjects, but we are indebted to Daniel Kelleher for his biography of Burke (Kelleher, 1988), our main source for Burke's life and work. However, you will look in vain in John Coolahan's book on Irish education in the section of technical education for any mention of Br. Burke and his work. Daniel Kelleher, himself a Christian Brother, has rescued Br. Burke from obscurity and given him back his rightful place in the history of Irish science education.

"*Even though the phrase 'guided discovery' appears over and over again in the literature of the 'new approaches' to science teaching, Br Dominic was championing the heuristic method, with modifications, during the latter part of the last [19th] century. Hidden away within the walls of the North Monastery in Cork, he was undoubtedly in the foremost ranks of Catholic teachers.*" (Kelleher, 1988, p.7)

His fame as an educator was widely known, even in America and on the Continent, as the appreciation below shows.

"*He must be considered one of the great educators of the nineteenth century, whose monastery schools in Cork were the wonder of all who visited them and in some ways were years ahead of similar institutions in England and on the continent.*"(Reville, 1916)

Br. Burke was born and worked at a time when Ireland was still part of Great Britain, although its education system was separate. Kelleher says (ibid, p. 37): "While England had Huxley and Armstrong, Ireland had James Dominic Burke who preached the value of science and practical education." Burke pioneered and promoted the heuristic method of teaching science in Ireland, now associated most with H.E. Armstrong (the subject of PoSE #7), a well-renowned English chemistry professor, in the second half of the 19th century. Br. Burke spent most of his teaching career at the North Monastery in Cork and he put the 'North Mon' (Figure 1) on the map as a centre of educational innovation in the late nineteenth and early twentieth century.

Education and early years

Dominic Burke was born in 1833 in Limerick city to John Burke, a cabinet maker, and Mary (née Ahern), but the family moved shortly afterwards to Newmarket-on-Fergus, in Co. Clare, where his father worked as a carpenter on Dromoland Castle. Dominic was educated at the CBS School in Sexton Street, Limerick. He left school at 15 and was apprenticed as a cabinet maker. Due to pain in his right arm he switched to bookbinding, which fostered his love for books. This is reminiscent of the young Michael Faraday, who was also apprenticed to a bookbinder and used the opportunity to read avidly. In 1852 he entered the Christian Brothers at age 18 ½, first in Waterford and then in September he was transferred to the North Monastery, Cork, where he spent most of his working life, except for a period 1890-96 when he worked in Dublin. He was trained on the job as a teacher and was widely read in mathematics, science, history and theology. Br Burke continued to read and study throughout his life, and this was probably the cause of his eye problems, which eventually left him sight in with only one eye.

Figure 1: Photograph of North Mon, 1919 from 'Cork: Its Trade and Commerce', showing the Gerald Griffin schools on the left and the Burke memorial Schools in the centre. (Source: Cork City Library)

The photo in Figure 2 shows him dressed in his usual clerical robe and everyone he met commented on his pleasant manner.

A more characteristic pose shows him (Figure 3) in his laboratory, surrounded by scientific apparatus, but reading a book.

Figure 2: Br. Dominic Burke

Career as a teacher at the North Mon

"*The Christian Brothers opened their Cork school in 1811. The system of secondary education was introduced in 1879. All secondary schools were fitted with fully-equipped laboratories for the teaching of science, and special workshops for manual instruction.*

However, the North Monastery pioneered science instruction early in the second half of the nineteenth century. In 1852, Br James Dominic Burke arrived at the North Monastery and under his guidance the students began the study of natural philosophy (science).

Br Burke is widely acknowledged as the father of vocational education in Ireland and made the 'Mon' a centre of excellence in scientific and technical education.

At this time, Br John P Holland, (inventor of the submarine) studied in the Mon under the guidance of Br Burke. Brother Burke established an industrial museum, bringing together materials for nature study, collecting scientific instruments, acquiring manual and mechanical equipment, and gradually building up a laboratory, all tending towards a fully-equipped Day Trades Preparatory School." (McCarthy, 2017)

Br. Burke joined the North Monastery schools in 1852 and apart from the period 1890-96, when he worked in the CB headquarters in Dublin, he remained at the school in Cork, celebrating his golden jubilee in 1902.

"*From the beginning [in Cork] he threw himself into the work of the schools with characteristic devotedness and energy. Being endowed with fine and varied talents, and being of studious habits, he quickly acquired an extensive and precise knowledge of many subjects, while his ardour in study was not greater than his desire to impart information to others. His interest embraced old and young. To diffuse knowledge among the men of the city he organised Sunday lectures on scientific subjects, and his popular treatment of these subjects created so much interest in his lectures that the spacious rooms of the North Monastery Schools were filled with men or varying ages eager to learn from so able a master. On these occasions he sometimes entertained his audience with experiments, showing many of the processes involved in the manufacture and preparation of things used in everyday life. On week days he was busy with his boys in the science rooms and laboratories, which he had furnished with all apparatus required for a complete and thorough instruction in practical physics and chemistry. To these laboratories he added rooms for metal-work and manual instruction in wood-work.*" (Christian Brother, 1926, p. 508)

The classes in his day were enormous: anything from 120 to 80 boys, presenting an educational challenge as well as disciplinary one. However, Br Burke was notable in his day for not using corporal punishment in his classes.

Br Burke's practical, hands-on approach to teaching also extended to other subjects outside science and technology, for example, music education.

"At the same time [1878], the influential Christian Brothers secondary school, the North Monastery, began 'pioneering work in music education.' Under the tutelage of Brother Dominic Burke, students learned singing and attended a formal music class. Burke promoted the tonic sol-fa method of sight singing (rather than reading sheet music), converting a number of Thomas Moore's Irish Melodies to tonic notation. The school was popular among Cork's ambitious working-class families, thus making music familiar and accessible to the emerging population of city residents." (Lane and Murphy, 2016, 28)

Displaying science and technology

"Another means he adopted for communicating information to the boys of the school and the adult population of the city was a well-furnished museum, into which he had collected an extraordinary number of specimens of minerals, birds, animals, and fabrics of various descriptions in their different stages of manufacture. On Sundays it was usual to see groups of men moving around the class-rooms observing closely these objects, which were displayed and classified in beautifully-designed glass-cases and discussing their origin, production, and uses." (Christian Brother, 1926, p. 508)

Table 1 Timeline of Br Burke's life

1833	Born in Limerick
1852	Entered the Christian Brothers in Waterford. Transferred to the North Monastery Cork on 10/9/1852
1878	Director of the North Monastery School
1889	Science exhibition organised by the CBS
1902-3	Cork Exhibition
1904	Died in Cork
1913	The Brother Burke Memorial Extension opened

Figure 3: Brother James Dominic Burke in the Science Laboratory of the North Monastery.
Image source: *North Mon 200: Comóradh 200 bliain na Mainistreach Thuaidh.*

One of the unusual and innovative aspects of Br. Burke's teaching of science and technical subjects was the formation of a museum of objects, spread through the school in laboratories, corridors and classrooms. These were an integral part of his teaching in connecting the theory with practice, the ideas with their application. The museum was not a random collection of objects, like the popular cabinets of curiosities of his day, but they were displayed and organised with an educational intention. Many manufacturers across Great Britain sent him samples of their products and raw materials.

Figures 3 and 5 give an impression of the density of equipment collected by Br. Burke in his laboratory and evidently this was true throughout the school in his museum.

He took science outside the classroom also by giving lectures in Cork at the Literary and Philosophical Society and later at the Scientific Association. He participated actively, together with his students, in the 1883 and 1902/3 exhibitions in Cork, the first being run in order to raise funds for the CB schools. He also sent exhibits to the 1904 World's Fair in St. Louis, USA.

An international reputation

"*His ability and capacity to give a lead in education were recognised by the best thinkers and workers in the same field, hence his advice and opinions were sought and valued.*"

Christian Brother, 1926, p. 509

In the late nineteenth century many people went to Cork to see the North Monastery Schools and the work of Br. Burke, and if anything, this increased after his untimely death. He was called to give evidence to various Commissions, whose commissioners came to Cork to visit the schools and see his work first-hand. Kelleher writes (ibid, p. 9):

"*Br Burke was able to overcome these hardships by the magnetism of his personality which attracted the non-Catholic no less than the Catholic, and towards the end of his life his school and methods of teaching were referred to in the House of Commons [in London] as an ideal system for his time. Educationalists and politicians from Great Britain, Europe, America and beyond began to arrive and admire his projects. His school was seen as a model which the technical system of education could emulate.*"

One thing that is frequently said about Br Burke and his achievements (see summary below), is that he was ahead of his time. A CB commentator in 1915 said:

"*He was a hundred years ahead of his time, and sixty years ago he introduced art, science, and technical training to the classrooms, when their meaning was hardly known in other schools and colleges in the country. His name is so inseparably connected with the North Monastery that one cannot be mentioned without the other.*" (CB, 1915)

Technical innovator

Br. Burke mentored the young John Holland, who worked in the North Monastery from 1858 to 1861, although later he left the CB order and moved to America. There he developed the first successful submarine. While in Cork Holland learned about using electric motors for propulsion and it is said tried out model submarines, helped by Br. Burke. In 1877 Br. Burke used a battery of 120 Callan cells to power a searchlight which lit up Cork.

"*Cork was ablaze with illuminations... to celebrate the Jubilee of the reigning Pontiff, Pius IX. The North Monastery, on its commanding site, presented a brilliant appearance, and people gazed in wonder at the great beam of white light which brightened up the hills far away across the Lee. Brother Burke had fitted up a battery of 120 Callan cells, connected with a great electric [arc] lamp.*" (Anon, 1916)

He invented a chemical bench, which was later marketed successfully by Philip Harris and Co., the English laboratory suppler. In 1889 Br. Burke organised a Grand Drawing and Bazaar in the Corn Exchange to raise funds for the schools. At this he built and displayed an electric tramway, nine years before the Cork public tramways were opened.

Main educational achievements

Br. Burke and the North Mon worked with working class boys, who otherwise would not have had an education. They gave them one of the best educations available at that time in Ireland. The North Mon regularly came top of the Intermediate Examination (introduced in 1878), even though the examination emphasised a liberal arts-based, classical view of education rather than one based on science and technology. Here are some of Br. Burke's main educational achievements:

- Introduced an emphasis on science and technology into Irish elementary and secondary education, especially in the Christian Brothers' schools.
- Pioneered the use of a museum of everyday objects as part of the teaching strategy to show the relevance of science and technology.
- Connected the world of education with that of work with his emphasis on fitting boys for their future workplace and giving them useful knowledge and skills.
- Introduced the use of object lessons with junior classes.
- Encouraged a hands-on, experimental approach to science teaching even with large classes.
- Trained boys to be able to give public presentations of their work at open days and in public exhibitions, usually without any direct supervision.
- Made science and technology available to working men through his Sunday lectures and exhibitions, thus pioneering life-long learning.

Br. Burke's legacy

"*Through the helps for education introduced by Br. Burke, and the splendid organisation and methods of teaching he fostered, the North Monastery Schools took and held a leading place among the great secondary schools of the country. In these schools the highest literary education was enhanced by thorough teaching in practical science, technical instruction and manual training.*" (Christian Brother, 1926, p. 509)

One test of a person's influence and impact is what survives of their work after their death. In 1913 the Burke Memorial School Extension was opened (Figure 4a and b). In 1908 the school sold it off to Cork City Council and it is now a music school. The museum that was the envy of the educational world has also gone, although some of its exhibits remain. In 1914 the British army removed the metalworking equipment for the war effort and closed the radio room. Does anything remain as a legacy to Br. Burke's pioneering work? The North Mon has continued to have a strong science and technology tradition, now referred to as STEM, and is in the process of building new laboratories and workshops (see below).

Figure 4.a: Burke Memorial School Extension

Figure 4.b The plaque on the Science School

"*His ability and capacity to give a lead in education were recognised by the best thinkers and workers in the same field, hence his advice and opinions were sought and valued.*"(Christian Brother, 1926, p. 509)

Figure 5: Br Burke (centre) in the old science lab, surrounded by equipment and apparatus (Photo: North Mon)

In 1903 we have a contemporary description of the CBS in Cork, just before Br. Burke's death. It is interesting to compare that with today.

"*As now completed, the Christian Brother's Schools at the North Monastery furnish accommodation to fifteen hundred pupils. The education provided extends from the primary stages through all grades of the Intermediate. All the students receive technical instruction – school museums and natural science objects being provided for the very young, and manual workshop practice and scientific laboratory work for the older. Drawing is universal for all ages. There is also a school garden in which a number of agricultural students look after their individual plots, and the ground are extensively planted with specimens of trees and shrubs, both indigenous and foreign. It is no exaggeration to say that the whole of this achievement is due to the personal effort of Br. Burke, who, therefore, stands out in Ireland as the grand pioneer of technical education.*" (Comerton, 1903, 122)

In 1919 a book was published on Cork, past and present and it gave this assessment of Br burke's legacy, 15 years after his death.

"*..Corkmen early took the lead in inaugurating a scheme of instruction in applied science for schools. The movement was started early in the second half of the nineteenth century by the late Brother Burke of the Christian Brothers' Schools, Cork, who realised the importance of practical demonstration in all his teaching, but especially in that of Science in which he was much interested. Observing the success of the application of the principle, and foreseeing its great possibilities, we find him organising- an Industrial Museum, bringing together materials for Nature Study, collecting Scientific Instruments, acquiring Manual and Mechanical Equipment, and gradually building up a Laboratory, all tending towards a fully-equipped Day Trades Preparatory School—an ideal which was practically realized before his death.*" (Coakley, 1919, p. 117)

The STEM legacy in the North Mon

Figure 6 above shows one of the new science laboratories at the North Mon, quite different from those pioneering labs in Br Burke's day (Figure 5). The current position of STEM in the school is described below.

"*Since Br Burke's untimely death the proud tradition of STEM subjects being taught in the North Mon has continued. The school has only recently installed 3 new state-of-the art labs. Technical subjects such as woodwork, metalwork and technical drawing are still very popular. Some of the items from the now demolished school museum are still displayed proudly around the school. The students of the "The Mon" still come from a largely working-class background and continue to still rise to new heights, with the school's Young Scientist programme achieving constant success in both the annual BT Young Scientist Awards and SciFest. Music is still going strong in the Mon and the school now puts on musicals and Christmas shows annually. Br Dominic having been so well read in History, he would also no doubt be very proud of the school's new History Club. This attempts to emulate the example set by Br Burke by allowing the boys some hands-on experience in historical research and critical thinking, this too has produced some good results for the school; the club having been successful in attaining prizes in the local Heritage Awards and the National Thomas Meagher Foundation Awards Programme. The school has also strived to achieve excellence in other areas with the green schools committee now looking to achieve their 3rd Green Flag and the Diversity Committee having been successful in the Mon's renewal of our Yellow Flag. This is perhaps made even more impressive by the fact that the school is the only secondary school in Cork County with a Yellow Flag. History continues to be made in the school with Mrs O'Sullivan being the first female principal in the school's history.*" (Ryan, 2019)

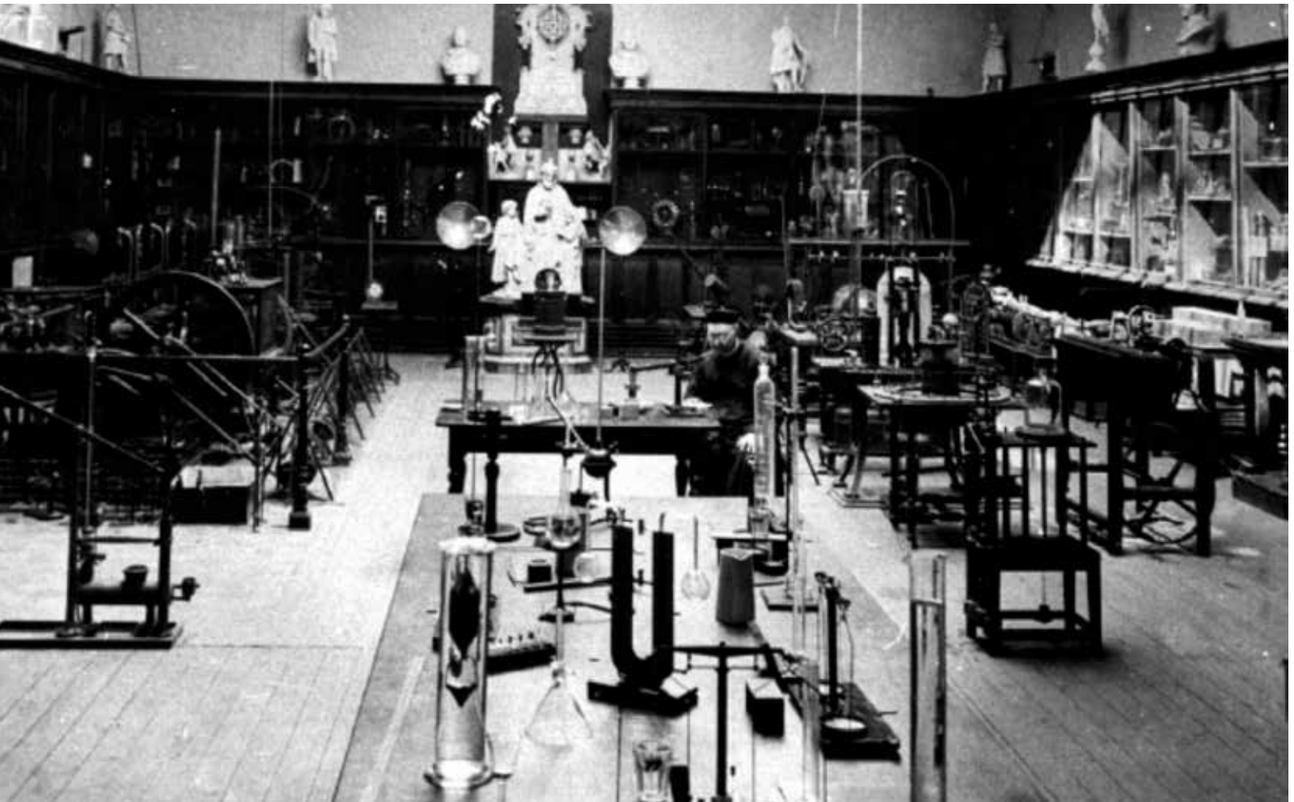

Figure 5: Br Burke (centre) in the old science lab, surrounded by equipment and apparatus (Photo: North Mon)

Figure 6: one of the new science laboratories at the North Mon (Photo: S. Ryan)

Conclusion

Br Burke's death at the age of 71 was a tragic accident, probably due to his poor eyesight, and he was still active and with his full mental ability. In his last public lecture, given in October 1903 as the incoming President of the Cork Scientific Association, he described his philosophy of science teaching through nature study. (Irish Examiner,1903), in which we clearly see his hands-on, inquiry-based approach to teaching science.

"*Now, however, it was proposed to make nature-study a branch of general education for all classes of pupils, and hence to have it become an important factor in school life and to find its place, and an honoured place, in the curriculum of each school, whether primary, continuation, secondary or technical. They were not faddists who advocated nature-study today. They were sober-minded, practical and eminent educationists; and they urged its claim from a deep and full consideration of its merits as a mind developer, and character-forming agent. ... nature study, as now understood, embraced the elements of the various physical and natural sciences, physics, chemistry, astronomy, geology, botany, zoology, and meteorology. .. The children and youthful students were introduced to them gradually, but surely, by the method of observation; classification follows; and finally deductions were made on the basis of these observations. Cultivation of the observing faculty was the paramount result expected to follow from nature-study. It was simply surprising how undeveloped that faculty of observing was in most people. That 'we have eyes and see not' was literally true of young and old. Hence, in nature-study more could be learned by outdoor than by indoor work. First-hand knowledge was best. The real object must be placed before the class – the living thing itself, if possible – bird, insect or plant.*"

Probably everyone had heard of the other names in this series of Pioneers of Science Education, but almost nobody has heard of Br. Burke, even in Ireland, although this would not have been true at the end of the 19th century and start of the 20th century. His accidental death in 1904 cut short a productive life and during his career he transformed the North Monastery schools into an educational powerhouse, despite its intake of poor, underprivileged boys. He is worthy to be remembered and celebrated as a pioneer of STEM education in Ireland, who raised the profile, value and reputation of manual work and the importance of a curriculum tailored to the needs of its recipients.

"*For him education was meant to actualise innate potentiality in the individual so as to produce a balanced integrated adult person. It was his basic belief that an education grounded on the practical could achieve this goal just as effectively as the prevailing idea that an 'educated' adult had to be the product of the bookish classical school. He intellectualised arts and crafts.*" (Kelleher, p. 216)

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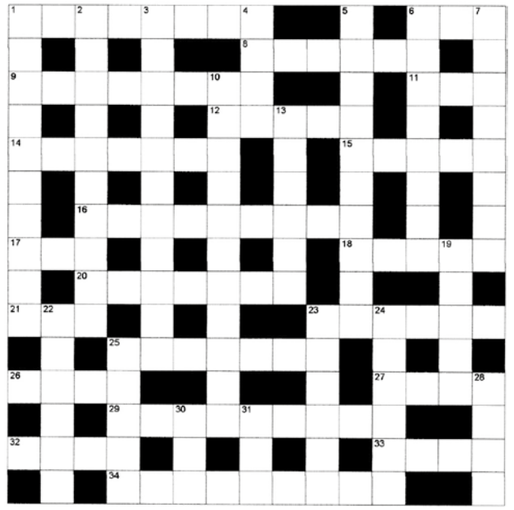
Crossword

Randal Henly

SCIENCE CROSSWORD 83



Clues Across

1. A quantity of motion, given by the product of its mass and velocity (8)
6. In short, it's the unit in which masses of atoms are expressed (3)
8. Large aircraft manufactured in Toulouse; many operated by Aer Lingus (6)
9. The large brown seeds of tropical palms (8)
11. It could be blue, coal or tom (3)
12. The terse product of an acid reacting with an alcohol (5)
14. American marsupial with a rat-like prehensile tail (7)
15. The rotating part of an electric motor (5)
16. Medieval scientist (9)
17. Flammable product of the distillation of coal (3)
18. By which name the noble gases were formerly described (5)
20. Strengthens metal by heating and then by slow cooling (7)
21. The colour of Mars (3)
23. Common garden molluscs (7)
25. The tidal mouth of a river (7)
26. 1×10^9 (4)
27. Plant of the mallow family consisting of potassium in ora (4)
29. Apparatus for producing gas, steam or electricity (9)
32. Part of a solenoid (4)
33. It's either computer software or the emperor who fiddled while Rome burned (4)
34. The outer layer of cells covering an organism or the outer layer of plant tissue (9)

Clues Down

1. This type of screw is a measurer of very small diameters (10)
2. A unit of electrical capacitance (10)
3. Very short periods of time (11)
4. Its SI unit is the kilogram (4)
5. Biological characteristic that departs from the norm, or the apparent displacement of a celestial object from its true position (10)
6. Halogen element (8)
7. A force exerted on an object in a fluid (8)
10. Its SI unit is the kelvin (11)
13. Antigenic poisons of plant or animal origin (6)
19. A governing distance measurer (5)
22. Thomas Alva, renowned American inventor (6)
23. A set of connected parts working together as a whole (6)
24. From little ones grow mighty oaks (6)
25. Bird of prey (5)
28. Particle of matter (4)
30. Sodium iodide (3)
31. A Shannon lake (3)

€20 Prize

First ISTA member drawn from correct emails entries received by March 31st will win €20.
Send your answer to: snjnfogarty@gmail.com via your ISTA registered email address.

Winner - November 2018

Well done to Mr Declan Finlayson, Kilkenny - who was first in with the correct solution (below) to the crossword in the last Novembers issue of Science.

Continued from page 1.

no more except to recommend that you read this excellently researched piece.

I must say a special welcome back to long time contributor Mr Ian McCulloch whose 'musings' have, over the years, raised many an interesting point on various topics of interest to science teachers. One point in this instalment of Ian's musings that I definitely agree with is the effect the increasingly demanding administrative chores being visited upon teachers is having on their willingness and ability to volunteer for events like the ISTA Science Quiz. I can only hope that Ian will not have too many demands on his time to prevent him from continuing to write his musings for us.

As always I must thank all our regular contributors and apologise to some if their articles have not yet appeared, they will in the next issue and please continue to send on material. If you have never written for the journal but would like to please feel free to send any material you have to me a snjnfogarty@gmail.com.

An area I know I do not adequitely mention as an employment option as much as I should to my students is the area of horticulture. Reading Dr Dorothy Hayden's piece on the 'Plant Power event' held at the National Botanic Gardens for Science Week 2018 opened my eyes to the vast range of work being carried out in this field and the opportunities for students to go into this field. Information on upcoming open days and courses offered is included along with the article.

Finally, thanks to Mary Mullaghy for supplying all the news and diary items and to Rory Geoghegan for supplying the AGM programme.

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