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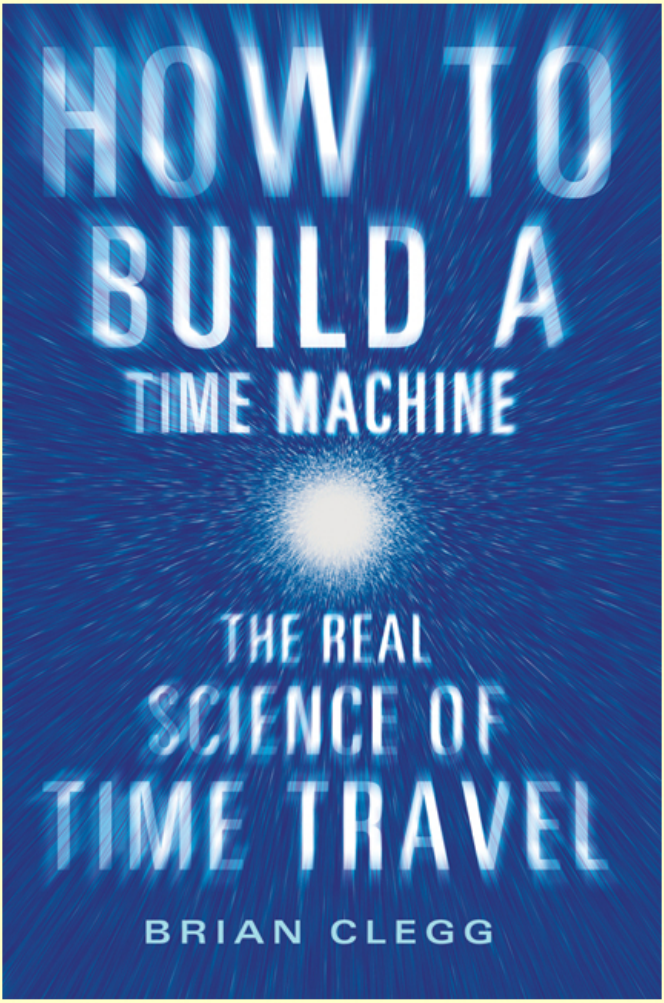

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CHAPTER ONE

A GLITTERING METAL FRAMEWORK

> *"Clearly," the Time Traveler proceeded, "any real 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. There is, however, a tendency to draw an unreal distinction between the former three dimensions and the latter."*
>
> —Herbert George Wells (1866–1946), *The Time Machine* (1895)

Everyone can travel in time. Our adventures in this mysterious dimension are limited, but they exist. As far as forward travel goes, we are all on a conveyor belt through time, rolling into an uncertain future at a rate of one second per second. Inexorably we glide into the future, converting it into the present just as the moment that was once the present becomes the past.

We can also all travel backward in time, but this experience is quite different from our stately forward motion, uninterrupted except by death. Our travels backward are through the medium of memory, and lack that smooth steady progress of our forward motion. Instead, we jump around from time to time with startling rapidity. One moment we might be at a point in our childhood,

which for some could be seventy, eighty, ninety years away. The next thing we know our memories are focused on events from ten minutes ago. There is no constraint to the speed at which memory can jump around in time.

You might argue, "That's just memory; it's not time travel." After all, memories aren't real. You aren't actually there. But consider just how much your memories define who and what you are. Without them, you aren't the same human being—this is what is so distressing about the onset of neural diseases where an individual loses his or her memories. The journey back in time produced by a memory may not involve being physically transported, but it is much more real to us than many objective "realities." A strong memory will far outweigh a news report from the other side of the world. The news may reflect something that is happening at that moment in time, but for the observer it could have relatively little significance.

There are even tourist destinations in the segments of time that have been relegated to history, points in our personal past that are hugely popular destinations for a whole host of mental time travelers. Most adults can remember where they were and what they were doing on September 11, 2001. These so-called flashbulb memories can be distorted like any other recollection. Yet this does not take away the fact that they are specific points in the time stream that many individuals can pinpoint and identify.

For those of us who are older, another date is a frequent destination, a date that is doubly significant for my personal interest in time travel. That date is November 22, 1963. Many people can remember what they were doing on that day when they heard the news that President John F. Kennedy had been assassinated. One of

the effects of the terrible news was a disruption of TV schedules. And this was to have an impact on a show that was broadcast in the UK for the first time on the next day, Saturday, November 23, 1963.

The TV show was a new family drama called *Doctor Who*. Because so few people were watching TV in the aftermath of the Kennedy assassination, that first episode was repeated the following Saturday before the second episode was shown. It was *Doctor Who* that brought the concept of time travel to many British viewers, and later would be seen around the world. It proved an enduring concept, and after a break of a number of years, the show is again being made more than forty years later.

Although it wasn't long after that I came across the H. G. Wells novel *The Time Machine,* it was *Doctor Who* that first got me thinking about what it would mean to travel in time. The show rarely explored the paradoxes and peculiarities of time, but early on it did indulge in visits to periods in Earth's history, past and future. Before long, the writers would focus more on travel to distant planets and alien life, but it was always possible to use time as part of the story line. To be honest, I always felt a lot more affection for *Doctor Who* than for the sometimes labored political allegory of Wells.

However, we can't dismiss that "glittering metal framework," as the time machine is first described in the 1895 novel—it is hugely significant. Although traveling in time was not a new idea even then, fictional time travel before that book had relied on dreams or magic to transport the time traveler. In Mark Twain's *A Connecticut Yankee in King Arthur's Court,* for example, the central character, Hank Morgan, travels back to medieval England as a result of

being hit on the head, and returns to the future after Merlin puts him into a magical sleep. (If your only experience of this story is the movie, read the novel—it's a much darker and more thoughtful book than the on-screen version suggests.)

In books like Mark Twain's, time travel was fantasy, largely a mystical experience. But Wells transformed it into science fiction (even though that term was yet to be invented), a fictional concept of practical, solid achievement, opening up speculation about how time travel might be achieved and what the implications of traveling back to the Crucifixion, or visiting the far distant future of humanity, might be. Wells set us on the path of something more concrete, the product of the new, all-powerful science and technology that were transforming the real world—Wells brought us the time *machine*.

The idea behind his book was to become a standard of science fiction. Along with a number of other conventions—faster-than-light space travel, for instance—the concept of time travel would be used as the hook for a thousand stories. I absorbed a huge amount of science fiction as a teenager. It had, without doubt, a major role in my growing interest in real science. The possibilities for mind-bending storylines were endless.

Take Robert E. Heinlein's classic short story "—All You Zombies—" (often confused with "By His Bootstraps," which is also a time travel story). In this story, a time traveler returns to the past, where he unwittingly makes love to his own mother, fathering the child that will eventually be him. Later the mother, who turns out to have a genetic condition giving her both female and male sex organs, undergoes a sex-change operation. The now male mother is transformed into the time traveler himself. He

has become a living paradox, a loop in time creating itself with no beginning and no end.

This sort of delightful paradox made time travel a gift to fiction writers, but the capability of freely moving around in time as if it were a true fourth dimension was assumed to be a fictional convention. It was the same kind of useful but unreal assumption as the ability to travel faster than light through some sort of "jump" or "warp" that has been common for many years in science fiction. But there was a surprise lurking behind that assumption.

There is no physical law that prevents time travel.

Reading those time travel stories involved a suspension of disbelief—but that was all that happened. No one really believed it was possible to build a time machine. It was fantasy rather than predictive science fiction. Time travel seemed so incredible that it would never be made real. Yet nothing in physics says we can't build such a machine.

Since 1895, when Wells published his book, science has moved on with frightening speed. And that progress has included the theories that makes time travel possible in principle. As we will see, turning these theories into practice has huge problems attached, which is why we haven't turned out time machines like automobiles off a production line. Yet look at the way technology sometimes moves forward. Consider how much of the technology that features in your everyday life was uncommon fifty years ago and unthinkable a hundred years ago. If we allow enough time, we may see time travel becoming real.

Unless we can use some sneaky possibilities of constructing small-scale time machines, the difficulties facing anyone wanting to make time travel possible mostly involve travel across huge

distances or manipulating vast objects. These are difficulties that should, in theory, be possible to overcome as technology develops. It would seem that unless our current theories are incorrect, building a working time machine is only a matter of . . . time.

There are aspects of time travel that Wells got very wrong. His machine seemed somehow to work its way through time on mechanical principles involving an interaction between crystal structures and the time flow. Like many time machines in fiction, Wells's device proved remarkably easy to control. Little more was involved than setting the controls for a particular year and throwing a switch to head off to the past or future. Yet real time machines would almost all depend on an indirect means of time travel where such simple interaction with the timeline would not be possible.

Wells's machine also had an unusual symmetry when compared with a typical concept based on real science. In the time machine, it was as easy to travel into the future as it was into the past, and travel in either direction involved the same action, just like with travel in space. Most of *The Time Machine* is concerned with visits to the distant future, but the traveler returns in exactly the same way. However, some real time devices are likely to work in only one direction—and those that can be used either way will still need a different approach to select direction (usually traveling in one spatial direction to move forward and another to move backward).

In the Wells time machine, the traveler sits still and time shifts around him. This seems reasonable because that's how we experience movement in time on our day-to-day, second-by-second basis. However, most of the real mechanisms for time travel will

involve moving spatially as well, reflecting the way that time and space are inextricably linked in the four-dimensional matrix of space-time. It is very unlikely that there will be a mechanism for time travel that doesn't involve motion.

We shouldn't be too dismissive of Wells, though. He does get one thing right with impressive accuracy. His protagonist explains that the time machine works by making use of time as a fourth dimension. This was a new concept back then, one that Wells addressed in fiction before it became a serious concept in science. Now, however, the notion of treating time as a dimension in an overall framework of space-time has become central to our understanding not just of time travel but of the universe as a whole.

Science would catch up with fiction when physical theory was transformed just a few years after *The Time Machine* came out, in the early years of the twentieth century. Our view of reality was about to be given a profound shock by a man who took this fictional concept of time as a fourth dimension very seriously indeed.

CHAPTER TWO

IT'S ALL RELATIVE

> *When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute—and it's longer than any hour. That's relativity.*
>
> —Albert Einstein (1879–1955), allegedly in the *Journal of Exothermic Science and Technology (JEST)*

Two absolute essentials of real time travel are the linkage of space and time, and the influence of gravity on the space-time continuum. Both of these fundamental insights came to Albert Einstein in moments of dreamy contemplation. His two great concepts first emerged while he was resting on a grassy bank and while daydreaming in the office. Yet these idle moments would be crucial in our understanding of how time can be manipulated. To see where the ideas came from, we need to start a little earlier in the time stream.

The drab apartment block where Einstein was born on March 14, 1879, gave no indication of the greatness to come. It is no longer there: the building in the southern German city of Ulm was destroyed by a bomb in the Second World War. Young Albert's father, Hermann, from whom Einstein inherited his tendency to

daydream, was a hardworking failure, a good counterexample to the old saw that if you try hard enough, you can achieve anything. Hermann put in a huge amount of effort, earnestly attempting to run businesses that had been funded by the family of Einstein's mother, Pauline, but he never had the focus, or the luck, that is necessary for success in business.

Although money was often tight, the Einstein family home seems to have been a happy one for Albert and his younger sister, Maria, or Maja as he always called her. But life outside the home was rarely to Einstein's liking. As soon as he started school, young Albert was to find irritation in a tense conflict between his urge to explore knowledge *his* way and the rigid educational system that existed in Germany at the end of the nineteenth century.

It seemed to Einstein that the system's role was to confine him, to stop him from discovering information and expanding his imagination. He had a stubborn streak in his personality, and the rigidity of the system made him inclined to rebel. From an early age he was unable to conceal his distaste for authority, and particularly for anyone who used his or her position to try to manipulate the way Einstein thought. Einstein was never one for following others, he liked to tread his own paths.

The dislike that Einstein felt for his educators was reciprocated. His first school was a Catholic establishment in the Bavarian capital of Munich (the Einsteins were ethnically Jewish but did not practice their faith). Einstein's father had moved the family to the city in a doomed pursuit of business achievements. The headmaster of the school once commented that it didn't matter what career young Albert tried, as he would never make a success of anything.

Things were different at home. There, playing with Maja in the

overgrown wilderness that was their garden, or more often alone in his room, Einstein felt in charge of his destiny. At school he had no opportunity to do things his own way. The regimen was strict and rigid, a matter of following the rules, ticking the boxes, doing what was expected. Einstein found this stifling and infuriating in equal measures.

He might have hoped that things would get better when he moved on to the equivalent of junior high, but if anything they went downhill. The Luitpold Gymnasium took an old-fashioned approach, stressing a classical education above everything else. Einstein struggled with the Latin and Greek languages, which seemed entirely useless, and was bored by the humanities. His teachers in their turn thought him lazy and uncooperative (this was probably not too unfair an assessment).

Einstein was not the kind of person to give in when faced by this kind of opposition. He began to turn elsewhere for intellectual stimulation, relying more and more on books. A pivotal role in his development was played by a young friend of the family, Max Talmud. A medical student when Einstein first met him, Talmud was a regular at the family dinner table and entertained the young Einstein by passing on tantalizing and intriguing facts and bringing him the latest scientific books, often at a level that would stretch a university student.