adjust the instrument for proper use.

By 1797, Dr Hamilton was worried about the instrument's accuracy because of the errors introduced by mechanical flexure of the telescope and mounting, as well as those caused by changes in temperature. The third director, Romney Robinson later said that useful measurements could nevertheless be obtained by applying certain correction formulae of his to them. The telescope had been damaged during manufacture as a result of the sulphurous air of London condensing on it. The acid caused pitting to occur in the brass work. Sometime in the middle of the 19th century, Dr Robinson painted the entire telescope and structure to prevent further deterioration of the metal. This paint was removed in the mid-1980s, and the instrument cleaned and lacquered. No doubt Dr Robinson's action saved the telescope.

Troughton Equatorial Telescope

In May 1838, Dr Robinson employed the telescope to calculate the longitude difference between Armagh and Dublin. To make this measurement, a signal had to be observed simultaneously at Armagh and Dublin. However, there is no point on the ground visible from both cities, the highest mountain, namely Slieve Gullion, is not high enough. So, Dr Robinson arranged for a party to travel to the summit of Slieve Gullion, instructing his son to camp there for about 10 days and to fire a series of rockets at five-minute intervals each night commencing at 10pm. It is recorded that several inches of snow fell and a strong NW wind was blowing. Dr Robinson and his colleagues observed the rocket flares at Armagh, while at Dunsink Observatory near Dublin, Dr William Rowan Hamilton and his assistant made the complementary observations. By this method, they computed an accurate longitude difference, proving that Armagh is 50 cm further west of Dublin than the previously accepted value.

Dr James and Mrs Hamilton had two daughters, Jane and Harriet, and two wards, Catherine and Juliana Tisdall. The girls used to entertain their boyfriends in the Troughton dome. They called this part of the Observatory '*heaven*', because '*it was a pleasant place where you only met those whom you loved and those whom you wished to meet*'. In Aleaxander Hamilton's diary for 1798, we read that '*Lord Caulfield and Alexander Hamilton (son of Dean Hamilton who built the Deanery), as they were leaving the Observatory after supper with the ladies, found the lodge gates locked and had to climb them – Caulfield (from practice) got over without difficulty but Hamilton found the first attempt difficult and at the second attempt tore his breeches*'.

Positional Astronomy

The work of the astronomer at the time when the Observatory was built was to calculate the positions of the stars for navigational purposes. This was done by setting up a telescope in the north-south line and which could be adjusted only in elevation. The telescope pointed south and the time recorded when a particular star crossed a wire in the eyepiece. This gave the star's longitude, or right ascension as astronomers refer to it. The telescope was supported on an axis which was connected to a large circular scale marked out in degrees. The star's latitude (declination) was read from this circle.

Dr Robinson and his assistants measured the positions of over 5,300 stars by this method between 1828 and 1854. The results were published in 1859 in a catalogue commonly referred to as the *'Armagh Catalogue'*. During the course of observations one November night in 1846, he noticed a *'deviation in azimuth'*, as he termed it, which he corrected for. Dr Robinson was unsure what had caused it, he assumed it may have been the shock of an earthquake or a violent storm off the coast of England. Three days later in the newspapers an earthquake was reported in France and Scotland!

Robinson Dome

When Dr Dreyer succeeded Dr Robinson as Director, he wished to erect a memorial to his distinguished predecessor. He ultimately decided on a 10-inch refracting telescope. £100 was collected in a fund which he set up. This was sufficient to construct the building and the Government contributed £1000 to purchase the telescope. The refractor was made by the Dublin firm of Grubb and the first observations were made in 1885.

Dr Dreyer used the telescope to confirm his galaxy observations for his *'New General Catalogue of Nebulae and Clusters of Stars'* (NGC). Most bright galaxies, star clusters, and the large luminous clouds of gas which permeate the Milky Way galaxy, known as nebulae, have NGC numbers. Astronomers still today, world-wide, refer to Dreyer's numbering system when describing these objects, even though it is now over 100 years old. In the early part of the twentieth century, the telescope was used by Mervyn Ellison, who later became Director of Dunsink Observatory, for double-star measurements. Double stars are stars which are in orbit around each other.

10-inch Grubb Refractor c.2005

By measuring their separations and orientation, their combined masses can be calculated using Newton's Law of Gravitation. So, we can actually 'weigh' stars here on Earth — we can't touch them, but we can weigh them!

During the 1960s, Patrick Moore, the first Director of the Armagh Planetarium, used the instrument for making observations of the planets Jupiter and Saturn, and so on. The BBC television programme, *'The Sky at Night'* has been hosted by Patrick Moore since 1957. His studies of the Moon's surface were of much use to the American astronauts who landed on our natural satellite in the late 1960s and early 1970s.

While much of the Observatory's observations are now made from spacecraft, or from remote mountain-top observatories around the world, the Grubb telescope is still in occasional use. During three public viewing nights in March 1997, for instance, almost two hundred people watched Comet Hale-Bopp with it.

Calver Telescope

The Calver telescope was originally made for an English astronomer Colonel G.L. Tupman by George Calver in 1883. It eventually came into the possession of Revd William Ellison who presented it to the Observatory in 1919. Around 1950 this telescope was converted into a wide-field 12/18-inch Schmidt camera. During the course of the last few years the telescope has been converted back to its original design.

18-inch Calver Reflector c.2005

The Modern Observatory

Dr Mart de Groot, an expert in stellar astrophysics, was Director from 1976 to 1994. He was followed in 1995 by Professor Mark Bailey, whose principal research interests lie in solar system astronomy and the dynamics of bodies such as comets and asteroids. There are now some 20–25 astronomers studying a wide range of topics including the physics of hot and cool stars, the Sun, the solar system, and solar-system — terrestrial relationships. The Observatory is one of the UK and Ireland's leading astronomical research institutes. Basic operational costs are borne by the Department of Culture, Arts and Leisure, while the Science and Technology Facilities Council supports individual research projects. For further information, contact the Director, Armagh Observatory, College Hill, Armagh, BT61 9DG, Northern Ireland, or visit the Observatory website: http://star.arm.ac.uk/ and http://climate.arm.ac.uk/.

John McFarland
Armagh Observatory
College Hill, Armagh
February 2012

A Tour of Armagh Observatory

The Armagh Observatory was founded and endowed by Archbishop Richard Robinson, who wished to establish a University of Ulster in Armagh. Previous attempts had been made to set up a university by Archbishop Dowdall in 1558, Queen Elizabeth in 1583, and the Earl of Tyrone in 1599, but all without success. It is believed that the Public Library and Observatory were two stages in the development of the university, and Robinson bequeathed £5000 for the work to be continued. It was stipulated that the money should be used within 5 years after his death, but political events in the interim period, including the 1798 rebellion and the subsequent Act of Union, diverted the attention of government, and Robinson's plans were never realised.

Richard Robinson

Richard Robinson was born in 1708 into a high society Yorkshire family. He was educated at Westminster School and Christ Church, Oxford. In 1751/52 he came to Ireland as Chaplain to the Lord Lieutenant of Dublin, the Duke of Dorset. In 1752, he was consecrated Anglican Bishop of Killala and Achonry.

He moved diocese, first to the See of Ferns and Leighlin in 1759, and then to Kildare in 1761, and was elevated to the Archbishopric of Armagh in 1765.

Known as the second founder of Armagh, Archbishop Robinson initiated many building projects in the city, including the Palace (now the Armagh City and District Council Offices); the Public Library; the Military Barracks, and the County Infirmary. He laid the foundation stone of the new site of the Royal School, provided the site for the prison, and made the Town Commons, a racecourse, into public walk-ways (now the Mall). In 1789, at more than 80 years of age, he commenced the construction of Armagh Observatory. This was to be his last completed building in Armagh.

Architecture and Grounds

Primate Robinson built the Observatory from his personal finances. The Act of Parliament establishing the Observatory 'for ever' is dated 1791. The architect

was Francis Johnston, born in 1760 at Kilmore, Co. Armagh, son of an Armagh builder. Archbishop Robinson trained him under his personal architect, Thomas Cooley of Dublin. Johnston succeeded Cooley at the latter's death in 1784 and he became known as the *'Wren of Ireland'* because he designed and renovated a number of public buildings and churches, among them the interior of the Archbishop's Chapel, beside the Palace, the tower of the Armagh Anglican Cathedral, and the Armagh Courthouse. In Dublin, he modified the Parliament House, and designed the General Post Office, as well as the now demolished Nelson's Pillar.

Armagh Observatory c.1990

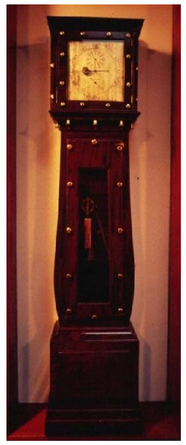
The main block of the Observatory was, for two hundred years, the residence of the Astronomer and his family. The exterior is a plain classical design, with several false windows providing the required symmetry.

The main feature of Johnston's work was the interior joinery decoration. The south side of the residence is dominated by the telescope tower.

To the east of the main building various extensions were added at different periods. In order eastwards, they are: a transit room, a meridian room, and a round telescope tower with a domed roof built in 1827. A square (Sector) Tower above the eastern section of the transit room was added in 1841. When built, the transit and meridian rooms were the main observing rooms, where the astronomers measured the positions of the stars. The Sector Tower was built by Archbishop Beresford to house some of the instruments from King George III's observatory at Richmond, Surrey, which Queen Victoria presented to Armagh Observatory in 1840. On top of the square tower, there is a version of the world-famous Cup-anemometer (wind gauge) which was invented at Armagh Observatory in the 1840s by its third Astronomer, Revd Dr Romney Robinson. The 1827 dome housed in turn a reflecting telescope by Sir William Herschel, a Grubb 15-inch reflector, and finally a 6-inch refractor by Revd William Ellison. It now contains the restored 1835 Grubb 15-inch reflector.

Astronomical Clocks

Around 1790, the Astronomer Royal of England, Nevil Maskelyne, was requested to approach a suitable person to make two clocks for the Observatory. He asked Thomas Earnshaw to provide the clocks, but Earnshaw was reluctant since he had never made one before. He was a watchmaker by trade and he said that he did not know how many wheels were in a long case astronomical clock. However, he was eventually persuaded and provided the so-called transit clock. He made it as airtight as possible by applying screws and waxed cloth to its doors to prevent dust and insects from entering the mechanism. Romney Robinson believed it to be the most accurate clock in the world running to an accuracy of ¼ second per day.



Earnshaw Transit Clock

In the 18th century, the Board of Longitude offered a prize to the person who could solve the longitude at sea problem. For ships crossing the oceans, it was essential to know their positions accurately. Earnshaw wrote to Dr Hamilton of Armagh Observatory requesting references for his clocks. Hamilton gladly supplied good testimonials and Earnshaw included these in his 1808 publication *'An Appeal to the Public'*. He eventually won part of the prize for his contribution to solving the longitude problem.

Two further clocks at the Observatory, are those by Louis Recordon and John Shelton, both gifts by Queen Victoria from the George III Collection. King George used the Shelton clock to time the Transit of Venus in 1769. The Observatory also possesses the telescope used by the King to observe the transit. Captain James Cook observed the event from Tahiti. This was an important event which enabled the size of the solar system to be measured accurately for the first time.

Transits of Venus occur in pairs separated by 8 years at intervals of more than one hundred years, for example 9 December 1874 and 6 December 1882, and 8 June 2004 and 5/6 June 2012.

Directors

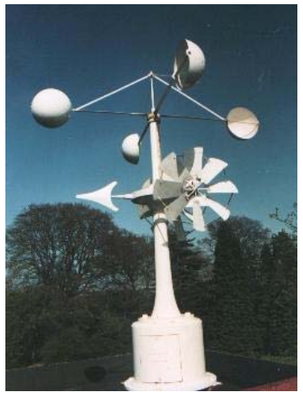
James Archibald Hamilton (1790–1815)
In 1790, Dr James Archibald Hamilton was appointed first Astronomer at the Observatory. He had a private observatory in Cookstown, Co. Tyrone in the 1780s, and became known to the Astronomer Royal, Nevil Maskelyne, through his accurate observations of a transit of Mercury in 1782, which were deemed superior to those made at Greenwich.

Hamilton was born near Athlone in 1748, the son of Col. Hamilton and Jane (*née* Givardot). He entered The Royal School, Armagh in 1754, and Trinity College Dublin in 1765. He was Rector of Kildress from 1776–1784, Treasurer and Rector of Creggan 1784–1790, Prebendary of Mullaghbrack, Archdeacon of Ross 1790–1804, and Dean of Cloyne 1804–1815. He died at the Observatory on 21 November 1815, and was buried at Mullaghbrack, Co. Armagh.

William Davenport (1815–1823)
Dr William Davenport headed the Observatory and was the incumbent of Clonfeacle from 1815 until his untimely death in 1823. Patrick Moore in his history of Armagh Observatory, relates that Dr Davenport committed suicide in the Observatory *'because his wife was an absolute fiend'*.

Thomas Romney Robinson (1823–1882)
Dr Thomas Romney Robinson was the son of artist Thomas Robinson and godson of the portrait painter Romney. In Robinson's 13th year, a book of his poems was published by subscription, the proceeds from which enabled him to enter Trinity College Dublin.

Robinson compiled his star catalogue *'The Places of 5,345 stars...'* in 1859, the culmination of thirty years work. It earned for him the Gold Medal of the Royal Society. Robinson also invented the Cup-anemometer, siting the instrument on the roof of the main building in 1846.



Robinson Cup-Anemometer

After Dr Robinson's first wife died he married Lucy Edgeworth, half-sister of the writer Maria Edgeworth. Maria Edgeworth was an occasional guest at the Observatory and was one of Richard Lovell Edgeworth and his 4 spouses 22 children. When Lucy died in 1897 at the age of 92 she was the last survivor of R. L. Edgeworth's family — she died 150 years after her father's birth.

Another sister, Harriet, resided at the Observatory from 1862 until 1882.

John Louis Emil Dreyer (1882–1916)
Dr Dreyer was born in Copenhagen in 1852 and was educated at Copenhagen University. He was the third son of Johan Christopher Frederik Dreyer, Lt.-General in the Danish Army. He came to work at the Earl of Rosse's observatory at Birr Castle, Co. Offaly in 1874. In 1878 he moved to Dunsink Observatory until his appointment at Armagh Observatory.

Dreyer compiled the *'New General Catalogue of Nebulae and Clusters of Stars'* (the NGC) at Armagh Observatory in 1888. He also wrote the standard historical astronomy textbook: *'A History of the Planetary Theories from Thales to Kepler'* and the biography *'Tycho Brahe'*. He edited about 15 volumes of the works of Tycho. Dr Dreyer resigned in 1916 to continue this work on Tycho at Oxford.

Joseph Alfred Hardcastle (1917)
Joseph Hardcastle was appointed in 1917 but on his way to Armagh he was taken seriously ill and had to travel to his parents home in Oxted and sadly died there at the age of 48. His wife, daughter and son did, however, come to the Observatory for about a year and a half. Hardcastle was a great-grandson of Sir William Herschel. During the first World War, he calculated the tides for the troops which landed at Gallipoli.

William Frederick Archdall Ellison (1918–1936)
Revd Ellison became well known as an amateur telescope maker, writing several articles and a book on the subject. He presented the Observatory with an 18-inch Calver reflector which was converted in 1950 to a 12/18-inch Schmidt camera. Ellison's son Mervyn used the 10-inch Grubb refractor for double-star research. Mervyn became Director of Dunsink Observatory from 1958–1963.

Eric Mervyn Lindsay (1937–1974)
Born in Portadown in 1907, Eric Lindsay was educated at the Queen's University of Belfast and at Harvard College Observatory in the late 1920s and early 1930s. At Harvard his thesis examiners included Harlow Shapley, Cecilia Payne-Gaposchkin, Ernst Öpik, and Bart Bok. Jointly with Harvard, and Dunsink Observatory, Lindsay was instrumental in setting up the ADH (Armagh-Dunsink-Harvard) telescope at Bloemfontein, South Africa, in 1950 which for many years provided the Observatory with its observational material in the form of photographic plates. While Harlow Shapley was on a visit to Armagh Observatory in 1959, Dr Lindsay was taken seriously ill, and for a period of three months or so Shapley was the Acting Director. Of Armagh Observatory, Shapley is reported to have said: *'It is the nicest little observatory in the solar system!'*

Ernst Julius Öpik (Acting Director 1974–1976)
Ernst Öpik was born in 1893 in Estonia. He worked for many years at the Tartu Observatory there. He was appointed Research Associate at Armagh Observatory in 1948 and stayed until his retirement in 1981 (aged 87). Dr Öpik undertook many fundamental investigations in various branches of astronomy, including the estimation of the distance of the Andromeda nebula, stellar energy production, cometary and meteor astronomy, motions of planetary system bodies, and predicting the existence of craters on Mars in the early 1950s. He won many gold medals, among them the Leonard Medal of the American Meteoritical Society, the Bruce Gold Medal of the Astronomical Society of the Pacific, and the Gold Medal of the Royal Astronomical Society.

Troughton Dome

One of the earliest scientific instruments which the Observatory acquired was the Troughton equatorial telescope. Manufactured by the firm of John and Edward Troughton in 1795, it has a 2¾-inch objective and is mounted in the English style. It had a novel design in that it performed the functions of a transit instrument and a quadrant as well as an equatorial. No astronomer at the time had used anything like it before. Due to its complexity, it initially required three months to