Science in St Albans: *Novum Organum Scientiarum*

LARGE PRINT TEXT

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Introduction Panel

(facing the entrance)

Science in St Albans: *Novum Organum Scientiarum*

Visitors may know of St Albans for its Roman heritage, its place in the Wars of the Roses, or for the Benedictine monastery of St Albans Abbey. However, they may be less familiar with the role St Albans has played in the lives and work of scientists throughout history.

From the scientific observations of medieval abbots to the pioneering work of Professor Stephen Hawking on black holes, St Albans has been home to every kind of scientist, including physicists, astronomers, entomologists, medical pioneers, engineering experts and many more.

At the heart of this story is Sir Francis Bacon - a philosopher, poet, author, garden designer, cryptographer, courtier and lawyer. He is also known as the ’father of Experimental Philosophy’ (or Science) because of his book *Novum Organum Scientiarum -* “a new instrument of science”.

In this exhibition, explore how Francis Bacon’s new experimental method was used by scientists and scientific companies in St Albans. Follow the steps from observation and theory to experimentation and results, to discover its relevance to us today.

[Image: Sir Francis Bacon, Viscount St. Albans and Lord Chancellor from an engraving by A. Bannerman.]

[Image: the black hole at the galaxy’s centre is nearly 7 billion times the mass of our sun, placing it among the most massive black holes discovered. Image courtesy of M. Helfenbein, Yale University / OPAC.]

[Image of Richard of Wallingford, mathematician and Abbot of St Albans. He is pointing to a clock, referring to his gift to the abbey, and his face is disfigured by leprosy. From the *Golden Book of St Albans* illustrator Alan Strayler, 1380.]

Label underneath the first case

Novum Organum Scientiarum

Novum organum, or to give it its full title, *Novum Organum, sive indicia vera de Interpretatione Naturae* ("A New Work, or true directions concerning the interpretation of nature") by Francis Bacon was published in Latin in 1624. In the book he outlines his belief that science should start with observations and lead to a theory.

Title page of Novum Organum

The original title page showed a Spanish galleon sailing through the mythical Pillars of Hercules in the Strait of Gibraltar. The pillars were seen as the gateway to the New World (the Americas) and represent Bacon's hopes that a new scientific method would lead to new scientific discoveries.

[Image showing a close up of a Galleon sailing through the Pillars of Hercules.]

Other works by Francis Bacon

Whilst Bacon wrote many books and essays on science and philosophy, he also wrote about religion and literature and published some works on the law. This case includes modern copies of his Advancement of Learning, New Atlantis and his Essays Civil and Moral.

[Image of a decorative engraving from the front of the first edition of New Atlantis.]

Novum Organum around the world

The Latin sentence on the original title page of Novum Organum can be translated as "Many will travel and knowledge will be increased". Bacon's book has travelled around the world and through time. As well as modern English translations, this case contains copies of Bacon's book in German, Italian and Spanish.

[Image of the latin motto from the front of *Novum Organum* which reads *Multi pertransibunt & augebitur scientia* – taken from the Old Testament (Daniel 12:4).]

Panel to the right of case

Novum Organum Scientiarum
A new way of thinking

Novum Organum Scientiarum, subtitled “True suggestions for the interpretation of nature” was published in Latin, in 1620. The first part of the book looks at how assumptions and mistaken thinking can make it impossible to find the truth. The second part sets out his new system of logic using specific observations to propose general theories.

For example, to study heat you should:

1. List all of the situations where heat is found.
2. Create a second list of situations that are similar to the first list but where heat is not found.
3. List all the situations where heat can vary.

You can then work out what the cause of heat must be by looking for something that the first list has in common, that is missing in the second list and which varies in the third list.

Whilst Francis Bacon did not focus on making significant scientific discoveries himself, he was pleased to have set out a framework that others could use:

"I hold it enough to have constructed the machine, though I may not succeed in setting it on work."

[Image of the title page of *Novum Organum* shows a boat passing between the mythical Pillars of Hercules that stand either side of the Strait of Gibraltar, marking the exit from the well-charted waters of the Mediterranean into the Atlantic Ocean. Bacon hopes that his book marks a new scientific boundary, leading to greater understanding of the world and heavens.]

[Image: Before Bacon's book, most philosophers used principles laid out by Aristotle, 2000 years before Bacon was writing. Many of Aristotle's writings only survive because of Arabic translations that were used in the

Islamic World. Image: Aristotle teaching from the Kitāb naʿt al-hayawān, a bestiary attributed to Jabril ibn Bukhtishu c. 1220]

[Image: Bacon was one of many early scientists to look at the nature of fire and combustion, but the first approximation of its true nature wasn’t made until 1772, by French chemist Antoine-Laurent Lavoisier.]

Next panel to the right

Francis Bacon

Father of Experimental Philosophy

Francis Bacon was the youngest son of Nicholas Bacon and Anne Cooke. He was brought up and educated at Gorhambury on the outskirts of St Albans and the ruins of the house he built there can still be seen today.

He studied Law at Trinity College Cambridge and went on to become an MP and a successful politician. He had been particularly interested in the philosophy of science from a young age. Bacon was particularly frustrated that methods of exploring the natural world had remained unchanged for nearly 2000 years. Philosophers and scientists in the 1600s still used Aristotle's method of proposing a theory and working it out through evidence working out a general rule through logical argument.

An account of a meeting between Elizabeth I and the 8-year-old Bacon shows this frustration:

Elizabeth I: “*Tell us, little scholar, what study is most necessary for man’s estate?”*
Francis Bacon: “*Madam, to unlearn what he has been taught.”*

Francis Bacon died in Highgate in 1626 from pneumonia. One story is that died whilst trying to discover whether snow could help preserve meat. He is said to have stopped his carriage to stuff a chicken with ice, caught a cold, and died. If true, this is one of the only experiments we know of, that Bacon carried out himself.

[Image of the ruins of the Gorhambury House that Francis Bacon knew, built by his father Nicholas Bacon, are still visible on the Gorhambury Estate. This drawing by an unknown artist shows what the house would have looked like.]

[A portrait of Francis Bacon from his book *The Historie of King Henry VII*. From an engraving by William Marshall, 1640.]

[Image showing Francis Bacon’s meeting with Elizabeth I was one of the scenes in the 1907 St Albans Pageant. This pen and ink drawing of the scene by Withycombe was drawn for the Pageant brochure.]

Panel in case with microscopes

Natural Sciences

Under the microscope

In the 1800s, observing natural history, or natural science as it was more commonly known, became a popular hobby. Museums, botanical gardens, and other scientific exhibitions educated and entertained the general public, introducing them to the discoveries of science.

Amateur scientists often held vast private collections of specimens or insects, plants or animals, which they or other scientists would then catalogue. Microscope slides showing these specimens could be bought in specialist shops or made by the collectors themselves.

One amateur natural scientist with a local connection is Anna Thynne. Thynne was born at Haynes Park in Bedfordshire and moved to London when her husband became Sub Dean at Westminster Abbey. She created the world's first stable marine aquarium in 1846 in her sitting room. Anna Thynne is recognised in St Albans

Cathedral with a stall named after her, but part of her success however should be attributed to her maid who had to add air to the water every day by pouring it between two vessels.

[Photograph of the Natural History Museum main hall. The Natural History Museum opened in 1881, this photograph shows the Central Hall in 1895 with a blue whale skeleton. This skeleton, ‘Hope’, has recently been returned to its central position. Image courtesy of the Trustees of the Natural History Museum.]

[Photograph of the Palm House at Kew Gardens which was built between 1844 and 1848. The gardens became a National Botanical Garden in 1840 and have been a popular visitor attraction ever since.]

[This woodcut shows British coastal corals of the type kept by Anna Thynne, including the Common Cup Coral (Caryophyllia smithii) and Sandy Creeplet (Epizoanthus couchii). Image from Holdsworth (1860).]

Label for case with microscopes

Nature under the microscope

Looking at the natural world as closely as possible has always been a popular pastime. The earliest lenses were made around 4000 years ago and the first objects we would recognize as microscopes were built around 400 years ago. Under a microscope we can see something as familiar as the back of your hand look completely new.

Microscope slides

These microscope slides were prepared during the 1800s when interest in the natural world became a popular pastime. Individuals could prepare their own specimens to create slides or buy pre-prepared slides to add to their collections. Paper covers on these slides developed from a practical need to fasten the thin glass covers. They started out quite plain, but around the 1840s these papers became increasingly decorative.

[Photograph of microscope slides which show off some of the more decorative papers in St Albans Museums' collection.]

Portable microscope

This microscope is recorded as having been given to St Albans Museums by Miss E. Gibbs, daughter of one of the founders of the museum A.E. Gibbs. We believe this to be his daughter Marjorie Eileen Gibbs. A.E. Gibbs was responsible for a large part of the natural history collection in St Albans, so it isn't surprising that his daughter was interested in the subject as well.

[This photograph shows A.E. Gibbs' three daughters, Marjorie, Phyllis and Stella, in around 1902.]

Doctor's Microscope

This microscope belonged to Dr Benedict Arthure. It was made by Charles Perry in the 1930s and used by Dr Arthure in his surgery in St Mary Cray, Kent. We believe he used the microscope for his own investigations in the days before he had access to laboratories through the

National Health Service. His son, John Arthure, also studied medicine and then passed the microscope to his daughter, St Albans resident Caroline Eldred, who has loaned it for this exhibition.

[Photograph of engraving on a microscope. All the microscopes made by Charles Perry carry his name and a serial number. The example in this case is 6743.]

Panel in case with drawers of insects

Eleanor Ormerod

Patient and determined study and observation

Eleanor Ormerod, born in 1828, was an expert in economic entomology - the study of insects that benefit or harm humans, domestic animals and crops. At this time, science was still very much a man's world, but she was determined to share her expertise and was the first woman to be awarded an honorary degree by Edinburgh University.

Ormerod's significant legacy as a scientist relates to her collection, organisation and interpretation of detailed observations. As well as observing insects and their effects, she also collected information from other researchers. In 1877, she distributed a questionnaire, asking for interested persons, to send in the results of their research, which resulted in an *Annual Series of Reports on Injurious Insects and Farm Pests.*

Ormerod's observations allowed her to give practical advice to farmers and agriculturists around the world on how to avoid or lessen insect damage to crops and animals. She took the view that entomology should focus on what was economically useful, believing that “pure” science was valuable only as a means to that end.

From 1887, Ormerod lived with her sister in a home on Holywell Hill in St Albans and died there in 1901. The building still has a plaque to mark her connection.

[Photograph of Eleanor Ormerod from *The People's Magazine* in 1901, shortly after her death.]

[Illustration of a turnip fly from *Annual Series of Reports on Injurious Insects and Farm Pests.]*

[Photograph of Torrington House where Ormerod lived with her sister from 1887 until her death in 1901. This photograph was taken for the St Albans Street Survey in 1964.]

Labels underneath cases

Natural philosophy

Natural philosophy or natural history is the study of living organisms in their natural environment. Humans have always been fascinated with the world around us, including its animals, birds, fish and plants, so observing and collecting from nature has always been a popular type of scientific discovery.

Collecting from nature

During Francis Bacon’s life in the 1600s, natural history specimens were collected from Europe and the New World and displayed alongside other intriguing objects in private collections known as ‘cabinets of curiosities’. These objects could include animals that were stuffed or preserved in spirit jars. Insect collections pinned in drawers and display cases were particularly popular.

[Painting called ‘Cabinet of Curiosities’ by Domenico Remps.]

Natural history in St Albans

In the 1800s, public museums and organisations brought together collections to help researchers and to inform members of the public. The Hertfordshire County Museum (now St Albans Museum + Gallery) was founded for this purpose in St Albans in 1898. The museum’s first Director George Bullen was a marine biologist so natural history was an important part of the museum’s early collections.

[Photograph of Specimen jars from St Albans Museums’ collection. These were conserved by volunteers for our recent exhibition The Pickling Project.]

Beetles, wasps and flies

Today St Albans Museums has several cabinets of insects which were preserved by previous curators. The first two drawers (to the left) are filled with wasps and flies (from the Tachinidae family). The second two drawers contain British beetles. The largest beetle in these drawers is the Hydrophilidae, or water scavenger beetle which is found all over the world.

[Photograph of an adult water scavenger beetle. Image courtesy of Darkone.]

Second label underneath case

Eleanor Ormerod

Eleanor Ormerod was the first person to define the field of agricultural entomology - the study of how insects interact with plants - from helpful pollination to attacks by pests. During her career, Ormerod published a series of articles on insects and pests in the Gardeners' Chronicle and the Agricultural Gazette, as well as several books.

Manual of Injurious Insects and Methods of Prevention by E.A. Ormerod

This manual follows Ormerod's pamphlet and questionnaire, Notes for Observations on Injurious Insects, published in 1877. Following the pamphlet, Ormerod wrote a series of annual reports and then published this manual in 1890. The manual is organised by the types of plants that insects may attack, so that non-experts could use it.

[A page from the manual showing insects that feed on fruit trees.]

Eleanor Ormerod LL.D edited by Robert Wallace

Eleanor Ormerod's autobiography was published in 1904. It was edited by Professor Robert Wallace of the University of Edinburgh which had given her the an honorary LL.D degree (Doctor of Laws). She was the first woman to receive this degree from the University. Browse a copy of this book in the exhibition reading area.

[A photograph of Eleanor Ormerod taken from the title page of her autobiography.]

Controversial ideas

Ormerod's knowledge of insects and pests led to her advising many people and groups, but we now know that it was not always good advice. She campaigned strongly for the use of the insecticide 'Paris Green', calling it "indispensable… in orchard-growing on a large scale" in a letter to a colleague. Paris Green is made from arsenic and is now known to be incredibly harmful.

[A page from an 1897 seed catalogue advertising 'Paris Green' insecticide.]

Panel on back wall of gallery, to the right of the fire escape door

Richard of Wallingford

A Medieval mathematician

Richard of Wallingford, the Abbot of St Albans 1327-1336 was a mathematician, astronomer and horologist (someone who studies time). His work dates from nearly 300 years before Francis Bacon’s, but his studies show how much could be discovered through observation.

Wallingford became a monk at the age of 23. Although he was part of the monastery of St Albans, he was allowed to continue his studies in philosophy, theology, mathematics and astronomy at Oxford University. In 1327 at the age of 35, he was elected Abbot of St Albans where he used his knowledge, observation of the stars, and the skills of local blacksmiths and millers to create his great clock.

Astronomy was important to Wallingford, partly because it was needed to fully understand the calendar and its lists of church festivals but also because the stars, sun, moon and planets were believed to affect both people's day-to-day and spiritual lives. His work on the mathematical principles of the calendar (known as 'computus') is now lost but its observations were used in his clock.

[Medieval illustration Richard of Wallingford shown seated at his desk measuring with a pair of compasses. This miniature is from The History of the abbots of St Albans by Thomas of Walsingham.]

[Photograph of St Albans Cathedral today. Only the Abbey church and gateway now survive of St Albans monastery but in this picture, you can see the pale outlines of the original cloister bays. Image courtesy of Matt Sims.]

[A photograph of a metal disc with circles engraved onto it. Another of Wallingford's creations was his *Albion*.

This was an aid to calculating the positions of planets and consisted of curcles of card or metal combined with threads. The Albion was named because all of the necessary circles could be fitted onto one plate, so ‘all by one.’ This is the only surviving metal Albion and it is now in the *Osservatorio Astronomico di Roma.*]

Label next to television screen

The development of complex mechanical clocks

In this film from 2004, Simon Schaffer describes how the mechanism of the Wallingford Clock works and particularly how Wallingford introduced the new technology of a ‘verge escapement’. This is the part of the clock that transforms the circular movement of the gears into a regular ‘tick’. It is made up of the horizontal beam with two weights on the ends called a ‘foliot’, and a vertical piece called a ‘verge’.

Film courtesy of Windfall Films and Alan Macfarlane.
[3:00 minutes long]

Panel to the right of the television screen

The Wallingford Clock

No clockmaker like himself

Richard of Wallingford spent much of his time as Abbot of St Albans working on the construction of his great ‘horloge’ or clock. He was so focussed on the construction of the clock, that Edward III complained to him that he had neglected the buildings of the monastery for the clock. Wallingford replied that future Abbots would be able to restore the buildings, but nobody else could make his clock.

The clock has two parts, the first tells the time on a 24-hour dial. It has a bell which rings every hour and is driven by weights which would have been hung from the ceiling. The second part is the astronomical section which shows the movements of the sun, moon and stars.

The astronomical section can be used to predict both solar and lunar eclipses and it contains a number of different gear types to allow the sun to move in solar time (365.25 days a year) and the stars to move in their own relative time (366.25 days a year). The clock demonstrates Wallingford’s observations of the stars on a smaller, clearer, scale.

[Photograph of a miniature Wallingford Clock. Before the replica Wallingford Clock was made, a miniature clock was built to confirm how all of the gears worked together. Image courtesy of St Albans Cathedral.]

Photograph of the Wallingford Clock in its previous location at St Albans Cathedral showing the star plate. Image courtesy of St Albans Cathedral.]

[Photograph of the metal clock face of the astronomical section being made in the 1990s. Image courtesy of St Albans Cathedral.]

Label next to the clock opposite previous panels

Wallingford Clock

The original Wallingford clock was designed and built soon after the year 1336. It was the most advanced clock of its time and it took so much money and time to construct that King Edward III complained to Richard of Wallingford that he should have spent more money on the church buildings and less on the clock. It is reported in the Gesta Abbatum (the Deeds of the Abbots) that Richard replied that other Abbots could repair the Monastery, but nobody else would be able to finish his clock.

The clock section of this replica was finished in 1985 and the astronomical section in 2000. The sections have not been joined together, so perhaps Richard has been proved correct.

On loan from St Albans Cathedral.

First panel on the green wall

Idols of the Mind

False opinions and mistaken theories

In Francis Bacon’s book *Novum Organum* he describes people who simply observe as ants - collecting and using, and those people who try to reason theories from nothing as spiders, creating cobwebs. Instead, he encourages scientists to follow the course of a bee, gathering material from the flowers of the garden and then transforming it.

In this move from observation to theory Bacon warns that false opinions, prejudices and assumptions will prevent us from ever reaching the truth. In particular Bacon warns that there are four “idols of the mind” which should be avoided.

Idols of the tribe

Errors that come directly from human nature; Bacon believes that human understanding is a false mirror that can distort what it observes.

Idols of the cave

Errors we make because of our individual backgrounds, likes and dislikes.

Idols of the market place

Errors which happen when talking to each other, especially when using vague or unclear language.

Idols of the theatre

Errors or false opinions that are part of our traditions or cultures.

[Engraving of Francis Bacon’s monument in St Michael’s Church St Albans. Drawn by W. Alexander, engraved by George Cooke.]

[Photograph of a bee with an antenna collecting data as part of an experiment at Rothamsted Research, the data will be analysed by scientists. Image courtesy of Rothamsted Research]

[Engraving of Plato. Bacon identifies Plato as an example of a thinker who falls into the idols of the theatre trap. Bacon says that from "this unwholsome mixture of things human and divine there arises not only a fantastic philosophy but also an heretical religion." Etching by D. Cunego, 178s. Image courtesy of the Wellcome Collection.]

Panel in case to the right of the green wall

Stephen Hawking

The Theory of Everything

Professor Stephen Hawking (1942-2018) is one of the few theoretical physicists widely recognised by the general public. His work has shone a light on the origins of the universe and provided a deeper understanding of black holes.

One of Hawking’s most important theories was the prediction that black holes emit radiation. This is now known as ‘Hawking radiation’. He was a strong supporter of the ‘many-worlds’ interpretation of quantum mechanics; the theory that there are many worlds which exist in parallel at the same space and time as our own.

He helped popularise science with his bestselling book *A Brief History of Time*, which sold over 10 million copies, alongside appearances and portrayals in television programmes like *The Simpsons* and *The Big*

Bang Theory and films such as *The Theory of Everything.*

Stephen Hawking and his family moved to St Albans in 1952 and they lived on Hillside Road. He was educated at St Albans School for Boys from the age of 11 to 17, when he won a place at Oxford University.
[Photograph of Professor Stephen Hawking. Image courtesy of A. Rogelio & C. Galaviz]

[Photograph showing Stephen Hawking building a computing engine with other students at St Albans School. Hawking spoke about how one teacher, Dikran Tahta opened his eyes to the "*blueprint of the universe itself- mathematics.*" Image courtesy of the Press Association]

[Photograph of the light sculpture *Black Hole Light* by artist Mark Champkins. In 2012, Champkins was commissioned by the Science Museum to design Stephen Hawking a 70th Birthday present. He created this work which represents the path light would take falling into a black hole alluding to Hawking radiation. Image courtesy of Mark Champkins]

Label underneath Stephen Hawking case

Stephen Hawking

When he was eight years old Stephen Hawking attended St Albans High School for Girls (at the time the school was mixed for children under 10). He then attended Radlett School for a short time before moving to St Albans School in September 1952. At school he met a group of friends with whom he enjoyed playing board games and making fireworks, model airplanes and boats.

Building a computer

From 1958, with the support of mathematics teacher Dikran Tahta, a group of students including Hawking built a computer from clock parts, an old telephone switchboard and other recycled components. The design probably used the same Boolean algebra used for the later example in this case, where the values of the variables are the truth values true and false, usually denoted 1 and 0 respectively. Input was achieved by the old-style telephone dial.

[Photograph showing Stephen Hawking (left) looking at the computer he is working on with fellow students at St Albans School. Image courtesy of the Press Association.]

Bamby - Binary Adder Manipulated By Yourself

This machine was designed and built by St Albans School Students under the direction of Alan J Smith, mathematics and computing teacher in 1962. It was an early prototype of a series of switch-operated computer simulators. It was capable of multiplication using a punch card input. Some of the students also programmed one unit to play ‘God Save the Queen’. This series and this unit in particular were used in the teaching of mathematics and computing for some 40 years. This computer has been loaned by St Albans School.

[Photograph of St Albans School was probably founded by Abbot Wulsin in the around the year 948. It has been a fully Independent School since 1975.]

Panel in case to the right

Thomas Mercer and Mercer Gauges

Measuring your experiments

In 1856, horologist, or clockmaker, Thomas Mercer opened a workshop in London's Clerkenwell, making marine chronometers. These instruments were used in scientific experiments, navigation and astronomical observations. Exact timekeeping is important for accurate navigation and Mercer won medals at international trade shows for the precision of his chronometers.

In 1874 Mercer opened a factory in St Albans on Prospect Road. As the business expanded, it moved to Eywood Road near the current St Albans Abbey railway station. It was here in St Albans that Mercer moved into the market for dial indicators and gauges; very accurate measuring equipment used in the development of all kinds of machines from cars and aeroplanes to refrigerators and washing machines. They can also be used in, more complicated experiments. Their big advantage is being able to take accurate measurements at high speed.

By the 1970s, Mercer employed around 200 people in St Albans, most of whom lived within a 15-mile radius of the city. Many developed highly technical skills working with tiny electronic parts, early computer programming and precision machining. The St Albans factory closed in 1982.

[Photograph of Frank ‘Tony’ Mercer, Thomas Mercer’s son, is shown here holding a sextant with Thomas Mercer’s regulator in the background. Image courtest of Anton Arcane.]

[Photograph of a Mercer Chronometers travelled around the world. It is said that Ernest Shackleton took one with him on the ship Endurance on its final Antarctic voyage. This chronometer is now on display at Queensland Maritime Museum in Australia.]

[Black & white photographic print showing a man working at Mercer's in St Albans, possibly Harold Scott.]

Label underneath case

Thomas Mercer Ltd

Between 1874 and 1984, Thomas Mercer Ltd made chronometers, dial gauges and electronic measuring devices from their offices in Prospect Road and then in Eywood Road. By the time the company closed, they had made over 30,000 devices.

The marine chronometer

A chronometer is a clock or watch that is accurate enough to be used to determine longitude (your position east to west). It does this by accurately measuring the time compared to a fixed point in Greenwich, London. Chronometers must be able to stand up to wind, rain and waves, so are usually designed to move within their cases so that they always stay level.

[Black and white photograph of a chronometer said to have been used on the ship ‘Endurance’ by Antarctic explorer Ernest Shackleton.]

Dial gauges

A dial gauge (also known as a test indicator), is a device used to measure very small distances or angles and make them more obvious to the naked eye. These indicators are still used in all kinds of scientific experiments and industries, where it is important that measurements are incredibly accurate.

[Photograph of a dial gauge made by Mercer, from St Albans Museums' collection.]

Mercer catalogues

By the 1980s, Thomas Mercer Ltd had made a third of all chronometers in circulation. These catalogues from the 1940s onwards show the company's range of products. Thomas Mercer Chronometers was revived in 2012 after 30 years without production and now makes high-end chronometers for the luxury market.

[Thomas Mercer Ltd advert from 1948. Image courtesy of Grace's Guide.]

Panel to the right (third in the run of cases)

Marconi Instruments

The right equipment for the right experiment

In order to carry out experiments, specialist equipment is often needed, and St Albans has been home to several companies making experimental equipment including John Bull; the Electrical Apparatus Company; Mercer Gauges and Marconi Instruments.

Guglielmo Marconi, inventor of the first successful radio transmission system, founded the Wireless Telegraph & Signal Company in England in 1897. This company eventually became Marconi Instruments, an international company with offices in the UK, USA, France and Germany. For much of its history, the company's headquarters were in St Albans with sites on Longacres and in Fleetville.

Marconi first opened in St Albans in 1939, ahead of the Second World War. Instruments and components made here were a crucial part of the war effort.

The range of instruments Marconi manufactured meant that elements made in St Albans have been used in all kinds of experiments, from agricultural instruments which helped increase crop yields, to instruments related to nuclear power in the 1950s. NASA even used Marconi Instruments' signal generators for the Voyager Spacecraft tracking system when it was launched in 1977.

[Photograph of Guglielmo Marconi with some of his radio equipment including the spark-gap transmitter (right) and coherer receiver (left) he used in some of his first long distance transmissions during the 1890s.]

[Photograph of a display of Marconi Instruments at an exhibition in around 1950.]

[An artist’s impression of Voyager in flight. Some of the components used to track the Voyager spacecraft were made by Marconi. Image courtesy of NASA.]

Labels underneath Marconi case

Marconi Instruments

Marconi Instruments had offices in St Albans, Colchester and Stevenage. Its headquarters was in Longacres to the east of St Albans, where it was one of the largest employers in the city, before moving to Stevenage. There were two other sites in St Albans, one at Hedley Road and one on Hatfield Road (Fleetville Works).

Signal generator spares

A signal generator is a machine that creates an electronic signal. These signals can then be used to take electronic measurements. This box contains the spare parts for a 'Marconi Signal Generator no. 2, mark IV', a model from the 1930s.

[Photograph showing a display of equipment made by Marconi including several signal generators.]

Moisture meter

A moisture meter measures the percentage moisture content of a wide range of materials, including cereal grains, tobacco, rice, paper and wood. Moisture meters like this one are used particularly in farming, however museums have similar tools to measure the moisture level in structures and walls.

[An advert for a Marconi ‘Moisture-in-Grain meter’. Although the company no longer manufactures these meters, some local farmers still use them.]

Medical equipment

Amongst many other products, Marconi made x-ray equipment for both medical and industrial use. Installed in hospitals from the late 1940s, industrial versions were also used by companies including Rolls Royce Ltd, UK Atomic Energy Authority, and Vickers Armstrong (Engineers) Ltd. Other medical equipment made by Marconi included an electro-encephalograph (EEG) which measures the electrical activity of the brain.

[Photograph showing a Marconi employee demonstrating head sensors to a crowd.]

Label underneath case with medical equipment

Medical pioneers

Surgeon Thomas Spencer Wells was a surgeon during the 1800s. This was a period when new discoveries based on scientific experiments were making a real impact on understanding health and disease. New tools were also developed to help diagnose patients: from the stethoscope invented by René Laennec in 1816, to the electrocardiograph invented by Willem Einthoveni in 1900.

Laryngoscope & monaural stethoscope

A monaural stethoscope is made from a single hollow tube. Today we are more familiar with the Y-shaped binaural stethoscope, but it works in the same way. It was placed on the chest or another part of the body to listen to organs such as the heart or lungs. The other instrument in this case is a laryngoscope, first developed in the 1850s to see the action of the vocal folds during speaking for the first time.

[Photograph of a modern stethoscope. Image courtesy of the Wellcome Library.]

Medicine chest

This portable medicine chest is most likely from the late 1800s. Many people today will have a medicine cabinet or box in their home with basic medicines, bandages and ointments. As medicines are used, they are replaced with new versions and the same would be true of this cabinet which can make it difficult to know exactly when it dates from.

[Photograph of a large, travelling medicine chest belonged to Sir Stuart Threipland and is believed to have been used by him to aid Prince Charles Edward Stewart during the Jacobite uprising in 1745. Image courtesy of the Wellcome Library.]

Bottles (Roman bottle)

The oldest medicine bottle in this case is the Roman stone ‘lekythos’, or vessel for storing oil. It is decorated with images of Asculapius, the god of medicine leaning on a snake-entwined pillar and Hygeia, goddess of medicine holding a jug and key. The other bottles come from chemists and other shops in St Albans or have been given to the museum by individuals. Some of them include their addresses on the labels.

[Image of the god of medicine, Asclepius, who is often shown with a snake curled around a rod. This symbol is still used as a sign of medical practice although sometimes the rod of Hermes which has two snakes is used instead by mistake.]

Panel to the right of case containing medical bottles

Thomas Spencer Wells

Medical experiments

Queen Victoria’s surgeon, Sir Thomas Spencer Wells, was born in St Albans in 1818 and attended St Albans School.

Wells served as a military surgeon during the Crimean War, where he discovered that despite the medical thinking at the time, not all abdominal wounds were fatal. This experience gave him the confidence to continue experimenting in abdominal surgery when he returned to England and he became an expert in obstetrics (pregnancy and child birth) and conducted the first successful surgical removal of ovaries.

Some of Wells’ discoveries, along with many other scientific findings throughout history, actually came from mistakes. Wells’ first successful spleen removal happened during an operation when he was supposed to be removing an ovary and the spleen was damaged by mistake.

Through his experience as a military surgeon, Wells was also one of the earliest surgeons to use anaesthetics in operations to help with pain relief. He was made a Baron in 1883 for ‘services to medicine and humanity’.
[Engraving of Thomas Spencer Wells, image courtesy of the U.S. National Library of Medicine.]

[A line drawing of an operation on an ovarian cyst from Wells’ book *Diseases of the ovaries: their diagnosis and treatment*.]

[Photograph of a pair of Spencer Wells’ artery forceps which have become the standard forceps used in abdominal surgery following their introduction in 1879. Image courtesy of the Wellcome Collection.]

with remote controlled boats and other past-times.

Hull model

The model ships tested in the tank were around five metres long, however sometimes smaller models like this one were made to show specific details such as the hull design. This hull is mounted upside down to show its shape even more clearly.

[Photograph of a display is from the 1970s when there was a focus on making sure the shapes of large tankers were efficient because the price of fuel was rising.]

Photography in the tank

To record the way that water and waves interacted with the model ships, Vickers employed photographers who took images both from above and in front. These images provided detailed information for the ship builders and showed the beauty of the crafts.

[One image from a series showing how different wave patterns interact with a ship.]

1914 letter

During the First World War, Vickers shared their building with members of the military. This sometimes led to misunderstandings and the letter here is a sarcastic response to a military officer who accused them of intercepting military phone calls. The letter points out that the offices belong to Vickers and that if callers do not check if they are speaking to the correct person, that isn't quite the same.

[Photograph of the Thai National Defence College members. Throughout its history, the Vickers

Experimental Tank team worked with the government and navy. In 1966, members of the Thai National Defence College toured the tank and workshop as guests of the British Government. Image courtesy of Valerie Moor.]

Panel on purple wall next to cases

Vickers Experimental Tank

Accuracy to the last detail

In 1913 the Vickers Experimental Tank opened at 222 London Road (next to the railway bridge). The tank was created to test the designs of submarines, ships and seaplanes, so it had to be large enough to fit the five to six-metre-long models it was testing. When it needed refilling, the St Albans Waterworks Company had to provide 600,000 gallons of water.

The tank suffered severe bomb damage during the Second World War, but it was quickly repaired, and testing continued. In 1952, the tanks were extended by the company’s Superintendent David Moor to its final length of 135 metres. Moor also oversaw the installation of a new overhead carriage and a wave-maker machine.

During the 72 years the tank was in operation, more than 2000 models were tested there, from prototype submarines to the Royal Yacht. Each model was crafted in wax and towed from an overhead gantry to test how the real full-size hulls would cope with conditions in open water.

[Photograph of Vickers House at 222 London Road. The main offices can still be seen on London Road, close to the railway bridge.]

[Photograph of a boat in the tank. The models used in the tank were around five metres long. Here, one of them is being floated in the tank ahead of testing. Image courtesy of Valerie Moor.]

[A photograph showing the wave machine in action during a test. Image courtesy of Valerie Moor.]

Label next to television screen

Ship research at Vickers, 1957

This film shows some of the testing that took place at the Vickers Experimental Tank. In this clip, the small-scale dry dock is being used to test scale models of ocean-going vessels. Shots show the models being made, which are manufactured from wax and are exactly to scale. A model is launched and moved through the tank by one of the team. High seas are then simulated by a wave maker to test how the models are affected.

Film courtesy of British Pathé. [2:08 minutes long]

Label next to large photograph

Vicker’s Experimental Tank

Looking at photographs, it can be difficult to fully appreciate the size of the tank and the models it contained. The ships were around five metres long and had to be lifted into the tank using pulleys and cranes. The electric gantry or carriage which moved across the top of the tank was large enough to hold several people. The Greater London Industrial Archaeology Society visited the tank in 1979 and reported that “we were allowed to ride on the electric carriage which runs on top of the tank while an experiment was in progress”.

Image courtesy of Valerie Moor.

Panel to the left of the freestanding case

John Bennet Lawes

From fertiliser to the Royal Society

John Bennet Lawes was an agricultural scientist and the founder of Rothamsted Experimental Station, the oldest agricultural research facility in the world.

Lawes was born at Rothamsted in Harpenden in 1814. After leaving university without a degree, he began to carry out experiments on the effects of manure on plants. In 1842, he patented a manure made from mineral phosphates treated with sulphuric acid. This led to the first fertilizer factory at Bow in London and to a collaboration with chemist Joseph Henry Gilbert. This partnership lasted for more than fifty years, leading to detailed experimentation to improve raising crops and feeding animals. These became known as the ‘classical experiments’ and they continue to this day over 170 years later.

Lawes was honoured in 1854 and became a Fellow of the Royal Society. In 1889, he formed the ‘Lawes Agricultural Trust’ which included his laboratory, the experimental fields and the sum of £100,000 to ensure the continuation of his work. The site became known as the Rothamsted Experimental Station, which continues to this day as Rothamsted Research.
[Photograph of John Bennet Lawes.]

[An illustration from Lawes’ book *On the sources of the nitrogen of vegetation; with special reference to the question whether plants assimilate free or uncombined nitrogen*.]

[An engraving of the Lawes Testimonial Laboratory at Rothamsted.]

Labels above case

The Park Grass Experiment

The Park Grass experiment is the oldest experiment on permanent grassland in the world. Started by Lawes and Gilbert in 1856, its original purpose was to investigate ways of improving hay yields by the application of inorganic fertilizers and organic manure. Because the experiment has continued for so long, the data it provides has also proved useful to ecologists, environmentalists and soil scientists. The illustration in this booklet shows an early layout of the Park Grass site, whilst the photograph shows the same site in 2001.

On loan from Rothamsted Research.

Data and the Rothamsted archive

One of the major benefits of Rothamsted's long history of research is that it has built up a large body of data which can now be analysed by scientists using new techniques and asking new questions, that Bennet

Lawes could not have imagined. This jar of soil is one of over 300,000 samples held in the Rothamsted sample archive. About 1200 crop and 200 soils samples are added each year.

As well as physical samples, Rothamsted'sdata is used by many scientists from different fields. This graph shows how the average annual temperature at Rothamsted has been growing since the 1880s in line with current climate change predictions.

Much of Rothamsted's research and data can be accessed through their electronic archive online: www.era.rothamsted.ac.uk.

On loan from Rothamsted Research.

Panel to the right of the case

Rothamsted Research

Securing national food production

One of the most important experiments at Rothamsted is the 'Park Grass Experiment' - a biological study originally set up to test the effect of fertilizers and manures on hay production. The experiment started in 1856 and is still running today, making it one of the longest-running experiments of all time.

As well as answering agricultural questions, the experiment has also provided additional information:

- showing that field trials underestimate threats to plant diversity
- providing one of the first demonstrations of how soils evolve under different environmental pressures
- creating an archive of soil and hay samples that have been used to track the history of atmospheric pollution, including nuclear fallout.

Two world wars in the early 1900s made the government very aware of the need to protect national food production and money was given to Rothamsted to expand its work in collaboration with the Ministry of Agriculture, Fisheries and Food.
Rothamsted continues to play a leading role in tackling the challenges facing agriculture around the world, and in supporting the United Nations' sustainable development goals.

[An early illustration of the Park Grass Experiment at Rothamsted. Image courtesy of Rothamsted Research]

[Photograph of a field being mowed. Rothamsted Research now has land in other parts of the country. Here a field in North Wyke, Devon is being mowed. Image courtesy of Rothamsted Research]

[Graph showing the changing annual average temperature at Rothamsted since 1860. Courtesy of Rothamsted Research]

Panel at the end of the red wall

Ronald Fisher

Statistics and prejudice

Ronald Fisher was a British statistician and geneticist. His statistical work led to him being described as the ‘founder of modern statistical science’. In genetics, his work contributed to the revival of Darwinism and the theories of evolution in the early 1900s.

From 1919 onwards, he worked at Rothamsted Experimental Station where he analysed data from crop experiments dating from the 1840s, and developed a statistical tool called the “analysis of variance” (ANOVA).

His work was vital in interpreting the results of experiments carried out at Rothamsted.
Fisher’s work on statistics and experimental design are key to the work of many areas of science today.

However, his research also led him to conclusions that show how Bacon’s “Idol of the Cave” (errors we make because of our individual backgrounds) can lead to problems. Through his interest in genetics and statistics, Fisher developed highly racist views. He was a prominent supporter of eugenics - the belief that the genetic quality of a population could be ‘improved’ by excluding certain ‘inferior’ genetic groups. He argued publicly against the 1950 UNESCO statement ‘The Race Question’ – seen as a moral condemnation of racism – instead insisting on his own racist belief in the superiority of certain races.

[Photograph of Ronald Fisher in 1929. Image courtesy of Rothamsted Research]

[Photograph of a peacock in flight. In his research on genetics Fisher theorised that the over the top decoration some male animals and birds show was selected through repeated choices by their female partners. This theory is called *Fisherian runaway* and a peacock’s tale is one common example.]

[Photograph of the UNESCO headquarters in Paris. The UNESCO statement “The Race Question” was a condemnation of racism following the Second World War however it had many critics on both sides and was revised several times to make its disapproval clearer.]

Panel on the white diagonal wall

The Scientific Process

Answers that lead to questions

Francis Bacon’s scientific method leads from observation to theory and from experimentation to results. However, the scientific process as we know it today has more steps, and is in fact, circular.

Today, scientists may start with questions that lead to background research or observation. From this information, a hypothesis or theory) is created which is tested with experiments. The results of the experiments are then analysed, leading to a conclusion. Conclusions almost always lead to new questions or predictions and so the cycle begins again.

In Hertfordshire, science continues to be an important part of the local economy. Over 38,000 people work in science, research, engineering and technology in the county - 50% more than the national average.

Local organisations working within St Albans City & District including the University of Hertfordshire, Oaklands College, Rothamsted Research, Physalia, Herts London Cardiology and AECOM. Galvani Bio Electrical (part of GlaxoSmithKline), Advanced Plastic Technology, Bioscience Catylyst and Aeroflex also have offices and laboratories nearby.

[A simplified illustration of the scientific process shows how its stages lead back to the begin again with a new question. Image courtesy of www.thebiologyprimer.com]

[Photograph of Bayfordbury Observatory is the University of Hertfordshire's astronomical sensing observatory, and one of the largest teaching observatories in the UK. Image courtesy of the University of Hertfordshire]

[Photograph of a scientist working in the laboratories at Rothamsted Research. Image courtesy of Rothamsted Research]

Label above case

Sharing your results

For many scientists, the stage after results is how to share them. As well as specialist, peer-reviewed journals, there are many popular science magazines, books, websites and podcasts which allow scientists to share their discoveries as widely as possible. For many years Penguin Books printed their series Science News at the Campfield Press in St Albans, including the copies in this case.

St Albans Museums collection.

Acknowledgements panel to the left of the exit

St Albans Museums everyone who has contributed to this exhibition including:

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