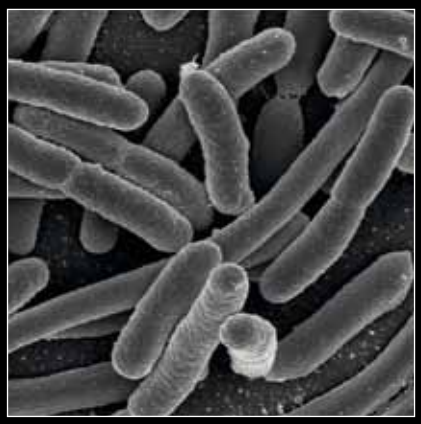
The Institute of Science & Technology

The Journal

Winter 2011



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Editorial

Welcome ▶

I hope that you enjoy this winter edition of the IST's Journal. There are some really interesting and informative articles inside. There is a distinctly astronomical feel to this edition but also an excellent article on Shrimp farming. My thanks extend to each and all of the contributors, with again special thanks to Alan Gall for helping me to put this edition together.

The Journal is a little late going to print this time, due in part to a very busy time for IST these last few months. There are a number of new IST initiatives, some of which are highlighted inside.

Recently, I read a very interesting paper by Will Crouch of the Uehiro Centre in Oxford University's Philosophy Faculty. Not that I regularly read papers on philosophy research in my spare time, in fact this is definitely a first, but what caught my interest was the suggestion that bankers can save the world - yet I thought that they were doing a pretty good job of screwing it up! Mr Crouch, however, strongly believes that ethically-minded people should really consider a career in banking rather than joining the third sector, and he has backed this up with research. His research suggests that those who seriously want an ethical career should consider maximizing their earnings so that they then have more money to give to charity.

You will typically spend 80,000 hours of your life working, so he believes that it's crucial that ethically-minded people really need to seriously think about their career early on. The careers traditionally considered the most ethical might not actually have the biggest impact. For example, aid workers are usually regarded as doing the most good because they directly benefit people in need. However, those jobs are in high demand, so even if you don't become that aid worker, there is always someone to take your place. There isn't a shortage of aid works, what there is a shortage of is ethical bankers. I'm certainly with Mr Crouch on the latter!

What's also not a surprise conclusion in his research is that bankers are generally not ethically minded, and typically donate only a very small proportion of their income. So if an ethically-minded individual were to enter the banking profession and donate a large proportion of their earnings to charity, then they will have made a difference that wouldn't have happened anyway, unlike the aid worker. The direct benefit that a single aid worker can produce is always going to be limited, whereas the philanthropic banker's donations might indirectly help ten times as many people.

Simply put, the typical investment banker will earn more than £6 million over their career and according to the research it costs £300 to save a life by treating tuberculosis in the developing world. So by donating 50% of their income, a banker would save 10,000 lives while still living comfortably on an average income of at least £100,000 a year.

The research also highlighted that 'Professional philanthropy' is not the only way to pursue a 'high-impact' ethical career. Currently, many ethically-minded people feel that they should refuse to take positions of influence, but if they did then they could use them to greatly further their ethical aims.

I guess, in a nutshell, he's saying that in a very cynical world you need to take a very cynical approach to being a good ethically-minded person.

Nevertheless, I think that we can see where many examples of non-cynical research careers and technology advances have had a real and major impact too. Just one example is Norman Borlaug, an agricultural researcher who developed short stem disease-resistant wheat, which is estimated to have saved hundreds of millions of people from starvation.

Best Wishes for the New Year
Ian Moulson
Editor

Acting Chairman's report

Terry Croft ▶

2011 has been a significant year for the IST, for the UK technical community generally, and particular for those of us working in the higher education sector (HE).

With the effects of the Comprehensive Spending Review (CSR) biting hard and further cuts and changes to our working lives through the implementation of many reports and recommendations (Browne, Diamond and Wakeham) the IST Executive and I have been working hard to ensure that the "technician's voice" has been heard. The Technicians Register was launched in the autumn through the Science Council and we have actively engaged with this initiative, believing that this will become a major component in technical career development in the future. HEaTED was also relaunched and now has a new home with Myscience at their headquarters in York. This was excellent news and we will continue to strongly support their activities through working in partnership with them going forward.

With all the changes and developments that will particularly effect technical staff working in HE, now and in the future, the chairs and senior officials of the specialist HE interest groups and HE professional bodies met at Durham University to discuss how we all could work together and have one voice. The outcome of these discussions was the formation of the National Association of Professional and Technical Specialists in Education (PTSE). The meeting agreed that their future annual conferences would be combined into one event where all the issues affecting our groups could be discussed. So a date for your diary is the first annual PTSE conference, which will take place in Sheffield on the 4th and 5th July 2012. This will include the IST, UCLAS, EMU, UBMA and NABBS.

You can keep up to date with these and other issues, also join the debate, and find out the latest news about the Institute of Science & Technology and our members, through the Linkedin group: http://www.linkedin.com/groups/Institute-Science-Technology-4226145

Please note both our current IST website and the PTSE website are currently being updated so apologies if you have any difficulties in accessing them in the intervening period.

Finally I wish to thank John Robinson for his continued encouragement and support whilst Acting Chairman and wish him well for 2012, and I'm sure with his spirit and determination he will be back in his familiar role in the near future. Also to all the members of the Executive who freely give their time to the Institute to ensure that you are supported and represented in these difficult economic times, within what appears to be an ever changing working environment. Also to Wendy and the team at our Head Office here in Sheffield, who ensure that the administrative side of the Institute works smoothly and efficiently.

2012 is a watershed year for many people, particularly for technicians and technologists in all sectors. Therefore can I encourage you to play an active part in the Institute and encourage others to also come on board and be part of, and help influence, the changes that will affect our future roles and careers. So please use our web sites, contact our office or email me directly. 2012 is YOUR opportunity. If we do not grasp this opportunity for the technical community we will lose it.

Please make your voices heard.
Many thanks
Terry

PTSE

National Association of Professional and Technical Specialists in Education

1st Joint Annual Conference in association with the IST Sheffield on the 4th and 5th July 2012

EMU

The Conference of Engineering Managers in Universities (EMU) is a loose association of engineering managers in universities throughout the United Kingdom with the following aims:

- To foster a corporate spirit across its membership.
- To enable sharing of best practice.
- To act as a focus for legitimate and common concerns with respect to support to engineering teaching and research in Higher Education.
- To add to individual and corporate knowledge.
- To broaden understanding of the profession from policy directives to implementation of the same.

http://www.emu-hei.uggle.co.uk/web%20pages/index.htm

UCLAS

The British Universities Chemistry Laboratory Superintendents and Administrators, BUCLAS, was formed in 1968. When in 2008 colleagues from Chemistry departments in Southern Ireland joined the organisation British was dropped from the title.

The group meet on an annual basis to:

- Provide a forum for exchange of ideas
- Influence university policy by the representation of the group's views
- Encourage training and development of staff at all levels
- Disseminate best practices.

NABBS

The National Association of Biochemistry & Biological Superintendents (NABBS) was formed in 1972 to provide a forum for University Laboratory Managers working in departments where Biochemistry teaching and research was carried out.

The aim of the association is to foster the exchange of ideas and information in the field of laboratory management and to provide a forum for the discussion of topics of common interest by holding regular meetings.

Membership is open to Laboratory Superintendents/ Managers and Administrators employed in University Departments of Biochemistry, or Departments of Biological Sciences that carry out Bioscience teaching or research.

http://www.nabbs.org.uk/

UBMA

The University Bioscience Managers Association (UBMA) is an organisation for University Laboratory Managers in biological, biochemical and life science departments, schools and faculties and its aims are:

To continually improve the management of resources in university science schools and departments, by:

- Providing a forum for the exchange of idea
- Seeking to influence national policy by the representation of the Association's views
- Encouraging training and development of staff at all levels
- Disseminating best practice

To achieve these aims we have an email based exchange service and an annual conference usually hosted at a fellow member's institution. Membership is open to all those meeting the qualifying criteria as set out on our website and having paid the annual subscription.

http://www.ubma.org.uk/

For conference details and updates go to: **http://ptse.org.uk/**

Please indicate your interest to wendymason@istonline.org.uk **http://www.istonline.org.uk**

Letters to the Editor

Ghana Science Technology Institute Annual Report to Executive 2011

As sand passes through glass so do our days of life. All too soon the Ghana Science Technology Institute has chalked its tenth anniversary. On that fateful day, 30 March 2001, with the help of Derek Sayers, Fellowship and Overseas Secretary, and Mike Hellowell of Eurotech, Cambridge, UK, we were inaugurated. During ten years in the life of an association a lot of achievement is expected, but like a newborn child learning to grow, it can be difficult. With determination and perseverance, however, goals can be reached.

The Ghana Science Technology Institute, an association formed on a very strong foundation and level of commitment, has had its fair share of problems due to changes in governance. The change of national government in 2008 has affected us in terms of recognition and also financially, a situation that is often seen in developing countries. With a different government has come its own priority area and education has suffered tremendously, although there is still a notion that all is going well. Is there hope for the technician?

Yes, there is hope but it takes commitment and perseverance to achieve our goals. The only setback is the apathy of our senior members because of their view that they will soon retire. A better achievement will be to leave a good legacy for the young ones who follow us by promoting our aim to fight for justice, good working conditions and remuneration. Technicians and technologists are involved in all sorts of work in research and academia but they receive little recognition. It is no mean job, but with a common strong front we can get there.

Secondly, the question most members ask is: "after IST Higher Diploma what next?" For members having gained this prestigious qualification and having been promoted, there is no further training. This has contributed to the apathetic behaviour of most of the chief technicians. There is no career or educational progression in Ghana at the moment and a handful of us who had opportunities to study abroad face challenges.

Further skill training

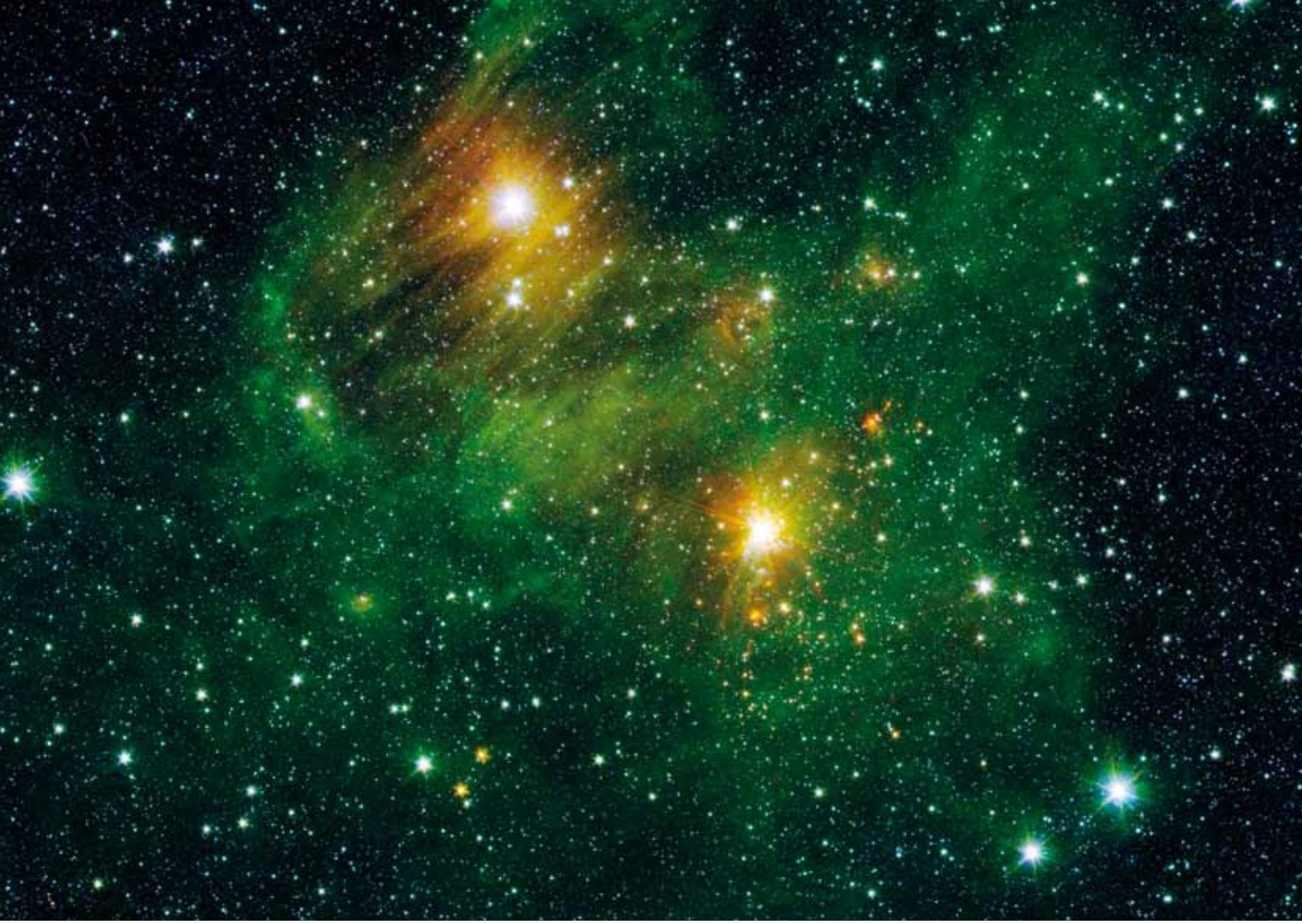
In light of the challenges being encountered, it will be prudent to collaborate with the IST to organize skill training courses, as is being done by HESDA with resources in the UK. I am personally asking this on behalf of our members, for the IST to help us in this regard, especially with the course taught by Derek Sayers on Basic Microscope Maintenance and Repairs. There are so many microscopes available that have been rendered obsolete by universities, research institutions, and the like, but no skilled persons to service them. I am of the conviction that such a workshop will have a good patronage and it will also help boost the image of our Association and that of the Institute. It also helps give skills to a lot of people rather than an individual attending such a course in the UK.

Appreciation

I take this opportunity to thank Mr Christoforous Pambou MIScT, Chief Technician of Islington Sixth Form College, for donating six calorimeters to be given to the Science Department of St John's Grammar Senior High School. They were very much appreciative when I passed on the equipment at the General Meeting of the School's PTA in September. Once again I appeal to any members or institutions that have good, working, basic laboratory equipment that is no longer in use, to kindly donate them to us.

Finally, I wish you all a successful and fruitful AGM. God willing, if my health improves, I will be with you next year. I also wish John Robinson good health and peaceful retirement.

Rosina K Nyarko



Astrobiology

Colin Neve ▶

This article will attempt to explain some of the ideas on how life was created, where the ingredients came from, and the conditions required for its creation. I have listed six areas of study that have influenced our understanding of the processes required for the existence of life. Also included in the second half is the subject of 'Habitable Zones' that are considered essential for human and other biological life-forms to exist in.

Astronomers studying interstellar gas clouds identified a few simple compounds in the 1930s by comparing their observed atomic spectra with those of laboratory samples. Significant advances in the search for more complex molecules did not occur until the late 1960s with the discovery of ammonia and formaldehyde. The problem lay in assigning the spectral lines to the correct molecule at a time when much of the necessary data for identification was lacking.

Picture above: Two extremely bright stars illuminate a greenish mist in this image from the Spitzer Space Telescope's "GLIMPSE360" survey. This mist is comprised of polycyclic aromatic hydrocarbons (PAHs) They are not actually green; but are colour coded in these images to allow scientists see their glow in infra-red. This image is a combination of data from Spitzer and the Two-Micron All-Sky Survey (2MASS).

Coutesy of NASA

One – Unidentified IR emissions:

a. The identification of anthracene and pyrene in the spectrum of the Red Rectangle planetary nebula was reported in 2004. These molecules are members of a large group called the polycyclic aromatic hydrocarbons (PAHs).

b. It is suggested that some unexplained infra-red molecular bands found between 3.3 and 11.3 microns can be ascribed to PAHs.

c. The PAHs are believed to be widespread in the Universe and have been detected in H II regions, Diffuse ISM, Molecular Clouds, Planetary Nebulae, Protostars and Galaxies.

d. It is believed that UV light absorption is re-radiated away in the infrared after the photon energy has been released across the bonds, therefore giving rise to the spectral emission.

e. It is believed that PAHs could have been delivered by comets in the early bombardment of Earth, and therefore helped to kick-start the beginning of life.

Two – In the context of comets and astrobiology:

a. The physical examination of new comets can detect and analyse first-hand the chemical structure of their nucleus before they get too near the Sun. Comets are the fossil record of how the solar system formed and what the conditions were like at that time.

b. Clay has the unusual property of plasticity, which makes it very malleable and very adhesive to itself. This is because of the extremely small flat plate particles which when wet will lubricate the plates to slide backwards and forwards. The moisture between the plates will also create a suction to bind the particles together giving it that strong doughy texture. There are many varieties of clay. Kaolinite, for example, has the chemical formula $Al_2Si_2O_5(OH)_4$. Because of their structure, clays are able to bind metallic ions to a negatively charged surface.

c. The clay found in ejected material from comets could indicate that liquid water had existed, thus allowing chemical reactions to occur. These chemical reactions might have had a hand in starting the early Earth "RNA world".

Three – Oparin and Haldane hypothesized that life could have developed by the creation of organic molecules from chemical reactions occurring on early Earth.

Stanley Miller and Harold Urey in 1952 tested this idea in experiments using a heated glass apparatus filled with water and the gases methane, ammonia and hydrogen. They used an electrical discharge to help create a liquid soup of organic molecules. After a week or more, amino acids, hydroxy acids, aldehydes, hydrogen cyanide and large amounts of adenine were created.

Year	Experiments after Miller & Urey 1952
1953	Miller used the materials CH_4, NH_3, H_2O, H_2 and electrical discharge to produce simple amino acids and other organic compounds.
1957	Groth & Weyssenhoff used CH_4, NH_3, H_2O, H_2 and UV light to create simple amino acids.
1959	Pavolvskaya & Pasynkii used Formaldehyde (HCHO) and nitrates (NO3) and UV light to create simple amino acids.
1964	Harada & Fox used CH4, NH_3, H_2O and heat (900 - 1200ºC) creating 14 essential amino acids.
1971	Sagan & Khare used CH_4, NH_3, H_2O, C_2H_6, H_2S and UV light to create simple amino acids.
1980	Yanagawa used various sugars, Hydroxylamine, inorganic salts and heat 105ºC to create glycine, alanine, serine, aspartic acid, glutamic acid.
1992	Kobayashi used CO, N_2, H_2O and proton irradiation to create glycine, alanine, serine, aspartic acid, glutamic acid, threonine and others.
1998	Hanic used CO_2, N_2, H_2O and electric discharge to create several amino acids.

Four – Life needs an energy source to exist.

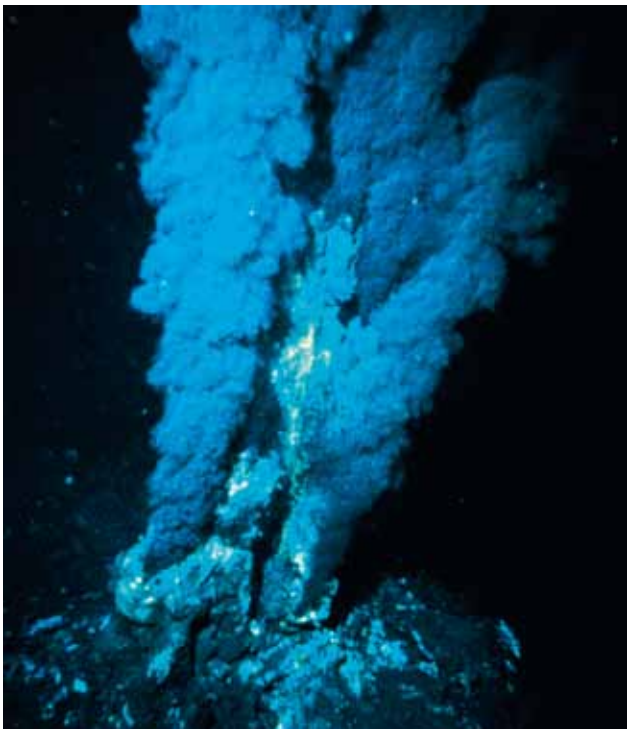
Energy sources (apart from the Sun's electromagnetic and nuclear radiation) would have come from volcanic activity in the form of heat, and from lightning as electrical discharge created by the turbulent weather system of early Earth. The abundant species of bacteria and animals (including humans) today feed on photosynthesised plants that create their energy from sunlight. Therefore bacteria that are phototrophs do have a competitive edge over non-phototrophs.

Five – Alternative chemistry:

a. Substituting the carbon atoms in alkanes with silicon will form unstable polymers chains of only a few atoms, each atom being larger than a carbon atom. The carbon atoms are ideal because they form stable chains of a few thousand atoms, and therefore the perfect choice for storing information in molecules. Both silicon and carbon will form chains, but silicon is more than twice the atomic mass and form unstable chains thus are a poor substitute for carbon.

b. Silicon life would have to overcome some very important biological problems: Silicon compounds are generally insoluble in water and so an alternative biological transport system would be required. Its biology will consume huge amounts of oxygen and produce SiO_2 as a solid waste product – a major challenge to its respiratory system.

c. There is no evidence of silicon life on Earth, but there are living systems that use silicon as part of their chemistry. The diatom single-celled algae uses its silica cell wall to "absorb light and release oxygen". Silicon life may not exist on Earth, but might exist on other planets that have the right chemistry and conditions for it to build on.



Six – Population III stars:

a. Population III stars are the oldest and date back to the early universe when its basic structure was forming. These massive population III stars created carbon atoms, which were essential in the building of organic molecules found in all living things. The carbon in molecules and dust clouds helped population-I and II stars to form by cooling them and acting as a shield. Population III stars were the first to exist and had short lives because of their high mass. It is believed that super-massive pop III stars in supernova explosions flung out the heavy elements C and Si found in the intergalactic medium.

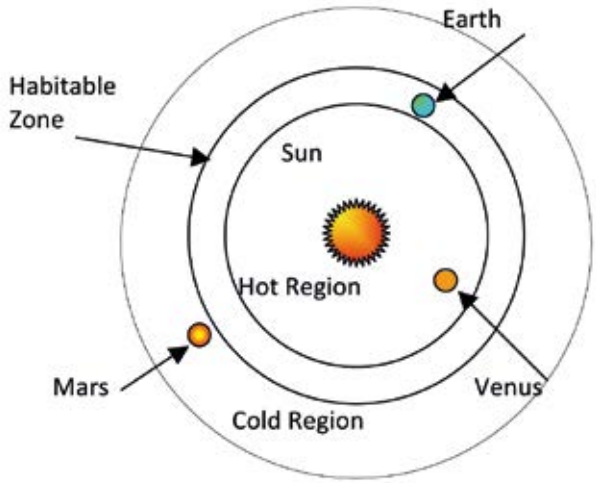
b. Because population III stars existed in the early universe and had high mass and short lives, it is hard to detect any faint light from that distant time or other signs of their existence.

c. Astronomers are puzzled by the two metal poor relic stars HE1327-2326 and HE0107-5240, which have low mass (less than a solar mass) and low luminosity, which contradict the need of heavy elements and high luminosity for the gases to collapse when forming the star.

The following six sections will look at the planets and moons in our own solar system that may harbour life in some form that can exist in extreme conditions outside the habitable zone. Also considered are other extra-solar planets spread amongst the Milky Way galaxy and beyond.

1) - Habitable Zones:

a. Earth exists in a habitable zone around our sun, Sol, where liquid water is found in temperatures not too hot or cold, but just right to support life.



This diagram illustrates the habitable zone in our solar system with the Sun at its centre. Earth is in a narrow strip (estimated to exist between 0.95 AU and 1.37 AU distance from the Sun, where water has not boiled away like on planet Mercury or frozen over like the outer ice worlds.

Diagram by Colin Neve

As the Sun increases in temperature with age, the habitable zone moves further away, making it hotter for Earth. This increased heat will make Mars warmer (in the habitable zone) and a potential new home for colonisation. Mars is located at 1.52 AU and at the outer edge of the habitable zone. The habitable zone is a special place within the star's solar system where the right conditions have developed over billions of years (an estimated 4.55 x 10^9 years for Earth). There is also a Galactic Habitable Zone where possible Earth type planets might exist and be capable of supporting life.

b. The exoplanet HD 149026b orbits its star at about 0.042 AU. This is far too near the star (where the temperature is a "scorching 1,500K") to be in the habitable zone. In Earth terms the habitable zone is between 0.95 AU and 1.37 AU from its star where liquid water and the right conditions are found, thus ideally suited for life.

Ref data from (http://exoplanet.eu/catalog.php)

2) - Life in the solar system:

a. On Earth simple life needed a set of events to occur for it to exist.

- Liquid water had to form to act as a medium for life's development.
- The right chemical elements to act as building blocks in creating life, and DNA/RNA as the mechanism for building this life.
- The life-bearing planet will need to be at the right distance (habitable zone) from the Sun. Too near, and the liquid water will boil away or too far and it will freeze over.
- An atmosphere to retain some heat and protect life against the Sun's intense radiation.
- Radiation from the Sun to give energy and warmth, but not too hot or cold.
- Possibly asteroid and comet bombardment.

Other planets in our solar system beyond Earth may also have liquid water and support some form of life. Life might not be exclusive to Earth, but may exist in extreme cold or extreme hot temperatures. Life (bacteria) on Earth has shown to exist at extreme pressures and temperatures as low as -70ºC in Antarctica and the hyperthemophiles existing at 113ºC around hydrothermal vents.

Earth - Apollo 17 - Full Earth showing Africa and Antarctica, Courtesy NASA

b. Solar system sites where these conditions might have existed.

- **Venus** is believed to have been like Earth before it went through a greenhouse event in its distant past, where liquid water once existed, but vaporised due to ozone gases (mostly carbon dioxide) that built up in its atmosphere.
- **Mars** could have had liquid water in its distant past, but a thinning atmosphere may have made it impossible for liquid water to remain on its surface (its poles have ice-caps).
- **Titan** is the largest moon of Saturn and has an atmosphere similar to an early Earth atmosphere.
- **Ganymede** has an icy surface of water ice.
- **Europa** has an icy mantle estimated to be 100 kilometres thick, with evidence of "sub-surface liquid water" that might be a habitat for life.

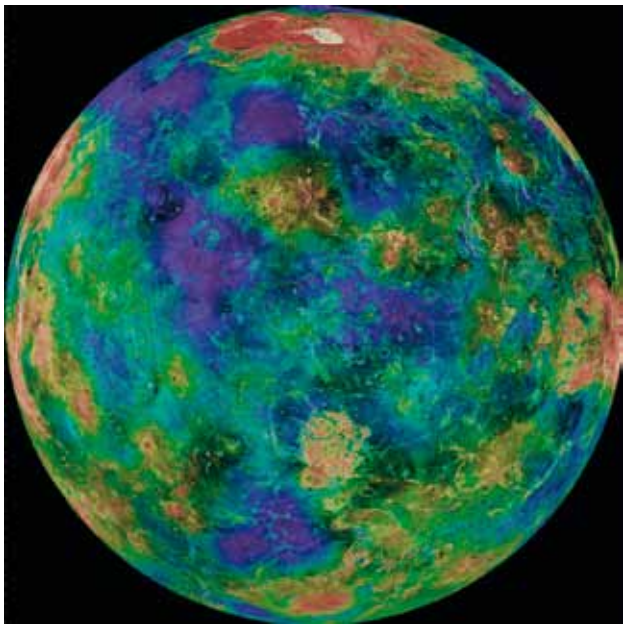
c. Priorities on each of these sites.

- **Venus** is an ideal example of the greenhouse effect and should be studied to give us a better understanding of what could happen to Earth in our future. It could also help us to use the same principles in terra-forming other worlds for human colonisation.
- **Mars** suffers from the lack of atmosphere, but if terra-formed using greenhouse gases, might create another habitable world for future colonisation.
- **Titan** has a similar atmosphere to early Earth and is made up of 97% molecular nitrogen (19% more than Earth's atmosphere) and with trace amounts of other hydrocarbons following. There seems to be some evidence of flowing water on Titan's surface, a mixture of "water ice and hydrocarbon ice" as shown using spectroscopy when the Huygens probe landed in January 2005. Therefore Titan might harbour some form of life, making it a candidate for closer inspection.
- **Ganymede** has shown signs of water ice, asteroid bombardment and tectonic activity, therefore it might have the potential to support a form of life.
- **Europa** has the potential for life (probably anaerobic) because it has liquid water; energy created by tidal forces, volcanic action and possibly by radiation from Jupiter, and also has organic compounds. Making it a prime site for further investigation in the search for life.

3) - The most likely sources of water on primordial Earth.

The environment might have provided water through the release of gases from volcanoes, which crystallised hydrated minerals. Rocks show that large quantities of iron pyrites (FeS), also some nitrogen, carbon dioxide, water vapour and sulphur oxides existed in Earth's early atmosphere.

Primordial comets hitting Earth might also have provided large amounts of liquid water and other material.



Using an imaging radar technique, the Magellan spacecraft was able to lift the veil from the Face of Venus and produce this spectacular high resolution image of the planet's surface. Red, in this false-colour map, represents mountains, while blue represents valleys. This 3-kilometer resolution map is a composite of Magellan images compiled between 1990 and 1994. Gaps were filled in by the Earth-based Arecibo Radio Telescope. The large yellow/red area in the north is Ishtar Terra featuring Maxwell Montes, the largest mountain on Venus. The large highland regions are analogous to continents on Earth. Scientists are particularly interested in exploring the geology of Venus because of its similarity to Earth.

Courtesy NASA

4) - No significant build-up of oxygen in the atmosphere until 2.5x10^9 years ago.

The primordial Earth was a ball of volcanic eruptions where churning seas of lava and flame dominated the landscape. As it slowly cooled, a surface crust formed and large areas became the Earth's surface. The cooling effect created a thick gaseous atmosphere where water and oxygen molecules developed. Over time rain clouds formed and drifted over the landscape, releasing their cargo of raindrops that created wide shallow oceans on this pocked-marked (asteroid and comet impacted) surface.

In these shallow oceans a form of algae (proto-cyanobacteria) produced large amounts of oxygen using solar energy to release O2 in the water, and from these oceans, highly oxygenated gas was released over millions of years into the atmosphere.

5) - How it might be possible to detect life on other worlds in our solar system and on the other exoplanets.

There are several possible habitable world candidates in our solar system that show similar environments found on Earth. Mars once had water on its surface; the Jupiter moon Europa is believed to have a subsurface ocean of liquid water under its icy surface. Another Jupiter moon Callisto may have liquid water on its surface. The search for extraterrestrial life will also be done using a blueprint of life in Earth's extreme environments, such as high temperature hydrothermal vents or salty lakes, where organisms have adapted to these harsh conditions, some with heat-shielding structures for those found in hot springs, and others

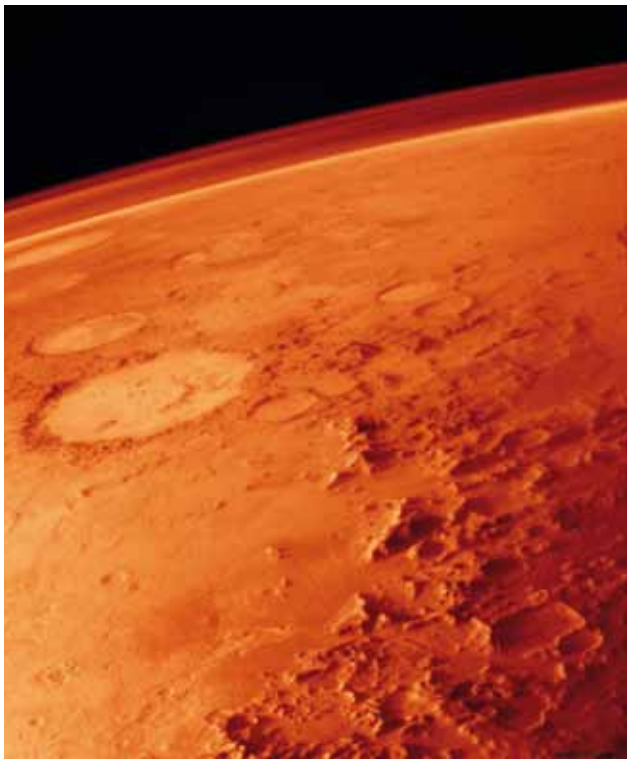
creating anti-freeze for extremely cold environments. Therefore searching for liquid water (its spectral signature might indicate oceans), and Earth type extreme environments in our solar system and outside would help to pinpoint potential planets that might harbour extraterrestrial life. Also searching for oxygen and ozone in the planet's atmosphere may indicate life.

6) - The atmosphere of Mars.

Mars' atmosphere consists mostly of carbon dioxide, a small percentage of nitrogen, also tiny amounts of water and other gases. Mars' thin atmosphere does not allow liquid water to exist on its surface (only as ice trapped at its polar caps and possibly beneath its surface). Some of the light elements would have escaped into space and only those trapped beneath the surface and some heavy elements remain. The thin atmosphere of Mars provides some protection against small meteor showers, but gives poor protection from asteroid bombardment, and due to lack of atmospheric pressure cannot hold liquid water. With no volcanic activity to recycle chemicals and minerals from the planet's interior to the surface (which would have thickened its atmosphere), Mars is possibly "geologically dead".

Conclusion

Astrobiology as a new science is the combination of knowledge and techniques used in many other scientific fields, therefore gives a larger view on the conditions for life found in extreme temperatures and very hostile environments. Astrobiology is a multi-scientific discipline of biology, chemistry, geology, astrophysics, etc., that considers the possibility of life on other worlds using the Earth's vast variety of living organisms and their habitats as the basic template for study.



Atmosphere of Mars taken from low orbit

Courtesy NASA

References:

Data reference source from the Open University book *"An Introduction to Astrobiology"* (2008), edited by Ian Gilmour and Mark A. Sephton.

Data reference material source from the University of Central Lancashire *"Introduction to Astrobiology"* notes (2008).

Additional images from Wikipedia & courtesy of NASA

Glossary

H II Region
A volume of space where hot young stars have caused the ionisation of surrounding hydrogen gas. In H I regions the hydrogen is in the form of neutral atoms.

Molecular clouds
Interstellar material composed mainly of molecular hydrogen at very low temperatures.

Diffuse ISM
Interstellar matter (ISM) is material found between stars in very low densities, mainly hydrogen and helium with a small proportion of dust. The hot, diffuse regions are ionised and of even lower concentrations.

Galactic habitable zone
Regions of a galaxy were the concentration of heavy elements favours the formation of rocky planets and excessive radiation from supernovae is absent.

Planetary nebulae
Material ejected from a star during its progression from a red giant to a white dwarf.

The part of the nebula close enough to the parent star is made visible by absorbing ultraviolet light and re-radiating.

Population I, II and III stars
Walter Baade, in 1944, introduced the concept of stars belonging to one of two groups: population I or population II. Typical population I stars are young, blue, and associated with dust and gas. They are identified by having a larger proportion of heavier elements than older stars, indicating that they have been formed from enriched interstellar material resulting from supernova events and other processes. Population II stars are older, red, and are found in relatively dust-free regions. The classification is a convenience only and stars can be found with a spectrum of characteristics between the typical members of each population. Population III stars have not been observed. They are the earliest to have formed, when the only elements available were hydrogen and helium (with a little lithium and beryllium) formed in the Big Bang.

Protostar
A body of gas collapsing under its own gravity. It will form a star when the central temperature becomes sufficiently high to trigger a nuclear fusion reaction.

RNA World
Hypothetical scenario in which early life was able to start with ribonucleic acid (RNA) without the need for deoxyribonucleic acid (DNA) or proteins.

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An inside view of a Venezuelan shrimp farm

Carlos Conroy ▶

Introduction

Aquaculture is a comprehensive term which refers to the farming of aquatic animals and plants in freshwater and marine environments. Fish farming and shrimp farming are important components of present-day aquaculture practices, and contribute approximately 50% to the total amount of seafood consumed worldwide (Valdimarsson, 2007). The sub-sector marine shrimp farming produces more than 30% of the shrimps available to supply a global market which increased by 92% between 1987 and 2006, and is an activity which is experiencing growth worldwide at a rate of 14 – 16% *per annum* (Anderson & Valderrama, 2007). An analysis of the world trade in fisheries and aquaculture in the year 2008 has been published by the Food and Agriculture Organization of the United Nations (FAO, 2009), which report yields the following salient and significant data:

(a) The total world production from "fisheries and aquaculture" in 2006 was 143.6 million metric tonnes, of which 92 million m.t. were supplied by capture fisheries, and 51.7 m.t. by aquaculture operations (excluding aquatic plants). The total basic sales value was US$91.2 billion in that year, of which the aquaculture components had a value of US$78.8 billion.

(b) Aquaculture continues to be the fastest growing food-producing sector in the world, with an average growth of 6.9% *per annum* between 1970 – 2006.

(c) Capture fisheries (inland and marine) and aquaculture, directly or indirectly, played an extensive role in the livelihoods of 43.5 million people worldwide in 2006.

(d) Aquaculture in the Latin American and Caribbean Region had the highest average annual growth rate of 22.0% in 2006.

Most marine shrimp farming operations are concentrated on the production of what are known as "penaeid shrimps", the taxonomy of which species has been modified by Farfante & Kensley (1997). The 'accepted' common names in English, and the 'old' and 'new' scientific equivalents of the species mentioned in this article, are summarised in **TABLE 1**.

Table 1. Common and scientific names of certain farmed species of penaeid shrimps

COMMON NAMES (English)	SCIENTIFIC NAMES "old"	"new"(*)
Brown shrimp,Caribbean brown shrimp, pinkspotted shrimp, redspotted shrimp, spotted red shrimp	*Penaeus brasiliensis*	*Farfantepenaeus brasiliensis* (Latreille, 1817) Farfante & Kensley, 1997
Southern pink shrimp, Southern red shrimp	*Penaeus notialis*	*Farfantepenaeus notialis* (Pérez Farfante, 1967) Farfante & Kensley, 1997
Caribbean white shrimp, Southern white shrimp	*Penaeus schmitti*	*Litopenaeus schmitti* (Burkenroad, 1936), Farfante & Kensley, 1997
Southern brown shrimp	*Penaeus subtilis*	*Farfantepenaeus subtilis* (Pérez Farfante, 1967), Farfante & Kensley, 1997
Pacific white shrimp, Western white shrimp, whiteleg shrimp	*Penaeus vannamei*	*Litopenaeus vannamei* (Boone, 1931), Farfante & Kensley , 1997
(*): according to Farfante & Kensley (1997)		

Venezuela was a relatively late arrival to the marine shrimp farming scene. The first attempts to study the possibility of farming marine shrimps in the coastal waters of the Caribbean Sea corresponding to that country were undertaken in the late 1970's, and were confined to the local native species *Farfantepenaeus brasiliensis, F. notialis, F. subtilis,* and *Litopenaeus schmitti* (Scelzo, 1983). Shrimp farming "took off", in terms of production, in the late 1980's, and was centred on the introduced species *L. vannamei,* which currently accounts for more than 90% of the total farmed shrimp production in Venezuela. The activity includes hatcheries and shrimp farms located in Anzoátegui, Nueva Esparta, and Sucre States in the East, and in Falcón and Zulia States in the West (**FIGURE 1**), the waters of which have been duly designated as "optimal" for shrimp farming purposes by the corresponding Governmental authorities.

The production of farmed marine penaeid shrimps in Venezuela over the period 2004 – 2010, with estimates for the years 2011 and 2012, expressed in terms of metric tonnes/*annum*, and as reported by Jory (2011), is shown in **TABLE 2**.

Under natural conditions, the life cycle of the penaeid shrimps is basically as follows:

(a) Spawning takes place in the ocean or open sea, where the gravid females lay their eggs;

(b) The eggs hatch, and undergo a series of developmental stages and moults which are known sequentially as the nauplius, protozoea, mysis and post-larva phases of growth;

(c) The juveniles migrate, as sub-adults, from the open sea towards the coastal waters of the shore and into estuaries, where they reach the adult stage of growth.

These processes can now be successfully undertaken in suitable artificial environments. In conventional shrimp farming terms, those stages are designated N4 – N5, Z1 – Z3, M1 – M3, and PL1 – PL17, in terms of the days and stages post-hatching of the eggs when produced in a hatchery. For biosecurity reasons, the hatcheries are located quite separately from the shrimp farm itself. The shrimp farms usually receive the post-larvae at a PL17 stage, or somewhat earlier, introduce them into nursery ponds, from which they are subsequently transferred to outdoor ponds for on-growing up to the adult stage, when they are harvested and dispatched to a processing plant where they are graded, cleaned and otherwise prepared for presentation to the end-users.

In the instance of *Litopenaeus vannamei,* a species whose natural distribution is in the waters of the Eastern Pacific Ocean, from Mexico to Peru, and which constitutes the basis of many commercial shrimp farming activities worldwide, the optimum

Figure 1

Map of Venezuela, showing its component States and their location.

water temperatures for growth are in the range of 23 – 30°C. Exposure to waters of 15 – 22°C, and above 30°C, may produce sub-lethal stress conditions. The ideal temperature for the farming of *L. vannamei* is 27°C. The species is euryhaline, and can tolerate water salinities of 2 – 40‰. It grows faster at lower salinities which – providing the environment and the haemolymph are isotonic – seem to be ideal. Growth at water salinity of 33‰ is reported as producing a better flavour according to the current tastes and preferences of the consumers (Wyban & Sweeney, 1991). In Venezuela, the complete cycle of production on the shrimp farm can be completed within a 5-month period, which means that an average of 2.5 production cycles/*annum* is the accepted norm.

In the present article, the author describes aspects of "daily life" on a shrimp farm in the Lake Maracaibo region of Venezuela, from the point of view of a working professional closely associated with - and involved in - such activities. As background information for the readers, Lake Maracaibo is the largest lake in the whole of South America, where it is located between Lat. 10° 39' 0" N and Long. 71° 36' 0" W, and covers a surface area of 13 300 km2. On the northern shore, it is connected to the Gulf of Venezuela (in the Caribbean Sea) by a narrow strait measuring 55 km in length. The major city of Maracaibo, situated on one shore of that strait, connects to the opposite shore by means of the General Rafael Urdaneta Bridge,

Table 2. Production of farmed marine penaeid shrimps in Venezuela (Jory, 2011).

YEAR	2004	2005	2006	2007	2008	2009	2010	2011 (*)	2012 (*)
PRODUCTION (metric tonnes)	22998	12956	21163	17658	16002	18000	20000	15000	15000
	(*): estimated values								

Figure 2

Map of Lake Maracaibo and its Basin

which measures 8.7 km in length, and is the largest bridge in South America (**FIGURE 2**). The waters of Lake Maracaibo are classified as brackish, and have a salinity ranging from 4 – 15‰. They receive the inputs of the River Catatumbo and other tributaries. The temperature ranges from a minimum of 23°C to a maximum of 34°C (average: 28.5°C). The average annual rainfall is 578 mm (from 0 mm in February to 150 mm in October), under normal conditions.

The shrimp farm and its operation

The farm: The shrimp farm complex proper is located inland in Sector La Ceiba, Municipio La Cañada, in Zulia State, approximately 100 km distant by road from the city of Maracaibo, on the northern shore of the Lake. The farm occupies a total surface area of 420 hectares, of which some 400 ha. correspond to the tanks and ponds. There are 24 concrete nursery tanks (30 tonnes each), and 114 ponds (3.5 ha. each) used for on-growing purposes. The Administrative Offices, fully-equipped laboratories, suitable accommodation for the resident personnel, storerooms, warehouses and workshops etc. are located on site. The farm employs a total of 144 persons, of whom 10 are qualified professionals and technicians, and 134 are auxiliary and field personnel. The installations are permanently protected by private security guards. There are no mangroves situated anywhere on site.

The water: The water is taken by gravity from Lake Maracaibo, is sedimented in a reception channel, and is then treated with probiotics prior to its being pumped throughout a recirculation system. The probiotics are beneficial microorganisms which are prepared on site from commercially available products, and are intended to promote growth of the shrimps and to provide a natural stimulus to their immune system in order to help prevent diseases. All of the water is filtered prior to, and following, its use, which means than no effluents are released to the outside. The physico-chemical, microbiological, plankton levels, and other parameters, are regularly monitored in the laboratory, to ensure that they comply with the recommended requirements for the farming of the shrimp species concerned. Among the advantages of using an enclosed recirculation system may be mentioned a better conservation of the available water, the ability to monitor and regulate the water quality parameters, and to prevent the entrance of undesirable predators, fish eggs, snails etc. from outside, as well as the escape of shrimps from the system itself. In such a way, the shrimp farm is able to exercise suitable biosecurity and management practices with respect to its aquatic environment.

The shrimps: The post-larvae are received at the PL8 stage of growth from a hatchery owned and operated by the Company, located in Piedras Negras, in neighbouring Falcón State. This hatchery is fully certified for the production of specific disease free (SPF) shrimp larvae. On receipt, the post-larvae are introduced into nursery tanks, where they are fed with a high protein content (45%) commercial pelleted feed for a period of approximately 10 days. Following that, they are transferred to on-growing ponds where they are fed a larger-sized commercial pelleted feed until they reach a size and weight suitable for harvesting. Where necessary, 'bokashi' – an alternative source of food duly prepared *in situ* by the treatment of vegetable material with beneficial microorganisms, and according to a patented procedure - is administered to the shrimps in the on-growing ponds to improve their feed intake and health status. In operational terms, harvesting is normally undertaken after 100 days of on-growing, at a weight required by the markets (usually 13 – 17gm). Regular samples are taken for laboratory examination to check for the presence of protozoan epibionts, potentially pathogenic bacteria, fungi and viruses, and other external or internal abnormalities, using the procedures as recommended by Aguirre-Ruíz

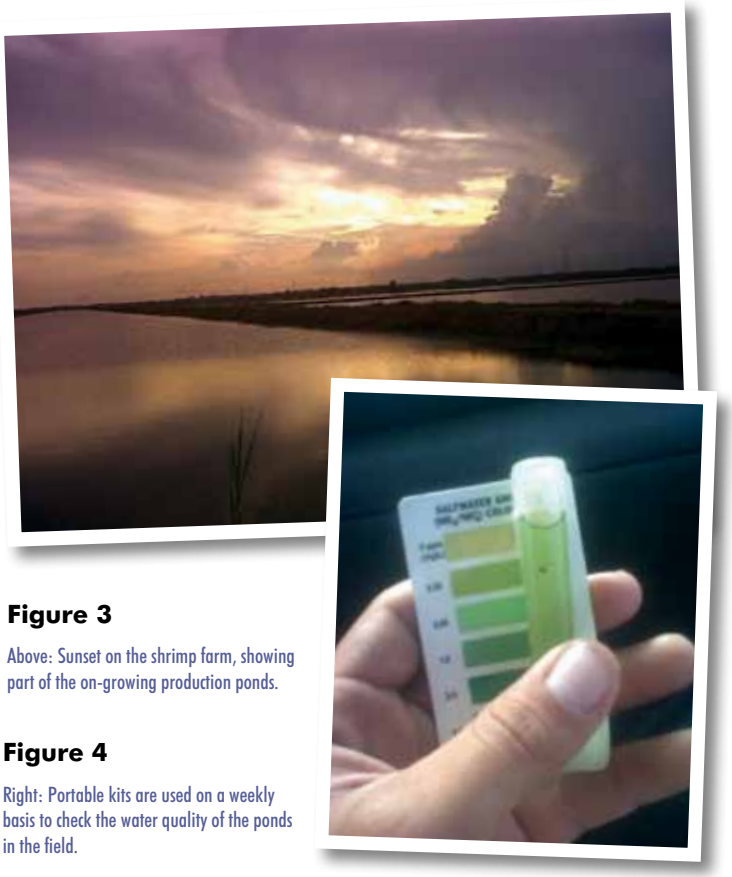

Figure 3

Above: Sunset on the shrimp farm, showing part of the on-growing production ponds.

Figure 4

Right: Portable kits are used on a weekly basis to check the water quality of the ponds in the field.

Figure 5

A small sample of post-larvae on introduction into an indoor nursery tank.

(2006), Jiménez-Guzmán (2009), Morales-Covarrubias (2010) and Morales & Cuéllar-Anjel (2008). The harvesting process is undertaken at night, and requires the presence and active participation of all members of the field staff. The final weight of the shrimp at harvest is recorded, and they are loaded into refrigerated compartments of the lorries which transport them to the off-site processing plant, where they are duly prepared and packed for commercial purposes. The average weight of the total amount of whole shrimp as harvested is between 1500 – 2500 kg/ha., depending on the density at which the ponds were originally stocked.

Illustrations of part of the production ponds at sunset, and of aspects of the regular chores which are undertaken on the farm, are shown here in FIGURES 3 – 8.

Discussion

The data recently published by the FAO (FAO, 2009) serve to establish the growing importance of aquaculture as a productive activity to meet the ever increasing demand for food at a global level. It should excite the interest of investors on the one hand, and of young science and technology practitioners aspiring to an attractive, reputable and responsible career on the other hand. It must be clearly emphasised, however, that involvement in aquaculture requires exclusive and full time dedication, and as such it is more than a part time hobby or leisure activity.

It is also convenient to mention that when the "boom" started to develop in shrimp farming in Venezuela during the late 1980's, concerns were expressed over the health status of exotic species of marine penaeid shrimps and freshwater palaeomonid prawns (*Macrobrachium* spp.) introduced from elsewhere for aquaculture purposes. To that end, the competent Governmental authorities enacted a series of obligatory legal requirements to be implemented with respect to the importation of those species (DGSPA, 1989, 1991; INAPESCA, 2005, 2005a). In the same way, international shrimp health norms and procedures (OIE, 2010, 2011), and the various environmental, health and social recommendations and guidelines formulated by international organisations and trade bodies (FAO, 2008; BAP, 2009), are strictly adhered to in everyday

Figure 6

The numbers and types of planktonic organisms are checked in a laboratory.

practice. The author, as a veterinary surgeon duly qualified, registered and licensed to practise, serves as the resident and on site veterinarian to provide the required veterinary supervision during the entire cycle of production on the shrimp farm, and to liaise with the official and private productive sectors in that regard. Antibiotics and potentially harmful chemicals are not used during the shrimp farming operations, which means that the final product can be shipped to its destinations in full compliance with the norms and requirements of the importing countries as to no traces or residues of such compounds being present on inspection and laboratory testing of the shrimps on their arrival there.

Speaking from practical experience in the tropics, and from the point of view of a shrimp farm which takes an enlightened and serious approach to that activity, the author can offer some basic advice to those professional and technical colleagues who may be considering a future career in aquaculture:

1. It is not necessary to seek increased responsibilities: such responsibilities will quickly find you, long before you ever start looking for them.
2. The possession of a robust mental and physical constitution is essential, in order to work long hours in the field without flagging.
3. The understanding that financial rewards, and other incentives, are available to all those who make the grade, and can prove their worth in the eyes of their employers and their working colleagues alike.
4. The acquisition of a beautiful natural sun tan, and plenty of exposure to fresh air and sea breezes, come about automatically within 2 – 3 days of first commencing employment on a shrimp farm in the tropics.

Figure 7

Batches of shrimp being weighed during weekly sampling.

5. A genuine liking for 'sea food' is a must, as you will eat plenty of that in the form of clams, crabs, fish, mussels, shrimps (or what have you), either served up as a soup, or accompanied by generous helpings of boiled rice, black beans, fried plantains, 'assorted greens' etc., all washed down with freshly prepared fruit juices, at meal times on site.
6. Ample opportunities are available to apply novel biotechnological innovations towards improving production of the aquatic species which is (or which are) being farmed.
7. For the most part, contact with the outside world is maintained by means of mobile phones and the 'Internet'.
8. The ability to communicate, and to establish excellent inter-personal relationships at all levels in the working environment, is essential to success and survival.
9. Abundant opportunities to fully admire the beauties of tropical sunrises and sunsets, the various types of local fauna and flora which are located within short distance, and so forth, are permanently available to those able to appreciate such natural attractions.
10. "Continuing Professional Development" is a guaranteed on-going process. It may range from 'administrative duties' (including 'problem solving'), personnel supervision, driving tractors, motorbikes and other vehicles, 'practical electricity', 'messing about in boats', 'voice training' (particularly useful to shout loudly against a prevailing wind in order to make oneself heard), and many others too numerous to mention here.

In setting out this brief advice, the author has tried to be personally honest, and hopes that this article in itself may encourage a greater interest in shrimp farming and in other types of aquaculture, including the desire to consume the final products of those activities.

Figure 8

A typical farmed adult shrimp from a population ready to be harvested.

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Origins, part 2:
The general theory of relativity

Estelle Asmodelle ▶

"The general theory of relativity is regarded as the greatest intellectual achievement of any one person," (Glendenning 2007), and 2015 will be the centenary of its publication. In part 1 of this report we explored the origins of the *special theory of relativity,* and the science leading up to its publication in 1905. The origin of the *general theory of relativity* is quite a different story and so this paper is about its development and the main steps that Einstein took to bring it to fruition. The *special theory of relativity,* was concerned mainly with the behaviour of light, or objects moving at speeds comparable to light, in a non-inertial reference frame; namely, a frame of reference that has no acceleration and does not include gravity. In order to include gravity and acceleration in relativity, Einstein would have to rewrite the law of gravity and use complex mathematical geometry to do so.

Albert Einstein lecturing in Vienna, 1921, enjoying the success of General Relativity.
Photo credit: Wikimedia Commons.

To understand how Einstein developed the general theory of relativity we must understand the enormous task involved and some concepts that preceded it. While special relativity was derived in a single paper, general relativity came together slowly over a period of time in portions, and so the order in which the portions were derived is instrumental in understanding its development. Furthermore, the tests of the general theory are of tremendous significance, and the means by which the theory was initially verified and marks a turning point in physics. The general theory was not a culmination of existing physics, like special relativity, but a completely new mathematical interpretation of the most treasured theory in physics of the time: *Newton's universal law of gravity*.

Galilean invariance:

In 1604 Galileo experimented with accelerated motion, which led to his law of falling bodies. As a result Galileo developed the first form of the equivalence principle, often referred to as the weak equivalence principle, which states that all masses accelerate at the same rate in a gravitational field. This invariance would later be referred to as Galilean relativity (Holcomb & Hawley 2005). Galileo expressed experimentally that the acceleration of a test mass due to gravitation is independent of the amount of mass being accelerated (Mannion & Grego 2010).

Space and time:

In 1644 Rene Descartes published his *Principles of Philosophy,* in which he argued that all motion is relative. Descartes proposed that the position and motion of any considered body is defined only relative to other bodies. And further asserted, since there are infinitely many bodies in the universe and all are moving in different ways; so any of these can be taken as a reference body, and any considered body has infinitely many positions and motions. He then proposed certain laws of motion, the most important of which exactly anticipated Newton's first law: a free body will either remain at rest or move rectilinearly at a uniform speed unless acted on by an outside force.

Of course there were others involved in discussions of space and time. After Descartes there followed Gottfried Leibniz, a German philosopher and mathematician who had developed the infinitesimal calculus independently of Newton, and who also believed space and time were relative.

Newton's universal law of gravity:

Sometime in the 1680s, Isaac Newton wrote *De gravitatione*. In that text he introduces the concept of absolute space by presenting an argument against Descartes' theory of relative space and time. Descartes had postulated that space and time formed merely from the relations among other material bodies, appealing to a particle's velocity in his theory of motion. Newton refuted this, claiming that in order to define velocity or motion coherently, the natural world must possess

a means of identifying the same spatial locations over time, namely an absolute space and time reference frame (Slowik 1994).

Then in 1687 Newton published *Principia,* and with it he hypothesized the inverse-square law of universal gravitation (Newton 1687). From his terrestrial observations, within the framework of Galilean invariance, in terms of absolute space and time, he deduced that the force that keeps things to the earth must be the very same force that keeps the moon, and indeed the planets, in their orbits. Using Kepler's formulas for planetary motion, and his own second law, he expanded the mathematics to reveal that this force, gravity, must be reciprocal to the squares of their distances from the centres. It was an insightful deduction and would become, not a theory, but the universal law of gravitation. Its magnitude form is shown in equation 1:

$$F = G \frac{m_1 m_2}{r^2} \qquad \text{Eq: (1)}$$

Whereby, m_1 and m_2 are the two masses in question: e.g., the earth and the moon. G is the gravitational constant[1]. Interestingly, Newton's law of gravitation resembles Coulomb's law of electrical forces, for both are inverse-square laws. Newton's force of gravity operated as an instantaneous action at a distance, yet there was no philosophical basis for this assertion.

Equation 2 is a mathematical representation of magnitude, using Newton's law, of Galileo's weak equivalence principle, where dv/dt is acceleration and is independent of m_1's mass.

$$\frac{dv}{dt} = -G \frac{m_2}{r^2} \qquad \text{Eq: (2)}$$

Newton's universal law of gravitation achieved real success when it was used to predict the existence of Neptune, for the motion of Uranus could not be accounted for by the actions of the other known planets. Calculations by both John Couch Adams and Urbain Le Verrier predicted the general position of the planet, which led Johann Gottfried Galle to the discovery of Neptune (Shore 2008).

Newton's universal law of gravitation became the cornerstone of astrophysics, yet it failed to explain a discrepancy in the orbit of Mercury. By the end of the 19th century it was realised that this orbit showed slight perturbations that could not be accounted for under Newton's gravitation. And so it was believed there must be another perturbing body, such as a planet, orbiting even closer to the Sun, but all searches proved fruitless.

Yet Newton's universal law of gravitation was considered proven correct, by the work of Alexis Claude de Clairaut and Pierre-Simon de Laplace (Celletti & Perozzi 2007).

Furthermore, Newton's laws were reworked over several decades by Leonhard Euler, Joseph-Louis Lagrange, Sir William Rowan Hamilton, and Carl Gustav Jacob Jacobi into very powerful and general methods, which employed new analytic quantities.

[1]*Accepted value of* $G \sim 6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$

Causality (classical):

The concept of causality in physics is of key importance to the logical construction of any mathematical framework. In classical Newtonian mechanics, a cause may be represented by a force acting on a body, and the effect of acceleration which follows as quantitatively explained by Newton's second law.

Mach's principle:

Ernst Mach was an Austrian physicist and philosopher, noted for his contributions to physics such as the Mach number and the study of shock waves, who introduced a profound idea. This concept was Mach's principle, which simply states that it did not make sense to speak of the acceleration of a mass relative to absolute space. In other words it was more accurate to speak of acceleration relative to the distant stars. This implies that the inertia of a body nearby is influenced by matter far distant. The idea addressed the concept of inertia which everyone previously, including Newton, had trouble explaining.

Lorentz & Poincaré:

In 1900 Hendrik Lorentz, whose transformation equations Einstein would later use in special relativity, in a paper conjectured that gravitation could be attributed to actions which propagate with the velocity of light (Lorentz 1900). Henri Poincaré published a paper in July 1905 (Poincaré 1905), which incidentally was submitted days before Einstein's special relativity paper, suggested that all forces should transform according the mathematics of the Lorentz transformations. He also comments that Newton's universal law of gravitation was not valid, and proposes the existence of gravitational waves, which would propagate with the velocity of light. Poincaré had pre-empted Einstein on more than one concept.

Einstein's equivalence principle:

After publishing the special theory of relativity in 1905, *"On the Electrodynamics of Moving Bodies,"* nothing much happened for Einstein. It would be a while before the significance of his relativity work was realised and so he continued to work in the Swiss patent office. Yet the concept of relativity in an inertial, or accelerating, reference frame eluded him. For special relativity only applied to a reference frame that was moving at constant velocity with respect to another reference frame.

Then in 1907, Einstein had what he would later refer to as his, *"happiest thought"* (Isaacson 2007). He realized that the principle of relativity could be extended to include gravity by means of the *equivalence principle*.

Einstein visualised *Gedankenexperiments*, or thought experiments, in order to conceptualise how nature operated. The visualisation for the equivalence principle consisted of two elevators, with a person in each, who are both sealed off from observing the outside world. The first contains a person who is in a gravitational field, while the second is in deep space free from any gravitational fields but is being accelerated.

Essentially, Einstein's equivalence principle states that these two reference frames are equivalent. This of course was neglecting tidal forces that actually distort the elevator in a gravitational field, as gravitating bodies are not flat but usually spherical, but this idea is based on a flat approximation.

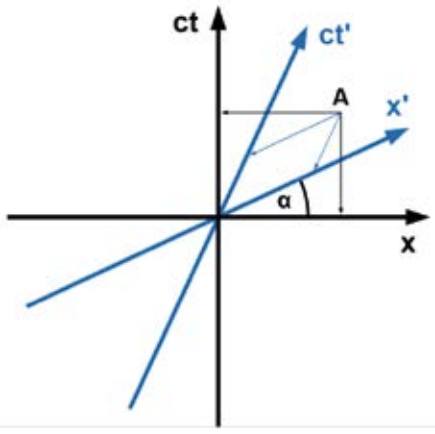
This was a crucial guiding principle for generalizing special-relativistic physics to include gravity, and logical progression towards a general theory of relativity. In 1907 he published this work, which is the ***first step*** (Howard & Stachel eds. 1989) towards a general theory. In *"On the Relativity Principle and the Conclusions Drawn from It"* (Einstein 1907), Einstein argued that free fall is really inertial motion and that for a freefalling observer the rules of special relativity must apply. This argument encapsulates the true essence of *Einstein's equivalence principle*. In this paper he also first describes *gravitational redshift* and the gravitational bending of light. *Gravitational redshift* was derived from the concept of *gravitational time dilation,* a natural corollary from special relativity, which is the higher the gravitational field, the more slowly time passes. Although Einstein merely introduces these vital ingredients to general theory, they are not mathematically expounded upon, and he doesn't publish anything else on general relativity for a few years. However, during this period Einstein published prolifically but we are only concerned here with the publications that pertain to the development of the general theory of relativity.

Then in 1908 Einstein was appointed lecturer at Bern University and a year later resigned from the patent office to accept an appointment as Associate Professor of theoretical physics at Zurich University.

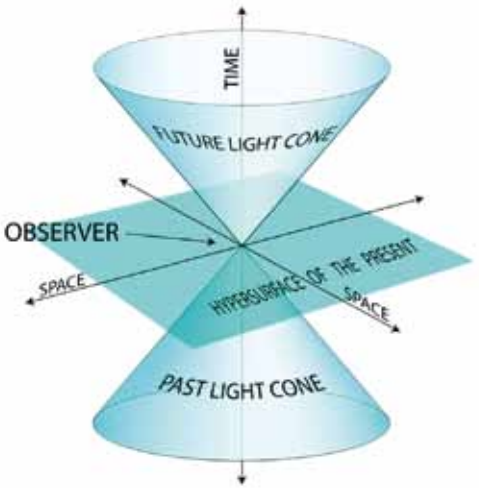
Spacetime:

By 1907 Hermann Minkowski, a German mathematician, realized that Einstein's special theory of relativity could be best understood in a four dimensional space. Now known as *Minkowski spacetime*[2], in which time and space are not separate entities but intermingled in a four dimensional spacetime in which the Lorentz geometry of special relativity can be most easily represented.

Einstein would adopt this conceptual treatment within the framework of his developing general relativity. The following diagram, shows two observers: in co-ordinate x and the second in co-ordinate *x'*.



Original Minkowski diagram, each observer assigns the event at A to a different spacetime. Image credit: Wikimedia Commons.



A modern version of Minkowski space, with two spacelike & one timelike dimensions. Image credit: Wikimedia Commons.

Pivotal papers (1911-1915):

Einstein had ardently been working on generalising relativity; during the period between 1911 and 1915, he published more than a dozen papers concerning general relativity but only a few mark the development of a conceptual methodology that define the framework of general relativity.

In 1911 he resumes his development of general relativity, by publishing, *"On the Influence of Gravitation on the Propagation of Light"* (Einstein 1911). In this paper he realises that a new mathematical theory is required to replace special relativity and Newton's gravitation. Additionally, he states that the equivalence principle holds locally, but not globally.

In 1912 Einstein published two key papers, *"The Speed of Light and the Statics of the Gravitational Field"* (Einstein 1912), and *"On the Theory of the Static Gravitational Field"* (Einstein 1912). This marks the ***second step*** in the development of general relativity, whereby he realizes that the Lorentz transformations of special relativity must be generalized and that the new theory of gravitation must be non-linear, since gravitational energy can itself gravitate. This is recognition of the non-Euclidean nature of the metric[3] and of its physical determination by gravitation.

Einstein consulted with his close friend Marcel Grossmann who incidentally was an expert in geometry. It was Grossmann who had introduced Einstein to the developments of Bernhard Riemann with Riemannian geometry, Gregorio Ricci-Curbastro with tensor calculus, and Tullio Levi-Civita with differential calculus. As a result in early 1913, Einstein publishes a paper with Grossmann entitled, *"Outline of a Generalized Theory of Relativity and of a Theory of Gravitation"* (Einstein & Grossman 1913). It's a breakthrough paper in which the single Newtonian scalar gravitational field is replaced by ten fields, which are the components of a symmetric, four-dimensional metric tensor[4].

[2] *Some believe Alexander Macfarlane developed this representation some years before Minkowski.*

[3] *A metric is a distance function, defining a distance between points, or sets of numbers.*

[4] *Tensors are geometric objects that describe linear relations between vectors, scalars, and other tensors.*

In 1914 *"Formal Foundations of the General Theory of Relativity"* (Einstein 1914), is published whereby the geodesic motion of point particles is derived; relates gravitational fields to rotation, and re-derives the 1907 results about the bending of light and gravitational redshift using the new metric tensor theory.

On the 18th of November 1915 Einstein submitted, *"Explanation of the Perihelion Motion of Mercury from the General Theory of Relativity"* (Einstein 1915). As the title suggests, in this paper Einstein mathematically and geometrically resolves the problematic orbit of Mercury. It was followed on the 25th November 1915 by, *"The Field Equations of Gravitation"* (Einstein 1915), which became the defining paper of general relativity. At long last, Einstein had found workable field equations, which would serve as the basis for subsequent derivations. These two papers mark the ***third step*** in a comprehensive general theory.

Interestingly, five days before Einstein submitted his 25th of November paper, David Hilbert had submitted a paper, *"The foundations of physics"* which also contained the correct field equations for gravitation.

Notably Hilbert's paper contains some important contributions to relativity, which were not found in Einstein's work. Hilbert's paper contains the hope that his work will lead to the unification of gravitation and electromagnetism, which is essentially *unified field theory;* something Einstein would spend the second half of his life pursuing, quite unsuccessfully.

Hilbert knew of Einstein's relativity work, also had correspondence with him, and had even invited Einstein to Göttingen to deliver a week of lectures on general relativity in early 1915, yet Hilbert fully credited Einstein as the originator of the theory and no public priority dispute concerning the field equations ever arose between the two men during their lives.

However, some historians are engaged in a second priority dispute over the Hilbert date issue, while the first is over Poincaré's predated version of special relativity in 1905.

Causality (relativistic):

In the theory of general relativity, the concept of causality is generalized such that an effect must belong to the future light cone of its cause, as seen in the Minkowski diagram, even if the spacetime is curved.

The notion that events can be ordered into causes and effects is necessary to prevent causality paradoxes such as the grandfather paradox, which asks what happens if a time-traveller kills his own grandfather, which would preclude the time-traveller from being born[5].

[5] *In 1992 Professor Stephen Hawking proposes 'the chronology protection conjecture,' to prevent time travel on all but sub-microscopic scales, to prevent such a paradox.*

[6] *Although widely attributed to Edwin Hubble, the law was first derived from the General Relativity by Georges Lemaître in 1927 (Livio 2011), where he proposed that the Universe is expanding and suggested an estimated value of the rate of expansion, now referred to as the Hubble constant.*

[7] *Einstein's original formulae were essentially the same as this but with subscripts. This form uses geometrized units.*

[8] *G is Newton's constant and c is the speed of light.*

Einstein's notation:

General relativity is essentially a geometric mathematical theory that uses tensors to map non-linear co-ordinates into a linear algebraic form. Einstein, in developing his theory, even developed his own form of mathematical notation to save time, which is so entrenched in the mathematics that one has to address it before even discussing the field equations. Equation 3 depicts Einstein's summation convention using dummy variables (Schutz 2009), while equation 4 is the original form:

$$A_\alpha B^\alpha \text{ and } T^\gamma E_{\gamma\alpha} \qquad \text{Eq: (3)}$$

This notation is simply shorthand for:

$$\sum_{\alpha=0}^{3} A_\alpha B^\alpha \text{ and } \sum_{\gamma=0}^{3} T^\gamma E_{\gamma\alpha} \qquad \text{Eq: (4)}$$

Einstein's field equations:

Einstein's field equations in general relativity can be represented in the following form. Firstly, it should be noted here that Einstein initially introduced the *cosmological constant* Λ, as a modification of his original theory of 1915 to achieve a stationary universe, as it was believed the universe was static at that time. Einstein then abandoned the concept of a *cosmological constant*, after the observation of the Hubble redshift indicated that the universe might not be stationary, but rather be expanding leading to Hubble's law[6]. Einstein said it was, *"the greatest blunder of his life"* (Isaacson 2007). Derivation of this form is shown below in equation 5 (Schutz 2009), where $\Lambda=0$; $G^{\alpha\beta}$ is the Einstein tensor (a trace-reversed Ricci tensor) and is used to express the curvature of a Riemannian manifold, and $T^{\alpha\beta}$ is the stress-energy tensor.

$$G^{\alpha\beta} = 8\pi T^{\alpha\beta} \qquad \text{Eq: (5)}$$

The form with Λ is shown in equation 6[7]:

$$G^{\alpha\beta} + g^{\alpha\beta}\Lambda = 8\pi T^{\alpha\beta} \qquad \text{Eq: (6)}$$

Equation 7, is the more popular form[8]:

$$G^{\alpha\beta} + g^{\alpha\beta}\Lambda = \frac{8\pi G}{c^4} T^{\alpha\beta} \qquad \text{Eq: (7)}$$

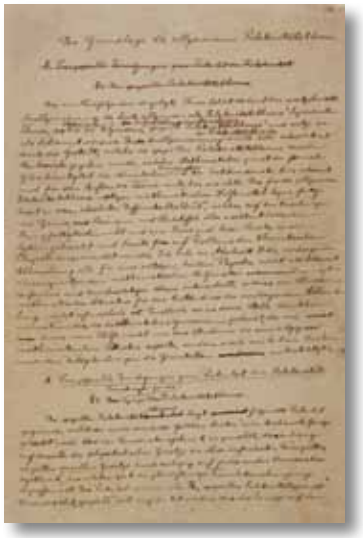
However, the discovery of cosmic acceleration in 1998 (Kirshner 1999) has renewed interest in Einstein's cosmological constant and so the latter form, namely equation 6, is the one used. Einstein died on the 18th April 1955, unaware that his cosmological constant would in fact be reintroduced. Many physicists believe Λ is dark energy (Harvey 2009), which is responsible for the accelerated expansion of the universe.

Solutions to General Relativity:

Many other theorists made contributions to Einstein's field equations, which only increased the validity of the general theory. Notable contributors were: Willem de Sitter, Alexander Friedmann, Georges Lemaître, Howard Percy Robertson and Arthur Geoffrey Walker.

[9] *Even after observational evidence, there were large public protests against relativity in Germany in the summer of 1920.*

[10] *Also referred to as the Lense–Thirring effect.*



First page from the general theory of relativity, handwritten by Einstein 1915-1916.

Image credit: Einstein Papers Project. www.alberteinstein.info

Validations to General Relativity:

It should be noted that many validations were performed for special relativity, which were outlined in part 1 of this paper, and in essence confirmed the framework of relativity. Einstein proposed three tests of general relativity, subsequently called the classical tests of general relativity (Einstein 1916):

Perihelion precession of Mercury:

The previously difficult to derive precession of Mercury, which Newtonian gravity could not account for, was shown by Einstein using general relativity to agree closely with the observed amount of perihelion shift. This was a very powerful factor that motivated the adoption of general relativity.

Deflection of light by the Sun:

Prior to Einstein's emergence, Henry Cavendish in 1784 and Johann Georg von Soldner (Soldner 1804) in 1801 had pointed out that Newtonian gravity predicted the bending of starlight around a massive object. In 1911 Einstein calculated the same value that Soldner derived, purely from the equivalence principle alone. Then in 1915, while completing general relativity, Einstein realised this result was only half of the correct value. And so Einstein was the first person to calculate the correct value for light bending, from the general theory (Will 2006).

Astronomers scurried to be the first to observe the deflection of light by noting the change in position of stars as they passed near the Sun on the celestial sphere – this could only be done during a total solar eclipse. After a few false starts, an English astronomer by the name of Arthur Eddington made the first successful observations in 1919 during a total solar eclipse at Príncipe on the west coast of Africa. Stars near the Sun were photographed to be in different positions due to deflection by the sun's gravity (Eddington et. al. 1920). The observation has been repeated several times since and measured more accurately[9].

Gravitational redshift of light:

The first observation of the gravitational redshift was the measurement of shift in spectral lines from the white dwarf star Sirius B by Walter Adams in 1925. Since that time, gravitational redshift has been verified with numerous observations. More importantly, in 1959 gravitational redshift was conclusively tested when Robert Pound and Glen Rebka, known as the *Pound–Rebka experiment*, measured the relative redshift of two sources situated at the top and bottom of Harvard University's Jefferson tower (Pound & Rebka 1959). The result was in excellent agreement with general relativity, and was one of the first precision experiments for testing the general theory of relativity.

Modern Validations:

Experimental validation of the general theory was achieved at various intervals, since 1919, but since that era more accurate tests have been performed that have all verified general relativity to very fine tolerances.

Light travel time delay:

Irwin Shapiro proposed another test, beyond the classical tests, which could be performed within the solar system; often referred to as the fourth classical test of general relativity. Shapiro predicted a relativistic time delay (known as *Shapiro delay*) in the round-trip travel time for radar signals reflecting off other planets (Shapiro 1964). The Cassini probe has undertaken a similar experiment which gave agreement with general relativity at the 0.002% level.

Gravitational lensing:

One of the most important tests is gravitational lensing and has been observed in distant astrophysical sources and is very important in cosmology. The most precise tests measure the deflection of radiation from a distant source by the sun. Recently, telescopes have measured the deflection of radio waves by the Sun to extremely high precision, confirming the amount of deflection predicted by general relativity aspect to the 0.03% level (Fomalont et. al. 2009). This effect has also been observed by the European Space Agency astrometric satellite Hipparcos in its cataloguing of the nearest stars.

Gravitational time delay:

Although the *Global Positioning System* (GPS) was not designed as a test of relativity, yet it is a working verification of gravitational redshift & time dilation. GPS must take into account relativistic equations in its timing system.

The *Gravity Probe* A satellite, launched in 1976, showed gravity and velocity affect the ability to synchronize the rates of clocks orbiting the Earth, in line with general relativity.

Furthermore using atomic clocks in aircraft which circumnavigate the earth, measured against clock on the surface, allow testing of general relativity and special relativity together. All such tests verified general relativity to 70 parts per million (Lambourne 2010).

Frame-dragging tests:

The general theory of relativity predicts that spacetime exhibits the following phenomena:

- *The geodetic effect:* is the amount by which a massive body warps the local spacetime.
- *The frame-dragging effect*[10]: is the amount by which the rotating massive body drags its local spacetime around with it.

The first experimental confirmation of frame-dragging was made using black hole observations by *NASA's Rossi X-Ray* Timing Explorer spacecraft as early as 1997 (Cui et. al. 1998), and additionally around neutron

stars (Morsink & Stella 1999). Other experiments have also confirmed the effect as well: the LAGEOS satellites (Ashby 2004), *Mars Global Surveyor* (MGS) spacecraft (Iorio 2007), and also attempts to detect the Sun's frame-dragging effect on the perihelia of the inner planets (Iorio 2007).

Definitively however, *Gravity Probe B*, launched 20th of April 2004, is a space experiment testing two fundamental predictions of Einstein's theory of general relativity: the geodetic and frame-dragging effects, by means of cryogenic gyroscopes in Earth's orbit. The experimental results are confirmed and are in agreement with Einstein's theoretical predictions of the geodetic effect within a 0.28% margin of error, and the frame-dragging effect within a 19% margin of error[11] (Everitt et. al. 2011).

Strong field tests:

Rapidly rotating neutron stars, called pulsars, which emit regular radio pulses as they rotate can act as clocks which allow very precise monitoring of their orbital motions. Observations of pulsars in orbit around other stars have all demonstrated substantial periapsis precessions that cannot be accounted for classically but are very accurately accounted for using general relativity.

Future validations:

Gravitational waves:

Lastly, a number of gravitational wave detectors have been built, with the intent of directly detecting the gravitational waves emanating from such astronomical events as the merger of two neutron stars. Currently, there are several detectors: GEO 600, CLIO, MiniGrail, TAMA 300, Virgo, AIGO, and Laser Interferometer Gravitational-wave Observatory (LIGO) which is the most sensitive. So far, there has not been a single detection event by any of the existing detectors. Future detectors will greatly improve the sensitivity of these experiments, such as the Advanced LIGO detector currently being built, the planned LCGT, and the proposed Laser Interferometer Space Antenna (LISA).

Epilogue:

Interestingly, Einstein published 320 journal papers, several dozen book chapters, and dozens of books, during his lifetime but none were as profound, concerning general relativity, as the paper of 1915 entitled, "The Field Equations of Gravitation," (Einstein 1915).

Today the news of faster than light neutrinos, at the OPERA detector in Gran Sasso Laboratory Italy (Adam et. al. 2011), taunt many physicists with the possibility that relativity may be inaccurate and need modification, yet claims of this kind have come and gone over the decades, and clearly relativity will continue to be vindicated with the correct interpretation of the superluminal data.

Einstein contributed in many other areas such as: special relativity, quantum theory, thermodynamics, and theoretical physics in general. It is even more intriguing that a man who had achieved so much would spend the second half of his life, over 30 years, pursuing unified field theory, quite unsuccessfully. Yet to this day many have taken up the mantle but none have solved the, "mind of God" as Einstein called it. General relativity is an unprecedented legacy, one that is systematically tested and retested, one that others have tried to replace or unify but have been unable to do so.

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[11] *This is because the predicted value was 39.2 milli-arcseconds and the probe measured 37.2 with an uncertainty of ± 7.2.*

"My Lunar Estate": the life of Hannah Jackson-Gwilt, Victorian lady and amateur astronomer

Alan Gall, IST Archivist ▶

Above: Earthrise from Apollo 8, Courtesy NASA

The Jackson-Gwilt Medal

In a letter dated 6 June 1983, Grote Reber, American pioneer of radio astronomy, wrote to the Royal Astronomical Society (RAS) from his adopted home in Tasmania. Reber had just been sent a prestigious award by the Society originally called "The Hannah Jackson (née Gwilt) Gift and Medal".[1] Illustrious past recipients include Patrick Moore (1977) and the discoverer of Pluto, Clyde Tombaugh (1931). The first presentation was made to the prolific comet spotter Lewis Swift in 1897, a few years after the death of the prize's originator: Mrs Hannah Jackson-Gwilt.

Grote Reber's letter of thanks expressed a curiosity about the medal's history and he duly received some information concerning the benefactor from J.A.Steff-Langston, Executive Secretary of the RAS. This material consisted of a copy from the Society's byelaws, a list of medal-winners, a few pages taken from a history of the Society and an obituary for Joseph Gwilt. Joseph had been identified earlier as Hannah's father[2] when in fact he was her uncle. The confusion no doubt arose because Joseph was a fellow of the RAS and like George Gwilt (the correct individual) a noted architect. Steff-Langston ended his return letter with the comment: "I think that is about the limit of information I can muster and hope it meets your requirements".

The Gwilt family

Hannah's grandfather, commonly known as George Gwilt the elder[3], served as surveyor to the county of Surrey and then district surveyor for St George's, Southwark. His sons, George the younger[4] and Joseph[5], studied architecture under their father, becoming well known in the profession, although George (II) was more inclined towards the study of architecture and the pursuit of his archaeological interests.

Early deaths blighted the life of the Gwilts, as it did many families in those days. George (I) fathered four victims of infant mortality, Hannah, Sarah, Richard and Samuel, whose remains he moved from one burial ground to another in 1797. His son George (II) married Mary Ann Applegath in 1800 and they had ten children. Of four boys, one died as a baby, three as young men. First born was Mary Ann Gwilt (II), also to die young, before the age of 30. The third daughter, Hannah, subject of this article, was born 20 August 1807.[6]

Both Hannah's father and her uncle Joseph were fellows of The Society of Antiquaries of London, a body formed in 1717. George wrote extensively for the Society's journal *Archaelogia*. Joseph made contributions in his field with a number of books including *Rudiments of Architecture, Practical and Theoretical,* published in 1826 with a dedication to Thomas Brandram,[7] *An Encyclopaedia of Architecture, Historical Theoretical and Practical* (1842) and also *Rudiments of a Grammar of the Anglo-Saxon Tongue* (1829).

Georgiana Matilda Gwilt, one of Hannah's younger sisters, kept a "friendship album" ca. 1824-1832. This contains paintings, autographed verses and includes a drawing by Edward Lear and the signatures of Chang and Eng, conjoined twins who were then on a world tour.[8] The Gwilts worshiped at St Saviours Church[9], Southwark and George (II) undertook to restore the Lady Chapel. To raise funds, as the restoration work was gratuitous, Georgiana acted as the honorary secretary of a committee superintending a fair at the Royal Gardens, Vauxhall. The event enjoyed the patronage of the Duchess of Kent and the Lord Lieutenant for Surrey.[10]

Living in Southwark

Union Street is a half-mile long thoroughfare running between Borough High Street and Blackfriars Road. George (I) designed houses that were built at the Borough High Street end, near to the Crossbones burial ground[11] and about a third of a mile south of London Bridge.

Following complaints, the local Board of Health attempted to prohibit the internments at Crossbones in 1849:

The minutes of the last meeting[12] were then read, and also some letters from a Mrs.Gwilt,[13] residing near the churchyard, complaining that corpses were left for ten days in the dead house under her window, and alleging individual cases of impropriety, especially as to a woman she stated that she saw brought to the ground to be buried, although only in a state of suspended animation from which she recovered; but in the struggle to escape she broke a blood vessel and died. The corpse was left under Mrs. Gwilt's windows, and the shavings and straw in the coffin were exposed, saturated with blood.[14]

The churchwardens decided to ignore the prohibition claiming that the Board of Health's report was "… chiefly founded on false and exaggerated statements in a letter from Mrs. Gwilt …" and that "… the case of suspended animation was entirely fictitious, and that for the last eight years there was no internment nearer to Mr. Gwilt's window than 50 feet."

George Gwilt (II) lived in his father's house at 8 Union Street where he converted the stables into a private museum to house Roman artefacts discovered in Southwark, and also other items of historical interest that he added from time to time. At some point[15] Hannah's brother Alfred Gwilt took up residence next door at 7 Union Street where he advertised himself as architect, auctioneer, surveyor and wine merchant.[16]

Hannah lived during a period when burglary, forgery or sodomy could lead to a death sentence. Executions were events open to the public and the hangman at Horsemonger Lane Gaol[17] despatched 120 felons between 1800 and 1836. The hangings there, less than a mile from the family home on Union Street, probably held more than a passing interest for the Gwilts because Hannah's grandfather, George (I), had designed the prison.[18] After one such spectacle in 1849, that attracted a large crowd of rowdy onlookers, Charles Dickens wrote in disgust to *The Times:*

The horrors of the gibbet and of the crime which brought the wicked murderers to it faded in my mind before the atrocious bearing, looks and language of the assembled spectators. When the day dawned, thieves, low prostitutes, ruffians and vagabonds of every kind, flocked on to the ground, with every variety of offensive and foul behaviour. Fightings, faintings, whistlings, imitations of Punch, brutal jokes, tumultuous demonstrations of indecent delight when swooning women were dragged out of the crowd by the police with their dresses disordered, gave a new zest to the general entertainment. [19]

William Rendle (1888, p.241) remarked about George the elder: "A firm, obstinately conscientious man, he resigned his surveyorship rather than inspect the gallows on the Sunday, very often, alas! in use at that time on the Monday mornings."

Marriage and after

Miss Hannah Gwilt became Mrs Jackson on the 13 December 1828 when she married William Jackson, a solicitor and later prothonotary[20] for the Borough of Southwark.

Four years later Alice Gwilt Jackson was born, a child of delicate health who died in Nice (at that time part of Italy) aged 4 years three months and seven days, from "fever on the brain".[21]

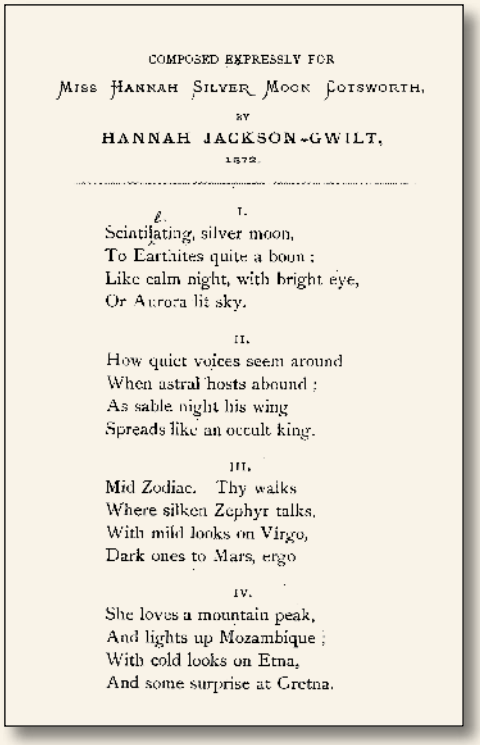
The lack of her own children may explain why Hannah became particularly attached to her nephew's family. Hannah's sister Sarah had married Thomas Cotsworth and their son Edward had, in turn, married Sarah Jane Thomas. When Sarah Jane gave birth to a daughter in 1872, the Christian names bestowed were Hannah Silvermoon. To commemorate the event, Hannah wrote 14 verses with a lunar theme and had them printed on good quality paper from William Joynson (the front page of which is shown here).[22]

Mr and Mrs Jackson lived at 5 Crown Square, and later at 85 Blackman Street, both in Southwark. Between the taking of the 1841 and 1851 census returns, William Jackson died. Hanna then adopted the name Jackson-Gwilt and moved to Wimbledon. The 1881 census records the names of houses on Merton Road, Wimbledon[23], amongst which are: Belmont Villa, Waterloo Villa, and Moonbeam Villa. It's not difficult to work out which one belonged to Hannah!

Several months after the death of George (II), his collection of historical artefacts, and other belongings, were offered for sale. Auctioneers Puttick & Simpson advised:

The well known taste of its late proprietor needs no comment. Besides the usual furniture will be found scientific instruments, philosophical apparatus, rare and choice music, musical instruments, between 300 and 400 valuable books, small quantity of wines, &c.[24]

According to William Rendle (1888, p241): "No sufficient warning reached family or friends, rare things passed, at the sale in Union Street, into the shop of, among others, a chandler in Kent Street …" and "When I saw the place [the museum at 8 Union Street] after his death, it was in a state of deplorable neglect, rain coming in upon books and upon other things of great value."



COMPOSED EXPRESSLY FOR
MISS HANNAH SILVER MOON COTSWORTH,
BY
HANNAH JACKSON-GWILT,
1872.

I.
Scintilating, silver moon,
To Earthites quite a boon;
Like calm night, with bright eye,
Or Aurora lit sky.

II.
How quiet voices seem around
When astral hosts abound;
As sable night his wing
Spreads like an occult king.

III.
Mid Zodiac. Thy walks
Where silken Zephyr talks,
With mild looks on Virgo,
Dark ones to Mars, ergo

IV.
She loves a mountain peak,
And lights up Mozambique;
With cold looks on Etna,
And some surprise at Gretna.

Verses written to celebrate the birth of Hannah Jackson-Gwilt's grandniece

Rendle also says: "From the care his daughter [Hannah] takes of the remains in her possession, as I saw when I visited her lately at Wimbledon, I could but wish that the whole had fallen into her hands instead of a Gallio.[25]" Presumably, it was the executor(s) of the will who showed a disregard for the value of the collection that had been built up over many years, in favour of a quick sale.

Hannah & astronomy

Mary Somerville's memoirs recount the obstacles to self-education faced by females of her time, even those born to a family of moderate wealth:[26]

My mother did not prevent me from reading, but my aunt Janet …greatly disapproved of my conduct. She was an old maid who could be very agreeable and witty, but she had all the prejudices of the time with regard to women's duties and said to my mother: "I wonder you let Mary waste her time reading, she never sews more than if she were a man."[27]

Mary went on to publish, in 1831, a translation of Laplace's *Mécanique Céleste* followed by *The Connexion of the Physical Sciences* (1834). *On Molecular and Microscopic Science* appeared in print when she was 89.

This comparison with Hannah Gwilt is slight. We do not know how much, if at all, the young Hannah was encouraged or discouraged in her study of science; and as avid as her interest in astronomy became, she did not make a mark on the subject and, as a woman, would have found it difficult to do so in any case. Her limited fame came only with the donation of funds to the RAS, which enabled promotion of the Gwilt name. But Mary Somerville and Hannah did share the honour of having a moon crater named after them, even if, in Hannah's case, it was not to be perpetuated (see later).

Edwin Dunkin's book (1869) describes the great comet of 1858, first observed by Giovanni Donati in June of that year. Dunkin picturesquely says of the comet's tail: "It was sensibly curved, and it had the appearance of an ostrich feather being gently carried through the air by the hand." Hannah underlined the word "curved" in her copy, writing "yes", and "I saw it & drew it" in the margin. She further commented about Donati: "He died 1874 of cholera" (although the correct date is 1873). Another hand written note, at the bottom of a page in the section "Astronomy and the Bible" reads:

Biela's comet[28] *touched the Earth on the 27th Nov 1872. Prof Klinkerfues*[29] *writes "a startling telegram to Norman R.Pogson*[30] *Esq, Madras Observatory, Dec. 5, 1872".*

Her appreciation of comets was enhanced by the acquisition of a cometarium[31] made by John Taylor of Liverpool. It was later presented by Hannah to the RAS in 1880 and bore the inscription "This cometarium was originally the property of Mrs Jackson Gwilt's friend Sir James South."[32] One of science's bitterest exchanges raged between the astronomers Richard Sheepshanks and Sir James South. For nearly 30 years the pair were at each other's throats, on and off.[33] As Sir James was another native of Southwark, it is not surprising that he and the Gwilts would become acquainted and Hannah would add another "astronomical friend" to her address book.

Comet C/1858 L1 (Donati) on October 5, 1858. Note the Big Dipper to the right.
The bright star near the comet's head is Arcturus in the constellation Bootes. Published 1888

Contact with the world of astronomy was no doubt made easier for Hannah because of uncle Joseph. On the strength of his mathematical prowess he became an FRAS in 1833. At that time, amateurs could make significant contributions to astronomy, and this was the case for much of the 19th century and even beyond. A "non-professional", the Reverend Theodore Philips, even held the post of president of the RAS (1927-1929). The advance towards domination by the professionals was marked by the formation of the British Astronomical Association in 1890 to "afford a means of direction and organisation in the work of observation to amateur Astronomers."[34]

On the flyleaf of The Midnight Sky[35], Hannah wrote "My Lunar Estate – 438". The explanation for this initially mystifying phrase is revealed by an entry in *Selections from the Portfolios of the Editor of the Lunar Map and Catalogue* (1873), which describes crater number 438:

In connection with the crater Mrs. Jackson-Gwilt, the surroundings of which possess an interest scarcely to be found in any other part of the moon … we may remark that it is an object well worth all the attention that can be bestowed upon it …

Hannah was delighted when she heard that the third edition of *Celestial Objects for Common Telescopes* by the Reverend Thomas Webb would contain mention of "her crater". Listed were 86 new names for lunar features, designated with numbers from 405 to 490. Numbers 455 and 456 were assigned to George Gwilt and Joseph Gwilt, respectively, and the following women were similarly honoured:

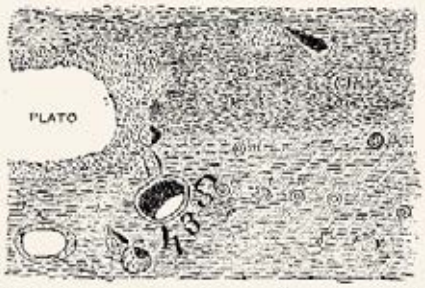
430 Miss Mitchell[36]

431 Mrs Somerville[37]

432 Miss Sheepshanks[38]

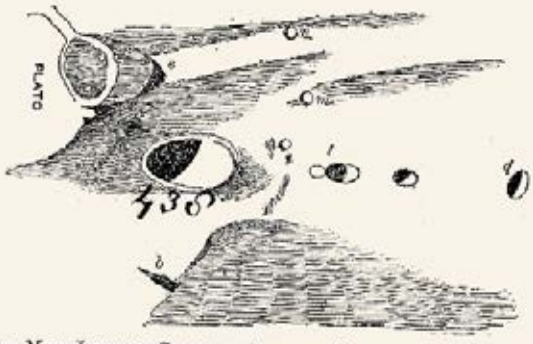
478 Miss Hershel[39]

William Radcliff Birt served as secretary of the Lunar Committee for Mapping the Surface of the Moon, a group that operated under the auspices of the British Association for the Advancement of Science (BA). Birt was one of the "Southwark set" and cousin of George (II) and Joseph, thus explaining why the Gwilt name featured so prominently. With the publication of *Named Lunar Formations* (NLF) in 1935 came an



Crater Mrs. Jackson-Gwilt *and surroundings, as observed by Schröter on the 9th of October, 1788, with his 7-foot telescope; power 161.*

From the 2nd issue of Selections from the Portfolios of the Editor of the Lunar Map and Catalogue



Crater Mrs. Jackson-Gwilt *and surroundings, as seen on the evening of December 29, 1873, with the R. A. S. Sheepshanks telescope; aperture 9·75 inches, power 100.*

From the 2nd issue of Selections from the Portfolios of the Editor of the Lunar Map and Catalogue

internationally accepted guide to the names of lunar features. Gone were Birt's craters Somerville, Jackson-Gwilt, G.Gwilt and J.Gwilt, although Somerville reappeared in 1976 in a different position (Whittaker, 2003, p.222). Hannah's "Lunar Estate" became simply crater Plato A until being renamed Bliss.[40]

As seen through the astronomical telescopes of Schrötter and Sheepshanks (see illustrations above), crater 438 is below and to the right of the lava-filled crater Plato. These images are inverted and the features are actually to the far north and only appear oval because of perspective.

A picture from Hannah Jackson-Gwilt's collection. Saturn as seen by John Browning 14 May 1868 using a 12¼ inch reflector

The York Herald reported in the 31st August and 2nd September issues on the BA meeting of 1881, held in the city. Hannah was there, staying in the house of Martha Magean of 46 Coney Street. The meeting drew many scientific luminaries such as James Dewar, Howard Grubb (of Dublin), Oliver Lodge, Francis Galton, Silvanus P.Thompson and Joseph Swan. There was, at the time, a controversy surrounding the

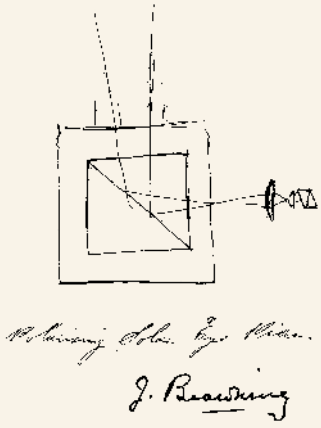
John Browning
(courtesy of the College of Optometrists/
British Optical Association Museum)

work of Norman Lockyer on spectroscopic studied of the sun, and James Dewer had arrived with a prepared lecture criticising this research.[41] Lockyer had been developing his "dissociation hypothesis" whereby, at sufficiently high temperatures, hydrogen was produced by the dissociation of other elements. This, he thought, explained why some metals observed in the spectrum of the sun were not to be found in other stars – they had been fully converted. Unfortunately, his efforts in the laboratory to obtain hydrogen from other elements gave false positive results. Locker is best known for discovering helium in the sun, before it was identified on Earth.

The astronomical groupie[42]

What Hannah lacked in known contributions to astronomy, she made up for by her enthusiastic following of the work of others. The RAS has in its collection the correspondence she received from some 25 leading astronomers, amateur and professional. She much admired the work of John Browning, a remarkable man by any standards (see additional notes in appendix 1). A skilled craftsman with an outstanding reputation, he designed spectroscopes, telescopes, cameras and barometers, to name but a few of the instruments that attracted his attention. Browning carried on his father's business and produced a reflecting telescope that was more affordable for amateur observers. Browning employed Adam Hilger who, with brother Otto, went on to found his own business, specialising in equipment for spectroscopy. The firm of Adam Hilger became Hilger & Watts in 1948.

Several letters were from astronomers at one time associated with Bishop's observatory, founded by the amateur astronomer George Bishop in the grounds of his house, South Villa, Reagents Park, in 1836. Hind, Marth and Talmage worked there (see Appendix 1 for short biographies). On the death of George Bishop in 1861, his son, also called George, moved the equipment and set up another observatory at Twickenham.[43] The Liverpool Observatory at Bidston connects Hannah's correspondents John Hartnup and William E.Plummer. John Hartnup (junior) came to an untimely end on 21 April 1892 when he overbalanced and fell from the observatory roof.[44]



A sketch probably sent by John Browning to Hannah. At the bottom, "J. Browning" is in Hannah's handwriting (glued into Hannah's copy of The Midnight Sky)

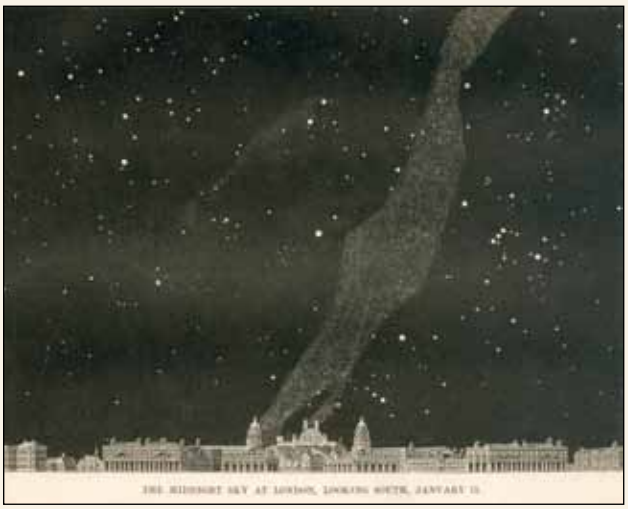


Illustration from The Midnight Sky

The legacies

The moves to establish the Jackson-Gwilt medal began as early as 1861 when, in June of that year, Hannah informed the Council of the RAS that she wished to donate £300 worth of 3% stock that would fund a prize from the interest generated.[45] Under the scheme, the interest would start to accrue after her death and the accumulation effectively ran from 1894 to 1896. The first thoughts were to make the medal in silver, followed by a change to bronze, and finally to gold.

A codicil to Hannah's will dated 15 May 1893 replaced Rosalind Cotsworth as one of the executors with grandnephew Haldane Gwilt Cotsworth. There must have been a rift between Hannah and her grand niece as the previous bequest was revoked: "It being my intention that the said Rosalind Cotsworth shall derive no benefit whatsoever under my said will". Haldane, however, was clearly in favour and received "two large telescopes by Dolland", all books on astronomy[46], two astronomical globes and a gold watch. Further: "… if Haldane Gwilt Cotsworth … should wish to become a Fellow of the Royal Astronomical Society to pay the expenses of his being so made …" Haldane Cotsworth had served an apprenticeship with the Chief Engineer of the Great Western Railway and ended his career as head of electrical engineering at Wigan Mining and Technical College.[47]

Determining longitude from lunar distances (The Midnight Sky)

Hannah Jackson-Gwilt died at home in Wimbledon on the first day of December 1893. As she had wished, Sarah Jane Cotsworth moved into Moonbeam Villa with daughters Sarah, Edith, Margaret, Mary, Ethel, Hannah Silvermoon, and also Rosalind. So Rosalind did, after all, gain at least some benefit from the will.

One hundred and seventeen years after the death of Hannah, the 2011 Jackson-Gwilt Medal has been awarded to Professor Matt Griffin at Cardiff University. He specialises in infrared and sub millimetre astronomy and is the lead scientist on the Spectral & Photometric Imaging Receiver (SPIRE) instrument on board the Herschel Space Observatory. In July of this year he featured on BBC Radio 4's Today programme talking about the latest findings from Herschel.[48]

> It may be given for the writing of an astronomical work or memoir, the invention or improvement of an astronomical instrument, the discovery of a new heavenly body, or the promotion in any other way of the science of astronomy.

The terms for receiving the Jackson-Gwilt medal quoted on the occasion of the award to Clyde W.Tombaugh for the discovery of Pluto

Professor Matt Griffin (left) receiving the 2011 Jackson-Gwilt Medal from RAS President Professor Roger Davies (courtesy of Quentin Stanley and the Royal Astronomical Society)

Portrait of Hannah Jackson Gwilt. (Courtesy of Peter Foulsham and the Royal Astronomical Society)

Hannah's notes from a visit to Newton's birthplace in 1863 (courtesy of the Royal Astronomical Society)

Appendix 1

Brief notes on some people known to have corresponded with Hannah Jackson-Gwilt (letters kept at the Royal Astronomical Society). Information taken variously from Obituaries in the Monthly Notices of the Royal Astronomical Society, Daintith et al (1994), Porter (1994) and the Sackler Archive of the Royal Society of London.

Adams, John Couch (5 June 1819 – 1 January 1892)
President of the RAS 1851-53 and 1874-76. Graduated from the University of Cambridge in 1843, became Lowndean Professor of Astronomy and Geometry in 1858 and director of the Cambridge Observatory in 1860. He declined a knighthood and the post of Astronomer Royal. Elected A Fellow of the Royal Society 1849.

Birt, William Radcliffe (15 July 1804 – 14 December 1881)
A meteorologist and amateur astronomer, who spent the years 1839-1843 working on meteorological observations for Sir John Herschel, and author of *Handbook on the Law of Storms* (1853). He is mainly noted for his work on lunar features (further details in the main text).

Browning, John (1830/31– 14 December 1925)
An instrument maker, amateur astronomer and author of the books *A Plea for Reflectors* and *How to Work with the Spectroscope*. He was the first President of the British Optical Association, from 1895 to 1900. Apart from his expertise in optics he devoted time to the study of new electrical devices – the telephone and phonograph.

Challis, James (12 December 1803 - 3 December1882)
Plumian Professor of Astronomy at Cambridge University, 1836-1882. He missed an opportunity to discover the planet Neptune by not believing that the calculations of John Couch Adams would give its position on a particular date. Elected FRS in 1848.

Donati, Giovanni Battista (16 December 1826 - 20 September 1873)
Appointed director of the Observatory of Florence in 1864. He was a pioneer of the spectroscopic study of comets, the sun and other stars. Although he discovered six comets, but the best known is "Donati's Comet", first observed on 2 June 1858.

Dreyer, John Louis Emil (13 February 1852 - 14 September 1926)
Danish-born astronomer and author of works on the history of astronomy. Appointed as fourth director of the Church of Ireland's observatory at Armagh. President of the RAS 1923-1924 and editor, with Professor H.H.Turner, of *A History of the Royal Astronomical Society 1820-1920*.

Gorton, Sandford (c.1824 – 1879)
A wealthy businessman and amateur astronomer. Founder and editor from 1863 to 1872 of the *Astronomical Register*, a journal for amateurs.

Hartnup, John junior (1841 – 21 April 1892)
A prominent member of the Liverpool Astronomical Society. He died after falling off the observatory roof. His father, John Hartnup senior, was Assistant Secretary at the RAS 1838-1843.

Hind, John Russell (12 May 1823 – 23 December 1895)
Superintendent of the private observatory belonging to George Bishop, from 1844. FRS 1863, President of the RAS 1880-1881 and Superintendent of the Nautical Almanac 1853-1891.

Huggins, William (7 February 1824 - 12 May 1910)
A pioneer of spectroscopic studies applied to astronomy. He made a far-reaching contribution when, in 1868, he was able to calculate the velocity of Sirius from the Doppler shift towards the red end of the spectrum (red shift). He was knighted in 1876 and served as president of the Royal Society 1900-1905.

Lee, John (28 April 1783 – 25 February 1866)
John Lee lived at Hartwell House, in Buckinghamshire, where he built an observatory and provided premises for the British Meteorological Society, of which he was a founder member. He was President of the RAS 1861-1863.

Leverrier, Urbain Jean Joseph (11 March 1811 – 23 September 1877)
French astronomer remembered chiefly for predicting the position of a new planet – Neptune – that resulted in its immediate observation by Johann Galle in 1846. The anomalous motion of Mercury led him to propose that an undiscovered planet, which he named Vulcan, would be found between Mercury and the Sun. The movement of Mercury was later explained using Einstein's theory of relativity.

Lindsay, James Ludovic (28 July 1847 – 31 January 1913)
The 26th Earl of Crawford and 9th Earl of Balcarres. Maintained a private observatory. Elected FRS 1878, President of the RAS 1878-1880 and MP for Wigan 1874-1880. He helped support the Royal Observatory at Edinburgh with a donation of books and instruments.

Von Mädler, Johann Heinrich (29 May 1794 – 14 March 1784)
An eminent German astronomer worked on maps of Mars and the Moon whilst at a private observatory set up by a wealthy banker, Wilhelm Beer around 1830. In 1836 he was appointed director of the Dorpat Observatory, Estonia.

Marth, Albert (5 May 1828 – 5 August 1897)
A German astronomer who came to work in England at the private observatory of George Bishop in 1853. He moved on to Durham Observatory and in 1862 joined William Lassell at Malta, cataloguing 600 nebulae with the aid of a 4-foot telescope. The University of Durham awarded him an honorary MA.

Parsons, Laurence (17 November 1840 – 29 August 1908)
The 4th Earl of Rosse, and son of William Parsons who built the largest telescope of its time, dubbed "the "Leviathan of Parsonstown", in Ireland. Elected FRS 1867.

Plummer, William Edward (1849 – 1928)
Appointed director of the Liverpool Observatory, Bidston, in 1892 and remained in the post for the rest of his life. His son, Henry Crozier Plummer became Royal Astronomer for Ireland in 1912.

Quetelet, Lambert Adolphe Jacques (22 February 1796 – 17 February 1874)
A versatile Belgian scientist who worked in the fields of astronomy, criminology and sociology, bring to bear his mastery of statistics. He introduced the body mass index relating a person's weight and height. Elected a Foreign Member of the Royal Society 1839.

Talmage, Charles George (12 November 1840 – 20 March 1886)
Began his astronomical career at the Royal Observatory, Greenwich in 1856. Appointed director of a private observatory at Leyton funded by J.Gurney Barclay of Barclays Bank fame. The Leyton observatory closed after Talmage's death.

Webb, Thomas William (1806 – 1885)
Victorian author of the standard work for amateurs, *Celestial Objects for Common Telescopes*, published in six editions between 1859 and 1917. Hannah described the third edition as " Rev W.Webb's charming little book". He was a rural clergyman, incumbent of Holy Trinity Church, Hardwicke, Herefordshire.

Wesley, William Henry (1841 – 1922)
Assistant Secretary of the RAS 1875-1922.

Whitbread, Samuel Charles (1796 – 1879)
A founder member of the British Meteorological Society (later the Royal Meteorological Society) on 3 April 1850 and grandson of the founder of Whitbread's Brewery.

Appendix 2

Winners of the Jackson-Gwilt Medal

2011 Matt Griffin
2010 Craig Mackay
2009 Peter Ade
2008 Stephen Shectman
2006 Keith Taylor
2004 Pat Wallace
2001 John Baldwin
1998 Alexander Boksenberg
1995 Janet Mattei
1992 Richard Stephenson
1989 Richard Hills
1986 David Malin
1983 Grote Reber
1980 Roger Griffin
1977 Patrick Moore
1974 Geoffrey Perry
1971 Alan William James Cousins
1968 John Guy Porter
1963 George Alcock
1960 F.M.Bateson and A.F.A.L.Jones
1956 R.P. de Kock
1953 John Prentice
1949 Algernon Newbegin
1946 Harold Newton
1942 Reginald Waterfield
1938 Frederick Hargreaves and Percy Ryves
1935 Walter Gale
1931 Clyde Tombaugh
1928 William Reid and William Steavenson
1923 A.Stanley Williams and William Sadler Franks
1918 T.E.R.Phillips
1913 Thomas Espin
1909 Philibert Melotte
1905 John Tebbutt
1902 Thomas Anderson
1897 Lewis Swift

Bliss is the somewhat irregular bowl-shaped crater to the left (west) of the large Plato crater.
Courtesy Wikipedia Commons

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Neil Handley, Curator, British Optical Association Museum.

Peter Hingley, Librarian, Royal Astronomical Society.

Research costs funded by SDA Electronics Ltd, Salford.

Notes:

1 Generally known as the Jackson-Gwilt Medal.

2 Dreyer (1923) p.236.

3 Here referred to as George (I). Born in Southwark 9 June 1746, died 9 December 1807. See M.H.Port (2004).

4 Here referred to as George (II). Born in Southwark 8 May 1775, died 27 June 1856. See G.W.Burnett & A.P.Baker (2004).

5 Born in Southwark 11 January 1784, died 14 September 1863.

6 According to the Davies family tree on Ancestry.co.uk.

7 Joseph was related via his marriage to Louisa Brandram.

8 See http://www.jamescumminsbookseller.com/store/246041.htm

9 Now Southwark Cathedral. http://cathedral.southwark.anglican.org

10 *The Morning Post,* 3 August 1832.

11 St. Saviours School was later built on the site of the Crossbones cemetery.

12 A meeting of the churchwardens of St.Saviours in the vestry of St.Saviours.

13 Presumably Mary Ann Gwilt, Hannah's mother.

14 *The Observer,* 16 September 1849.

15 Listed at 7 Union Street in the 1856 *Post Office Directory of London.*

16 Alfred Gwilt is listed in the 1856 *Post Office directory of London.*

17 Officially, Surrey County Gaol.

18 See http://www.capitalpunishmentuk.org/horsemon.html

19 *The Times*, 14 November 1849.

20 Prothonotary – principal clerk of a court.

21 Death reported in *The Standard,* Monday 24 April 1837 as occurring on the 13 April.

22 Noted for "Joynson Superfine" watermarked paper.

23 Dates for these changes have not been established.

24 *The Times,* 3 October, 1856.

25 A reference to the Roman Proconsul of Achaia. He refused to pronounce on a charge brought by the Jews around 52 AD against the Apostle Paul for proclaiming Jesus as the Messiah (Acts 18:12-17). A Gallio came to mean a person indifferent to the sensibilities of others.

26 Mary Fairfax Somerville (1780-1872), after whom Somerville College, Oxford is named.

27 Dorothy McMillan (2001) p.23.

28 After Wilhelm von Biela who observed it in 1826.

29 Ernst Friedrich Wilhelm Klingerfues (1827-1884), German astronomer.

30 Orbital calculations suggest that whatever Pogson had observed, it was not Biela's comet.

31 A device that shows the path of a comet in its orbit around the sun.

32 Martin Beech (2006).

33 A full account of the feud is given by Michael Hoskin (1989).

34 As quoted by John Lankford (1981) p.21.

35 Edwin Dunkin (1869).

36 Maria Mitchell (1818-1889) of Nantucket. The first female professor of astronomy in the USA.

37 Mary Somerville. Honorary FRAS in 1823.

38 Anne Sheepshanks (1789-1876), sister of astronomer Richard Sheepshanks (1794-1855). She was elected as an honorary fellow of the RAS (in 1862) after donating valuable scientific instruments from her late brother's collection in 1857 (Peggy Kidwell, 1984, p.538).

39 Caroline Hershel, sister of astronomer Friedrich Herschel. With Mary Somerville, one of the very few female honorary fellows of the RAS.

40 After the 4th Astronomer Royal, Nathaniel Bliss.

41 Meadows (2008) pp.152-153.

42 With thanks to Janet Robinson, co-editor of *The Stargazer of Hardwick,* for the idea of this title.

43 *Illustrated London News,* 9 October 1869, p.368.

44 *Cheshire Observer,* 23 April 1892.

45 Dreyer (1923) p. 236.

46 The original will left Hannah's astronomical album to the RAS and this was carried out.

47 Obituary Notices, *Journal of the Institution of Electrical Engineers, June 1950, pp.167-168*

48 http://news.bbc.co.uk/today/hi/today/newsid_9544000/9544060.stm

Teaching secondary science to non-scientific children

Christine Thompson ▶

I spent eight years teaching all abilities in a Greater Manchester secondary school in a very deprived area where some of the children were "special needs" and many were either not interested in or unable to understand scientific principles. These are some of my recollections.

Rory was a traveller – a rough diamond who was a pleasure to teach. We were studying density, which was a concept that Rory could just not come to terms with. After doing numerous practical sessions – which he enjoyed – the ideas were still not making any sense to him. Imagine my surprise and delight, when I started asking questions about the relative densities of different metals. Rory's hand went up and he put the 3 metals in the correct order of their increasing density. I was astounded and asked how he knew that. "It's easy, Miss. You get £3 a pound for Copper, £50 a pound for silver and £60 a pound for gold."

Lee was on the school rugby team. He was about a foot taller and wider than the other boys in the class – good at his rugby but struggled with anything academic.

We were doing the periodic table and Lee enjoyed guessing that the symbol for oxygen was O, nitrogen was N, sulphur was S but was really perplexed when he heard that gold was Au etc. After covering a few of these "obscure" symbols, Lee put me to the test. "Off the top of your head, like, miss, what is the symbol for mercury?" I, of course, answered – "Hg". After checking this on his copy of the periodic table, Lee shouted out: "They make you ruddy sick teachers. They know everything!!"

Emma was a lovely girl who liked sewing and art but science was a complete mystery to her. We were learning about estimating the volume of irregular solids by displacement of water. I had told the class the story of Archimedes and his "Eureka" moment in the bath (Never sure whether this was factual or not). The class

were using Eureka cans or displacement vessels filled to the spout with water, into which they lowered a series of irregular objects – stones etc. tied on strings. They collected the displaced water in a measuring cylinder and this was the volume of the object.

The class were told to run tap water into the vessel "until it stopped coming out of the spout" and then lower in the object. I wandered around the class as the pupils did this and got to Emma about 5 minutes later. She was utterly dejected. She was holding the can under the tap and said in a whining voice: "But Miiiiiiiss, it's NEVER going to stop running out".

The science class were now in year 11. After 5 years of watching teacher-led demonstrations it was their turn. I asked the pupils to think of any science-based experiment – very open-ended – that they would be prepared to demonstrate to the rest of the group. One girl really liked this idea and I could see that she knew what she would do. After a week in which they were to work out their 'act', the lesson came round. They were given 10-15 minutes to demonstrate the new practical skill to their peers. The girl volunteered to go first. She sat at the teacher's desk at the front of the class and asked all the boys and girls to gather round her. She produced a camera (non-digital then) and a largish black bag with a drawstring top, explaining that she was going to show the rest of the class how to remove the film from the camera for developing. She put the camera in the bag, drew up the string tightly and then proceeded to move her hands about inside the bag. This carried on for a few minutes and her face was rapt with concentration. After completing the 'demo', with a Tommy Cooper like flourish, she removed from the bag, the camera in one hand and the film in the other and waited for the accolade. None came.

Even though teachers are meant to try to like and respect all their pupils, it is only human to have exceptions to this rule. One boy, who shall be nameless, had very little to commend him. He was dishonest (stole a miniature Swiss Army Knife from my key ring), badly behaved, disruptive and very spotty. Writing his reports was a nightmare as these had to accentuate the positive and there wasn't much of that.

One day, I received a message in my register that concerned him. Opening it, it asked if I would remind him that his library book – from the Science section – was 2 weeks over-due and please could he return it. Even though he was in trouble again, I thought I saw a glimmer of hope in that he had taken out a library book at all. I gave him the message and then asked brightly what the title of his book was. "Ferrets" came the reply!

Albert was a typical Romany, jet-black hair and eyes and a smile to melt the heart. School was something to fit in between fairs and other gypsy events. He was in my form during my first year of teaching. One day during the first term at this school I was taking a physics class (my subject was actually chemistry). Albert asked me at morning registration if he could leave, in my prep-room, a carrier bag containing what he needed to illustrate a talk he was giving in biology. I agreed but was surprised and amused when Albert appeared with a brown paper bag in which a there was a full sized cockerel. The bag was stored in the room behind my lab and I progressed with my lessons. Just before the bell went for the end of the second lesson I was in the process of dictating some notes for the class. I was quite nervous and the atmosphere in the room was tense - they had a reputation for being a difficult class and I was finding my feet regarding controlling them. All of a sudden Albert's cockerel gave out an enormous cock-a-doodle-do at the top of its voice. Quite ridiculously, I ignored it and carried on dictating. There were lots of amazed faces in front of me but I continued. A couple of minutes later, the bird crowed again. This time, I broke out into laughter and continued until tears were streaming down my face. The class joined in. Albert then walked in, on the bell, and strode past me with his bag. As he walked past, the cockerel pushed its head above the bag, looked round as they do and did its third loud crow. Priceless.

Author:
Christine Thompson

Christine left the Wigan Girls' High School after sitting A-levels to work as a trainee glass analyst at Pilkington Brothers in St. Helens and then as a research assistant at The Tetley Walker Brewery in Warrington. During these years she took day-release and obtained H.N.C and L.R.I.C at the Wigan and District Mining and Technical College. After marrying in 1969, Christine spent the next 8 years at home with her children before becoming a school laboratory technician. At the age of 40, she decided to do a B.Ed at Crewe and Alsager College and then worked for the next 20 years, firstly as a Chemistry teacher and later, as a teacher of Physics and Maths in two Wigan schools. Christine combined this occupation with helping her husband run their micro-brewery and managing the local scout group. She retired in 2006 and is still helping the local scouts and doing some voluntary teaching for the Prince's Trust.

Frog trade link to killer fungus revealed

Natural Environment Research Council ▶

The global trade in frogs, toads and other amphibians may have accidentally helped create and spread the deadly fungal disease chytridiomycosis, which has devastated amphibian populations worldwide.

What's more, researchers say that unless the trade is regulated, even deadlier strains of the disease may soon emerge.

An international team of scientists, led by Dr Matthew Fisher from Imperial College London, found that the trade may have let non-lethal strains of the chytrid fungus from different parts of the world come into contact with each other.

This means they've exchanged genes in a process called recombination, creating a new and lethal strain which has decimated frog populations around the world in recent years.

"It's likely that the amphibian trade has allowed different populations of the fungus to come into contact with each other, allowing recombination to occur", said Rhys Farrer from Imperial College London and ZSL's Institute of Zoology, lead author of the study published in *Proceedings of the National Academy of Sciences*.

"This has created a hypervirulent strain leading to losses in amphibian biodiversity."

The chytrid fungus, or *Batrachochytrium dendrobatidis* (Bd) as it is sometimes called, infects the skins of amphibians like frogs, toads, salamanders and newts.

Declines in many amphibian populations around the world are due to the disease and over 200 species are suspected to have become extinct as a result. In Central America alone, chytridiomycosis has led to the loss of up to 40 per cent of wild amphibians, including the Panamanian Golden Frog.

Despite much research on the disease, scientists have struggled to figure out where it came from or explain how it spread. The problem is even more puzzling because some amphibians coexist alongside Bd with no sign of disease.

"This strongly suggested there may be more than one type of strain of chytrid fungus", said Farrer.

Farrer and his colleagues decided to sequence and compare Bd genomes from 20 disease samples isolated from 11 amphibian species worldwide to find out more about the fungus' ancestry.

They found three different strains. One of these, the Global Panzootic Lineage (GPL), has made its way to at least five continents and has caused infections in North America, Central America, the Caribbean, Australia and Europe.

The researchers found evidence of gene exchange in this lineage, which turned out to be the deadliest of the three strains.

In one example, a captive breeding and reintroduction programme to boost numbers of the endangered Mallorcan midwife toad may have helped Bd spread from captive African clawed frogs to the toads.

The fact that they found three strains in just 20 samples also suggests Bd is much more diverse than previously thought.

"What's interesting is that they're not all causing disease", said Fisher. "Only one lineage is a killer, and it has evolved very recently." Scientists had until now thought there was just one strain of Bd.

Farrer, Fisher and their colleagues also found that the start of the decline of amphibians around the 1970s coincides with the emergence of the amphibian trade.

"The age of the lethal BdGPL lineage coincides with the start of the amphibian trade in the 20th century, when we started moving many frogs and toads around the world", says Fisher.

"The horse has well and truly bolted, but to halt the further spread of this disease, we really need to increase global biosecurity", said Fisher.

The study was funded by the Natural Environment Research Council, the UK Department for Environment, Food & Rural Affairs, the Biotechnology & Biological Sciences Research Council and the European Research Council.

AHRC history students to make ship history

Arts and Humanities Research Council ▶

Brunel's SS Great Britain is the world's first great ocean liner. Launched in 1843 to provide luxury travel to New York, the iron-hulled steamship revolutionised travel and set new standards in engineering, reliability and speed. Today Brunel's SS Great Britain, is one of the UK's most exciting museums and visitor attractions. www.ssgreatbritain.org

Arts and Humanities Research Council (AHRC) funded doctoral students are making history, as part of a new joint initiative between the SS Great Britain Trust and the University of Bristol.

PhD students Claire Connor and James Muirhead are splitting their time between Brunel's SS Great Britain and Brunel Institute and the University of Bristol and will research the history of Brunel's iconic steamship, the SS Great Britain, from 1843.

Claire Connor is covering the SS Great Britain between 1843 and 1886, when the ship carried:

- Passengers to the USA and emigrants to Australia;
- Troops to the Crimean War and Indian (Sepoy) Wars;
- Cargo between Great Britain and the USA.

She is researching the experiences of passengers and crew, relationships between different groups, and how travel had an impact on class, gender, race, nation and empire.

James Muirhead is examining the ship's history from 1886 including:

- Use as a floating storage hulk, before abandonment, in the Falkland Islands;
- The 1970 salvage and return to Bristol;
- Conservation and restoration work leading to the museum attraction's 're-launch' in 2005;
- Award-winning success and developments after 2005.

As well as using the 40th homecoming anniversary's oral history project, James Muirhead is also examining what and why stories have been told at the museum attraction, and SS Great Britain Trust's place in the context of today's heritage industry.

The three-year studentships will include up to three months' study in Australia and the Falkland Islands and the awards will give the students the opportunity to work outside an academic environment. Their findings will add to the Trust's wealth of knowledge and help further improve the award-winning visitor experience at Brunel's SS Great Britain.

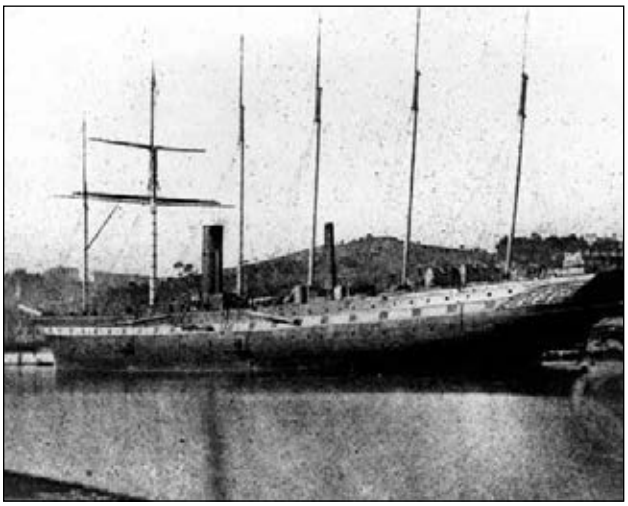
The two PhD students will be supervised by the Trust's Director of Museum and Educational Services and the University's Department of Historical Studies' Dr Tim Cole, alongside Professor Peter Coates and Dr Simon Potter from the University of Bristol.

Left to Right: The University of Bristol's Dr Tim Cole, with PhD student Claire Connor, the SS Great Britain Trust's Director of Museum & Education Services Rhian Tritton, and PhD student James Muirhead

Image Courtesy of Jodie Lucas-Jones

The SS Great Britain Trust's Director of Museum and Educational Services Rhian Tritton commented: "These doctoral awards, funded by the AHRC, are highly prestigious and given to projects which involve active collaboration and benefit to the wider community. We are delighted to welcome the two PhD students as part of the Trust's museum and educational team and look forward to incorporating their findings into telling the true stories of the ship, her passengers and crew, and those who have helped care for the historic vessel since her return to Bristol."

Early findings by the students include images of timber huts built by gold prospectors, who may have emigrated to Australia on board the SS Great Britain. As part of their PhD they will also be giving visitors lunchtime talks and lectures.



SS Great Britain fitting out alongside Gasworks quay in Bristol Floating Harbour (not Cumberland Basin), April 1844. This photograph of Great Britain taken by pioneering photographer William Henry Fox Talbot is not only the first taken of Great Britain, but also believed to be the first photograph ever taken of a ship.

Image courtesy Wikimedia Commons

How parasites modify plants to attract insects

Biotechnology and Biological Sciences Research Council ▶

Anopheles albimanus mosquito feeding on a human arm. Image courtesy of Wikipedia Commons

Pathogens can alter their hosts, for example malaria parasites can make humans more attractive to mosquitoes, but how they do it has remained a mystery. Scientists from the John Innes Centre on Norwich Research Park, which receives strategic funding from the Biotechnology and Biological Sciences Research Council (BBSRC), have identified for the first time a specific molecule from a parasite that manipulates plant development to the advantage of the insect host.

This finding could help scientists to find new ways of managing the spread of insect-borne crop diseases. This will be vital in order to ensure future food security, especially, in this case, in the face of climate change.

"Our findings show how this pathogen molecule can reach beyond its host to alter a third organism", said Dr Saskia Hogenhout from JIC.

Leaf hoppers are tiny sap-sucking, highly mobile and opportunistic agricultural pests. Certain species can acquire and transmit plant pathogens including viruses and phytoplasmas, which are small bacteria. Dr Hogenhout and her team focused on a phytoplasma strain called Aster Yellows Witches' Broom, which causes deformity in a diverse range of plants.

"It is timely to better understand phytoplasmas as they are sensitive to cold and could spread to new areas as temperatures rise through climate change", said Dr Hogenhout.

Infected plants grow clusters of multiple stems which can look like a witches' broom or in trees like a bird's nest. The strain was originally isolated from infected lettuce fields in North America.

The phytoplasma depends on both the leafhopper and the plant host for survival, replication and dispersal. The new findings show how it manipulates the interaction of the plant host and insect vector to its advantage.

The scientists sequenced and examined the genome of the witches broom phytoplasma and identified 56 candidate molecules, called effector proteins, which could be key to this complex biological interaction.

They found that a protein effector SAP11 reduces the production of a defence hormone in the plant that is used against the leafhopper. As a consequence, leafhoppers reared on plants infected with witches broom laid more eggs and produced more offspring. The leafhoppers may also be attracted to lay eggs in the bunched branches and stems.

The higher fecundity rate is probably matched by a similar increased rate in transmission of the witches broom phytoplasma by leafhoppers to other plants.

"Phytoplasmas that can enhance egg-laying and offspring numbers in leafhoppers are likely to have a competitive advantage", said Dr Hogenhout.

Given their opportunistic nature, the leafhoppers are likely to migrate to uninfected plants and spread the pathogen.

"This is a vivid example of the extended phenotype, a concept put forward by Richard Dawkins, where an organism's phenotype is based not only on the biological processes within it but also on its impact on its environment", said Dr Hogenhout.

The research was funded by the Biotechnology and Biological Sciences Research Council and The Gatsby Charitable Foundation. It will be published in PNAS.

Reference:

Doi: http://dx.doi.org/10.1073/pnas.1105664108

John Innes Centre

The John Innes Centre, www.jic.ac.uk, is a world-leading research centre based on the Norwich Research Park www.nrp.org.uk. The JIC's mission is to generate knowledge of plants and microbes through innovative research, to train scientists for the future, and to apply its knowledge to benefit agriculture, human health and well-being, and the environment. JIC delivers world class bioscience outcomes leading to wealth and job creation, and generating high returns for the UK economy. JIC is one of eight institutes that receive strategic funding from the Biotechnology and Biological Sciences Research Council and received a total of £28.4M investment in 2010-11.

Mating pair of Bothrogonia ferruginea (Cicadellinae). Image courtesy Wikipedia commons

Growing computers

Engineering and Physical Sciences Research Council ▶

Synthetic Biology researchers, funded by EPSRC, have successfully demonstrated that they can build some of the basic components for digital devices out of bacteria and DNA, which could pave the way for a new generation of biological computing devices.

The researchers, from Imperial College London, have demonstrated that they can build logic gates, which are used for processing information in devices such as computers and microprocessors, out of harmless gut bacteria and DNA. Their work was announced through a paper published in Nature Communications and later covered by the Financial Times Magazine.

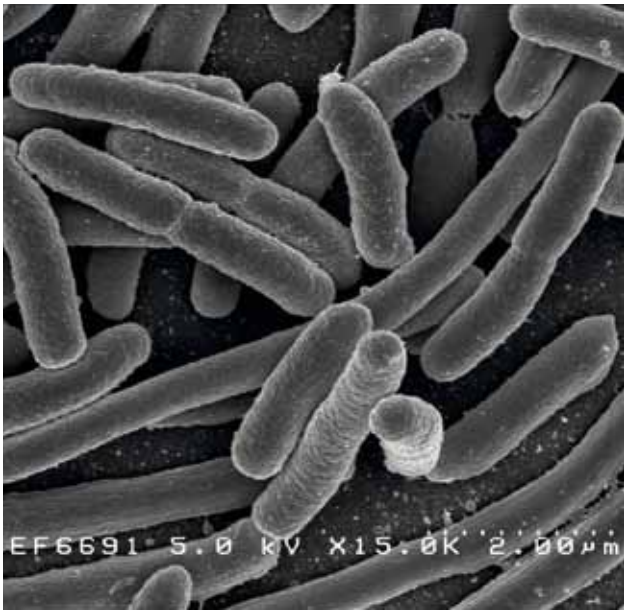
Professor Richard Kitney, co-director of the EPSRC Centre for Synthetic Biology and Innovation, says:

"Logic gates are the fundamental building blocks in silicon circuitry that our entire digital age is based on. Without them, we could not process digital information. Now that we have demonstrated that we can replicate these parts using bacteria and DNA, we hope that our work could lead to a new generation of biological processors, whose applications in information processing could be as important as their electronic equivalents."

Although still a long way off, the team suggest that these biological logic gates could one day form the building blocks in microscopic biological computers. Devices may include sensors that swim inside arteries, detecting the build up of harmful plaque and rapidly delivering medications to the affected zone. Other applications may include sensors that detect and destroy cancer cells inside the body and pollution monitors that can be deployed in the environment, detecting and neutralising dangerous toxins such as arsenic.

The team say that the advantage of their biological logic gates over previous attempts is that they behave like their electronic counterparts. Previous research only proved that biological gates could be made. The new biological gates are also modular, which means that they can be fitted together to make different types of logic gates, paving the way for more complex biological processors to be built in the future.

In the new study, the researchers demonstrated how these biological logic gates worked. In one experiment, they showed how biological logic gates can replicate the way that electronic logic gates process information by either switching "on" or "off".



Scanning electron micrograph of Escherichia coli, grown in culture and adhered to a cover slip

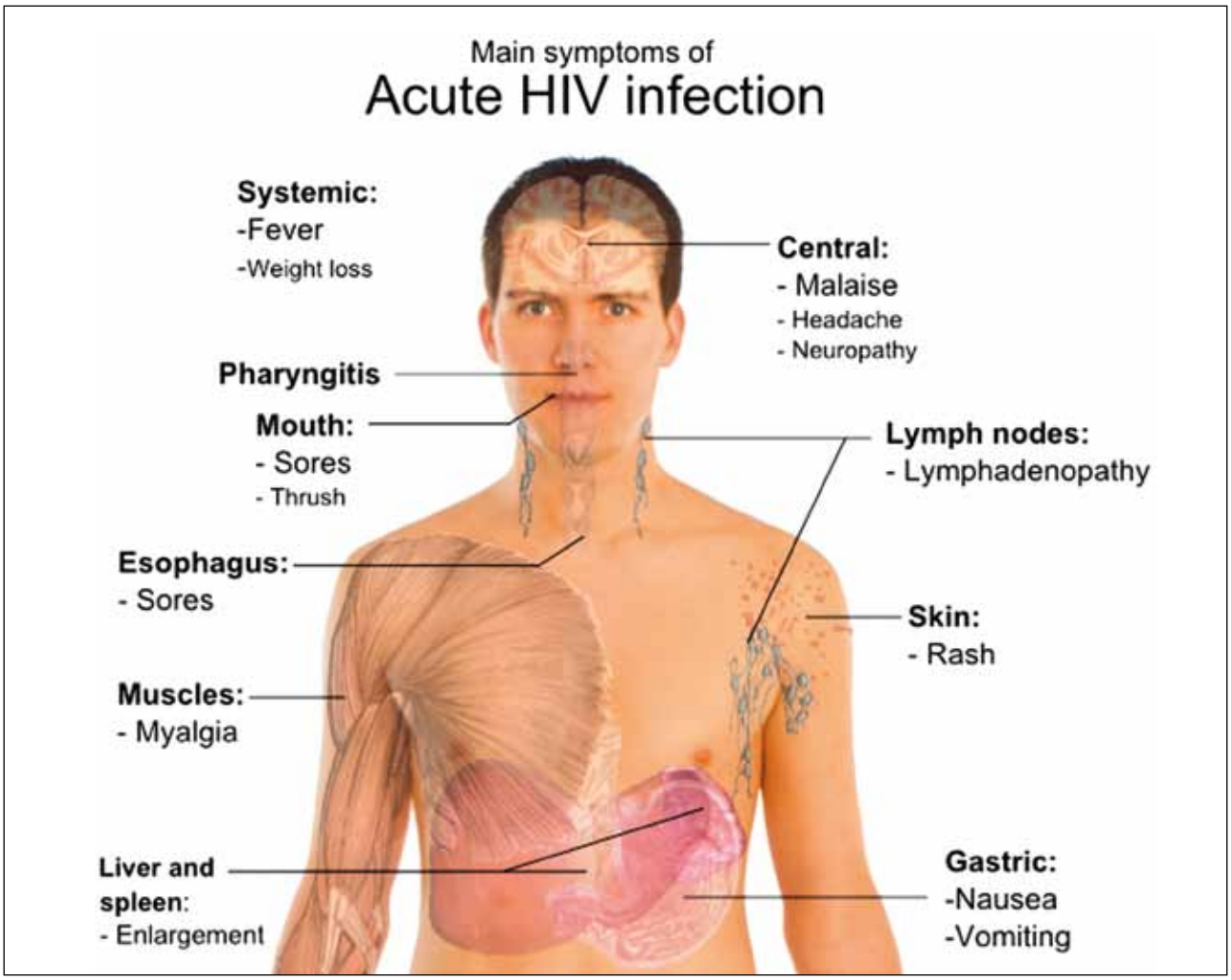
The researchers demonstrated that biological logic gates could be connected together to form more complex components in a similar way that electronic components are made. In another experiment, the researchers created a "NOT gate" and combined it with the AND gate to produce the more complex "NAND gate".

The next stage of the research will see the team trying to develop more complex circuitry that comprises multiple logic gates. One of challenges faced by the team is finding a way to link multiple biological logic gates together similar to the way in which electronic logic gates are linked together to enable complex processing to be carried out.

Professor Martin Buck, co-author of the paper from the Department of Life Sciences at Imperial College London, adds: "We believe that the next stage of our research could lead to a totally new type of circuitry for processing information. In the future, we may see complex biological circuitry processing information using chemicals, much in the same way that our body uses them to process and store information."

HIV study identifies key cellular defence mechanism

Medical Research Council ▶



Scientists have moved a step closer to understanding how one of our body's own proteins helps stop the human immunodeficiency virus (HIV) in its tracks.

The study, carried out by researchers at the Medical Research Council National Institute for Medical Research and The University of Manchester and published in *Nature*, provides a blueprint for the design of new drugs to treat HIV infection, say the researchers.

Scientists in the United States and France recently discovered that a protein named SAMHD1 was able to prevent HIV replicating in a group of white blood cells called myeloid cells.

Now, crucially, UK researchers have shown how SAMHD1 prevents the virus from replicating itself within these cells, opening up the possibility of creating drugs that imitate this biological process.

Dr Ian Taylor from the MRC National Institute for Medical Research explained: "Our research has given us an insight into the detailed interactions between the HIV virus and a particular protein inside human cells.

We now wish to define more precisely, at a molecular level, how the SAMHD1 protein functions. If we can achieve this, it will pave the way for new therapeutic approaches to HIV and even vaccine development."

Dr Michelle Webb, who led the study in Manchester's School of Biomedicine at the University of Manchester, said: "HIV is one of the most common chronic infectious diseases on the planet, so understanding its biology is critical to the development of new antiviral compounds. SAMHD1 has been shown to prevent the HIV virus replicating in certain cells but precisely how it does this wasn't known. Our research has found that SAMHD1 is able to degrade deoxynucleotides, which are the building blocks required for replication of the virus. If we can stop the virus from replicating within these cells we can prevent it from spreading to other cells and halt the progress of the infection."

The study was funded by the Medical Research Council, the European Union Seventh Framework Programme and the European Leukodystrophy Association.

Physicists shed new light on supernova mystery

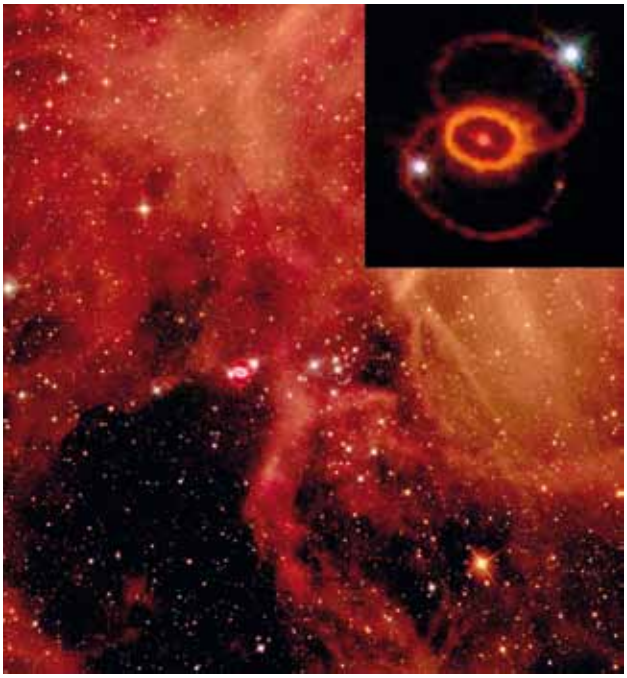
Science & Technology Facilities Council ▶

Physicists have a new theory on the mysterious mechanism that causes the explosion of massive, or core, stars. These Type II supernovae, the term given to exploding core stars, are huge and spectacular events; intriguing because for a short time they emit as much light as is normally produced by an entire galaxy. In fact, the enormous amount of energy they release is second only to the Big Bang itself. While there is general agreement on how the collapse of a core star begins, how the energy escapes from the star (the process that causes the explosion) is not fully understood. A paper published in Physics Letters B (3 November 2011) offers a new theoretical explanation.

A core star collapses when it runs out of the nuclear fuel it depends on and folds in on itself in less than a second under its own huge weight. This process releases enormous amounts of gravitational energy, causing an explosion. A small fraction of the total energy released during a supernova Type II (collapse of a lone massive star that burns energy through fusion), is emitted as light, the kinetic energy of the exploding stellar envelope is 10 times greater again, but by far the most energy is carried away by neutrinos. It is by studying these neutrinos (among the most difficult particles to detect) that physicists have come to general agreement that gravitational collapse does start the Type II supernova process.

Less understood is whether the outgoing pressure wave causing the explosion - that soon becomes a huge shock wave - travels all the way out and ejects the outer part of the star. Simulations have shown that the prompt shock stalls at distances of about 300 km from the centre because of the immense energy required to keep its momentum. Further simulations have found that the shock could re-start if the electrons could absorb a small amount of energy - about 1% of the neutrino energy available.

Physicists at the University of Aberdeen, STFC's Rutherford Appleton Laboratory, the University of Strathclyde and the Instituto Superior Técnico in Lisbon suggest in Physics Letters B that the solution to the Type II supernovae mystery might lie in a fundamental field long proposed by physicists to answer many important questions. They claim that a component of gravity called the 'scalar gravitational field' may be the driving force behind the release of energy that causes the star to finally explode. The existence of scalar fields are predicted but have not yet been detected.



Detection of neutrinos from supernova 1987A strongly supports the gravitational core collapse theory of type II supernovae, but what re-energises the stalled shockwave to allow such an immense explosion to take place remains unknown. The emission of scalar gravitational waves from the neutron core of a collapsing heavy star may provide an explanation

(Courtesy NASA)

"Scalar fields, unlike electromagnetic fields do not have a direction. They are needed to explain inflation in the early universe and dark energy in cosmology. They are also being hunted at CERN's Large Hadron Collider as the Higgs particle, giving rise to the origin of mass. In our case, we believe it is responsible for accelerating particles", said Professor Bob Bingham from STFC and the University of Strathclyde.

"The theory is that emission of these scalar gravitational waves from the neutron core of a collapsing heavy star may re-energise the stalled shockwave", added Dr Charles Wang from the University of Aberdeen.

FROM THE ARCHIVES

Alan Gall - IST Archivist ▶

It seemed like a good idea at the time!

Necessity is not always the mother of invention and sometimes not even a distant relative. As a result, patents have long been a happy hunting ground for finding strange, but interesting, ideas. The following are two devices that never made any money for their creators.

UK Patent 2910, A.D. 1895- Improved method of and apparatus for removing snow or ice from the streets or other places.

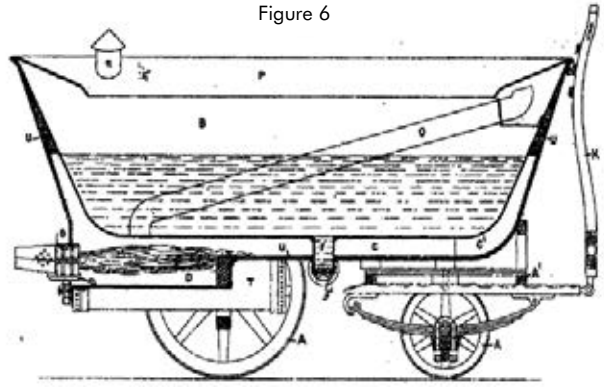
Richard Ripley was a manufacturer of a once common whitening agent, used when washing clothes and popularly known as "Dolly Blue". Mr Ripley's manufacturing experience led him to devise several forms of packaging and a natty wire handle for holding the washing-blue bags. His inventive powers, however, did not stop at commercial improvements. In 1895 came the results of observing men clearing the streets of snow during the winter months. Why not deal with the offending material immediately rather than move it elsewhere? In a nutshell, Richard Ripley's contrivance was a bathtub on wheels used to melt snow and discharge the water down the nearest drain.

It will be seen that the apparatus possesses this great advantage of dispensing with the old and costly system of employing men to cart the snow away, the snow in my apparatus being far more quickly disposed of by melting it and running it to waste through the public drains.

Figure 6 of his specification shows the heat source, a "petroleum burning furnace".

What he seems not to have taken into account is that about 80 times more energy is required to melt snow than to increase the temperature of water by one degree. The replacement of cheap labour with a fuel bill for melting a street's worth of snow cover could hardly be described as economical! But the device had another function: "At other seasons of the year when the apparatus is not required for use as a snow melter, the apparatus may be used as a watering cart …"

Figure 6



Patent 2910 of 1895

Richard married twice, the second time at age 55 and went on to add a further four children to his existing six. He must have taken a liking to the initials R.R. as his offspring were called Ralph, Ruby, Rita, and Renée. Ralph succeeded with a patent of his own in 1922: An improved portable appliance for pressing trousers.

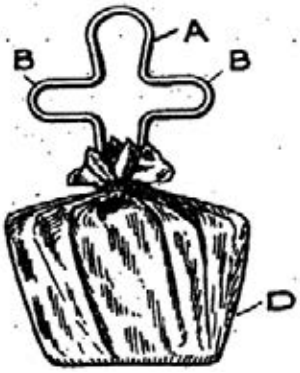
Richard Ripley's trademark of a "dolly-tub" registered in 1876

One of a number of trademarks used by Richard Ripley consisted of the words "Oval Blue". When a rival in London sold a similar product with the same oval shape, the case of Ripley v. Bandey went before Justice Kekewich in 1897.[1] Ripley lost because he had not taken action over other previous infringements: "…the action must be dismissed, owing to the neglect of plaintiff to assert his rights."[2] This must have infuriated Richard and other court actions followed: Ripley v. The New Hydroleine Co Ltd, Ripley v. Edge, Ripley v. Griffiths, and possibly others. In the case of Ripley against William Edge, both claimed the rights to "Dolly Blue".

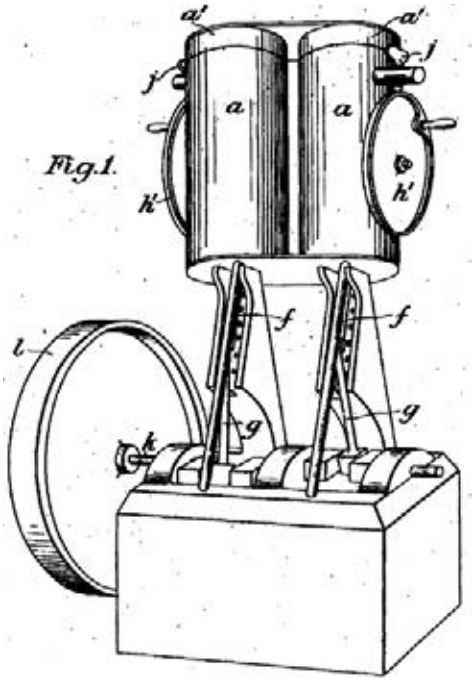
The death of Richard Ripley in 1907 signalled the end.[3] Reckitt & Sons, later to merge with J & J Colman to become Reckitt & Colman and then Reckitt Benckiser,[4] acquired the business shortly after.

Richard Ripley's trademark of 1884

Thanks to Pamela and Valerie Ripley, daughters of Ralph Ripley, for family information.



Patent 10980 of 1898: Improvements in devices used for handling or manipulating washing blue and dyes for laundry purposes



A twin-cylinder arrangement of the reciprocating "perpetual heat engine"

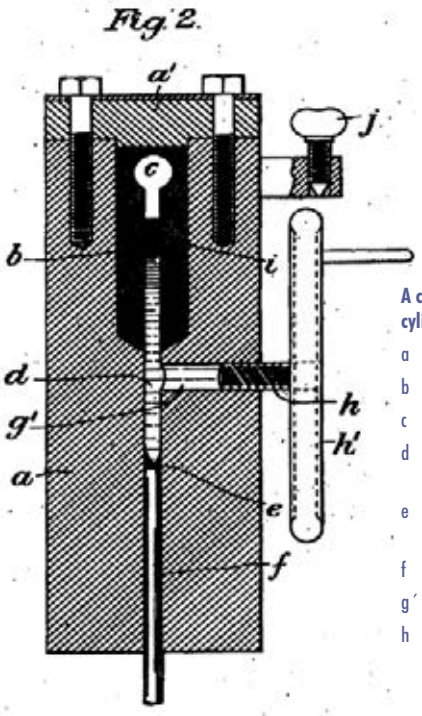
UK Patent 7335, A.D. 1913 – A perpetual heat engine, worked by liquid air or the like.

In 1913, Gerald Augustus Newgass submitted a patent application for a device that would extract heat from its surroundings to provide the sole energy source for generating mechanical motion. As the inventor explained:

Although it is now generally considered that a perpetual motion machine is an impossibility, it may here be pointed out that one which makes use of the eternal heat vibrations of the universe, by no means contradicts the doctrine of the conservation of energy.

The cycle of operations begins with liquid air inside a thick cylinder fitted with a narrow piston rod on which sits a column of mercury. Heat is conducted through the mercury to gasify the air and so create a high pressure. A small insulating plug rests on the top surface of the mercury but as the arrangement (a spherical chamber marked c in the drawing) allows the mercury to contact the liquid air, it is not clear what prevents the mercury from solidifying.[5] The now expanding gas, driving the piston down, experiences a temperature drop to the critical point and returns to the liquid state. At the same time the plug on the mercury prevents significant heat transfer. The piston moves back to its original position having performed work equivalent to the heat transferred into the system. Of course there are all the thermal and mechanical problems to be considered and the inventor says:

As there is neither a perfect gas, nor an ideal conductor or obstructor of heat, the preceding cycle will be modified, since latent heat of evaporation, the Joule-Thompson[6] effect, and other imperfections have not been accounted for. However it is a well known fact that, if liquid air be boiled at constant volume it produces a pressure of about 900, atmospheres, and it has also been found that if air at a pressure of 900 atmospheres, be allowed to expand adiabatically, liquid air is formed. Thus the said cycle has got beyond the stage of pure theory.



A cross-section of the cylinder showing:

- a the cylinder body
- b insulating material
- c the liquid air chamber
- d mercury column (the "reciprocating conductor")
- e a low friction seal between the mercury and piston rod
- f piston rod
- g´ mercury reservoir
- h screw plug for adjusting the mercury level

We can reasonably gather from this statement that a working model hadn't been built and it was just theory. Could it possibly have worked? Unlikely with heat transfer problems and the losses but it would make an interesting project for series three of James May's Man Lab.[7]

A remarkable fact behind this patent is that the author was a 15-year-old student at Tonbridge School, in Kent, who corresponded with Albert Einstein. Gerald **was** the son of Benjamin Newgass (c.1838-1921), a German born merchant and financier trading as B.Newgass & Co, in London. Benjamin became quite wealthy and gave support to Jewish and other charities. He gave a farm that he owned to Baden Powell, for the Boy Scout movement. Gerald, surprisingly, did not take up a career in science but studied law. He died at the relatively early age of 50 in 1948.

Thanks to Miriam Nicholls, granddaughter of Benjamin Newgass, for family information.

Notes:

[1] See J.M.Evans (1968), "Passing-off and the Problem of Product Simulation", *The Modern Law Review*, Vol. 31, No. 6, pp.648.

[2] Ripley v. Bandey (1897) 14 RPC 591.

[3] Based at Blandford Works, Kempston Street, Liverpool.

[4] Owners of the brands Dettol, Durex, Steradent, Airwick, Nurofen, Scholl, and Cillit Bang.

[5] The freezing point of mercury is approximately –39°C, that of air about –212°C.

[6] The spelling should be Thomson.

[7] Series 2 has just finished on BBC Two.

Solutions to Journal brainteasers

Alan Gall, IST Archivist ▶

From soup to fly

Starting with the word SOUP change each letter in turn to obtain the word FLY according to the following rules:

1. Only one letter at a time can be changed and the new word must be a valid 'dictionary' word.
2. To eventually arrive at the word FLY, one of the letters must be discarded.
   This can be done at any time provided the word produced is also valid.
3. Each change of letter or the removal of a letter counts as one step in the process.
4. To make life more difficult, the word SOY is not allowed.

Find any route that uses no more than four steps.

Answer

One possible route is SOUP - SOU - FOU - FLU - FLY
All are in the Collins English Dictionary, 3rd Edition.

Bluebottle Soup

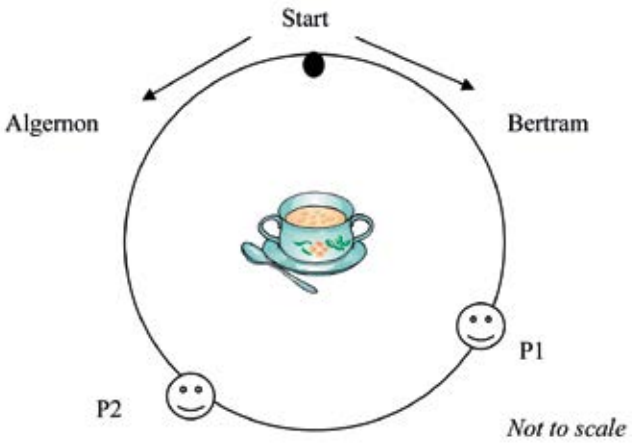
Two bluebottles, Algernon and Bertram, are practising their breaststroke in a bowl of chicken broth. Both set off from the same point but in opposite directions. They swim along the inside edge of the bowl and since Algenon has eaten less of the soup beforehand, he is faster than his companion.

The flies first meet each other at a point P_1, which is 176mm from the start (measured clockwise). Algenon meets Bertram for the second time at a point P_2 207mm past the start point (measured anticlockwise).

How big is the bowl in circumference?

Assume that each fly swims at constant speed and that distances are measured along the circumference.

Hint: The solution can be obtained without the need to solve a quadratic equation.



Answer:

Let C = circumference of the bowl. All values are in mm.
Consider the first meeting point at P1
Algernon has travelled a distance of C - 176
Bertram has travelled a distance of 176

They have taken the same time to cover these distances so the ratio of their speeds is: $\frac{C - 176}{176}$

At the second meeting point, P2
Algernon has travelled a distance of C + 207
Bertram has travelled a distance of C - 207
Since each fly's speed is constant, the two ratios are equal and (putting x = 176, y = 207):

$(C - x)(C - y) = x(C + y)$

Multiplying out, the xy term vanishes and on dividing by C we get $C = 2x + y = 559$

Same flies, different bowl

Bertram swims around a square soup bowl. Along the first edge he swims at 1 kph, along the second 2 kph and along the third 3 kph. Algenon has been observing with his stopwatch and works out that the average speed over the whole distance was 2 kph.

How fast did Bertram swim along the fourth edge?

Answer

The appropriate mean to consider is the harmonic mean, which is the reciprocal of the mean of the reciprocal of the individual speeds:

$$\frac{1}{\left(\frac{1/1 + 1/2 + 1/3 + 1/x}{4}\right)} = 2 \text{ kph}$$

From which x = 6 kph.

To see this clearly, it is only necessary to give the bowl a size (as the result is independent of this dimension).

Let each side = 6 km (a very large bowl but it makes the arithmetic simpler)

At 1 kph the time taken to cover the first side is 6 hours
At 2 kph the time taken to cover the second side is 3 hours
At 3 kph the time taken to cover the third side is 2 hours
At 6 kph the time taken to cover the fourth side is 1 hour

A total of 12 hours to cover 4 x 6 km gives 2 kph average

It is interesting to note that even if the last side was traversed at infinite speed, the average would only increase to 2.181… kph.

String Theory

Take a piece of string with unit length. Make two cuts at random places.
What is the probability that one of the three resulting sections is at least half a unit long?

Answer

There are probably other ways of looking at this but:

Split the string into two imaginary halves A and B. There are only three possibilities (ignoring cuts exactly on the dividing line): either both cuts are in section A or both cuts are in section B or one cut is in A and one cut is in B.

(1) If both cuts are in A then there is a length of string at least as long as B (ie a half unit length). The probability one cut is made in A is 0.5 and, separately, the probability that the second cut is in A is also 0.5. The probability that they are both there together is $p_1 = 0.5 \times 0.5 = 0.25$

(2) If both cuts are in B then the same logic applies and the probability is $p_2 = 0.25$

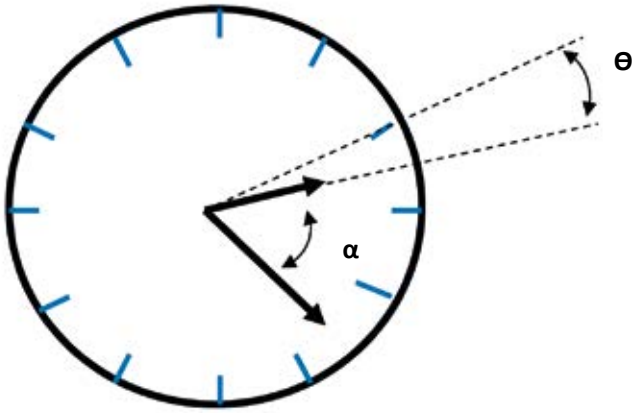
(3) For the third situation, not only must the cuts be in separate halves, they must be outside a band of width 0.5 units of length. This leaves them with 0.5 units of length to be placed in and the probability is again $p_3 = 0.5 \times 0.5 = 0.25$

The probability of obtaining a length of string at least a half unit long is:

$p_1 + p_2 + p_3 = 0.75$

Hungarian Clock Problem

Lajos Kaczynsk is a wildly eccentric Hungarian mathematician. He owns a clock that has hour markings but no numerals and as the clock is perfectly round and sits in a random position on his bedside table there is no way of telling which mark indicates 12 o'clock. Lajos wakes up one morning thinking that he has probably overslept. With a protractor, handily kept under his pillow, he measures two angles. One angle is between the hour hand and the nearest hour marker to be found in the anticlockwise direction (theta), the other (alpha) is between the two hands as measured clockwise, starting with the minute hand. A quick sum in his head gives the time. How does he do it?



Answer

The easiest way of solving the problem is to look at the hour hand to see how many minutes there are past the hour. Tracking back (anticlockwise) that number of minutes from the position of the minute hand then locates the position of 12 o'clock and the time can be determined in the usual way. However, the problem specifically requires the use of two angles.

Let h = the hour indicated by a number 1 to 12
n = the number of minutes past the hour

θ = angle between the hour hand and the nearest hour marker measured anti-clockwise.
α = angle between the two hands measured clockwise from the hour hand to the minute hand.
β = angle between 12 o'clock and the nearest hand measured clockwise.

All angles in degrees.

The minute hand moves through 6 degrees for every minute.
The hour hand moved through 30 degrees for every hour (0.5 degrees for every minute).

The position of the hour hand can be expressed as $\beta = 30h + \theta$

The position of the minute hand can be expressed as $\beta + \alpha = 6m = 12\theta$

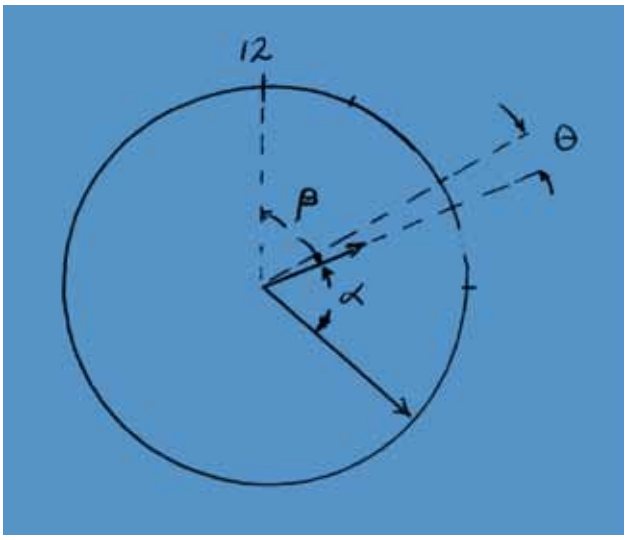
By eliminating β the position of 12 o'clock is no longer required.

Hence $30h + \theta + \alpha = 12\theta$

So $h = (11\theta - \alpha)/30$

And $m = 2\theta$

For certain arrangements of the hands, the result will be zero or negative for h. In this case simply add 12.



Example 1: The clock is at 5:55

α = 152.5 degrees, θ = 27.5 degrees.
h = (11 x 27.5 – 152.5)/30 = hour 5
m = 2 x 27.5 = 55 minutes past.

Example 2: The clock is at 6:01

α = 185.5 degrees, θ = 0.5 degrees.
h = (11 x 0.5 – 185.5)/30 = -6
Add 12, hour is 6
m = 2 x 0.5 = 1 minute past.

NB The original question should have stated that angle α was measured clockwise starting with the **hour** hand, not the minute hand. The drawing shown was correct.

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T14788	Mr C Smith	MIScT
T14789	Dr R Conte	MIScT
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Total 1		

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Membership no.	Members name	Grade
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Total 2		

What is the IST?

The Science Technologists Association was formed in 1948 and granted a certificate of incorporation in 1954 to become the Institute of Science Technology (IST). Its past traditions lay in the promotion and development of the science and practice of laboratory science technology. A further name change was agreed in 2007 to the Institute of Science & Technology in order to broaden our focus area.

As we know, the world of science and technology moves forward at a tremendous pace and is one of continual and rapid change. Our modern technology-driven world has opened up many new and exciting fields of science. Where, increasingly, the multi-disciplined approach towards developing new and innovative solutions is changing the face of industry, research and education.

The IST itself has continued to move forward and expand its own horizons so that it can best position itself to support its members and their needs in the 21st century.

So who is the IST for?

We now reach out to provide individual and focused professional support to a wide group of specialist, technical, and managerial colleagues in a broad range of environments such as science, engineering, industry, local authorities, schools, FE, HE, research/analytical/health facilities, government departments, and many more in the UK and overseas.

Our aim is to make the Institute all embracing and, in order to achieve this, help/advice networks, skills training, specialist forums, recognised qualifications, continuing career development opportunities and guidance will be available to the membership.

Recognition of professional standing is high on our agenda and, most importantly, expansion of the vibrant community of specialist, technical and managerial colleagues who will work together to help make a difference and shape the future.

So why join?

IST can help by supporting and developing your

- career and interests
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- knowledge and skills
- network of contacts

Help us maintain, build and expand the (IST) community. **Together we can be a voice to be heard and listened to.**

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Contact the editor: i.moulson@shef.ac.uk

Or the IST office: office@istonline.org.uk

The guidelines for article submissions to the IST Journal are as follows:

1. Article submission deadlines;
   - Summer edition is **31st May.**
   - Winter edition is **30th November.**
2. Articles should be submitted electronically in Microsoft Word .doc format with images sent separately as JPEG files. This is our preferred option; please contact the Editor for other formats.
3. **Short articles:** these can be submitted in any length up to roughly 1500 words.
4. **Major articles:** these should normally be no longer than roughly 4000 words. Please contact the Editor for longer submissions as they may need to be serialised.
5. All accepted articles will be edited into the IST Journal's house-style.
6. All articles must be written in UK English. *(If English is not your first language, you should ask an English-speaking colleague to proofread your article.)* Articles that fail to meet basic standards of literacy may be declined by the editors.
7. Articles should be submitted as separate email file attachments. The email should clearly state "Journal Article Submission" and be sent electronically to office@istonline.org.uk

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Before completing this form please read the Notes for Guidance for Applying, available at www.istonline.org.uk. All relevant sections of the following form must be completed, even when additional information is provided on a separate sheet. New members apply to join on the basis that the appropriate grade of membership will be awarded by the Institute on acceptance, and that the level will be determined by the details supplied on this form.

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I agree to my details being passed onto individuals involved in the application review process.

Please accept my application for membership. If accepted I agree to abide with the By-Laws of the Institute.

Signed: ..... **Date:** .....

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Surname: .....

Other Names: .....

Date of Birth: .....

Home Email address: .....

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Telephone: .....

Address for correspondence: .....

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A. DETAILS OF PRESENT POST

Job Title: .....

Date of Appointment: .....

Employer Name: .....

Employer Address: .....

.....

Email: .....

Type of work or discipline: .....

.....

Brief details of practical work undertaken in the year prior to application: .....

.....

.....

.....

B. PREVIOUS EMPLOYMENT HISTORY

Date	Employer	Type of Work/ Status/Title/Discipline
.....	.....	.....
.....	.....	.....
.....	.....	.....

C. QUALIFICATIONS

Give details below of any examinations passed, prizes or scholarships awarded etc. (Documentary evidence must be forwarded with this form, scanned images in jpg format are acceptable)

Date	Examinations/Prizes/ Scholarships etc	Institution
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The Institute of Science & Technology

The Journal

Winter 2011

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