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Contributor Letter written in verse by Lewis Carroll to his child friend Margaret Cunningham, Christ Church Oxford, January the 30th 1868.

"Dear Maggie

No `[[cart 0:00:13]]` has yet been done of me that does real justice to my smile. And so I hardly like you see to send you one.

Meanwhile I send you a little thing to give you an idea of what I look like when I'm lecturing.

The mirror sketch you will allow.

Yet I still think there's something grand in the expression of the brow and in the action of the hand.

Your affectionate friend.

C L Dodgson

P.S. My best love to yourself. To your mother my kindest regards. To your small, fat, impertinent, ignorant brother, my hatred.

I think that is all."

Well that letter to Margaret Cunningham shows up two aspects of Lewis Carroll. First of all his love of children and the fact that he was a teacher. In fact a teacher of mathematics.

If he hadn't written the 'Alice' books, he'd be mainly remembered as a pioneer Victorian photographer as we'll see.

And if he hadn't been known for that, he'd have been largely forgotten as an Oxford Mathematician who seems not to have contributed much.

But is that really the case? That's what I want to look at today. And I want to describe his mathematical life and works. And don't worry, it's a Sunday morning, you haven't got a lot of heavy mathematics to come.

But certainly mathematics pervaded his life and works. And even the 'Alice' books, as I would like to remind you, for example in the mock turtle scene. The mock turtle started "We went to school in the sea. The Master was an old turtle. We used to call him tortoise." Alice said "Why did you call him tortoise if he wasn't one?" "We called him tortoise because he taught us."

"I only took the regular course, reeling and writhing of course to begin with and then the different branches of arithmetic. Ambition, distraction, uglification and derision."

"And how many hours a day did you do lessons?"

"Ten hours the first day, nine hours the next, and so on."

"What a curious plan" said Alice.

"That's the reason they're called lessons, because they lessen from day to day." (Laughter)

And in 'Through the Looking Glass' which was the sequel, the White Queen and the Red Queen set Alice a test to find out whether she should become a Queen. You may remember that 'Alice's Adventures in Wonderland' is based on cards. Whereas 'Through the Looking Glass' is based on a game of Chess. And the idea is that as the chapters progress Alice starts as a pawn and then moves up right to the other end of the board and becomes a Queen. But she can't become a Queen until she's been examined by the White Queen and the Red Queen.

And the White Queen said "Can you do addition? What's one and one and one and one and one and one and one and one and one?"

Poor Alice didn't know, she'd lost count. She can't do addition.

"Can you do subtraction? Take nine from eight." "Nine from eight I can't you know, but" "She can't do subtraction."

"Can you do division? Divide a loaf by a knife." What's the answer to that? Bread and butter of course was the answer.

But anyway the Queens decided, came to the conclusion that Alice could not do sums at all.

And another character that couldn't do sums was Humpty Dumpty. And in the original drawings of Humpty Dumpty, Humpty was represented as a young boy. We always think of Humpty Dumpty as an egg, don't we? But that actually arose through the tenure of drawings for Alice.

Humpty Dumpty preceded Lewis Carroll but was always presented, well not presented as an egg until after this book.

Anyway Alice is admiring his cravat. And Humpty said "It's a present from the White King and Queen. They gave it to me for an un-birthday present." So Alice says "What's an un-birthday present?" "A present given when it isn't your birthday of course." "I like birthday presents best." "You don't know what you're talking about. How many days are there in a year? 365 and how many birthdays have you, one. And if you take one from 365, what remains? 364 of course." Humpty Dumpty's a bit puzzled by this and says "I'd rather see that done on paper." 365 minus one is 364. And he says "That seems to be done right but I haven't time to look it over thoroughly right now." But you will actually see this sum appearing in 'Through the Looking Glass' if you look at it you will see it there.

I mean it's hardly higher mathematics this but it's interesting that Carroll does bring in these mathematical ideas all over the place in his 'Alice' books. And also in his other books that he wrote for children.

Many of you will probably know his long poem 'The Hunting of the Snark'. And in this, it's great fun to read. All the characters begin with a B. There's a bellman and in this particular scene the butcher is trying to convince the beaver that two plus one is equal to three. And in the verse you'll get these particular stanzas.

"Two added to one if that could be done, it's said with one's fingers and thumbs.

Recollecting with tears how in earlier years it had taken no pains with its sums.

Taking three is a subject to reason about. A convenience number to state. We add seven and ten and then multiply out by one thousand, diminished by eight.

The result we proceed to divide as you see by nine hundred and ninety and two Then subtract seventeen and the answer must be exactly and perfectly true."

That of course does not prove that two plus one is equal to three. Basically whatever number you start with, if you add seventeen and multiply by nine, nine, two and then divide by nine nine two and then subtract seventeen, you're going to get back to where you started from. But there we are.

More substantial was his last couple of books for students. Well for children.

They're called 'Sylvie and Bruno' and 'Sylvie and Bruno Concluded'. They're not recommended. They're not a good read in any sort of sense. But there are quite a lot of things in Sylvie and Bruno and the sequel, the concluded one. There's a discussion of gravity. And it has some quite sophisticated ideas in it. And I thought I'd show you a couple of the scenes.

Basically, imagine yourself in a shady nook and Lady Muriel is there, being very English and hemming pocket handkerchiefs while she has her tea. And her father the Earl is next to them. And up came a German Professor, Mein Herr. German Professors are very very highly regarded in Carroll's day. And German Professors feature more than once in his writings.

And the German Professor comes up and says "Oh hemming pocket handkerchiefs are you? Do you know that if you sew them up properly you can create Fortunatus's purse. Fortunatus's purse has all the wealth of the world inside it. And basically the idea is that if you've got three pocket handkerchiefs, if you sort of sew them up you get a sort of pocket. But if you give one of them a twist before you do it then you actually get a mathematical surface called a projective plain, which has no inside and no outside. And therefore it has all the wealth of the world inside it.

Some of you will have heard of a merbia strip. Have you heard of a merbia strip? What do you call a one sided whale Moby a stick. Yes we all knew that one. (Laughter)

And why did the chicken cross the merbia strip, to get the other erm, other erm.

The point about a merbia strip, if you've ever done this. Take a long strip of paper, of course if you glue the ends together you'll get a cylinder. But if you give a 180 degree twist before you join it up you get this thing called a one sided surface. It doesn't have two sides anymore, it only has one side. And you might like to try this also. If you draw a pencil mark all the way around the centre you will actually find that you cover both sides, except there aren't two sides.

And another thing you might like to try – and then cut it down the middle. Try to imagine beforehand what happens if you cut it all the way around the middle, what do you get? And then if you're really good at thinking of things like that, try it by cutting it a third of the way across and go all the way around, and try to predict what you get. It's all quite intriguing. If you haven't done that, do try it after the show.

But the point is you're joining these up and you're twisting this around so that the arrows meet. Now the idea of a projective plain is that you do the same thing. You make a merbia strip. You twist these, join them up and then you join this one to this one. But instead of joining them straightaway you give this one a twist. Don't try that at home. It can't be done in three dimensions, so you won't be able to do it in practice, but there's no reason why mathematicians shouldn't look at it.

And it made a nice teaching point in Sylvie and Bruno Concluded.

So Charles Dodgson was interested in mathematics generally and he thought that was a rather nice illustration of an important and interesting mathematical concept.

Here's another thing from the same scene. Mein Herr, say "there's another thing we've learnt from your nation, map making. But we've carried it much further than you. What you consider the largest map that would be really useful? Fly about six inches to the mile. Only six inches. Mein Herr said "We very soon got to six yards to the mile. Then we tried a map with a hundred yards to the mile. And then came the grandest idea of all. We actually made a map of the country on the scale of a mile to the mile. (Laughter)

It has never been spread out yet. The farmers objected they said it would cover the whole country and shut out the sunlight. So we now use the country itself as its own map and I assure you it does nearly as well. (Laughter)

So there are all sorts of quirkiness and whimsiness in the Alice things but there's some interesting sort of mathematical ideas in there as well.

But who was this Lewis Carroll person we are talking about? Who was Charles Dodgson as was his real name. Well he was born in 1832 into a good English Church family in Daresbury in Cheshire. His Father, the Reverend Charles Dodgson was incumbent until 1843 when they all moved to Croft Rectory in Yorkshire.

Now Charles Dodgson senior had been at Christ Church here in Oxford and he had got a double first. In those days everyone – it's often said that it's Oxford for the arts and Cambridge for the sciences, which has really never been true. But the reason that arose is because if you did a Degree in Oxford, everyone had to pass a degree in the Classics, Latin and Greek, before they could go through honours in any of the other subjects. The other subjects being things like Mathematical sciences, the natural sciences and law.

Whereas in Cambridge you could not get a degree until you had done a degree in Mathematics. Everyone had to pass an exam in Mathematics first before they could go on to study the other subjects.

And that lasted for about fifty years and I think it's why it gave rise to that myth. But certainly Charles Dodgson – he took on as he did the four year course at Christchurch he got a first in the Classics and then he got a first in Mathematics. And he stayed on as a student – a student at Christ Church is what everyone else calls a fellow. And he stayed on and he was able to stay on for life as long as he trained for the priesthood and he remained unmarried.

But in fact he decided he wanted to marry and so he did marry and he had eleven children. Which was quite normal in those days.

So most of the children were born in Daresbury in Cheshire. The last one arrived while they were at Croft Rectory. And so the young Charles Dodgson, Lewis Carroll and his seven sisters and three brothers. He was number three out of the eleven and he was the oldest boy. And they had a very happy childhood there. He as the oldest boy sort of took on himself the mantel of entertaining all his younger brothers and sisters. He used to sort of dress up in a cape and do magic tricks for them. And he used to make model railways and sort of thing. Remember railways were just coming in then.

Later on he took up photography and here is a couple of his pictures. Here at Croft Rectory you can see – this is later on when the girls had grown up a bit. So this was a photograph that he took there. And here's one of his – I think this is a wonderful photograph this of his two maternal aunts playing chess.

Anyway he was very very happy at Croft and it was obviously where he developed his love of children, through providing entertainments for his young brothers and sisters. In fact one very snowy winter he created in the garden of Croft Rectory a very complicated maze, more complicated for example than the one at Hampton Court. And then later on for his younger brothers and sisters he compiled this maze here. Which is very interesting historically because, as you can see, there are paths that go over and under other ones. And I'm told by one of my maze expert friends, one of my amazing friends, that this is the earliest example known of a three dimensional maze. So that was another of his innovations.

Because his father, as I say his father got married and so had to leave Christ Church and took over this church in Daresbury, where the young Charles was baptized and grew up. And the father's stipend was very small so they were all – all the children were educated at home, until they moved to Croft, when the money was freeing a lot more and the boys were sent to private school. And the young Charles was sent first of all to Richmond School, that's Richmond in Yorkshire.

Croft incidentally is on the border between Yorkshire and Durham. And it's about ten miles from Richmond. And so the young Charles went there, before going to Rugby.

And he learnt the Classics and Mathematics from his father. The story goes that the young Charles had learnt about logarithms and said to his father "Please explain logarithms to me." And the father said "Oh you're far too young to understand that." And he said "Oh but please explain it." Just to show how interested he was in mathematics, this was one of the earliest, if not the earliest bit of writing of the young Charles.

I think it's remarkable for two things. First of all the handwriting's very good. He was 12 at the time that he wrote this. I don't know how many 12 year olds these days have got handwriting as good as that. And he set himself a problem to trisect a right angle, that is divide it into three equal parts.

Now it's been known since the ancient Greeks, well the ancient Greeks had the problem of trisecting the angle; it was like squaring the circle and doubling the cube. The three classical problems of ancient Greece. You had to do it using just a straight edge and a pair of compasses. And those problems, it took 2,000 years actually to prove that they're impossible.

But for some particular angles like right angles, you can actually construct – you can divide it into three, you can construct 30 degrees. And this is the first of two pages where he actually describes this construction. And again I don't know how many 12 year olds these days would be able to do that.

Anyway he went to Richmond and then he went up to Rugby. Rugby he didn't enjoy. He didn't like all the rough and tumble. He didn't particularly enjoy the sports. In fact I don't think he enjoyed the sports at all. Of course as a young boy going in at 14, the older boys terrorized the younger ones. For example the dormitories in the middle of winter, the older boys came and took away all the blankets and sheets and left the younger boys shivering while they kept themselves warm. And he certainly hated all that.

But he really did enjoy the academic work. He won prizes in lots and lots of different subjects, not just the Classics and Mathematics.

And when I was in New York a couple of years ago, I managed to see the actual Maths book that he studied from. And it was his own copy because it has his plate at the front. And so, here are some of the problems that you will find in the arithmetic's text. The arithmetic text that he used, I think at Richmond and certainly at Rugby, because the copy he's got is marked 1845, when he was 13. So he must have used it at Richmond too.

It was Francis Walkingame's arithmetic text. That had been around for about a century and it had gone into oodles and oodles of editions. And so here are some of the problems that were in this book and as I say he was just 14. I don't know how many 14 year olds these days could work out the cube root of this number here? 673373097125.

Here's another one on arithmetic. London to York is 50 leagues. Do you know what a league is? A league is 3 miles okay. So how many miles, yards, feet, inches and barleycorns? A barleycorn, in case you don't know is a third of an inch. And so the idea is to do all these calculations.

It's quite entertaining looking at this book. Both for the sort of problems that were set to a teenager at that time. And also some were delightfully politically incorrect. Let me show a few of the more entertaining ones.

I don't know how many arithmetic books these days would say "What sum did that gentleman receive in dairy with his wife, whose fortune was her wedding suit. Her petticoat having two rows of furbelows, whatever they are, each furbelow is 86 quills and each quill cost 21 guineas." 3836 quite expensive.

Here's another one you wouldn't see in a modern arithmetic book. A gentleman going to garden meets with some ladies and says to them "Good morning to you ten fair maids." "Sir you mistake us", says one of them "We are not 10 but if we were twice as many more as we are we should be as many above 10 as we are now under." How many were they?

And I'm sure a 14 year old would really want to know that 110 and a quarter per cent, what is the purchase of 2054 pounds 16 shillings itself [[?? 0:21:00]].

But my favourite one, which I challenge you to find in a modern arithmetic book is "The Spectator's Club of Fat People, though it consists of 15 members is said to have weighed no less than 3 tons. How much was that per man?" The answer was 400 weight. So there we are.

Anyway, at Rugby he won all the prizes and he then the natural thing was to go up to Oxford and to his father's college of Christ Church. Here's a picture of Christ Church in 1850, which was the year that he went up for matriculation. And matriculation was exams in theology, in knowledge of the Bible, in Latin and Greek and in Elementary Mathematics, meaning arithmetic and a bit of Euclid and I'll talk more about Euclid later.

So this was Christ Church at the time. Christ Church was a bit full so he wasn't actually able to go up until January 1851. And in fact he had to return home after two days because his mother died unexpectedly at the age of 47. And so it was really a very bad start to his career.

But he had to do three exams. The first was Responsions. Again, papers, this was a sort of hurdle which allowed you then to go on to do Moderations, which is the first major exam, and then finals later on.

And you could either be a sort of pass man or a class man. A pass man was someone that did a three year degree and that was mainly for the hunting, shooting and fishing types that came up to Christ Church. Who were there basically because it's the next step up. They didn't intend to do any work.

And then the Honours was a four year course, which led to where you had to do Classics first and then you went into these other subjects if you wanted, and of course he chose mathematics.

But Responsions he had that. And normally one took that after about seven terms. He took it very very quickly, within six months, because of course he was very very well prepared with all his school work and his work at home.

And in fact he wrote to one of his sisters "Letter written in olde englishe from Christ Church student 1871. My beloved and thrice respected sister. Onee moonee his day nextee we goee in for responsions I'me uppee to my eyes in workee." This is to his sister Louisa, "Thine truly Charles."

And I won't go into what this is all about, you will have to buy the book to find out.

The teaching was done in colleges mainly. They didn't have the intercollegiate lecturers that most people had. That's not quite true. There were a couple of professors. The civilian professor of geometry, which is a professorship founded in 1619 by Savile of Merton. He founded professorships in geometry and astronomy and they still exist today. And the current holder in 1850 was The Reverend Baden Powell. And if that name rings a bell, it was his sixth son who founded the Boy Scout movement. And Baden Powell was more a sort of mathematical physicist. In fact he was really a physicist. And then there was the Sedilian professorship of applied mathematics and I'll tell you about that in a minute.

But anyway these professors, they gave lectures to people studying in the whole university. But most of the teaching was done in college. Here is the Christ Church lecturer, Fawcett his name was. And he got the lectureship in 1845 and held it until 1855, when he went off to the Crimean War and Dodgson took over from him as mathematics lecturer at Christ Church.

What were the exams like? Well some were written exams. Written exams, certainly in mathematics came in the 1820s. And everything got more formalised then. And a new natural science curriculum, the whole science teaching was sorted out around 1850. That's when responsions came in or were revised. But there was also an element of a viva, an oral examination. And I came across this wonderful cartoon or drawing of an Oxford viva examination, which looks absolutely terrifying.

Anyway after he had taken his responsions in the next year 1852, he took his second Oxford examination in Moderations and he got a second in Classics and a first in Mathematics. And he said "Whether I shall add to any honours and collections I can't at present say, but I think it's very unlikely as I have only today to get up works in the acts of the Apostles, two Greek plays and the satires of Horace." That's his revision for one day. "And I feel myself almost unable to read at all. I'm beginning to suffer from the reaction of reading for Moderations."

"I'm getting quite tired of being congratulated on various subjects. There seems to be no end of it. If I had shot the Dean I could have had hardly more said about it." (Laughter)

Anyway he was made a student, as his father, which meant that he was meant to train for the priesthood and remain unmarried. And that was for life. So from that time onwards he was able to live in Christ Church for life. He had to support himself by doing private teaching, but that's later.

Anyway he didn't do so well in his Classics finals, he got a third in that, which can't have pleased his father very much. He was determined to do much better in his mathematics. And so in the summer of 1854 he went on a reading party with a civilian professor, the newly appointed Sedilian professor of natural philosophy. That means applied mathematics, who was Bartholomew Price. Who was across the road at Pembroke college and in fact later became Master of Pembroke College. He was also a very important figure in the Oxford University Press. Probably Chairman of the delegates or something.

He was known as Bat Price, you know an abbreviation of his name. But it's also said that his lectures were way above the audience. So that's another reason for it.

And he is immortalised. How many people know of The Mad Hatter? Okay, you're all wrong. There is no character in Wonderland called 'The Mad Hatter'. There is a hatter and there's a mad tea party but I challenge you to find a Mad Hatter.

Anyway the hatter in the tea party, at one stage there's a skit on twinkle twinkle little star, which went "Twinkle twinkle little bat, how I wonder what you're at. Up above the world you fly, like a tea tray in the sky." And that bat is meant to refer to his mentor, Bat Price.

Anyway finals were twice a year then and in 1854 he took finals. This isn't actually the papers he took. The Bodleian had all the papers up to then and all the ones from then onwards, they didn't have the one that I wanted. But this was a paper actually set in the summer of 1854.

There were ten papers. I'm not sure if he had to do all of them. But they started from Geometry and Algebra and I'm not going to go through all this. And then there's the calculus. And there were sort of various applied math topics, astronomy, optics and various other things of this kind. And I don't know whether he had to do all the papers, whether there was a choice. But anyway there was certainly ten papers in all, and he did very very well, in that he came top of the list.

And in fact here is the class list of 1854. You can't see it very well but basically this is the mathematics bit and there were five of them who got firsts. Four got seconds, no one got thirds. Four got fourths. And then 35 got fifths.

Now basically they're the pass degree people and because they were all wealthy and had wealthy parents and were going to give money to the university, they didn't want to upset them, so they actually gave them a class on the list of fifth.

Anyway, Dodgson came top of the list. He was the top of his five and he said "I must also add," As he wrote to his sister. "I ought to get the senior scholarship next term" Which he didn't. "And one thing more I will add, I find I am the next first class maths student to Fawcett in that I stand next to the lectureship." And in fact, so Fawcett went off to the Crimean War and Dodgson himself was indeed appointed.

So we're now in 1855 and the start of his career. This is Christ Church and here's the famous hall, made famous of course through Harry Potter. But Dodgson, ten years before he died he wrote

to one of his young child friends, and said "I've actually dined here 8,000 times." And so this is obviously a hall that was very dear to him. In fact I gave a version of this lecture in Christ Church Hall earlier this Summer, having the portrait of Dodgson looking straight at me while I was doing it.

There was a new Dean appointed in 1855, the old Dean Gainsford died and the new Dean came in. His name was Henry Liddle. And Henry Liddle, well he was known as a Greek Scholar. In fact, anyone here studying Classics? Liddle and Scott. Yes, well Liddle and Scott was the famous Greek dictionary which is still used by under-graduates today, even 150 years on. And a very very famous and important dictionary.

Liddle had come from being a headmaster at Westminster School. He came to be Dean of Christ Church. And one of the first things that he had to do was appointed the Mathematics lecturer and that was Dodgson. Now Dodgson of course all this time was supporting himself by private teaching. But getting the lectureship was what he really wanted.

And he started that officially at the beginning of 1856. Two other things happened in 1856. One was that he was writing comic verse and entertaining little bits of writing for various magazines and so on. There's one called 'The Train' a first class journal. And he started writing all of these things. And he decided for his non mathematical writings he would choose a pseudonym. He thought of Dares to start with, DARES, short for Daresbury. And there were various other ones. But eventually they came up with Lewis Carroll. And Lewis Carroll, of the course the Carroll comes from Carolus, which is the Latin for Charles and the Lewis is a corruption of Lutwidge, which was his middle name and his mother's maiden name. So that's where the Lewis Carroll comes from. And so from then on he used that whenever he was writing for children or whenever he was writing more popular things.

The other thing that he took up was photography. And in fact he was one of the most important photographers of Victorian times. He was certainly the most important photographer of children. And there are about 3,000 photographs that have survived. Now this is my favourite. There was an undergraduate at the same time. He got the photography bug.

Photography had come in 20 years earlier but it really hit the big time in the 1850s. Lots of amateur photographers. And it was very complicated. They used the old Collodion process where you had to go into a dark room, mix your chemicals, take your plate, put the chemicals over this plate. And then put them in the camera and then if I were photographing you you would have to stay still for quite a long time, while I photographed. And then I would have to sort of pull out the plate and then develop it and so on. It was a really complicated procedure and failures were frequent. But we have 3,000. There are about 3,000 that have survived, of which 1,500 are of children.

But it's very important his photography because he photographed a lot of the Oxford figures of his day. We wouldn't know what they looked like if it hadn't been for Dodgson taking it. And also important people of the day. When the British Association met in Oxford he had a photograph of Faraday. And the photograph of Bat Price I showed you was his. He also photographed many artists. Holman Hunt, Millay and the whole Rossetti family. And he used photography as a way of getting to meet the great and the good.

It's often said that he was very shy and didn't like meeting people. That's obviously not the case. He enjoyed, he wrote to Tennyson in the Isle of Wight and said "Would you like me to come and photograph your family?" And so he used to go down and photograph the whole family and the children in particular. And a lot of these children's photographs are really wonderful works of art. Because he was probably the first person, or certainly one of the first people to regard photography as an art.

Instead of just taking a mug shot he actually, he used to pose his subjects and also sometimes dress them up and have props. And here you can see this undergraduate Reginald Southey, he's the one

of the left, and he was also very keen on photography. They used to go on photography expeditions together and this was three years before Darwin. And this is quite a remarkable picture I think. The way it's posed, it's a very interesting one.

Of course the new Dean had four children, three daughters Edith, Lorina, and Alice. And here they are. We always think of Alice don't we as a sort of fair haired girl in a blue dress. But in fact Alice had short dark hair and not as Tenniel had portrayed here. And so there were several pictures of the Liddle children.

He also took lots of photographs of boys as well as girls. Now here's one of them playing around with some cherries. And his most famous photograph is Alice dressed as a beggar girl, which Tennyson described as the most beautiful photograph he'd ever seen.

So there are lots and lots of interesting photographs. There are books of his photographs well worth looking at. And in fact in 1859 I think it was – or was it 7. In 1857 he wrote a comic poem called 'Hiawatha's Photographing'.

The famous Longfellow poem of Hiawatha had come out in 1855 with its rhythm dada dada dada dada, dada dada dada dada dada. And so as a skit on Hiawatha, Lewis Carroll wrote a whole poem about how Hiawatha with his camera was trying to photograph a rather dysfunctional family. And every photograph went wrong for a different reason. It's quite an entertaining poem. It's starts off.

"From his shoulder Hiawatha took the camera of rosewood. Made of sliding, folding rosewood, neatly put it altogether in it's case it lay compactly. Folded into nearly nothing but he opened out the hinges, pushed and pulled the joints and hinges, til it looked all squares and oblongs, like a complicated figure in the second book of Euclid."

Right, so now we've got to Euclid that brings us on to his mathematics. But don't worry.

Most of his early writings on mathematics were for undergraduates. And in particular in geometry he was fascinated by traditional Euclidian geometry. But before I talk about Euclid, here's something he wrote about Pythagoras's theorem. And you're all familiar with Pythagoras's theorem I hope. It's about right angled triangles. And we normally think of it as an algebraic thing. If you've got a right angled triangle then a squared plus b squared equals c squared. So in the three, four, five, you've got three squared plus four squared equals five squared. In its original Greek version they didn't have algebraic formulae then, it was about the area, if you have a square on here, and a square on here, and a square on the hypotenuse, the area of the square on the hypotenuse is equal to the sum of the areas on the other two sides. And that's how it was originally. It's geometrical result it's not an algebraic one.

But Dodgson loved Pythagoras's theorem. And he later wrote "It's as dazzlingly beautiful now as it was in the day when Pythagoras firstly discovered it. And celebrated the event, it is said, by sacrificing a hecatave of oxen. That's a whole oxen. I've read different things. Some people say its 100 Oxen and some people say it's a whole oxen.

Anyway a method of doing `[[olative 0:39:42]]` science has always seemed to me slightly exaggerated and uncalled for. (Laughter)

Well imagine oneself, even in these degerate days, making the epoch of some scientific discovery by having a convivial friend or two to join you in a beefsteak and a bottle of wine. But a hecatave of oxen it would produce quite an inconvenient supply of beef.

So even when he was writing about serious geometry he could be quite whimsical.

But he wrote a lot about the elements. Euclid's elements. Now Euclid's elements were written about 300BC or possibly later. It's the most printed book after the Bible. It was used for teaching in universities and elsewhere for 2,000 years. It consists of 13 books. Some are on geometry, others are on arithmetic. Some of you will know that Euclid proved they're infinitely many primes. And that's in book nine. And there are various other things to do with prime numbers and so on.

The point is it's axiomatical and hierarchical. What that means is it starts off with a few basic axioms and then from them proves some simple results. And then some more complicated results. And then more and more complicated ones. A huge hierarchy or results with everything depending on what was done before in a completely rigorous and logical way. That was the way. And here for example is book one, which starts off with some axioms and some simple results and ends up with 47 and 48. Book one proposition 47 is Pythagoras's theorem. And you can see how it depends on everything beforehand.

Now because it encouraged logical thinking it was wonderful training the mind. And so it was widely used in Victorian times. Everyone had to do some Euclid. You needed Euclid for the Civil Service. You needed it for the army. The best training for the mind was Latin and Greek which of course everyone had to do at university. And then the next thing, if you did any science at all. It was Euclid's elements. So it was very widely used.

There were dozens of Euclid texts produced in Victorian times. One by a guy called Isaac Todhunter sold half a million copies. You know it was really huge sales. And Dodgson being very conservative and old fashioned strongly supported Dodgson. But not everybody did. Everybody said "Well why should geometry be restricted to five axioms? Why shouldn't you be allowed to measure things?" And there's a big reaction in the 1860s and 70s those people wanted more practical geometry. The geometry of surveying for example. The geometry of, as I say, real practical work rather than having to think things logically from just a few axioms.

And if you're interested in Cambridge on Thursday afternoon I'm giving a talk about what happened in the 1860s and 70s with the rivalry between Euclid and his modern rivals. Following Casablanca I thought of calling my talk 'Here's looking at Euclid'. (Laughter)

Anyway he did a lot of writing for undergraduates. He did a syllabus of plain algebraic geometry as he called it, by Charles Dodgson. So this was to help students learn Euclid. And to present it more easily for them.

And he wrote guides for students on trigonometry and algebra as well. But Whimsy was certainly around still. He wrote in 1865 'A Dynamics of a particle' and this is deliberate. Because this was actually not a geometry text or a mechanics text, it was a skit on – it was an entertaining pamphlet.

He wrote 250 pamphlets on various things. This was a pamphlet about the party elections. The parliamentary elections that were taking place in 1865 in Oxford. Because in those days you had multi MP constituencies. Multi member constituencies. Oxford had two MP's at the time. Some had one, as we do now, some had as many as five. And Dodgson was very much in favour of proportional representation and of multi member constituencies.

But he wasn't in favour of the current emcumbrant, who was Gladstone, who was very conservative and in fact when I gave this lecture in Christ Church Hall and I was saying all these anti Gladstone things, there was a picture of Gladstone looking right down on me. Looking very disapproving.

No Gladstone was far too liberal for him and he wanted Gathorne Hardy who was much more conservative. Anyway in this he starts off with various so called definitions. I will just show you some of these. Euclid's element starts off "Let it be granted that a line may be drawn from any point to another point." One of his axioms, one of his postulants was if you've got two points you can join them by a line.

So Dodgson's version was "Let it be granted a speaker may digress from any one point to any other point." A finite line may be produced to an extent. If you've got a line you can extend it as far as you like in the same direction. That's what Euclid says. "Any finite argument, that's one finished and disposed of, may be produced to any extent in subsequent debates."

"A circle may be drawn about any point and any distance from that point. A controversy may be raised about any questions at any distance from that question." (Laughter)

And then he gets on with his definitions. Here's Euclid. He defines an angle, an inclination of two straight lines to one another which meet but not in the same direction.

Dodgson plain anger is the inclination of two votes to one another who meet together but whose views are not in the same direction.

So he's got all these skits.

Here's Euclid. "When a proctor meeting another proctor makes the votes on one side equal to those on the other. The feeling entertained by each side is called right anger." (Laughter)

"Obtuse anger is that which is greater than right anger." And so on. And that goes on in quite a jolly way.

And then it ends up with what looks like a geometrical result. A geometrical theorem. Well it's a construction. "To remove a given tangent from a given circle to bring another given item to contact with it." So you've got this circle meeting these two lines of a triangle and you want to make it so this actually meets this one but not that one any longer. Well that doesn't look very exciting. Until you actually realise what's going on. Because lets look at the circle. You've got UNIV be a large circle, okay. Whose centre is OV of course being the very place at the top. V of course is the Vice Chancellor.

And then the three sides are WEG, WH and GH and these are the three candidates. Gladstone, Heathcot and Gathorne Hardy. Gathorne Hardy was the conservative one that – and the idea was that he should become a member of Parliament and should unseat Gladstone. So you want to withdraw this contact and create it here. And at one stage it said it would be fine and convenient to project WEG to infinity. (Laughter)

Anyway there was all these other geometry books that were being produced and his most well known writing was 'Euclid and His Modern Rivals', which is where he took each of the – he took 13 geometry books and analysed each of them in a really detailed way, showing that each was inferior to Euclid.

To make it more interesting and more for the general public he set it as a drama in four acts. There are four performers, well four characters, Minos and Rhadamanthus, these are two of the gatekeepers to Hades, who appeared here as Oxford examiners, having to mark a whole lot of geometry scripts. Then Minos in the middle of the night he gets so tired he falls asleep and has a dream. And who should come to life in his dream but Euclid. So now he's come back to life. And there's also a Germany professor called Herr Kneemunt. Who presents each of the rival books in turn and then Minos basically demolishes each of them.

And a lot of it is very very entertaining. But there's a lot of hard geometry in there actually and he argues his case well. I mean Dodgson really did know his Euclid in geometry very very well and he was a great supporter of Euclid, against all these modern rivals and he really explained why.

Around this time he was writing lots of letters. He used to write to adults. He used to write to his child friends. He's a puzzle letter. "My dear Ena, though I don't give birthday presents til I may write a birthday card etc. etc."

So he used to write these things and in fact occasionally you had mathematical things in here.

Here was a letter that he wrote to a young boy of 14, called Wilson Rix. And if I can find it – oh I should say that in the last 35 years of his life he sent and received over 90,000 letters. He used to spend hours every day writing letters and receiving them. He catalogued them all. He actually had a list and kept copies of the ones he sent and there's a list of all the things he sent and received. So he sent and received certainly tens of thousands of letters in the last 35 years of his life. Some were to his brothers or sisters or distinguished figures of the time. Many were to child friends.

Here's one that he wrote on algebra to young Wilson Rix.

"Honoured Sir, Understanding you to be a distinguished algebraist. That is distinguished from other Algebraists by different face, different height etc. (Laughter) I beg to submit to you a difficulty which distresses me much. If x and y are each equal to one, it is plain that 2 times x squared, minus y squared equals zero. And also that 5 times x minus one is equal to zero. Hence 2 times x squared minus y squared is 5 times x minus y. Now divide each side of this equation by x minus y Remembering of course that x squared minus y squared is x minus y times x plus y. That cancels, gives you 2 times x plus y is equal to 5. But x and y are equal to 1, so x plus y is 2, so you have that 2 times 2 is equal to 5. (Laughter)

He carries on. "Ever since this painful fact has been forced upon me I have not slept more than eight hours a night and have not been able to eat more than three meals of day. I trust you will pity me and will kindly explain the difficulty to your obliged. Lewis Carroll."

While he was also doing other writing and of course on July 4th 1862 it was the famous excursion up to Godstow, the rowing trip with the three little girls. And he always used to tell them stories. He used to take them around Oxford. He used to take them to the New University Museum, that's where they saw the Dodo. And all the Dinosaurs. And he took them later to Keeble Chapel, because that was a new college then.

And after this trip where he told the Alice story. Alice said "Oh do write it up, you know it's a wonderful story." And so he spent the next two years writing it up and this is Alice's Adventures Underground, which he presented to Alice in 1864. And it's full of allusions. I mean the hatter actually did refer to a particular hatter in High Street. And here you can see Dodgson, the three girls and the Reverend Robinson Duckworth a fellow of Trinity College. They were the ones that went on the trip. So the Duckworth came out to be the duck. Lorina her sister became the Lory, which is a sort of parrot. Edith became the Eagle and Dodgson himself became Dodo Dodgson. That was the Dodo. And so there were lots of allusions.

And the book was eventually published but not with Dodgson's own drawings but with Tenniel's in 1865. Actually it was badly printed so it had to be withdrawn and came out again in 1866.

Anyway I'm sure you all know the well known story. We don't know whether it's true or not. That Queen Victoria was so charmed by the book that she said "Send me the next book that Mr Carroll produces." And was a bit surprised to get 'Elementary treatise of Determinants'. (Laughter) With her application to simultaneously linear equations and algebraic geometry. (Laughter) She was not amused.

And so this really is his only work on Algebra. And I won't go into what determinants are but basically he was concerned with solving simultaneous equations and they're a sort of mathematical device used to help with that. And the book did not sell very well because he actually made up his own notation and everything. It had a lot of interesting stuff in it and in fact there's a certain well known result, well known to mathematics students. They meet it in their first year, about when you can solve systems of equations. Which is sometimes credited to other people but the first time it appeared in print was in Dodgson's book. It was discovered independently by several people, including himself, but the first time it appeared in print was here.

So I think it was quite an important book but it didn't have much influence.

So that takes us to 1867. How am I doing for time? Right. I've got another quarter of an hour. I've got some more things to say or there's time for questions. Perhaps I can say a bit more and then, since I'm doing a book signing, you know if you've got questions come up afterwards.

Can I go on for a few more minutes and then if you've got questions, as I say, come and ask me privately afterwards. I know I'm breaking all the rules but is that allowed?

Well it's so fascinating all I'm saying. (Laughter) I'm fascinated I don't care about you lot. (Laughter)

Two things happened in 1867 and 1868. One is that Christ Church, instead of being run by the Canons, actually initiated a governing body. And so Dodgson of course, being well established there, was part of the governing body and was involved with things like voting for lecturers and being involved with choosing architects for buildings and so on.

It was also in the following year that his father died and of course there's this entire family that he felt responsible for. And eventually they bought this house, The Chestnuts in Guildford, which is where he used to go and spend Christmas and it is in fact where he eventually died. He used to have his summer holidays in Eastbourne but Guildford was the family home, from then on.

And here was this room. His room at Christ Church. I said a room, he had a suite of ten rooms, can you imagine having ten rooms. It included a dark room for his photography and everything. This is now the middle Common Room at Christ Church.

But it was while deciding on which architects to have for building and who to appoint for lectureships that he got involved with methods of voting. And possibly some of his most important writings are on the theory of voting. Because he felt very strongly that all the ways that we use for voting are flawed. The first past the post is a very flawed system. The single transferable vote is very flawed. And he looked at each of these in turn and actually came up with examples for why they are unsatisfactory. I'll just show you the one for a simple majority.

The idea is that supposing you had four candidates, A, B, C, D. And you had 11 voters. So the first one ranks the candidates A, C, D, B. And so does the second and the third. The fourth one ranks them B, A, C, D. Which candidate is the best? So that's what one has to decide.

Well with the first past the post system who wins? B wins. Okay because B has four votes and A only has three. But A is clearly the best candidate because A is chosen first by three of them and second by all the rest. And yet B wins even though more than half of the voters had put them bottom.

So you know that shows that the whole study of voting was quite complicated. It was studied by Condorcet in France in the late 18th century. But Dodgson did some really interesting work on this.

Sadly he never wrote a book on it. He had planned to. And some of you know the philosopher Sir Michael Dummett, the expert on Frager. And he later remarked "It is a matter for the deepest regret that Dodgson never completed the book he planned to write on the subject. Such was the lucidity of his exposition and mastery of this topic, it seems possible that had he published it the political history of Britain would have been significantly different."

Of course he knew people in high places because you know most politicians at the time had been to Christ Church and he'd known them as students and so on. And Dodgson was the one that really pushed the idea that no vote should be counted until all the polls are closed. That wasn't the case before then and of course it's not the case in America for geographical reasons. But Dodgson pushed that and eventually that came into this country.

And he was also a strong proponent of proportional representation as I said earlier.

Another thing he looked at was tennis tournaments. He was somewhat dismayed, that's Wimbledon of the day. He was somewhat dismayed that a friend of his had been in a tennis tournament and saw people a lot worse than him getting the second and third prize. And because there was no seeding in those days. So what Dodgson did, he came up with this example. He said "Well supposing you've got 16 players, the best is one, the next is two and so on. And in the first round one will beat two, three will beat four, five will beat six and so on. So the odd numbers survive the first round. After the second round you've got one, five nine and thirteen, Third round one and nine. One of course wins, the right person wins. But the person that wins the second prize actually was in the lower half of the ranking.

And so he worked out a sort of combinatorial way of actually sorting out the matches so that the best three candidates would win first, second and third prizes. And I think the idea of seeding probably came from there.

There are just a couple of more things I want to do. One is his mathematical puzzles. It's all been far too serious up to now. And I will just show you one of these, which he may not have invented but he certainly invented a version of it. And he did some teaching at a school just opposite Christ Church and he used recreational puzzles to teach mathematical ideas. He was one of the first people to do this in fact.

Here's one that many of you will know. Can you hold on to this. Yes, but don't look inside it yet.

So I'd like someone to give me a three digit number and the first and last digits must differ by two or more, So someone give me a number.

Male One four seven.

Contributor One four seven is a brilliant choice. We haven't met before have we?

We're going to reverse it. That gives you seven four one, okay. And I did it this way around because I'm going to subtract the smaller one from the larger one. Okay, so said Dodgson, this is the difficult bit okay.

Is that right. Now you reverse that. Okay, now we add. Carry one. So we get 1089. Would you like to open the envelope please. And you can see it says 1089. Okay. (Clapping)

You don't have to applaud me. I'm not going to do it again. Because you always get 1089. In fact when I was 11 I came across the puzzle and tried to prove why you always get 1089 and I failed. But I tried again two years later and I succeeded. I got that sort of real Eureka or Ha-ha thing for solving a mathematical puzzle. So I did actually manage to explain why it works. And it's explained in the book.

Dodgson certainly knew this but whether he invented it or not I don't know. But he certainly invented the pound, shillings and pence version. So for those of you who remember pounds, shillings and pence, where there were 12 pence in a shilling and 20 shillings in a pound. It seems jolly complicated now doesn't it?

You start with any sum of money, reverse it, subtract, reverse and add. You also get 12 pounds, 18 shillings and 11. And so...

Male Do the initial pounds and pence have to differ by more than two?

Contributor Yes, yes they do. Yes to make it work, by two or more. Yes, more than one.

Here's this monkey puzzle thing which is quite famous. You've got a pulley, you've got a rope over it, you've got a weight and you've got a monkey. They balance each other exactly, okay. The monkey starts to climb the rope, what happens to the weight? Does it go up or down? Does it go up or down with uniform velocity or does it accelerate? And all the senior common rooms in Oxford were really arguing like mad about this. They all came up with different answers. I'll leave it for an exercise for the reader. (Laughter).

And here's a poem which may have been by him. It's certainly been attributed to him. It's a symmetric poem in that you can read it either horizontally or vertically. It's certainly hard to construct these things. So-

"I often wondered when I cursed, often feared where I would be.

Wondered where she'd yield her love, when I yield so will she.

I would I will be pitied, cursed be love she pitied me.

So you can go forwards or downwards and it's not great poetry but there we are.

He also wrote a book of stories which had mathematical puzzles hidden in them, called 'The Tangled Tale'. And again they're very entertaining. I won't go into it now but I'll just read you the preface.

"To my pupil" And you can try to work out who his pupil was.

"Beloved pupil tamed by thee, addish subtracts multiplication." Great poetry this.

"Division, fraction, rule of three, a test I deft manipulation.

Then onwards let the voice of fame from age to age repeat thy story til thou has won thyself a name, exceeding even Euclid's glory."

So who was the pupil that he wrote this to?

If you take the second letter of each line, you get Edith Rix. And she was the sister of Wilson Rix to whom he'd written that Algebra letter. And in fact, he was trying to persuade her to study Maths in Oxford when in fact she went to a modern university in the Fens instead. (Laughter)

I'd like to conclude by talking about what he did in the last few years, and this is his work on logic. Because he was fascinated by logic. Having thrown my notes on the floor, I'm going to have to make this up as I go along, but there we are. Oh here we are.

You may remember the scene with Tweedle dum and Tweedle dee. Alice comes across them and they're bickering as always. And Tweedle dum says "I know what you're thinking about, but it isn't so, no how." Tweedle Dee "Contrary wise if it was so it might be and if it were so it would be. But as it isn't it ain't that's logic."

Well he'd been interested in logic ever since he had to do it for his Classics finals and he got involved with symbolic logic. Now symbolic logic goes back to Aristotle. And you get premises like "All men are mortal Socrates is a man" and from then you eliminate the common term and you get therefore Socrates is mortal. And Dodgson thought these syllogisms were an ideal way of training the mind of adults and also of young children as well.

And so he wrote the game of Logic. And he actually found a way of solving these things, which I won't go into detail now. But it was involved with red counters and grey counters and you put them on a board to represent the various premises and then by moving them around in a certain way you could actually work out the conclusion. And he used this quite effectively.

He then wrote it up as a more serious book for adults called 'Symbolic Logic' and here, this is the frontice piece. A syllogism worked out. So supposing your first premise is, and they're always entertaining Dodgson's ones. That story of yours about you once beating a Sea Serpent always sets me off yawning. Also you know that I never yawn unless when I'm listening to something totally devoid of interest. And you can represent these with the various circles. The book will show you how to do it if you want to know. And then at the end you deduce from these that that story of yours about you once beating a serpent is totally devoid of interest.

And he showed, using his counters, how to do these. And in fact he then went to more terms, here's a straightforward one with three premises. Getting quite entertaining.

"Babies are illogical. Nobody is despised who can manage a crocodile. Illogical persons are despised."

Well this one you can work out in your head because if babies are illogical and illogical persons are despised then it means that babies are despised. But if nobody is despised who can manage a crocodile, you deduce that babies cannot manage crocodiles. (Laughter)

And the first 60 of these he produced went up to ten premises. Here's one with five.

"No kitten that loves fish is unteachable. No kitten without a tail that will play with a gorilla. Kittens with whiskers always love fish. No teachable kitten has green eyes. No kittens have tails unless they have whiskers."

And then using his counters and working through all this you can actually deduce the conclusion from this is that no kittens with green eyes will play with a gorilla. (Laughter)

And these are all published. He used to go into the Oxford High School. He used to go into LMH to see students and he used to get them working on all these things with the counters and everything and sorting out these syllogisms. Excellent training for the mind for both children and adults.

And he started working on the second book and in the second book, which didn't get published because he died before it came out. But the second book, extracts have survived. And he had examples with ten premises, with 40 premises. His longest had 50 premises. And 50 different sentences and you had to work them all out and come up with a conclusion. Quite remarkable and of course they are very entertaining the way he writes them. But there's some good mathematical logic underneath it.

He also came up with a couple of paradoxes. And I mean if his second book had come out he might have been regarded as one of the best British mathematical logicians between the time of George Boole and Bertrand Russell. But Bertrand Russell in particular said that two of his paradoxes, which are really quite ingenious, were really quite interesting and important.

But sadly he died and all the stuff he wrote about logic disappeared and didn't surface again until the 1970s. And by which time of course it had no influence.

Anyway he died. Here's his posthumous portrait in Christ Church. Here's the stained glass window at Daresbury. A whole lot of stained glass windows showing him. And so that's the end of the story.

He went for Christmas with the family in Guildford and he caught pneumonia and died at the age of 66.

I'd just like to end up though appropriately with his self portrait. In the 1860s or 70s there was a college ball going on. Very noisy and he didn't really want to get involved with that. So he hid himself away and he wrote a double acrostic, you know one of these puzzles where you solve it and the first letters give you one word and the last letters give you another. Here is one of the verses, which has been described as his own self portrait.

"Yet what are all such gaieties to me whose thoughts are full of indices and surds.

X squared plus 7x plus 53 equals 11 thirds."

What more can you say, thank you very much.
