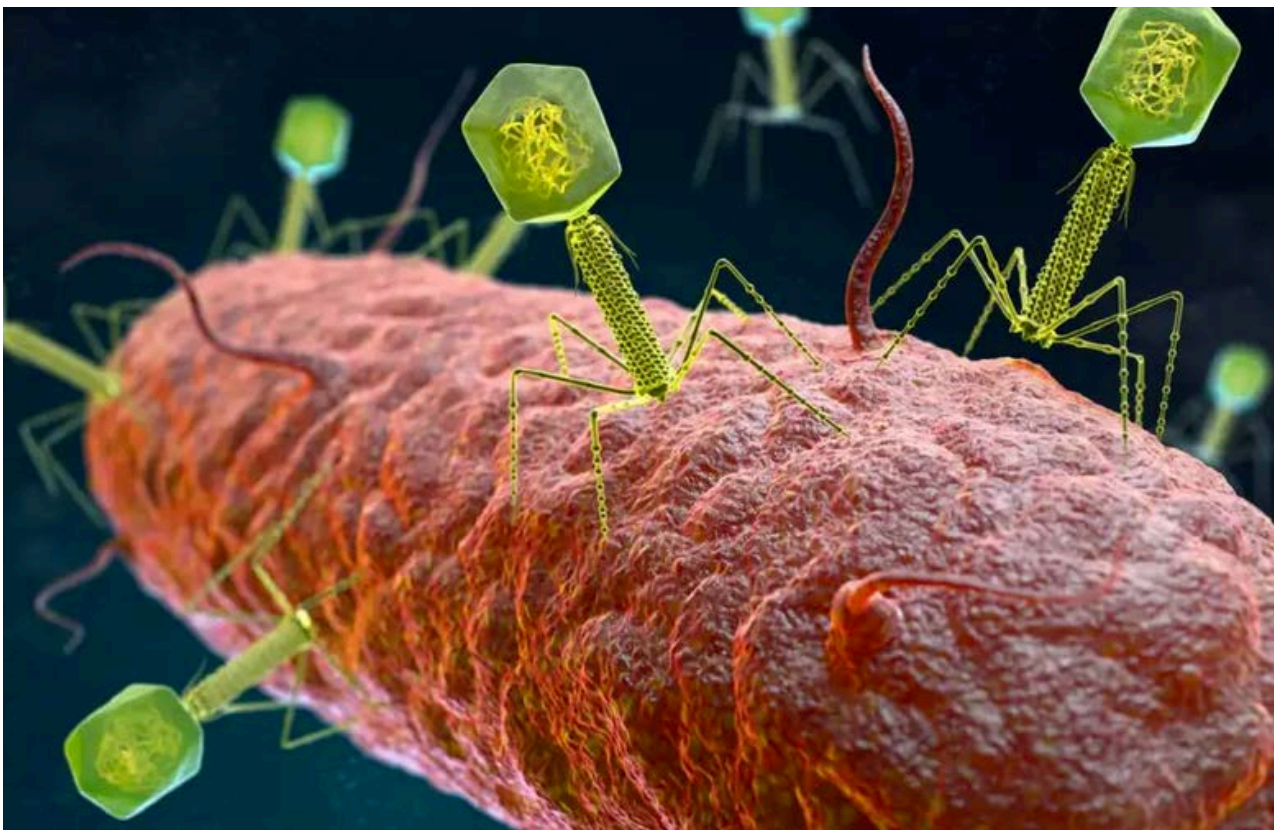


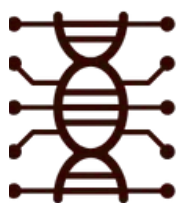


# BRI Journal

A fascinating dive into the research carried out by students in the Baltic Research Institute at Liverpool Life Sciences UTC



In this edition, read about the potential of bacteriophage viruses in the fight against AMR and an affordable bionic arm concept designed and developed by one of our students.



**BRI**

Liverpool  
Life Sciences UTC

THE **STUDIO**

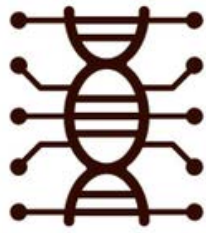
Baltic Research Institute



15th July 2024

Volume 2

Issue No.1



# BRI

# Journal

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*This journal is written and edited by pre-university level students in the Baltic Research Institute (BRI) based at Liverpool Life Sciences UTC and The Studio School Liverpool.*

*For full articles, references and source information, please visit the website using the QR Code or link provided.*

*<https://sites.google.com/lifesciencesutc.net/balticresearchinstitute/journal>*

# Foreword

## from the editorial team



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 Article Writer



**Wiktorija Jasinska**  
**Editorial Director**  
 Article Writer  
 Reviewer



**Elliott Heap**  
**Editor**  
 Reviewer

We are delighted to bring you this exciting new edition of the Baltic Research Journal. The journal showcases the exceptional research conducted by students in the Baltic Research Institute at Liverpool Life Sciences UTC and The Studio School Liverpool. All of the original research reported here is carried out by students aged 13-19 and peer-reviewed by sixth form students who are part of the editorial team.

This edition features fascinating research from students who completed their extended projects (EPQ) at either Liverpool Life Sciences UTC or The Studio School Liverpool. They selected their topics, conducted their own background research, analysed their data and reached

their own conclusions. These extended projects can take the form of investigations, literature reviews or original artefacts.

Our aim is to give students the opportunity to showcase their incredible research and to make sure they have the opportunity to reach an audience beyond the walls of our schools. We welcome constructive feedback and are always looking for new opportunities to collaborate.

We hope you enjoy reading this edition of the Baltic Research Journal as much as we have enjoyed producing it.

Thank you for taking the time to read about our research.



**Rahima Mohamed**  
 Reviewer / Editor



**Affeynaya Raveenthirarajah**  
 Reviewer / Editor



**Pawel Dobrzanski**  
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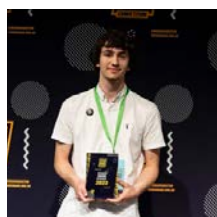
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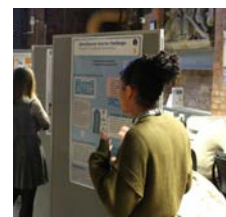
**Ryan Parry**  
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**Erin Rhead**  
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**Tania Benham**  
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**Giada Gozzelino**  
 Research Contributor

# Featured Industry Project

## AstraZeneca Vaccine Challenge

This year we collaborated with AstraZeneca to set the students a challenge consisting of designing a vaccine for a fictional viral threat.

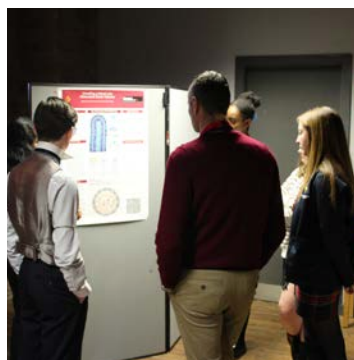
The COVID-19 pandemic highlighted the importance of Scientific research and the pharmaceutical sector in saving lives, preventing serious disease and allowing society to emerge from lockdowns. One of the biggest scientific achievements in recent years achievements has been the rate at which a range of effective vaccines were developed, tested and approved for human use. This challenge aimed to get students thinking about how vaccines are developed and what stages a vaccine would have to pass through before being approved for widespread use.

Students were tasked by staff at AstraZeneca in Speke to design a vaccine strategy to deal with a fictional emerging viral threat. The challenge aimed to develop an understanding of the vaccine development process and give students the chance to apply this knowledge to design an effective vaccine strategy from antigen selection through to clinical testing and distribution.

Over 20 students from the Baltic Research Institute took part in the project which started in October 2023 with a series of masterclasses delivered by staff from AstraZeneca, including:

- Introduction to Live Attenuated Influenza Vaccine Development.
- AstraZeneca and the COVID Pandemic
- An Introduction to UK Apprenticeships.

Students then had several weeks to research and develop their vaccine strategy before presenting back to 6 visitors from AstraZeneca at a mini-conference event. The winning student, Giada gained a week of work experience at AstraZeneca including spending time with the vaccine team. 11 more students have also competed work experience placements with AZ. On the final day I was lucky enough to be invited in to watch the student present to Senior Leaders at AstraZeneca Speke about their experiences on placement. An excellent end to a great project.



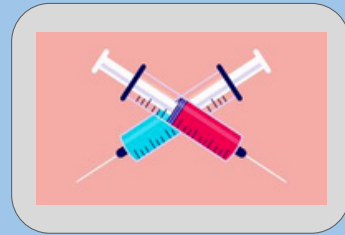
See Giada's excellent vaccine development academic poster in full on the next page...

# AstraZeneca Vaccine Challenge-

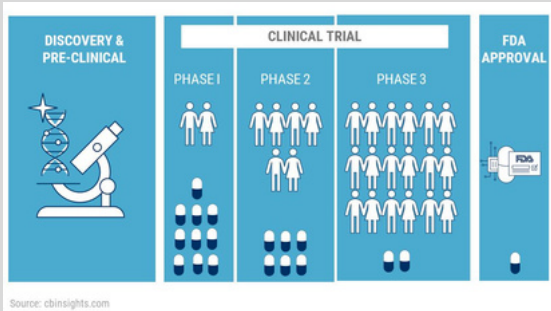
## The path to an airborne Ebola Vaccine



Giada Coimbra Gozzelino  
Liverpool Life Sciences UTC



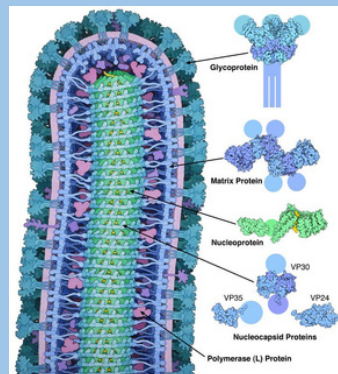
### pre-clinical trials and clinical trials



The purpose of this project is to create a sufficient vaccine for a airborne Ebola variant. I completed this by going through each step of creating a vaccine and then chose what would be included in my vaccine very carefully.

### The process

Pre clinical testing- Chosen animal- large animal models (pigs) they are similar size to humans so would be good predictive models. Clinical trials- We would perform the usual clinical trials with our new vaccine against a placebo ;this helps us learn if the vaccine works better than current treatment.(4)



### Antigen selection

One antigen that stuck out to me was the glycoprotein, this protein is essential for the virus attaching to the cell and the catalyst of membrane fusion. With producing a sufficient vaccine we can prevent the virus even entering the cell in the first place. (1)

### Vaccine formulation

The chosen adjuvant to add to the vaccine was Aluminium salts. However, a downside to this is this adjuvant induces injection site pain and tenderness; though most vaccines do and what's most important is how well it protects. (3)

### Vaccine technology

I chose the recombinant subunit vaccine. It had some promises to provide a long-lasting immune response. In case people would need multiple doses i'll add a strong adjuvant to allow it to elicit a protective immune response.(2)

### References:

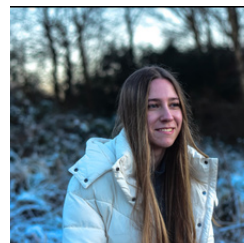
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## Featured Event

# The Business of Science Conference - Salford 2024



*BoS 2024 at University of Salford*



Editor: Wiktorja

On the 22nd of May I had the honour to attend the business of Science conference which was hosted by the University of Salford which is located near the city centre of Manchester and specialises in subjects such as engineering and mathematics. Since 2016, the Business of Science Conference has united top minds from the science and innovation sectors for a day of exchanging insights and forging connections. The event attracts business leaders, industrialists, academics, and policymakers who explore contemporary opportunities and challenges in the field. It also fosters future innovation by connecting industry professionals with school students. The 2024 agenda included discussions on AI, climate solutions, space tech, and health advancements and concluded with an awards ceremony that honours ambitious students aspiring to be future leaders in the business of science.

The first talk our group attended at the conference was focused on Net Zero, a crucial concept in the fight against climate change. Net Zero aims to balance the amount of greenhouse gases emitted into the atmosphere with the amount removed from it, serving as a key objective in limiting global temperature rise. During the discussion, the issue of greenwashing was highlighted. Greenwashing occurs when companies falsely

portray themselves as environmentally friendly without taking meaningful actions to protect the environment. The panel emphasised that the priority should be on carbon prevention rather than carbon offsetting.

Midway through the talk, a lively yet civil debate erupted between the panel and attendees on the use of hydrogen for energy. This segment was particularly memorable, showcasing the intelligence and articulate nature of the participants. A consensus emerged that one of the main barriers to achieving Net Zero is the lack of effective government initiatives. Interestingly, as we exited the conference, news of an upcoming general election broke, sparking hope for potential policy changes in the future.

Following the engaging talk, we transitioned to our lunch break—a prime opportunity for networking. During this time, attendees explored students' projects, engaged in discussions, and voted for the most impressive entry. One key takeaway from this session was the importance of LinkedIn for professional networking. It became evident that having a LinkedIn profile is essential, as participants frequently exchanged their profiles to connect and explore business opportunities.

Our team submitted two innovative projects to the contest: a self-charging phone and a project named VPRESNCE. The self-charging phone aims to "innovate a fresh method for generating electricity," enhancing sustainability in mobile technology. VPRESNCE utilises a virtual reality headset to enable users to control a robot remotely, facilitating virtual visits to places like hospitals, allowing people to see relatives and friends. Both projects are detailed at the end of this article. Continue reading to view the winner.

During the final sessions of the conference, younger attendees took the lead, with a significant focus on students. One notable student-led talk delved into the diverse lives and careers of the panellists. Despite their varied backgrounds, each panellist was united by a shared passion for pursuing what they loved. Their stories were truly inspirational, showcasing remarkable achievements such as becoming a homeowner at 21 or completing A-levels in just three months. This session highlighted the value of exploring apprenticeships and degree apprenticeships, emphasising that there are multiple pathways to success beyond traditional routes.

The concluding talk addressed the importance of inclusivity in the workplace and strategies to achieve it. As the workforce ages, a significant challenge has emerged: the older employees are not being replaced at the same rate, particularly in fields like engineering. This has led to significant age gaps, often around 30 years, creating social barriers within teams. The seminar underscored the necessity of overcoming these barriers, even if it means actively encouraging communication and interaction between different age groups.

The day culminated in an exciting announcement: congratulations to Deva, Imran and Elkhatim for their innovative idea of a self-charging phone. The team was awarded a trophy and £1000. This moment marked a fitting end to a day filled with inspiration, learning, and forward-thinking ideas.



*Innovation Prize - Poster Competition*



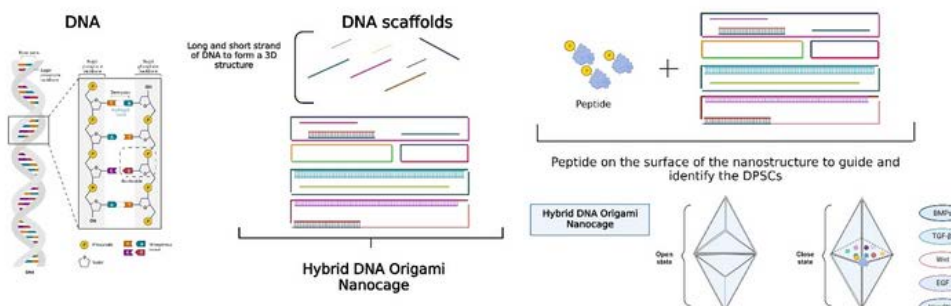
*Deva, Imran & Elkhatim win the Innovation Award and £1000 for their project.*

# Young Researcher of the Year

## Selma El Benni



Selma El Benni



Selma joined Liverpool Life Sciences UTC as a year 12 student in 2022. It quickly became apparent that she has a real passion for research and innovation during our Project Based Learning sessions. Selma combined her interest in dentistry with her passion for research and innovation and developed her idea of a “nano-robot dentist” which uses cutting edge research in DNA nanotechnology to deliver molecules which stimulate enamel regeneration in damaged teeth.

Since joining us Selma has been awarded “Young Researcher of the Year” by the Institute for Research In Schools (IRIS) at an awards ceremony at the Francis Crick Institute in London. She also won the “Innovation Award” at the Business of Science Conference 2023 and has an offer to study Dentistry in Paris. What a year it has been for this amazing young researcher.

Selma first became aware of DNA nanotechnology through taking part in an IRIS project called DNA Origami. This project introduces students to recent research developments in the exciting field of DNA origami before getting the students to research and design their own DNA nanostructures using specialist CAD software. Selma decided to apply this technology to the field of dentistry and started to develop her nano-robot dentist concept. Selma became so interested in this idea that she continued to

research and develop her concept for the extended project qualification (EPQ).

This is an incredibly ambitious project which has required outstanding skill development across a wide range of technical and transferable skills. Selma has undertaken extensive scientific research using mostly peer-reviewed sources. She has researched stem cells, molecular biology, DNA nanotechnology and dentistry and dental technology in order to produce a very thorough and well considered design and strategy to use DNA nanotechnology to help regenerate tooth enamel. Alongside an excellent research report she has developed her own DNA nanostructure and used separate software (CanDo) to analyse the stability of her DNA nanostructure. She also built a very professional looking website for her project.

For her project presentation, Selma invited Dr Andrew Lee, the Head of the Bragg Institute for Materials Research at the University of Leeds and Dr Neil Garrido, Regional School Engagement Lead at IRIS to attend. Both were amazed by the quality of her project work and by the way she communicated her research.

Congratulations Selma on a fantastic two years at the Baltic Research Institute. It has been a pleasure working with you and we look forward to hearing about future research.



## Featured Young Innovator

# Mika Kazassoglou



Mika Kazassoglou



Mika, is a dedicated student with an unwavering passion for the physical sciences, who has carved a remarkable path toward becoming an exceptional engineer. His journey is a testament to the power of interdisciplinary learning and industry collaboration, at our schools.

During his time in the studio school and the Baltic Research Institute Mika has demonstrated an academic prowess which shines through his mastery of mathematics, physics, and engineering. He seamlessly integrates these disciplines, creating a solid foundation for his future endeavours. His holistic approach ensures that he not only excels in theoretical knowledge but also understands the practical applications of scientific principles.

Mika's has also demonstrated an amazing ability to learn directly from industry giants. Companies like Vinci, the Manufacturing Technology Centre (MTC), Surface Transforms, and Autodesk have been his mentors. Through internships, workshops, and collaborative projects, he has absorbed real-world insights, gaining a deeper understanding of engineering practices beyond textbooks.

Mika's crowning achievement in his time here has been the sustainable and innovative housing scheme he conceptualized and brought to life for his Extended Project (EPQ).

Located in the scenic Festival Gardens, this project seamlessly blends environmental consciousness with modern living. His engineering prowess shines as he tackles challenges related to energy efficiency, materials, and community well-being.

Mika used a range of industry-standard software to realise his project, including:

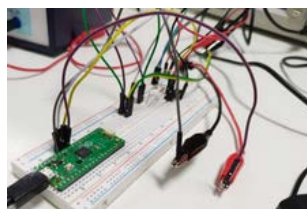
- AutoCAD: Precision design and drafting.
- Fusion: 3D modeling and prototyping.
- Revit: Building information modeling (BIM).
- Autodesk CFD: Fluid dynamics simulations.

The seamless integration of these tools allows Mika to create robust, functional designs.

Mika isn't just about technical prowess; he's an eloquent communicator. His ability to convey complex ideas to diverse audiences sets him apart. He has been selected as a keynote speaker at Autodesk University in San Diego, where he will share his journey, insights, and passion for engineering with fellow learners. Mika's story exemplifies the synergy between education, industry exposure, and creativity. He's not just an engineer; he's a visionary shaping a sustainable future.

**Dan Howard, Employer Engagement Lead**

## Designing and developing the electronics for a myoelectrically controlled bionic upper limb prosthetics using affordable off the shelf components.



Harvey Harwood

Prosthetics are extremely expensive and are often inaccessible for amputees and those living with congenital limb deficiencies. Here in the UK, we are lucky enough that the NHS will provide these prostheses to patients. However, everywhere in the world, including the UK, bionics are so much more expensive that they are inaccessible to almost everyone. Due to the expense, the NHS cannot afford to provide these.



The following article describes how a previous student proved that bionic prosthetics could actually be cheaper by using different components. Before I finished reading the original EPQ, which can be read using the QR code, I stopped to ask about Harvey as he was an exceptional student. There was nothing except high praise about him. He is currently studying chemistry in Liverpool university. The following information has been extracted only from his EPQ. Before this I was not familiar with the topic and he expertly explained the theory behind it and the practical work.

Harvey used a method called electromyography which is a technique that measures the electrical activity in muscles, which provides data that he could use to drive the motor in a prosthetic. In this project he proved cheaper alternative components could be used to capture an action potential which he stated a program could be used to interpret the signal to control an electronic device

An action potential is exactly what it sounds

like. It is the potential to perform an action, each signal sent from a neuron is an action potential. However, when a neuron is at rest it must maintain its resting potential by the utilising the sodium-potassium pump. This pump actively transports 3 sodium ions out of the neuron's membrane for every 2 potassium ions that are actively transported in. This unequal exchange of ions creates a potential difference across the membrane, where the outside of the neuron is more negative than the inside. As a result, there is an extremely low concentration of sodium ions ( $\text{Na}^+$ ) inside the neuron. This process helps to establish and maintain the resting potential, which is essential for normal neuronal function.

When a neuron is stimulated, the sodium-potassium pump is disabled. This allows sodium ions to diffuse across the membrane into the neuron down a concentration gradient, leading to depolarization of the neuron. Once the potential difference reaches the threshold potential, sodium ion channels open, increasing the rate of sodium ion

diffusion into the neuron. If the threshold potential is not reached, the neuron repolarizes, following the "all or nothing principle."

As the potential difference reaches around 40mV, the neuron depolarizes further. The membrane becomes more permeable to potassium ions, causing potassium ion channels to open and allowing potassium ions to diffuse in. After reaching 0mV, the neuron hyperpolarizes during the refractory period, where the potential difference goes below the resting potential to ensure that action potentials only move in one direction. The sodium-potassium pump is then re-enabled, and the resting potential is re-established.

The action potential jumps from node to node (node of Ranvier), where new action potentials are generated at each node to prevent depolarization along the length of the axon.

When the action potential reaches the end of the axon, it enters the synaptic knob, which is part of the synapse. The action potential triggers the opening of calcium ion channels in the synaptic knob, allowing calcium ions to diffuse in. The presence of calcium ions leads to the fusion of vesicles containing the neurotransmitter acetylcholine with the cell membrane, releasing acetylcholine into the synaptic cleft through exocytosis.

Acetylcholine diffuses across the synaptic cleft and binds to receptors on the postsynaptic membrane. When stimulated, these receptors open sodium ion channels, generating an action potential in the next neuron in the same manner as described earlier.

Neurotransmitters can play a role in inhibiting the generation of an action potential in a neuron. This inhibition occurs when certain neurotransmitters, such as gamma-aminobutyric acid, glutamate, or chloride, are released. These neurotransmitters bind to specific receptors on the membrane of the neuron receiving the signal. When neurotransmitters bind to their receptors on

the postsynaptic membrane, chloride ion channels open up. Chloride ions are negatively charged. When they enter the neuron, they make the inside of the neuron more negative, which is known as hyperpolarization. This hyperpolarization makes it more difficult for the neuron to reach the threshold potential required to generate an action potential. In simpler terms, it makes the neurone less likely to fire an action potential when stimulated.

In a cholinergic synapse, acetylcholine is released as a neurotransmitter. After its release, the enzyme acetylcholinesterase breaks down acetylcholine. The components leftover are reabsorbed into the pre-synaptic membrane for reuse. Without this enzyme, acetylcholine would linger, causing continuous action potentials in the neurones.

The synapse between neurons and muscles is called the neuromuscular junction. Its function is similar to other synapses, but it lacks inhibitory action potentials. After an action potential is generated in muscle cells, it travels through T-tubules, which are small tubes allowing the action potential to reach all muscle cells in a muscle. In a project, detection focuses on the voltage caused by T-tubules and the initial action potential.

Harvey used electrodes to detect the potential difference caused by the T-tubules. There are two main methods in electromyography : needle electrodes and surface electrodes. Needle EMG requires extremely fine needle electrodes to be inserted through the skin and into the muscle. This technique is much more invasive in comparison to surface EMG (electromyography). The disadvantages of needle EMG vastly outweighed the advantages for his project.

During his first recording of an action potential he managed to Harvey record the correct frequency however in addition he also recorded another unexpected frequency which at the time he couldn't explain.

This happened multiple times and even though he couldn't explain it he could narrow it down as it wasn't noise as that would've come up on his recording. The unexpected frequency was also peculiar as it only occurred after every action potential and writhing the same distance each times.

Another issue arose when his components had not yet arrived so he used resources available, one of them was an oscilloscope which he connected them to directly and without amplifying the signal he connected the electrodes to his own bicep. This time the results were what he was expecting, which were around 10mV.

After this initial success the repeats unfortunately were much different but the root of the issue was found to be mostly noise from 50Hz AC. However, the noise still needed to be cancelled out and amplify the signal so he used an instrumentation amplifier which takes a differential input and outputs a single ended amplified signal. This means that only the difference between the two inputs is amplified and since all of the noise picked up by the electrodes would be the same on both of them, any noise would be cancelled out.

The instrumentation amplifiers and much more expensive so he decided to find a schematic online which builds an instrumentation amplifier out of three operational amplifiers. To work out the resistance of each resistor he used a spreadsheet, and wrote in various resistances until I achieved the desired output voltage based on the estimated input voltage mentioned earlier. The building of the instrumentation amplifier was not successful after multiple tries which could have been due to a number of reasons like the schematic could have been wrong even after conferring with more experienced colleagues no solution could be found.

So instead it was decided a Raspberry Pi Pico microcontroller board would be used. The built-in serial plotter was not an option so, a suitable serial plotter was needed to

essentially view the data output as seen on an oscilloscope, he found an open source software named "serialplot" which fit his needs. Another issue was found when using "serialplot", the maximum sample rate of the Pi Pico was not high enough to properly sample this sine wave (429Hz) which would be much lower frequency than that picked up by the electrodes. So this method was entirely unfeasible.

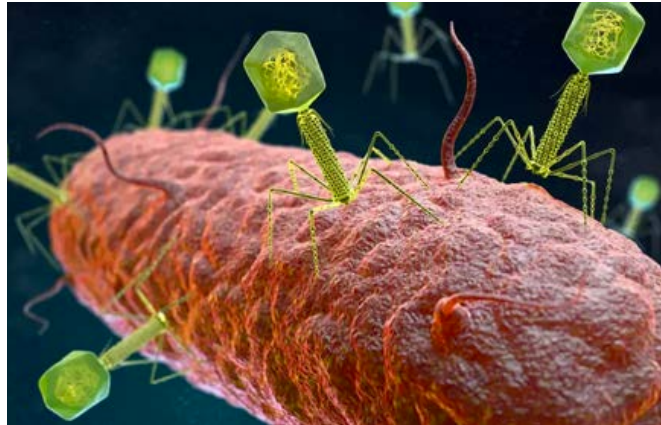
Harvey himself described the process as "endless obstacles", which caused him to change the direction of the project, but improving the quality of the prototype. In exchange of the instrumentation amplifier circuit, a differential (subtracting) amplifier was used and rather than the RPi Pico and ADC, this was swapped for a standard USB sound card with a line in input and Audacity to capture the recording.

Harvey found a website that fully explains how the differential amplifier works, along with schematics and formulae to calculate the gain etc. Having fully understood how this worked, he was better equipped for undertaking the task of building the differential amplifier. Although, he couldn't make the EMG signal control something he definitely opened the door for the future. Harvey is hoping to implant his technique in the future.

More on Harvey from his project supervisor... "Harvey is an outstanding student who is interested in a wide range of subjects and in particular the crossover between different STEM disciplines. This project allowed Harvey to build on his knowledge of neuroscience but also to develop new skills in electrical engineering and programming in order to complete his ambitious and outstanding project. Harvey got an A\* for his extended project and achieved excellent A Level grades going on to study Chemistry at the University of Liverpool. This was a difficult decision for him as he has such a wide range of academic interests and is a bit of a polymath. I would not be surprised to hear of Harvey inventing something original and useful in the future."

**Edited by Wiktoria Jasinska**

## A New Phage for Antibiotics!



**Ryan Parry won the Big Bang Senior Science Award for his work investigating the potential of bacteriophage viruses to tackle the problem of antimicrobial resistance.**

### Abstract

Bacteria are a large group of unicellular organisms that were one of the first types of life form to appear on Earth and are present in almost all of its habitats, being able to survive in hostile and extreme conditions. This ability to survive and adapt causes some pathogenic bacteria to be a major problem for humans. Although survival rates from bacterial infections have gone up significantly over the years, more recently there has been an increasing challenge due to antibiotic resistance. Bacteria acquire mutations that make them resistant to our antibiotics and because there is such widespread use of antibiotics, resistant bacteria survive and reproduce and resistance spreads. Bacteriophages are an interesting group of viruses that infect and reproduce inside bacteria, destroying the bacterial cells in the process. They have been suggested as a potential alternative to antibiotics or could be used in combination with them to make them more effective against resistant strains. This study isolated phage viruses from environmental water samples before testing them against *Escherichia coli* (*E.coli*) in liquid cultures. Although not conclusive, the results suggest that bacteriophage viruses may be at least as effective as ampicillin in inhibiting the growth of *E.coli*.

### Introduction

Since the dawn of time bacteria have been a force of good and of evil for humans, from the healthy bacteria found in our guts, to the pathogenic bacteria that infects wounds and cause disease and death. Bacteria are a large part of the unicellular domain, with a lack of complexity they are able to occupy vast biological niches and extreme conditions, great for the bacteria, but sometimes causing havoc for animals and humans infected with them, due to toxins they produce. Since the dawn of antibiotics, death rates from bacterial infections have decreased dramatically.

Since the discovery of antibiotics, starting with penicillin, we have developed various types and their use on both humans and animals is widespread. However despite the benefits of antibiotics, we are now encountering problems due to antibiotic resistance, due to their overuse. This occurs when bacteria gain mutations which give them resistance to one or more of our antibiotics. Due to the overuse of antibiotics, resistant strains are favoured and survive and reproduce which causes the resistance to spread within bacterial populations.

## Antibiotics

Multiple types of antibiotics exist, with the main ones being: specific, general/ emergency, and last line. Specific antibiotics are used on identified strains of bacteria, whilst emergency/ general are used on infections that must be cured with no time to diagnose, and last line antibiotics are used when all other antibiotics fail.

A potential alternative to antibiotics however is phages which are viruses that infect bacteria, consisting of three parts, a head, body, and tail. The head is made of proteins surrounding genetic material, the tail used for host recognition and triggering DNA insertion. Bacteriophages inject their genetic material into susceptible cells, where its ribosomes and proteins replicate and cause the host cell to undergo lysis, this leads to the DNA being integrated into host DNA and replicated leading to termination of the host cells.

## Aims and Objectives

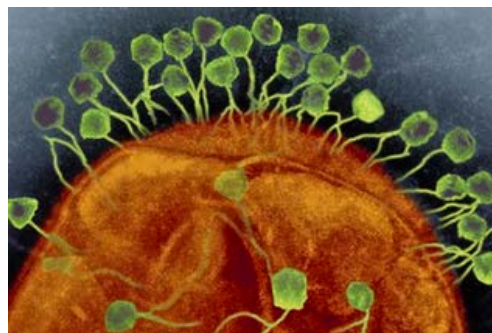
This study aimed to isolate bacteriophage viruses from water samples and then test their effectiveness against *E.coli* compared to and in combination with ampicillin antibiotic.

## Methodology

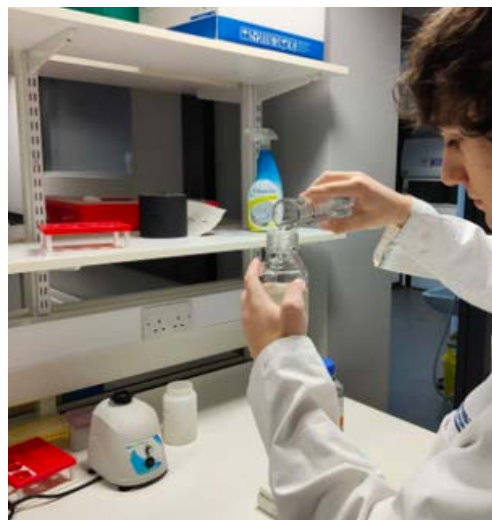
Water selection would come from rivers and ponds, taken with the idea that these dirty water samples would have a high likelihood of containing phages. These phages would then be isolated via three methods, the first using 100 microliters of *E coli* on a lawn spread and via an inoculating loop streaking water onto the plate, with a week-long incubation period. This however wouldn't allow for a conclusive phage to be present, and other organisms could interfere with results.

Method 2 would use agar plates topped with luria agar, *E.coli* and the phage and spread evenly over the agar plate. However this method did not work potentially due to the top agar being too hot and damaging the bacterial cells and possible the bacteriophage viruses.

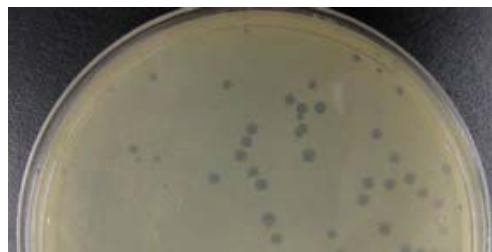
The 3rd method had the samples split into 5ml



**Figure 1. Phage surrounding bacteria**

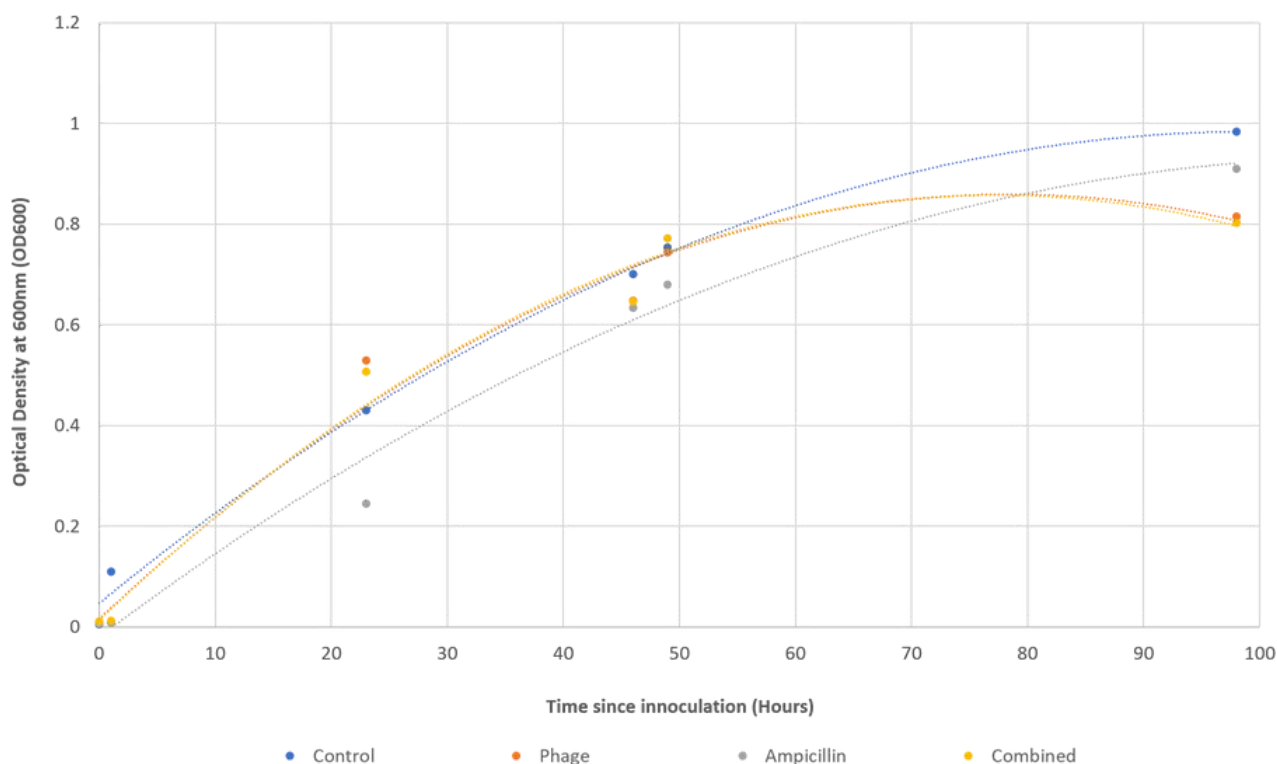


**Figure 2. Ryan preparing media**



**Figure 3. Plaques caused by phage**

volumes and centrifuged to collect debris, which removed impurities. NZ Amine broth was then added for the cultivation of *E.coli* and lambda bacteriophages. 100 microliters of *E.coli* were added and 4800 microliters of amine broth, with the water samples added in a 100 microliter amount. These were then left to incubate and grow plaques. Phages would then be isolated and incubated on agar plates for 48 hours at 25 degrees celsius. Bacteriophages were then transferred to liquid cultures of *E.coli* which could then be tested for growth using OD600 via visible light spectroscopy.



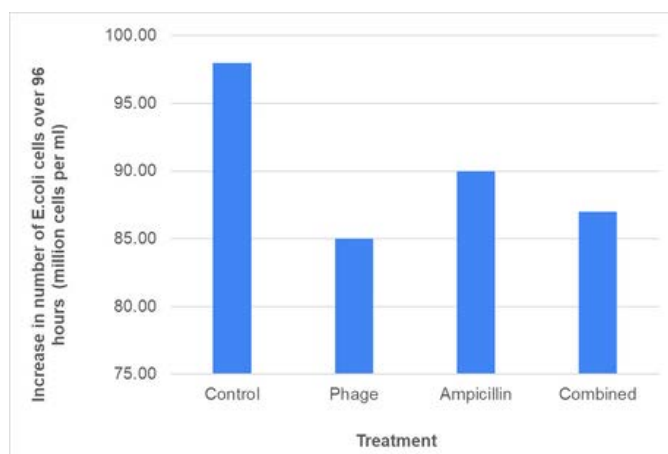
**Figure 4. Bacterial growth curves for E.coli cultures subjected to different treatments**

## Results and Conclusions

Four treatments were tested against liquid cultures of E.coli using OD600

- Control (distilled water)
- Phage (100 microliters of phage)
- Ampicillin (100 microliters of ampicillin)
- Combined (100ul phage and amp added)

OD600 was measured using a spectrophotometer for 96 hours after inoculation. Bacterial growth curves were produced for each treatment (Fig 4). Comparisons were then made between the estimated change in the number of bacterial cells in each of the 4 treatments (fig 5). The results demonstrate the stages of a bacterial growth curve - lag phase, log phase, stationary phase (figure 4). There is limited evidence that the phage and combined treatments started to inhibit the growth of the bacteria more than the control and ampicillin treatments however this would need further testing (figure 4). Overall, the estimated increase in the number of bacterial cells was lower in the phage and combined treatments however more repeats would be needed to confirm this non-significant trend.



**Figure 5. Increase in bacterial cells in each treatment**

Although this work is limited by a small sample size it demonstrates phage may be worth investigating further as we search for potential alternatives to antibiotics. It would be interesting to explore a greater range of phage viruses against different bacterial strains including resistant ones.

Ryan completed his A Levels and this extended project in 2023 and is currently studying for a degree in Chemistry at the University of Nottingham.



# Original EPQ Artefact

## Creating a veterinary skills suite for the BRI



Researcher - Erin Rhead  
Editor - Rahima Mohamed

Erin Rhead created her own veterinary suite within the Baltic Research Institute at Liverpool Life Sciences UTC to allow aspiring vets and veterinary nurses to gain valuable hands-on experiences.

Applications to veterinary science courses are incredibly competitive. As well as achieving top grades in A Level studies, students must gain work experience in multiple different areas of veterinary practice. Each area must focus on different animals, for example veterinary practices of large and small animals, kennels, catteries, farms and stables, along with experience gained in veterinary or medical laboratories which help students appreciate and understand the scientific basis of veterinary medicine.

Erin decided she wanted to help students at Liverpool Life Sciences UTC have competitive edge compared to other applicants. For her EPQ Erin aimed to research, design and create a veterinary skills suite for aspiring vets at the school. This would enable students to develop specific technical and transferrable skills for their future courses. The veterinary skills suite would include specialist equipment such as a SIM dog, dissection microscope and anatomical models as well as information sheets/booklets, careers information and practical scenarios.

Erin started by surveying vets for their input as to the equipment and skills that they thought would be beneficial for students to know and develop before applying for university. Whilst doing research for this project, Erin was simultaneously attending open days where she spoke to course leaders and admissions to see what they were looking for in students along with

viewing teaching labs to see what equipment could be present within her own suite. Erin was also attending work placements that gave invaluable insights into farming and small animal medicine the point of view of both the vet and the pet owner. This led to Erin including resources and activities to help demonstrate the importance of empathy and effective communication to aspiring veterinary science students.

Erin had to plan all aspects of the training suite including where equipment and posters would be placed to make the best use of the space available along with making sure that the lab and equipment was accessible to all students who were considering a career in veterinary science.

Erin researched and selected specialised equipment such as a SIM dog used for practical experience such as CPR and resuscitation of dogs along with intubating dogs and taking a dog's pulse from their hind leg. The dog also came with IV attachments that will allow students to simulate the movement of blood through a dog's arm, finding veins and visualising the placement of IV along with giving students hands on experience with similar equipment found in vet practices.





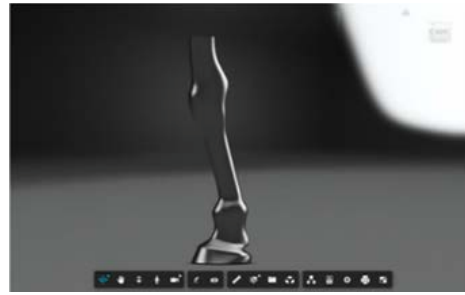
Balances and worming patches were also purchased to simulate the application of medication in a way that does not cause harm to the animal along with giving students the opportunity to track animals weight and see how external factors can affect animals health and wellbeing. The school has also used existing equipment and resources from other departments such as designing and 3D printing a horse leg to teach young students how to wrap swollen or damaged limbs of larger animals.



*Students observing pet hair using a dissecting scope*



*Dog hair viewed using a dissecting scope*



The advanced manufacturing team at the Baltic Research Institute assisted in the development of the horse leg using fusion 360 to produce a 3D model, which could then be 3D printed. This was then used for the development of skills like wrapping to add compression to a swollen area and support for livestock.

Visiting vets from ICR vets, part of the IVC Evidensia group, provided advice in regards to skills they think would be beneficial to focus on and led practical workshops in their areas of speciality, like keyhole surgery and ultrasound. Erin also spent time in a number of different veterinary practices and settings, seeking advice and knowledge from a range of different experts to help inform the design of her veterinary suite and resources.

To conclude Erin Read has successfully created a space within the school to help students to develop a range of important technical and transferrable skills for veterinary and animal science careers. She also trained a number of younger students at the school. The veterinary suite and the support she has given to other students ensure that her legacy lives on at the school long after she has left for University.



# Literature Review

## Does immigration provide an overall benefit to the UK in terms of society and economy ?



Research by Tania Benham  
Edited by Affeynaya Raveenthirarajah

Tania conducted this research after spending time at an immigration school with Fragomen, an international law firm dedicated exclusively to immigration services worldwide. She wanted to address some of the media disinformation dominating public opinion.

### Introduction

Immigration has become a large part of the political discourse in the UK and in the last decade it has become a particularly contentious issue. For her extended project Tania Benham utilised extensive research using over 45 reliable sources to assess whether immigration provides an overall benefit to the UK. She considers a range of factors including the economy, levels of unemployment, wages, pressure on the NHS, culture and skills before coming to balanced conclusions based on the evidence.

### Research Methodology

Due to the fact that immigration can be such a contentious and divisive issue it was important that Tania conducted her research in a way which minimised bias and led to balanced evidence-based conclusions. She uses extensive research with almost 50 sources cited, many of which are from peer-reviewed journals. Tania used a literature review approach summarising the findings in a table grouped by whether the research considered economical or societal factors, the main conclusions and whether they concluded a positive or negative impact.

Key terms	Definition
Refugee	Someone who has been forced to flee conflict or persecution and has crossed an international border to seek safety
Economic immigrants/migrants	A person who relocates from their place of origin in search of better employment or living conditions.
Asylum seeker	A person who has fled their country and is looking for safety from persecution and grave human rights violations in another country is known as an asylum seeker. But has not yet received legal recognition as a refugee and are awaiting a decision on their asylum application.
Immigrant	a person who has come to a country that is not their own in order to live there permanently
Migrant	A migrant has <b>not</b> been forced to leave their native country but is moving for better work / education opportunities or living standards.

### Main Findings

- There is strong evidence that immigration has a positive impact on the UK economy leading to increased GDP per capita.
- Immigration has a positive effect by reducing the dependency ratio of the UK.
- Overall, immigration provides a net fiscal benefit to the economy but this depends on the age and skill levels of individuals.
- Immigrants to the UK arriving after 1999 were 45% less likely to receive state benefits compared to UK born population.
- As immigration levels to the UK have increased in recent years, unemployment has decreased overall. However, levels of unemployment are likely to depend on age, skill level and ability to speak English.
- Although there may be local pressures on NHS health and social care services, overall immigration provides a net benefit to the NHS through providing skilled healthcare workers.
- There are societal benefits that are harder to measure such as food, music, sport etc.

### Conclusion

Overall it is clear that immigration provides a net benefit to the UK in terms of economy and a range of societal factors. The relative benefits vary depending upon the age and skill level of immigrants. There are local differences in the impact on services but overall there is a net benefit on the health service.



# Analysing and Recovering Valuable Metals from Black Mass Lithium Ion Battery Waste

By Jess Lynam and Alex Bunting



Alfred H Knight is an independent, family-owned business spanning five generations. They enable global trade by providing independent inspection, analysis and consultancy services to the metals, minerals, solid fuels and agricultural industries. One of the biggest growth areas for Alfred H Knight is the analysis of black mass from end-of-life electric car batteries. Year 12 Chemists were set the challenge of researching and reporting on a method to analyse black mass and recover valuable metals. Jess and Alex were awarded the first AHK prize for their outstanding report based on extensive research.

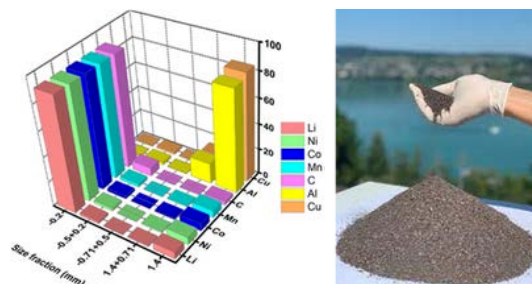
Black mass is the product left when lithium ion batteries are recycled and the metals and plastics have already been extracted. The black powder that remains is known as black mass.

Throughout the history of Lithium ion batteries, only 3% has been recycled (1). By recycling the batteries this will have a positive impact on the environment as we will become less reliant on mining which is finite. Recycling will in addition financially benefit companies who choose this sustainable option. By 2030, over 15 million tonnes of lithium ion batteries will be produced (8). The average profit margin for processing black mass each year is 21%, reinforcing that it has the potential to be an incredibly lucrative process. (12)

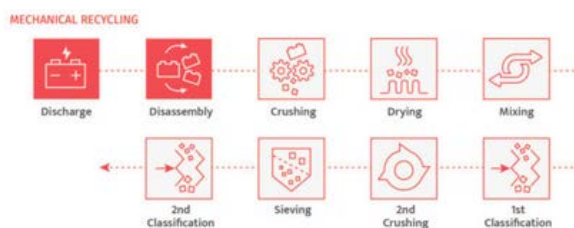
A typical lithium-ion cell contains a transition metal oxide/phosphate-based cathode and graphite as an anode(7). Black mass is made up from many metals some of the most common being: lithium (3.19%), manganese (4.82%), cobalt (15.79%), nickel (6.94%), copper (1.97%), aluminium (5.13%) and more (4). Each of these metals have many different uses so by recycling them rather than mining them, it is much better for the environment of the future.

### Analysis of Black Mass Sample

There are many methods to find out what is in the average black mass sample and a variation



of methods is needed due to the variation of elements in it. There is a routine way of separating the substance, such as the way Alfred H Knight does this (as seen in figure 1), so the elements can be identified easier. Black Mass can be obtained by discharging and mechanically disintegrating the batteries and removing the plastic and some metals that can be easily recycled (2). The small mass that remains is known as Black Mass.



[Figure 1] Mechanical recycling process for black mass.

How do we separate important methods?

The methods listed below are commonly used by Alfred H Knight use to separate and identify materials: (4)

- A visual examination and binocular microscopy.
- Manual scanning electron microscopy (SEM).
- Automated scanning electron microscopy with linked energy dispersive spectrometers (SEM-EDS).
- Advanced mineral identification and characterization systems (AMICS).
- X-ray computed tomography (X-CT).
- Laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS).
- Pyrometallurgy (or thermal industry) - This technique is suitable for the majority of batteries and accumulators.
- Hydrometallurgy - Saline, alkaline, zinc-air and lithium batteries are concerned in this process, making it possible to upgrade zinc and manganese.(3)

At UTC, we could attempt a visual examination using the microscopes available to us. Then I would consider using magnets to separate some of the metals as cobalt and nickel are magnetic. We would be unable to use pyrometallurgy as the temperature of 1200°C is too high to achieve in a school laboratory. Hydrometallurgy only requires a temperature of below 100°C, there are no concerns about dust formation, disposal of waste solutions is simpler than disposing of gases from pyrometallurgy and there is no production of SO<sub>2</sub> in hydrometallurgy (9). Hydrometallurgy involves dissolving the black mass in a strong acid to recover some of the valuable metals found in black mass (10), something which I believe could be possible in our school's laboratory. Europe's largest hydrometallurgy plant can recover 95% of the metals found in black mass (11) demonstrating that this extraction process is really effective. Another new process is using bacteria to extract metals from black mass which would be much better for the environment. This would reduce the usage of hydrometallurgy as a consequence. (13)

How do we extract valuable metals and other elements?

One of the main methods used to separate metals from black mass is the hydrometallurgical process. This involves using a leaching process, where the black mass is dissolved in a solution, often a strong acid or base, to liberate the valuable metals from the black mass allowing them to be recovered. We could then use separation and purification methods. We may use techniques such as; solvent extraction, ion exchange or precipitation to separate the individual elements based on their chemical properties. Further purification may be done to ensure the metals are of good standard to be reused. Companies usually use other techniques like crystallisation or electroplating. However some more environmentally friendly methods such as leveraging bacteria or other biological agents, possibly removing the need for traditional hydrometallurgical processes. (10) Sometimes it may require thermal pre-treatment (pyrolysis) as well.(16)

More into the metallurgical process:

First some companies may apply thermal pre-treatment (16), to decrease the surface area which is exposed to oxidation in contact with air (17). After this Leaching is applied and this is seen as the most significant step for this process as its purpose is to convert the metals present in the cathode material, from the pre-treatment, into an ionic solution. This most often mineral acids (H<sub>2</sub>SO<sub>4</sub>, HCl and HNO<sub>3</sub>), alkalis and organic acids. Studies have shown that inorganic acids are highly effective for the recovery of Co and Li; 99% of the Li is recovered during the leaching process when applied in optimal conditions. Graphite is not recovered and stays in a solid residue after filtration of the leachate. The leaching solution has a complicated composition, so the separation step is necessary to recover valuable metals, e.g. Li, Co, Ni, Mn and more. The most common methods to do this are, solvent extraction, chemical precipitation and electrochemical deposition; it is difficult to remove valuable materials using one of these due to the leachate's complicated structure, meaning two or more are typically used.

In figure 2 we can see what metals and other materials are recovered from each step. (16)

### Dangers

Black mass is a highly toxic powder and must be handled with care. When dealing with it, the production line must be adapted to fit its properties as it has such fine and volatile particles.(6). This mass needs to be recycled as it is considered toxic to human health as well as the environment if just dumped into a landfill; it may lead to the contamination of water streams with heavy metals such as copper, cobalt and many more. It also could lead to harmful and dangerous gases being produced such as, HF, Cl<sub>2</sub>, CO<sub>2</sub> and CO.(5) These gases may be produced in a process called pyrometallurgy.

### Conclusion

Mining for metals isn't good for the environment so being able to recycle and reuse metals could be vital for the future of our planet. The most important metals found in black mass are copper, lithium, manganese and cobalt. Copper has many different uses such as in wires and motors as it is a great conductor of heat and electricity.(15) Lithium is valuable due to its usage in batteries and cobalt is important in catalysts (18). In addition, Manganese is used as an alloying agent as it provides strength to metals (19). The extraction processes used in black mass have significantly advanced recently and the new process of using bacteria could be revolutionary for the extraction of metals.

For more information and a full list of references cited in this article, please use the QR code below...



<https://sites.google.com/lifesciencesutc.net/balticresearchinstitute/journal>

### Alfred H Knight - Lab Metalytics Project

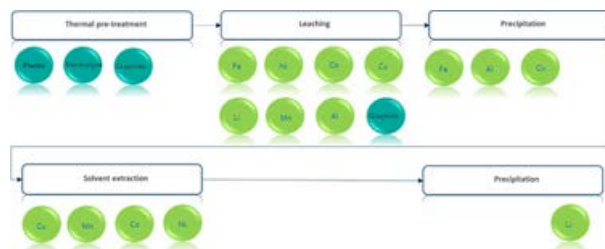
This was the first year we have run the lab metalytics project with Alfred H Knight.

In addition to Jess and Alex being awarded a prize by staff at AHK, Lucy, Monas and Kira were also awarded a prize after a practical skills assessment during which staff from AHK set the students a lab based, analytical task and judged the skills level achieved by the young scientists.

Each of the five students received a trophy and a week-long work experience placement in the X-Ray Spectroscopy department at AHK.



Five students from Liverpool Life Sciences UTC (Monas, Kira, Jess, Alex and Lucy) are awarded trophies by AHK



# Featured Article

Pawel Dobrzanski summarises four areas where AI is having an impact

## At the cutting edge: How Artificial Intelligence is already shaping the future

When you think of AI nowadays, what comes to mind? You might think of things like ChatGPT, widely used by people all around the world. Yet artificial intelligence is capable of so much more than that, capable of improving the world in ways that could seem like science fiction. In this article, I would like to bring to light some of the recent uses and developments in artificial intelligence in industry, to show how AI can do things some might consider science fiction.

### The future of Aerial Combat: Autonomous Fighter Jets

Anyone who knows about military aviation knows how dangerous jet-to-jet combat is, and just because you're trying to kill each other. Accidental collisions, losing too much speed, it can go wrong in so many ways. But what if it could be done autonomously, by AI? You might think it's science fiction, but it's much closer than you might think. As of quite recently, the Defense Advanced Research Projects Agency (DARPA) has flown an AI fighter jet, having it perform various manoeuvres, the kind you might see in combat or at an airshow using a modified F-16, called VISTA or X-62A. But don't worry in case you want to be a pilot, DARMA has stated that these jets, when ready, will operate alongside human pilots.

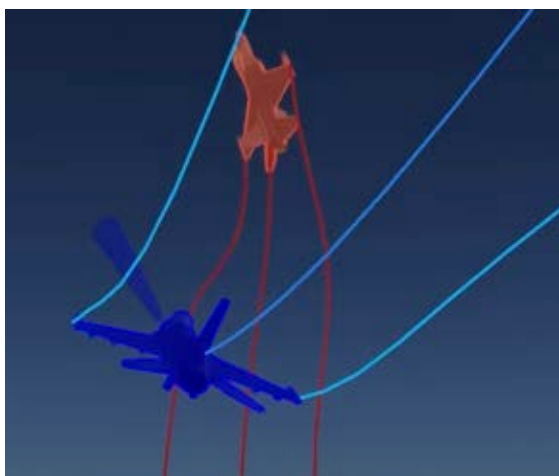


Image is a still from Video at DARPA (2024), read more... (<https://www.darpa.mil/news-events/2024-04-17>)

### AI Climate Response: Predicting Ecological Disaster

When you think of AI, you might think of it harming the environment, not helping it. However, an EU funded project is changing that notion, using artificial intelligence to help us understand and predict our climates. Not only can this AI predict events such as wildfires or droughts, it has been trained to provide cause data for why it has predicted it, allowing scientists to understand possible causes behind such events. This AI taps into the data produced by already established Sentinel satellites of the Copernicus program, the European Space Agency's earth monitoring program. This AI, called DeepCube, can use the data from Sentinel satellites to help Copernicus provide better predictions to end-users, helping world governments to plan for events such as droughts and thus help mitigate their impacts. This is especially important for countries where they may rely on successful crop harvests for food, as it can tell them in advance if it would go wrong and thus help them to plan ahead.

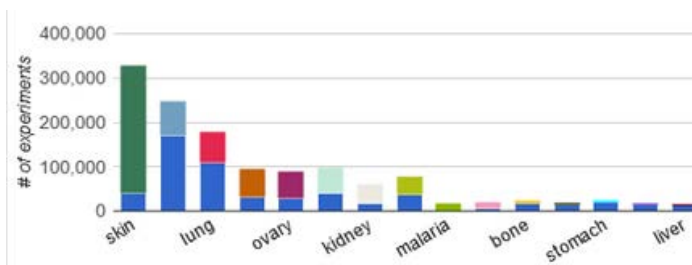


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Read more at.. <https://cordis.europa.eu/article/id/446034-infusing-ai-into-earth-observation-ushering-in-a-new-era-in-climate-response>

## AI for Cancer: Drug Combination Prediction

For a very long time, chemotherapy has been one size fits all. It has generally been difficult to innovate new drug combinations when a combination doesn't work on a patient, even if it works on others. However, this use case is one of artificial intelligence's biggest strengths, finding patterns. This project has been named the DrugComb project, finding drug combination patterns amongst a large dataset of used combinations, analysing not only effectiveness, but their synergistic effects and side effects, and has been of interest to pharmaceutical companies for their own analysis. Not only has this project already seen successes in predicting combinations for cancers such as breast cancer, but it is still evolving and growing.



A list of experiments conducted by DrugComb, taken from the data portal here. Copyright belongs to DrugComb.

AI is already being used or trialed in a wide range of medical applications including the diagnosis of cancer, predicting the spread of the disease and predicting patient responses to treatment. However, experts and clinicians in the NHS have warned that the health service should not rely too heavily on novel solutions and should prioritise cancer care basics. This is not to say that AI cannot be a useful solution, just that this should not be at the cost of basic services and solving some of the more urgent problems in the health service.

Find out more at...

<https://cordis.europa.eu/article/id/446035-unlocking-the-future-of-personalised-cancer-treatment-with-the-help-of-ai>

<https://www.theguardian.com/society/article/2024/jul/08/nhs-cancer-care-basics-over-tech-ai-magic-bullets>

## The Future of Space Exploration? Autonomous Space Robots

From the title, you might think that we already have autonomous robots, rovers. However, not exactly. Rovers still require orders and instructions alongside nearly real time guidance from operators. This project demonstrates the capability of robots to autonomously explore and act within harsh conditions and environments without human guidance. These robots completed sets of tasks using artificial intelligence enhanced control and perception systems. A basic example would be the images of AI labelling what's in an image. Of course, these robots would be much more advanced. In general, these robots may pave the way for much more advanced rovers and robots for space exploration, reducing future risks within missions.



Image taken from this article.

<https://cordis.europa.eu/article/id/446032-mission-accomission-accomplished-ai-gives-autonomy-to-space-robots> Copyright belongs to Thomas Vögele






Find out more at...

<https://cordis.europa.eu/article/id/446032-mission-accomission-accomplished-ai-gives-autonomy-to-space-robots>

# Project Highlights 2023-24

**It's been a great year for young researchers in the Baltic Research Institute.**

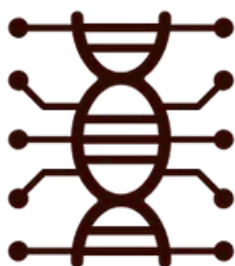
Here is a brief summary of some of the highlights from the BRI project programme this year...

 <p>Crick Institute - Y13 Selma was awarded the IRIS Best Researcher for her Nano-dentist robot project</p>	 <p>Year 12 Biologists complete vaccine development project with AstraZeneca leading to 12 WEX placements</p>	<p>Ignite Project Based Learning (PBL) programme delivered to all students in Y9. One group worked on industry challenges including Unilever</p>	 <p>Y12 Alfred H Knight 5 Chemists rewarded for technical excellence with WEX placements</p>	<p>Big Bang Finals Y10 Zach and Sam collaborated with the Urban Bee Keepers association to begin to map which pollen bees are bringing back to the hive at different times of year using SEM .</p>
				
 <p>Industry Insight Days (250+ Y10s &amp; 200+ Y11s) Employer partners: Ford, AstraZeneca, Vue, LSTM, Mast, NHS, UoL, LIMU, DSTL</p>	<p>Y12 Maths PBL The team in Maths have developed data dashboards using Microsoft power bi to analyse large data sets of scrap from Ford for years 2022 and 2023</p>	<p>Y12 EPQ Programme High uptake (50+) across multiple pathways in year 12 including 10 Ford Funded Projects each receiving an award of £2000 to develop the project</p>	<p>NHS APEX Digital Health Challenge Y10 &amp; Y11 entered a range of exciting projects competing against other UTCs. For 2<sup>nd</sup> year running we swept the board winning 1<sup>st</sup>, 2<sup>nd</sup> &amp; 3<sup>rd</sup>!</p>	<p>24 Students from Ignite, 10 &amp; 12 have been invited to present their SEM Research at the IRIS conference, "A Diorama of Diatoms" was presentation an audience of hundreds of people!</p>

Next year we have ambitious plans to expand the Baltic Research Institute to allow more talented young people from across Merseyside to benefit from taking part in innovative research projects.

If you would like to get in touch about contributing to the Baltic Research Journal or potential collaborations, please use the email address below...

**Dr John Dyer - [dyer.j@lifesciencesutc.net](mailto:dyer.j@lifesciencesutc.net)**



**BRI**

Baltic Research Institute

