Wild Extravagant Theories:
The Science of The Time Machine

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by Stephen Baxter

> *"Long ago I had a vague inkling of a machine... that shall travel indifferently in any direction of Space and Time, as the driver determines."*
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> *Filby contented himself with laughter. "But I have experimental verification," said the Time Traveller.*
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> *The Time Machine* by HG Wells, p6. [1]

Here I am with the double handicap of the graveyard slot (straight after lunch) and opposite an *X-Files* video. But what I have to talk about is something of an *X-File*: the strange case of HG Wells, Albert Einstein and Physical Optics.

Perhaps the most common question you're asked as an sf author is: "Where do you get your ideas from?" And that question has never had more point than when asked of HG Wells, about his first novel *The Time Machine* . And once I was invited to come and talk here - at Imperial College, where Wells began work on *The Time Machine* - I knew I had a topic I had to dig into.

Now, *The Time Machine* was 100 years old in 1995, and it remains a wholly remarkable book. With its novel premise of time travel as a matter of engineering, and its 'desolating myth' of man's decline in the far future, it was hailed as a work of genius on its first publication, and it caused an explosion of interest in the possibilities of time travel and the fate of humanity on the far future.

And one of the most remarkable aspects of Wells's book is its scientific vision. The language Wells uses of a four- dimensional spacetime - of time as a 'direction' - is familiar to us now; it's the language of Einstein's Relativity: or rather, Minkowski's geometric formulation of the theory of Special Relativity, with time presented as a fourth dimension, in addition to the three of space.

Now, in 1886 or 1887 - when Wells started to work on the tale that would become *The Time Machine* - there was much speculation about the existence of a fourth dimension. And many of the elements of Special Relativity were in the air. In particular, in 1887 was published the

result of the celebrated Michelson-Morley experiment on the anomalous behaviour of light. And Einstein would eventually come up with his theory by pondering the peculiar properties of light.

But, remarkably, *The Time Machine* - with all its relativistic language - was published, in 1895, a decade before the publication of Einstein's first Relativity papers. And Minkowski's geometric formulation was not presented until even later: 1908, in a talk in Cologne called "Space and Time".

It's true that in 1895, Albert Einstein was already speculating on the relativistic consequences of Lord Maxwell's formulation of the laws of light and electromagnetism. What would happen if you could travel with a beam of light through space?... [2].

But in 1895 Einstein was only sixteen years old. So where did HG Wells get his idea from? How did he come up with what we would recognise as a relativistic explanation of time travel, so many years before Einstein? Did he know about four-dimensional geometry, and Michelson-Morley?

And what has Imperial College got to do with it?

Now, I have to tell you that what follows is my own answer to these questions, based on my own research, sometimes going back to the source documents. The fact is the various biographers and literary analysts of Wells have tended to avoid digging too deeply into the scientific origins of books like *The Time Machine*, perhaps because they tend in general to hail from the Eng-lit side of the arts-sciences divide. To such scholars, General Relativity perhaps is an alien a topic as post-modernism is to, well, me.

I'll start with a brief summary of the plot of *The Time Machine*. Then I'll talk about how Wells wrote the book; what I want to demonstrate is that Wells's ideas on time travel were pretty much fixed by 1887 or 1888, here at Imperial, so wherever he got his pre-Relativity ideas from, that was when he got them. Then I'll try to reconstruct what Wells must have been reading and hearing when the ideas started to form.

The plot:

The Time Machine is the story of a late-Victorian scientist - who we know only as The Time Traveller. Actually, the Traveller is more of an inventor, or engineer, than a scientist. He puts together a bicycle-like Time Machine, in a boarded-up conservatory on the back of his house in Richmond. The introduction of the book depicts a dinner party one Thursday evening in which the Traveller discusses the principles of time travel - and we'll talk more about that later. Then, the next morning, the Traveller boards his Machine for his first journey into time.

After his journey through time the Traveller finds himself on a lawn with rhododendron bushes, in the shadow of a huge White Sphinx, in the year 802,701 AD. At first the world seems idyllic: the climate is lush and sunny, and England has become a huge, somewhat dilapidated garden.

The Traveller meets gentle, rather childlike people called the Eloi. He befriends one, a female, called Weena. It seems to the Traveller that humanity has advanced to an extraordinary degree, to the point where nature has been conquered, and humanity has become decadent.

But eventually he begins to uncover a darker side of the idyll. The Eloi's physical needs are met by an altogether more unpleasant race called the Morlocks, who live beneath the earth in huge caverns filled with machinery. (The way Wells reveals the existence of the Morlocks, hint by dark hint, is reminiscent of the techniques of a modern horror novel - and, incidentally, that's another aspect of the book which has largely been left unexplored, as far as I know.)

Anyway, the dark secret of the future world is that in return for sustaining the Eloi, the Morlocks are using their cousins as cattle: at the dark of each moon Eloi are culled and butchered. The Traveller realises that far from being advanced, both Eloi and Morlock are actually *degraded* forms of humanity. They have evidently devolved from a split of mankind into an upper and lower caste; and the lower caste had been thrust into underground servitude. The Traveller observes:

"But, clearly, the old order was already in part reversed. The nemesis of the delicate ones was creeping on apace. Ages ago, thousands of generations ago, man had thrust his brother man out of the ease and the sunshine. And now that brother was coming back - changed!" (*The Time Machine* , p52.)

The Morlocks steal the Traveller's Time Machine. In the second half of the book, we follow his efforts to get the Machine back. He eventually succeeds, and escapes back to his present - although he loses Weena to the Morlocks.

Back in the 1890s he updates his dinner companions with an account of his adventures - which is supposedly the account we read in the book - and then sets off into time again, to bring back proof. But he never returns ... at least not until 1995. [3]

Now let's look at how Wells came to write the novel.

H.G. Wells started work on *The Time Machine* in the mid 1880s. In 1884 at the age of eighteen he'd come to the Normal School of Science (later the Royal College of Science, eventually later merged into Imperial). And the education Wells received here was crucial in shaping the ideas that led to *The Time Machine*.

The courses he took here were enlightened, geared at producing teachers of science. Wells did fairly well. He took biology, maths, physics, geology, geometrical drawing, and astrophysics. He got a first or second in every course he took except astronomical physics, which he failed in 1886, but repeated and passed in 1887. He did well in zoology, taught by TH Huxley.

He left the school to take up teaching, fell ill and returned to London after a football accident (which is another story ... watch this space), and returned to London to finish his degree. He went on to graduate in 1890 with first-class honours in zoology and second-class in geology.

In the middle of all this, Wells began to conceive the ideas that would lead to *The Time Machine* . He would produce his first time travel story in 1888, and would keep redrafting it until its final publication as a book in 1895.

Wells's first publication of a time travel story was called *The Chronic Argonauts*. It was published in 1888, in three parts, in the *Science Schools Journal*, a magazine Wells helped to found here at the Royal College. Wells was just twenty-two at the time. *Argonauts* doesn't bear much relation to *The Time Machine*. It features a mad inventor called Moses Nebogipfel, who is working on a time machine in a ruined manse in Wales. We don't see any actual time travelling, but we do hear that Nebogipfel kills a man in the past, and the climax of the story is the local villagers storming the house, accusing Nebogipfel of witchcraft. So this was a bizarre mad-scientist epic more reminiscent of Mary Shelley's *Frankenstein* than anything by the mature Wells. Wells was later embarrassed by this "imitative puerile stuff" (his words), and would destroy every copy he found.

Over the next three years, Wells produced two more versions of his story, which are now lost. But the first of these introduced the idea of the upper and lower worlds in the future, although mankind hasn't yet evolved into separate species. (This story seems reminiscent of Wells's "A Story of the Days to Come" (1897), and of his novel *When the Sleeper Wakes* (1899), which feature dystopian arcologies. So we can speculate that, given the common source of these works, Wells was developing, if implicitly, a kind of 'future history' - a portrait of a consistent future, with the upper-lower arcologies of "Days to Come" prefiguring the evolution of the Morlock-Eloi duality.)

The second of these lost drafts got rid of Nebogipfel, and showed a future world ruled by an elite who use mass hypnosis to control their fellow humans.

In 1894 - by which time Wells had left the College - the next draft was published in the *National Observer* magazine, as three linked stories under the title of *The Time Machine* . The date is 12,203 AD, and we now have the Victorian gentleman- traveller of the final novel. The future is shown much as in the final version, with the Morlocks named (but not the Eloi), and the structure of the story is very similar, with the time travel justification by spacetime dimensions as in the final novel. But there is no Weena, and Wells shows the Morlocks rather plainly, rather than revealing their existence horror-novel style through the plot, and there is no voyage into the further future.

The editor of the *National Observer*, WE Henley, left the magazine before the publication of Wells was finished. Henley moved to another magazine called The New Review in December 1894 and commissioned Wells again, and the book was serialised again, under the title *The Time Machine* .

Wells lengthened his text and tried out a lot of new material, much of which was never printed. Wells's manuscripts included versions in which the Time Traveller journeys *into the*

past. He encounters a prehistoric hippopotamus, and travels to 1645 to meet Puritans. In one version, time travel kills him.

The version of the story eventually published in the *New Review* was substantially the one that finally appeared, in May 1895, in book form. For the book, Wells did rewrite the introduction, in which the Time Traveller justifies his Machine, and he cut some sections of the final chapters in which the Traveller journeys to the end of time. In the cut sections the Traveller makes more stops, where we see more of the degradation of life on Earth, and Wells drops broad hints that the sad creatures we encounter are human descendants, further devolved from Eloi and Morlock. But he cut all this, leaving the final vision much more stark, but richly ambiguous. (Wells would later do some tinkering with later editions, but that's beyond our scope here.)

Now, the point of my relating that long and complex saga is to show that the changes Wells was making, between 1888 and 1895, were to do with the heart of the novel - the vision of evolution in futurity - rather than the justification for time travel itself. He wasn't really interested in the 'mechanics' of time travel, except as a device - and as the spark that launched him on the story in the first place - and he certainly wasn't interested in following up some of the aspects of time travel which would intrigue later generations of sf authors. It seems clear that he thought this would detract from the main story he had to tell.

So from his drafts, Wells cut ruthlessly any of the *history-changing* possibilities of time travel - of modifying the future, of perhaps averting the Morlock-Eloi catastrophe (in my sequel I confront the Time Traveller with the history-changing consequences of his first return to the 1890s). One of the best and most famous examples of history-changing in later science fiction is "A Sound of Thunder" by Ray Bradbury (1952), a poignant tale in which the time-travelling protagonist, despite elaborate precautions, accidentally steps on a golden butterfly in the deep past. When he returns to his present he finds himself in a world altered subtly and darkly. And Wells steered clear of *time paradoxes*. If I had a Time Machine I could go back and murder my grandfather. There is a paradox (apparently) because if my grandfather is killed before he sires my father, I could never be born. But if I am not born, I cannot go back to murder my grandfather... ad infinitum, and apparently without hope of resolution.

One entertaining exploration of such paradoxes in science fiction is "All You Zombies" by Robert Heinlein (1959), in which a man travels into the past to become his own father *and* mother. Later, in fact, Wells showed that he didn't really believe in time travel anyhow, and thought that history would be pretty much immune to changes. In 1927 JW Dunne published a book called *An Experiment with Time*, a serious study of time travel which was at least in part influenced by *The Time Machine* . Wells read this, and commented, according to Dunne, that he never intended his description of time as a dimension to be taken seriously. And in a lecture to the Royal Institution in 1902 called "The Discovery of the Future", Wells says "The portion of the past that is brightest and most real to reach of us is the individual past, the personal memory. The portion of the future that must remain darkest and least accessible is the individual future." Wells did believe you could prophesy trends on a large scale, using the laws of physics to predict the return of a comet or the death of the sun, for example - and, on the human scale, using such statistical means as actuarial tables. But individual futures would remain unknown. And of history-changing he says, "I must confess I believe that if by some juggling with space and time Julius Caesar, Napoleon, Edward IV, William the Conqueror, Lord Roebery and Robert Burns had all been changed at birth, it would not have produced any serious dislocation of the course of destiny. I believe that these great men of ours are no

more than... the pen-nibs fate has used for her writing, the diamonds upon the drill that pierces through the rock."

But we *do* know possibilities of history-changing and time paradoxes did occur to Wells when he was working on The Time Machine. As I said, in *The Chronic Argonauts* Nebogipfel is the victim of a paradox when he kills the man in the past. And even in the final version of *The Time Machine* Wells drops some hints of the wider implications of time travel in the book's introductory dinner party, in throwaway remarks about viewing great historical moments - like the Battle of Hastings - or using time travel to become rich through compound interest investments.

But Wells cut all this. He deliberately decided against sending his Traveller *back* in time in the final draft - for it is backwards travel which changes history, and causes paradoxes.

So the mechanics of time travel didn't actually matter much to Wells's final novel. As he redrafted *The Time Machine* , Wells was working towards his final, complex Morlock-Eloi fable of evolution and social decay, and it was this aspect of the book that the more mature Wells was interested in.

Without the idea of time travel in the first place, there would have been no novel. But it seems clear that Wells had formulated his ideas on time travel by 1888, and wasn't interested in developing them further, and he ruthlessly cut anything which would detract from the grandeur of his central idea - and he showed remarkable restraint in this, for some of the stuff Wells *cut* would be sufficient to support lesser writers' whole careers.... continued.

So where, at Imperial in 1887, did Wells get his idea? In foreword to a 1932 edition of *The Time Machine* , Wells himself says: "[The idea of the novel] was begotten in the writer's mind by students' discussions in the laboratories and debating society of the Royal College of Science in the eighties..." And in a biography by Wells's son, Geoffrey West, we learn that the idea came during the reading of a particular paper by another student in a college debating society.

The paper in question was about four-dimensional spaces, and, probably, a four-dimensional space and time.

Nowadays, the idea of many dimensions is a common mathematical tool. You can use it to visualise, and apply geometric ideas to, any system with many variables: the motion of a multi-particle system, for instance, or in optimisation problems about, perhaps, stock quantities in a supermarket.

Some theories of physics posit that extra dimensions actually physically exist - that they aren't just mathematical conveniences. For instance some variants of superstring theories describe 7, 8 or 13 extra dimensions. These are rolled up so tightly we can't see them - but they determine the physical constants (like the speed of light) that govern our universe.

In Wells's day, however, theories of multi-dimensional spaces were on the fringe of physics and mathematics, but there was a good deal of published speculation on the subject. One authority on higher dimensions who we know Wells read (I'll explain how we know later)

was Professor Simon Newcomb. Newcomb was an astronomer, who went on to become the President of the American Mathematical Society - and he had been publishing papers on the topic of four dimensions since 1877. He spoke to the New York Mathematical Society on the subject, in December 1893. [4]

Newcomb's talk was a speculation on a variety of future directions in mathematics. He touched on the "fairy land of geometry". "When [the mathematician] enters fairy land he must, to do himself justice, take wings which will carry him far above the flights, and even above the sight, of ordinary mortals..." Newcomb spoke of the idea of a *space* direction as the fourth dimension, rather than *time*. As an example he talked about escaping from an enclosed sphere by a four-dimensional transfer. And he says, "Add a fourth dimension to space, and there is room for an indefinite number of universes, all alongside of each other, as there is for an indefinite number of sheets of paper when we pile them upon each other". (Wells liked this image, and would use it in two parallel-world novels, *The Wonderful Visit* (1895) and *Men Like Gods* (1923).) Newcomb goes on to speculate on curved-space geometries, mathematical techniques which would inform much of the Relativity theory to come.

Now, as I've said Newcomb was talking about the fourth dimension being spatial. The idea of *time* as the fourth dimension, rather than space, is an old one. You can trace it back to the eighteenth century [5]. For example, in 1751 the French physicist d'Alembert wrote of "a clever acquaintance of mine [who] believes... that duration could be regarded as a fourth dimension... [the idea] seems to me [to have] some merit, if only that of novelty."

The most prominent thinker on spacetime geometry in Wells's day was probably Charles Howard Hinton, who published a paper on "What is the Fourth Dimension?" - the answer being "time" - in 1880. It was later reprinted in his "Scientific Romances No. 1." [6]

(Hinton incidentally was an intriguing character [7]. He was British, and he took an MA at Oxford. He married Mary Boole, one of the five daughters of George Boole, of Boolean logic fame. But he left Britain in disgrace following charges of bigamy. He knew Simon Newcomb, and Newcomb eventually got him a position at the Naval Observatory in Washington DC. By the time he died in 1907, Hinton was an examiner in the United States Patent Office.

(Hinton achieved a certain notoriety as an inventor himself, for example of an automatic baseball pitcher. It shot balls with charges of gunpowder and could be adjusted to produce a pitch of any speed or curve. The Princeton team practised with it for a while, but after a few accidents the batters were afraid to face it.)

Hinton speculated widely on higher dimensions. He used the fourth dimension to justify ghosts, God and an afterlife. He wrote an ambitious book about a flatland - a two-dimensional world. This was more ambitious than the more widely known *Flatland* of Edwin Abbott; it featured physically reasonable two-dimensional stars and planets, and the plot was a socialist melodrama.

Hinton developed a method of building models of four- dimensional structures (in three-dimensional cross-sections) using hundreds of small cubes, labelled and coloured to represent

'height' in the fourth dimension. (You might have seen one of Hinton's representations of four-dimensional cubes, in Salvador Dali's *Corpus Hypercubus* (1954), which shows Christ crucified against an opened-out Hintonian hypercube. And in Robert Heinlein's "And He Built a Crooked House" (1941) a Californian architect builds an opened-out Hinton hypercube - and an earthquake shakes it into the real thing.) By working with his cubes for many years, Hinton maintained he taught himself to think in four dimensions. "For my own part, I think there are indications of such an intuition..." But Hinton's method would attract critics, who said his "visualisation" amounted to a dangerous form of autohypnosis.

Now Hinton certainly influenced later thinkers on spacetime geometry. But did HG Wells read Hinton? We do not know. It's interesting that it is Hinton who seems to have coined the term "scientific romance", to title collections of his speculative essays and stories, in 1886 and 1898. This is, of course, the phrase that Wells would later use to label his own science fiction. And even if Wells didn't read Hinton he may very well have seen the favourable review of his "Scientific Romances" which appeared in *Nature* in 1885 [8]. *Nature* was a weekly news sheet at the time, the nearest thing to a "pop science" paper like our own *New Scientist*, and we know Wells read it.

The *Nature* review summarises Hinton's ideas of spacetime as a *rigid* four-dimensional geometry, with movement being generated as an illusion, by an object passing through a three- dimensional surface. "Each part of the ampler existence which passed through our space would seem perfectly limited to us. We should have no indication of the permanence of its existence... Change and movement seem as if they were all that existed. But the appearance of them would be due merely to the momentary passing through our consciousness of ever-existing realities."

A few weeks later *Nature* published another brief piece on the fourth dimension. This was a letter by an author who signed himself (or herself) only as S. [9] This letter was evidently a response to the Hinton review. "What is the fourth dimension?... I propose to consider Time as a fourth dimension... Since this fourth dimension cannot be introduced into space, as we commonly understood, we require a new kind of space for its existence, which we may call time-space. By picturing to ourselves the aggregate formed by the successive positions in time-space of a given solid during a given time, we shall get the idea of a four- dimensional solid, which may be called a sur-solid... As an example of a solid which satisfies this condition sufficiently well, is afforded by the body of each of us. Let any man picture to himself the aggregate of his own bodily forms from birth to the present time, and he will have a clear idea of a sur-solid in time-space."
Who was S.? Nobody knows...

So this is the material around, and accessible to Wells, at the time. Maybe Wells read the Hinton review, and S.'s reply. Or maybe Hinton, and S., were referred to in the paper Wells heard in the famous college debate.

Certainly, the idea of spacetime geometry - the vision of space and time as a sort of huge museum, with historical events fixed like exhibits, amongst which the explorer could wander - caught Wells's imagination. Wells wrote a paper on the subject called "The Universe Rigid" (which was never published). And he began to think of the idea as the seed for a new sort of time travel story. (There had been such stories before *The Time Machine*, of course, but these were generally fantastic. They'd featured such 'justifications' as angels and reincarnations. For example, Mark Twain's Connecticut Yankee made it to Camelot through a blow on the

head.)

Let's look now at the final novel. You can clearly see Wells's influences - what he must have read - in the language with which the Time Traveller justifies his Time Machine, to his guests at the famous dinner party the night before his first venture into Time.

The Traveller says, "Any body must have extension in four directions: it must have Length, Breadth, Thickness, and - Duration... There are really four dimensions, three which we call the three planes of Space, and a fourth, Time..." (*The Time Machine*, p4.)

The Time Traveller briskly dismisses the idea that the fourth dimension could be a spatial direction, as propounded by "foolish people [who] have got hold of the wrong side of the idea." He mentions Professor Simon Newcomb, who was "expounding this to the New York Mathematical Society only a month or so ago". (*The Time Machine* , p4.) Well, as we've seen, Newcomb was a real scientist. And he really did talk to the New York Mathematical Society, in December 1893 (which, incidentally, dates the Traveller's dinner party as January or February of 1894). And Newcomb's talk was reprinted in full in *Nature*, and we know Wells read *Nature*, so this is how he must have heard of Newcomb's talk.

But Newcomb's talk wasn't actually all that relevant to *The Time Machine*, because he was talking generally about a *space* direction as the fourth dimension, rather than *time*. Perhaps Wells was using the hoary old hard-sf author's trick of quoting a real, prominent and reasonably relevant scientist, to give his work some spurious plausibility.

After slagging off Professor Newcomb, the Time Traveller goes on to discuss four-dimensional space and time. "I do not mind telling you I have been at work upon this geometry of four dimensions for some time. Some of my results are curious. For instance, here is a portrait of a man at eight years old, another at fifteen, another at seventeen, another at twenty-three, and so on. All these are evidently sections, as it were, Three- Dimensional representations of his Four-Dimensioned being, which is a fixed and unalterable thing." (*The Time Machine* , p5.)

In this passage, I contend, you can clearly see the influences of the *Nature* articles I've mentioned, on Hinton and by S. Recall the S. article: "Let any man picture to himself the aggregate of his own bodily forms from birth to the present time, and he will have a clear idea of a sur-solid in time-space." Compare that to Wells's succession of portraits. And recall the quote I gave from the Hinton review: "Each part of the ampler [four-dimensional] existence which passed through our space would seem perfectly limited to us...Change and movement seem as if they were all that existed. But the appearance of them would be due merely to the momentary passing through our consciousness of ever-existing realities." Compare this to Wells's talk of a "Four-Dimensioned being, which is a fixed and unalterable thing."

The closeness of the language in the *Nature* articles to what's in *The Time Machine* - not to mention the "scientific romances" link to Hinton - convinces me that Wells must have seen these articles. He may have been pointed to them by other students, after the famous college debate. One authority on Wells, Professor AM Bork [10], has even speculated that Wells knew the mysterious S. himself (or herself).

Or perhaps - we can but speculate - *Wells himself was the mysterious S.*? Perhaps the article in *Nature* is an extract from his "Universe Rigid" piece?

Sadly, I'm afraid we're never going to know for sure.

So that's the source of Wells's speculations about a four- dimensional spacetime. But what about the *physics* of Relativity? Is it possible the young Wells was aware of Michelson-Morley and subsequent speculations, and was influenced by them in the construction of *The Time Machine* ? The Michelson-Morley experiment was notorious at the time Wells was drafting *The Time Machine* , because it was proving impossible to accommodate in any Newtonian framework. But the contemporary debate around Michelson-Morley was all to do with the existence, or not, of the "luminiferous ether", the hypothetical substance that was supposed to be the "sea" on which light propagated as waves. The ether theory had to be killed off before the physicists could make themselves ready for Relativity. And a generalist reader of *Nature*, as Wells was, would have had trouble spotting the significance of Michelson and Morley. They were there, however; in 1887 there is a brief review of their report in the *American Journal of Science*. "From the delicate researches here described... it is inferred that, if there be any relative motion between the earth and the luminiferous ether, it must be small..." [11]

The controversy over Michelson-Morley developed in the following years, as Wells worked on *The Time Machine* . In the pages of *Nature* you'll find, in 1892, a Dr Oliver Lodge defending the ether hypothesis - saying that the ether must be dragged along with the earth. [12] But wiser heads were coming to terms with the true implications of the Michelson-Morley experiment. By 1892, the Leiden physicist Hendrik Lorentz, presumably in a desperate attempt to come up with a consistent physical framework that could accommodate Michelson-Morley, had devised a basic scheme of space-time contraction, which would later form an integral element of Relativity. (Crudely, rulers are shortened and clocks slowed by motion, to make observed light-speed come out at a constant value, regardless of the observer's velocity.) This was written up in a major treatise in 1895, and a few years later Lorentz and others began to proclaim the death of the ether hypothesis, and physics was ready for Relativity.

This stuff is rather austere, is couched in the language of ether, and at the time must not have seemed as earth-shattering as it does in retrospect. It is certainly not as *sexy* a topic to a jackdaw mind like Wells's, as four dimensions. It's not clear to what extent even Einstein himself - let alone Wells - was aware of Michelson-Morley, and as we've noted it was not until 1908 that Special Relativity was merged with four- dimensional geometry, by Minkowski.

One authority on the behaviour of light Wells might have seen, however, is the French astronomer and writer Camille Flammarion. In 1873 he published a story called *Lumen*, about an adventurer who travels back through time faster than light and he witnesses, among other things, the end of the Battle of Waterloo before the beginning.

> "You only comprehend the things which you perceive. And as you persist in regarding your ideas of time and space as *absolute*, although they are only *relative*, and thence form a judgement on truths which are quite beyond your sphere, and which are imperceptible to your terrestrial organism and faculties, I should not do a

true service, my friend, in giving you fuller details of my ultraterrestrial observations..."

Flammarion gives us a very crude outline of Relativity theory, and such speculations seem remarkably close to what must have been going through the young Einstein's mind in 1895. But could it have influenced Wells?

Flammarion's story was published in English in America in 1874, so it doesn't seem likely that Wells can have been aware of it directly. But Flammarion's essays were reprinted in the popular magazines where Wells worked, and he may have encountered these ideas there. (Flammarion's disembodied cosmic wandering is, however, very reminiscent of a Wells short story about an out-of- body experience during surgery, "Under the Knife" (1896).

In any event, presumably, the physics of Relativity was *not* a key source of influence on *The Time Machine* .

But... that's not the end of the puzzle.

Wells's Time Traveller was an expert in "physical optics." Wells notes, in passing, the Traveller's "seventeen papers" on the subject in Philosophical Transactions (*The Time Machine* , p60.). It is tantalising to speculate that even if Wells didn't know about Michelson-Morley, the Time Traveller surely *would* have known of it, and the mysterious consequences of Maxwell's equations. (I explore this idea in *The Time Ships*.)

After eight years of redrafting, no element in *The Time Machine* is there by accident! So why would Wells make the Traveller an expert in a field of physics so relevant to Relativity? I'm afraid this too is an open question, and I think Bruce Sommerville's explanation [13] - that the Time Traveller was an optical illusionist who hoaxed the whole journey - is too contrived to be convincing!

At last, in 1895, *The Time Machine* was published - and, it must have delighted Wells, it got a review in *Nature* itself. "Apart from its merits as a clever piece of imagination, the story is well worth the attention of the scientific reader, for the reason that it is based so far as possible on scientific data, and while, not taking it too seriously, it helps one to get a connected idea of the possible results of the ever-continuing process of evolution... From first to last the narrative never lapses into dullness." [14]

(Incidentally the other great source of the ideas in *The Time Machine*, of course, also derives from the Royal College. This was Huxley's teaching on evolution. Wells, we should remember, was one of the first generation of young people to be taught as a matter of course of evolution - and the immense geological age of the earth, and the sweeping distances of space, and the existence of such different eras as the Stone Age. But the idea of evolution, in particular, was still being absorbed, rather painfully, into the public consciousness. Wells was dissatisfied with what he saw as the general complacency of mankind in the face of the issue of evolution. Why should we assume that we are the crest of the evolutionary process, and the only way forward is onwards and upwards? In fits and starts, as Wells started working on the project that would finally become *The Time Machine* , he set out to dramatise how

civilisation could fall, and the human species itself slip backward, under the pitiless shaping of evolutionary forces.)

We've seen that *The Time Machine* sprang from the notion of spacetime as a four-dimensional structure, making travel in time possible. Around this primitive seed sfnal coalesced, in the mind of the maturing Wells, a fictional means by which he could express the themes and issues that concerned him. And as he worked on his book Wells wrote out paradoxical passages of backwards time travel, to focus his tale on what the Traveller would find when he reached futurity.

But, of course, to tell the story, Wells did have to leave in *one* backwards journey: from the remote future visited by the Traveller, back to his 1890s present. And (as I argue in *Time Ships*) surely the dread warning of his account of Eloi and Morlocks would serve to change history in itself.

Wells, after 1900, became, more self-consciously, a prophet. In his later books he was trying to write *for* the future - he was trying to shape it, through exhortation - rather than *of* the future. And his writing and thinking did have a lot of impact at the time. But for us, it is perhaps in the careful, compressed genius of *The Time Machine* that Wells as prophet has been, ironically, most effective.

Wells tried to avoid history changing. But we live in a history which has been changed, by Wells's own *Time Machine*.

Thank you.

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Don Brockway, April 21, 2000 (updated October 12, 2004)

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