# Colin Humphreys

Born 1941. Professor of Materials Science.
Available online at www.livesretold.co.uk

## Contents

# 1. Introduction

*Chapters 1 to 6 of this life story were archived in 2021, with acknowledgement and thanks, from the This Cambridge Life section of the www.medium.com website. The article was published in February 2018.*

Sir Colin Humphreys is known for his pioneering work in LED technology. In parallel with his scientific career, he's spent 50 years studying the Bible. As he (reluctantly) approaches retirement from Cambridge, he reflects on some formative experiences. He writes:

*Cambridge University Department of Materials Science and Metallurgy, on the West Cambridge site.*

My room looks over open fields. It's on the ground floor of the Department of Material Science and Metallurgy. The uninterrupted view of trees and flying birds helps me compose my thoughts not only about science, but also about the wonderful world in which we live.

*Colin Humphreys at the Cambridge Centre for Gallium Nitride.*

Next door is the Cambridge Centre for Gallium Nitride. In this centre, which I founded in 2000, researchers from all over the world are developing ways in which gallium nitride can be used to make a wide range of technologies more energy efficient.

*The Centre's website explains:*

Gallium nitride is probably the most important semiconductor material since silicon. It can be used to emit brilliant light in the form of light-emitting diodes (LEDs) and laser diodes, as well as being the key material for next generation high frequency, high power transistors capable of operating at high temperatures.

The Cambridge Centre for Gallium Nitride is based in the Department of Materials Science and Metallurgy at the University of Cambridge. We are one of a small number of places in the world to have, in close proximity and on the same site, gallium nitride growth equipment, extensive advanced electron microscopy characterisation facilities, advanced X-ray diffraction characterisation facilities, atomic force microscopy, photoluminescence (PL) for measuring optical properties, Hall effect equipment for measuring electrical properties, and basic theory for understanding in detail physical properties.

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# 2. Early Life

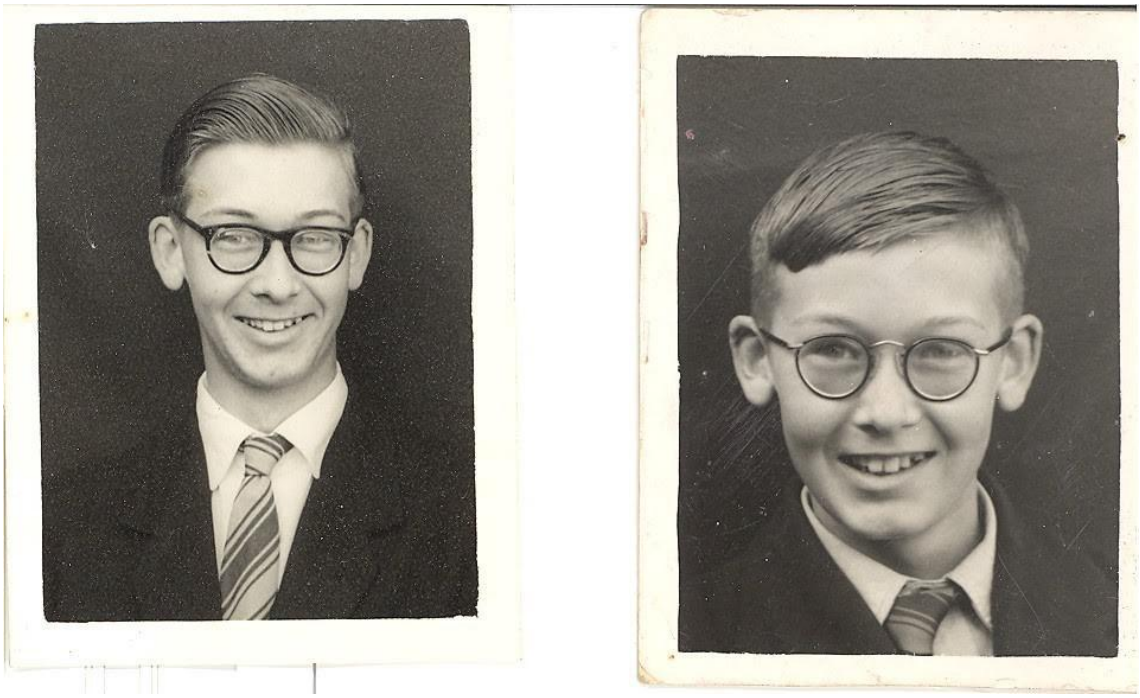
Cambridge is in many ways a place of privilege. My early years were strikingly different. I was born with a deformity in both feet and had a major operation when I was two. After the operation, I was in plaster for six months and wore leg irons till I was 12. They were contraptions to straighten my legs.

Home was a small house in Luton. We were really quite poor. The house didn't even have an inside lavatory. Despite the leg irons, I joined a street gang which fought with other gangs. Some of the kids had air pistols. I was often the one who got caught. My father decided we should move to a better part of town.

*Denbigh Road Primary School in Luton. Colin is back row, far left.*

My father took me to enrol in a new primary school. The headmistress said I'd be going into the bottom of three classes. Her decision was based on the dismal record of my previous school. My father insisted I should be in the top group. She asked me some general knowledge questions, none of which I could answer.

He announced that he wasn't moving from his chair until I was put in the top group. The headmistress agreed to give me a month's trial. I started bottom of the class but began to make progress. I realised what a lot I had to learn to keep up with the brightest. Had my father not been so brave, I mightn't have got into grammar school.



*School photos.*

I passed the 11-plus exam and went to Luton Grammar School for Boys. Pupils from a wide range of backgrounds were at the school, which enabled social mobility on quite a large scale. In the sixth form I specialised in maths, physics and chemistry. I regretted stopping biology, French and music — but not art at which I was hopeless.

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# 3. Butterflies and Moths


It wasn't school alone that put me on track for a career in science. When I was eight my parents took me to London. Walking down the Strand, I spotted a shop called Watkins & Doncaster that sold everything to do with moths and butterflies. We went in and I begged my parents to buy some butterfly eggs but they wouldn't.

Eventually, my parents gave in and we ordered some moth eggs from India. I made a simulated steaming jungle out of cardboard, wet blotting paper and an electric lamp underneath. When the eggs arrived, I tended them until they hatched. The caterpillars wandered about our living room and made cocoons containing chrysalises on the curtains.

I went on to breed other moths and butterflies — including the Atlas moth. I taught myself their Latin names. I researched the plants that caterpillars ate in their native countries and found related plants in the UK to feed them on. I think this laid the foundations of my complex multi-million pound research projects.

*The Atlas moth.*

## The story of Watkins and Doncaster

*A Watkins and Doncaster specimen cabinet.*

*The following history of Watkins and Doncaster was archived in 2021, with acknowledgement and thanks, from the company's website at www.watdon.co.uk. The company had an important influence on the young Colin Humphreys.*

Watkins & Doncaster was founded in 1874 by William Watkins in Eastbourne. His house, called 'The Villa Sphinx' was named after the Hawkmoth and gained the nickname 'The Villa Stinks' as a result of the all-pervading smell of moth balls. He established a butterfly farm in his grounds, three-quarters of an acre being devoted to rearing Lepidoptera collected from all over the world.

In 1879 Watkins moved the business to 36 The Strand, London - pictured here. He formed a partnership with Arthur Doncaster which only lasted until 1880 when William Watkins left to continue independently.

Arthur Doncaster carried the business on and was a remarkable man. He was completely deaf and speech impaired and all his conversations were carried out on a slate hung around his neck. When customers went into the shop and asked for something, he wrote the reply on the slate and passed it to them to read and pass back. Being handicapped to that extent, it is quite surprising that he built up a business of the size he did. He became a world authority on tropical butterflies and worked in close conjunction with the British Museum, giving much advice and assistance to the curator of

tropical butterflies. At the end of the Victorian era one of the popular things in those days was glass cases of stuffed birds, and at one time the firm employed five taxidermists, fully engaged in stuffing and mounting birds under glass domes.

Arthur Doncaster had an assistant, Frederick Mette, who later became his partner and finally took over the business when Doncaster retired in the 1930s. Mette knew little about tropical butterflies but was an acknowledged expert on birds eggs. He continued until 1939 when he died, and the business ran for about a year with nobody in charge until Richard Ford, a field entomologist, bought the company in 1941.

During the time Richard managed Watkins & Doncaster, the company purchased large entomological collections (mostly butterflies) as they became available for sale. This continued the practice of William Watkins, Arthur Doncaster and Frederick Mette. These were first offered for inspection to the British Museum (Natural History) [now the Natural History Museum] which resulted over the years in the donation of nearly 27,000 specimens of butterflies and moths to that institution.

The post-war rebuilding of The Strand led to the move of the company down to Welling, Kent in 1956 (pictured right). This became the new head office and where the postal side of the business expanded.

Robin Ford joined his father Richard in 1963 and the expansion of the firm progressed steadily, with a demand growing from export customers, education and research. In 1969 Richard moved to the Isle of Wight to further his research in geology, particularly fossilised mammals, leaving Robin to run the business. The Welling office site became too small to accommodate the firm so in 1973 Robin found a larger site (pictured below) - still the current premises, in Hawkhurst, Kent with his wife Julia who became a partner of the business.

In 1976, Watkins & Doncaster took over the lease of the famous butterfly shop in the Lanes at 21 Brighton Square. The shop catered for the entomologist with attractive displays of butterflies and insects, and also appealed to the public in general who were becoming more aware of nature and conservation. The shop ran until 1985 when rents became too costly to continue. The office in Hawkhurst

continued to run a showroom for customers to browse and buy products, both new and old.

In 2004 Robin and Julia's daughter Amy, with a background in business studies and marketing, joined the company. When the time came for Robin and Julia to take a back seat in the running of the company, the business relocated in October 2013 to Amy's chosen home in Herefordshire with her husband and young family.

Watkins & Doncaster remains a highly specialised family-run business with equipment sent all over the world, not only for private collectors but also for important crop research and pest control. An extensive range and variety of products continues to be offered, with a large proportion manufactured in-house. Great pride is taken with the quality of the traditional equipment adapted to modern day usage with the emphasis on the study of insects.

*Beginner's Sweep Net. One of hundreds of products available in 2021 on the Watkins and Doncaster website. Described as ideal for beginners and children for collecting in grasses and heather etc. Size: 30cm (12") diameter. Supplied complete with white bag and 30cm wooden handle. £15.10 ex VAT.*

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# 4. University & Research

With a state scholarship I went to Imperial College to take a degree in physics. I went on to do further research at Cambridge, Oxford and Liverpool, where I became Head of Materials Engineering. I forged links with industry and, with colleagues, made advances in understanding the structure of materials using electron microscopy.

As a materials scientist, I'm best known for my work in LED technology. When we first put forward the idea that gallium nitride could be used as a light source throughout the world, people said it was nonsense. The costs were prohibitive.

We developed a new way of making low-cost gallium nitride LEDs. Our technology was transferred to Plessey, which is now manufacturing millions of low-cost LEDs at its factory in Plymouth. These are sold to manufacturers of LED bulbs. Plessey estimates that our technology reduces the price of LEDs by five to ten times.

The key was finding a way to grow gallium nitride on silicon rather than sapphire. Once we'd done this, we could focus on making the development a commercial reality. People said it would take two years for us to transfer our technology to Plessey. We did it in eight weeks.

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# 5. A Shredded letter from the Queen

In 2010 I was knighted. When I received a letter saying that I would be knighted in the Queen's Birthday Honours List for "Services to Science", I thought it was a student prank. The letter had arrived torn to bits inside a plastic bag with a note from the Royal Mail apologising that it had been damaged in its sorting machine.

I put the pieces of the letter together like a three-dimensional jigsaw puzzle. I was still convinced it was a student joke but my wife encouraged me to phone to check it wasn't a hoax. It was genuine. I accepted the knighthood with great pleasure. Who or what organisation proposed me, I still don't know.

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# 6. The Bible

Alongside my work in materials science, I've always studied the Bible. My parents were Creationists who believed that God made the world in seven days and I accepted this. When I was doing my A levels, and learnt about radio carbon dating, I began to question my parents' beliefs. I never confronted them but I think they knew that I'd rejected Creationism.

At university I rediscovered my Christian faith. People are surprised to meet a scientist who's also a believer — but there are lots of us. I did have a letter that began: "Cobbler stick to thy last." Once a Chinese student knocked on my door and said: "I'm told that you believe in God. That's impossible." It led to a lively discussion.

I've found no conflict between science and the Bible. Scientists and Christians are both seekers after truth. If there is a God, then the God who reveals himself to us through the Universe, which he created, and which scientists study, is the same God who reveals himself to us through the Bible.

According to my research into the Gospels, the Last Supper was on Wednesday. My argument is based on a combination of Biblical, historical and astronomical research. At first sight, the four Gospels appear to contradict themselves over the date of the Last Supper. But they were using different calendars.

I can't quite believe that I've reached the age of 76. Under Cambridge University rules I have to retire soon. Fixed retirement ages are not something I agree with. People like me, who are lucky to have good health, may still have a lot to contribute. I've already had offers of projects from several universities, both here and overseas.

Richard Dawkins has done a great job with his anti-God arguments. One of the things I want to do when I have more time is write a popular book that puts across the arguments for the existence of God. I've been very fortunate to have spent 30 years of my life in Cambridge with its pool of talent. There's a lot more I want to do.

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# 7. Gallium Nitride

*This chapter was archived in 2021, with acknowledgement and thanks, from the website of the Brazilian Materials Research Society at www.sbpmat.org.br. Colin Humphreys was interviewed by the SBPMat Newsletter. The interview took place in 2014.*

Sir Colin Humphreys, PhD from Cambridge and a BSc from Imperial College, is Professor of Materials Science and Director of Research in the Department of Materials Science and Metallurgy at the University of Cambridge (United Kingdom). His research covers three main areas: gallium nitride (GaN) materials and devices, advanced electron microscopy, and ultra-high temperature aerospace materials. He has published hundreds of papers on electron microscopy and given many plenary and invited lectures throughout the world. He has received national and international medals for his research in electron diffraction and microscopy and on gallium nitride.

He founded a spin-off company (CamGaN) to exploit the research on gallium nitride of his group on low-cost LEDs for home and office lighting. The company was acquired in February 2012 by Plessey, which manufactures LEDs based on this technology. He is the founder and director of the Cambridge Centre for Gallium Nitride, a center with world-class growth and characterization facilities where research is carried out from fundamental studies on GaN to applications in LEDs and lasers. He also founded and directs the Cambridge/Rolls-Royce Centre for Advanced Materials for Aerospace, which developed materials that now fly in Rolls-Royce engines.

He is a fellow of the Royal Society, the self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine, and of the Royal Academy of Engineering. He is also a fellow of Selwyn College, one of the Cambridge University 31 autonomous units in which students live, eat, socialise and receive some teaching sessions. In 2010 he was Knighted (receive a special honor and the title of Sir from the Queen of England) for services to science.

Professor Humphreys has authored over 600 peer reviewed papers with over 9,400 citations and his h-index is 43.

In his limited spare time he writes books on science and religion, such as "The Mystery of the Last Supper: Reconstructing the Final Days of Jesus", which has recently been translated into Russian, German, Portuguese, Japanese and Greek.

SBPMat newsletter: – Why do you think gallium nitride is one of the most important semiconductor materials? Which are the main challenges in the field of gallium nitride for materials scientists and engineers?

Sir Colin Humphreys: – I think gallium nitride is one of the most important semiconductor materials because of the huge range of potential applications and the benefits to mankind which will result from these applications. The main challenges to realising these applications are reducing the cost of GaN devices and improving the efficiency still further.

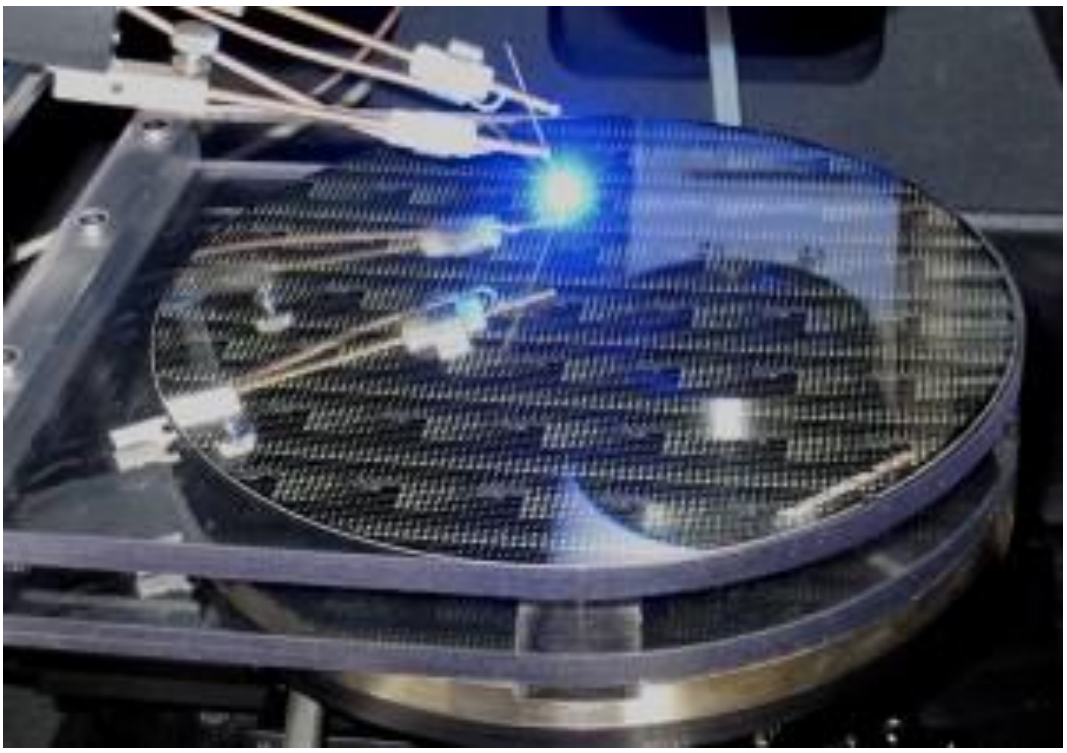
SBPMat newsletter: – Which are the principal contributions you have done for the development of Materials Science and Engineering?

Sir Colin Humphreys: – The principal contributions I have made for the development of Materials Science and Engineering are solving some fascinating problems in basic science and also developing materials for industry. For example, I direct a Rolls-Royce Centre in Cambridge on Advanced Materials, and some of the materials we have developed are now flying in Rolls-Royce engines. In addition, I direct the Cambridge Centre for Gallium Nitride, and the low-cost GaN LEDs on silicon that we developed are now being manufactured in the UK by Plessey.

SBPMat newsletter: – Brazil is making efforts to transfer technology to the industry. You have founded a spin-off company and research centers, in both cases having good technology transfer results. Based on these experiences, what would you say to the Brazilian Materials community about making technology transfer real?

Sir Colin Humphreys: – First, scientists and engineers have to have an idea for a new or better product. In order to convince industry, it is important that the scientists and engineers make prototype devices to show to industry. If the scientists and engineers decide to set up their own company, it is usually helpful to bring in a CEO from outside to run the company because most scientists and engineers are not so good at running a company. The choice of the CEO is critical. It is also possible to set up a company for virtually nothing, set up a website for virtually nothing, etc.

It is really important to get lots of good advice. I was fortunate in setting up two companies, in that I got a lot of good advice for free because there are a lot of people around Cambridge in the UK that have set up companies and can give good advice. Finally, making technology transfer real is good fun, but also hard work! You may have lots of set-backs, but keep persevering! Also, be enthusiastic about your product, if you are not enthusiastic, no-one else will be! You have really to believe in what you are doing.



*GaN LEDs on a 6-inch Si substrate.*

SBPMat newsletter: – If possible, tell us a little about the topic of your plenary talk at SBPMat meeting.

Sir Colin Humphreys: – In my plenary talk at João Pessoa I plan to start by showing some striking atomic-resolution electron micrographs showing single silicon impurity atoms in graphene, and showing that they can occupy two different sites. I will also show images of dancing silicon atoms in graphene (I know Brazilians are experts in dancing!). I will then move on to talk about Gallium Nitride (GaN) and how this amazing man-made material is likely to save more energy and CO2 emissions than solar, wind-power and biomass together! I will describe how advanced electron microscopy and atom probe tomography have been used to solve the fascinating problem of why GaN LEDs are so bright when the dislocation density is so high.

I will also describe how growing GaN LEDs on large area silicon substrates can substantially reduce the cost of LEDs, and this cost reduction is likely to enable GaN LEDs to be the dominant form of lighting in our homes, offices, streets, etc, in the near future. In addition, I will show how GaN-based power electronic devices are 40% more efficient than silicon power electronic devices, so replacing Si power electronics by GaN would save another 10% of electricity, on top of the 10-15% electricity savings from using GaN LEDs. So GaN could potentially save 25% of the world's electricity consumption, which is amazing.

In addition to saving energy and carbon emissions, if aluminium is added to GaN, then deep-ultra-violet (UV) light is emitted and this can kill all bacteria and viruses. So such deep-UV LEDs could be used for water purification in the world, saving millions of lives. Finally I will talk about how optimised quality LED lighting can improve the health of all of us and the exam results of school children! My talk will range from basic science through to applications.

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# 8. Faith & Science

*The following chapter was archived in 2021, with acknowledgement and thanks, from the Christianity website at www.christianity.org.*

Professor Sir Colin Humphreys is a materials scientist. He sees Christianity as a very logical and reasonable faith. Among the posts he holds are the Director of Research at Cambridge University and Professor of Experimental Physics at the Royal Institution. His research has included work on electron microscopy, semi-conductors, superconductors and ultra-high temperature aerospace materials. He also pioneered the development of energy-saving LED lights. Sir Colin has also published two books on events in the Bible.

## Finding faith

Sir Colin's parents were Christians and he decided to follow suit as a teenager but rejected Christianity on arriving at university, concluding it was 'all fairy stories'. He changed his mind after going to church services with a college friend who announced he wanted to be a Christian and asked for Sir Colin's help. 'It got me thinking,' he remembers. 'I sat up all night. His question challenged me. Was I a Christian or not? That night I decided I would become a Christian, and I started reading the Gospels and Christian books. I confirmed this decision later.'

Sir Colin believes his Christian faith has an impact on the how he deals with people and the conflicts which can arise as a scientist. He says science has affected his faith too. 'I think scientists see the world slightly differently. To me, Christianity is a very logical and reasonable faith. When I read the Bible, I tend to look for natural explanations. That doesn't mean I don't believe in miracles but that I think God often works in and through nature to achieve his purpose. Often the miracle is in the timing of an event. And there are some things, like the resurrection of Jesus or the virgin birth, for which we can't give a scientific explanation and which certainly are miracles.'

'I think scientists see the world slightly differently. To me, Christianity is a very logical and reasonable faith.'

## Miracles and answered prayers

Sir Colin believes that God uses nature to accomplish his purposes. 'Aristotle spoke about prime movers and agents. He said that God is the prime mover and agents can be things like natural events. So how do you know an event is a miracle or not? It is determined, said Aristotle, by the timing. (But) if prayer is meaningful – if prayer can change things – then there has to be flexibility in the system.

‘I think that some things are fixed. God plans things. I believe, for example, that God planned that Jesus would come into history at a certain point of time and would be crucified when he was. I also think that God leaves a number of things flexible, that he interacts with us to achieve his purposes. Because God has given us free will, life cannot all be rigidly planned. For example, the Bible says that God wills for the whole world to be saved. But it hasn’t happened yet because humans exercise their free will and reject God. And God allows that.’

## Creation, evolution and scientists ‘playing God’

‘As a Christian, I believe God is in charge. He worked with his created order for the emergence of life, including humans. He planned from the beginning that humans would emerge at a time and in a way of his choosing. I was brought up to believe that the Earth was around 6,000 years old. But I now believe that evolution is the way God developed life. Evolution does not say that humans evolved from apes. It says that humans and apes share a common origin. For non-believers, evolution is taken as evidence that life is nothing more than a series of blind chances and is, therefore, meaningless. From a faith perspective, I see evolution consisting of a lot of events which look like chance but which are part of a process guided by God.’

'From a faith perspective, I see evolution consisting of a lot of events which look like chance but which are part of a process guided by God.’

Sir Colin believes that, in future, science will continue to throw up difficult ethical issues and it is important for Christians to be at the forefront of its progress. ‘Scientists will increasingly have the ability to play God, especially in the biological realm,’ he says. ‘We will be able to do remarkable things which can be used for good or evil. It is vital that there is moral guidance.’

## Researching the Star of Bethlehem in the Christmas story

Sir Colin’s notion that God often uses natural events rather than the miraculous is seen in his spare time research into one aspect of the birth of Jesus Christ. The Bible book Matthew tells how Babylonian astrologers or Magi came to see Jesus as an infant in Bethlehem after seeing a star in the east. The Bible account suggests that the star was new and travelled in the sky – leading the Magi first to Jerusalem then south to Bethlehem. The Bible book, Matthew, says the star then ‘stopped over the place where the child was’. Sir Colin says this would suggest it was actually a comet. This is supported by the accounts of two historians of the era and Chinese astronomers.

‘Between 20BC and 10AD Chinese astronomers recorded three comets – just one was a long-tailed comet,’ says Sir Colin. ‘It appeared in 5BC and was visible for 70 days. It is an indication that Jesus really lived. It helps place him in history.’

Sir Colin believes the Magi were encouraged to come to Jerusalem by three astronomical events which they would have seen as very significant. These were the alignment of Saturn and Jupiter three times during 7BC; that alignment happening in the constellation of Pisces, which the Babylonians associated with Israel; and the alignment of Mars, with Jupiter and Saturn in 6BC.

To me, it speaks of how God uses natural phenomena,’ he concludes. ‘He could have made a special, miraculous star, but he didn’t. He used what he’d already created: planets and stars. Significantly, God chose to use foreigners to herald the birth of Jesus. This speaks of God being inclusive. He sent Jesus for the whole world and whole-world citizens are represented in the events of his birth. Being able to identify and date the star adds scientific weight to the fact that Jesus was born where and when the Bible says.

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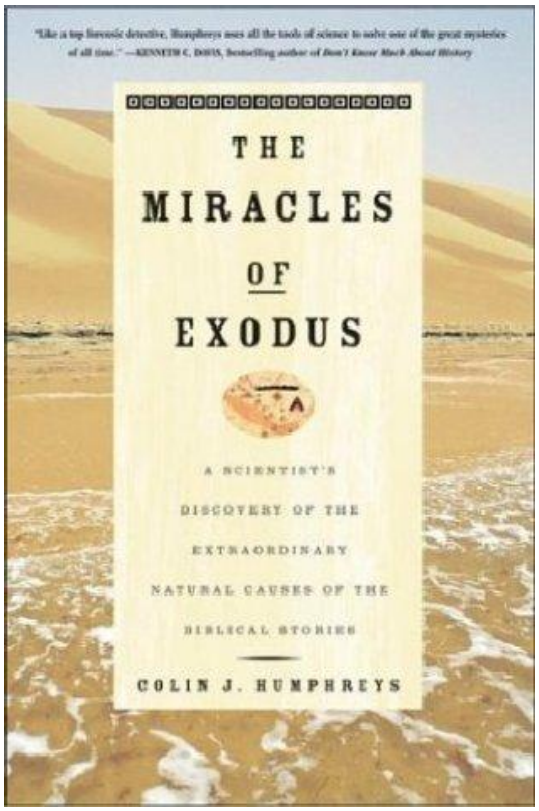
# 9. Books

*In addition to authoring more than 600 academic papers, Colin Humphreys has written two books on Biblical history.*

**The Miracles of Exodus**



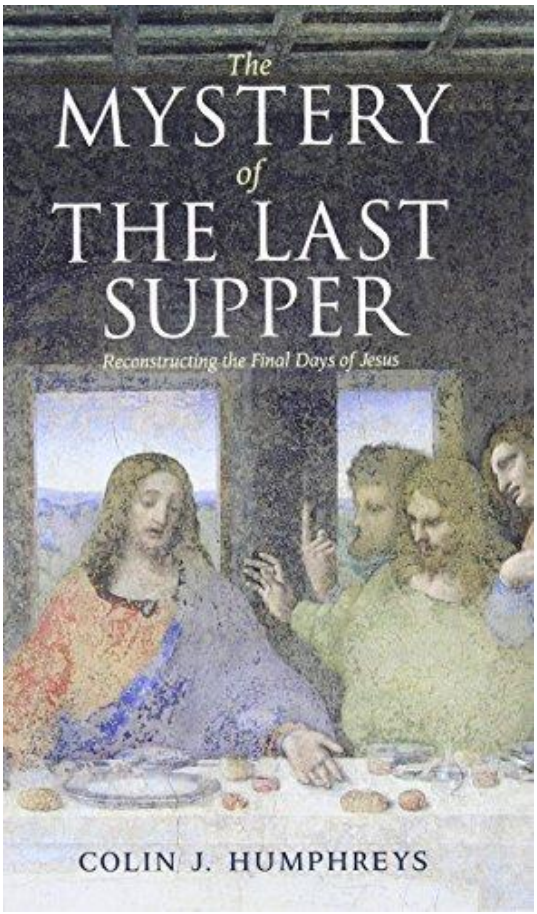

After seven years of meticulous research Colin Humphreys has written a fascinating and involving book on the miracles of Exodus and the Israelites' escape from Egypt. Although Humphreys uses science to explain the events of Exodus he does not believe that this makes them any less miraculous - rather, God is the force behind the science. The author answers key questions about the Exodus, such as how many Israelites were involved and how they manage to survive in the desert for 40 years. He argues that the Israelites did indeed cross over the Red Sea (and not the Reed Sea as some scholars claim) and that the real Mount Sinai is not in the Sinai Peninsula but is a volcano in Arabia. Humphreys provides convincing biblical evidence to support his views and his treatment of the subject is fresh, passionate and often amusing.

Humphreys concludes: 'I am well aware that most scholars believe the book of Exodus is riddled with errors and inconsistencies. I've subjected the biblical text to a real grilling in this book, and I can only stand back in amazement at its accuracy and consistency, down to points of tiny detail...The Exodus story revealed in this book is truly astonishing.'

Review:

The book is easy to read, and is well worth reading. Read it with an open, but critical, mind. Faith and Thought 'Humphreys is trying to understand, with painstaking examination, how one can be even more impressed by the natural explanations of how the plagues of Egypt came about, how the waters rose up, how bitter water turned sweet' -- Sanford Lakoff.

**The Mystery of the Last Supper: Reconstructing the Final Days of Jesus**




Apparent inconsistencies in the gospel accounts of Jesus's final week have puzzled Bible scholars for centuries. Colin Humphreys explains these inconsistencies, whilst proposing a compelling new theory - that the last supper took place on a Wednesday, rather than Thursday as traditionally believed. The contrasting interpretations of the last supper arise from Matthew, Mark and Luke's assertion that it was a Passover meal, whilst John states that it occurred beforehand.

To confuse the issue, there does not seem to be enough time for all the events recorded between the last supper and the crucifixion to take place, whilst Wednesday appears to be a 'missing day' on which Jesus did nothing. Humphreys draws on evidence from the Dead Sea Scrolls and Egyptian texts and uses astronomy to reconstruct ancient calendars. In doing so he shows how the last supper took place on a Wednesday and successfully unifies the supposedly contradictory gospel stories.

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