Einstein, Albert (1879-1955)

Physicist, one of the most creative intellects in history, advanced a series of theories that proposed entirely new ways of thinking about space, time, matter and gravitation and revolutionised science and philosophy. Einstein also possessed a “passionate sense of social justice and social responsibility”, though his endeavours in this field were not as successful.

Born to the family of a small-scale industrialist in Germany, Einstein left school at 15 with poor grades in the humanities and without any diploma. His family had moved in the meantime however to Milan and the young Einstein went to join them and resumed his education in Switzerland, graduating in 1900 in physics and mathematics at the renowned Federal Polytechnic Academy in Zürich.

After graduating, Einstein became a Swiss citizen, and went to work as an examiner at the Swiss patent office in Bern. After publishing his PhD thesis for the University of Zürich, **A New Determination of Molecular Dimensions** early in 1905, only 9 years after his first lesson in Physics, Einstein published four papers that transformed natural science forever.

> **On the Motion - Required by the Molecular Kinetic Theory of Heat - of Small Particles Suspended in a Stationary Liquid**, applied statistical methods to demonstrate that the observed “wandering” of particles suspended in a liquid (“Brownian Motion”) was exactly as would be caused by the random impact of the unseen molecules of the liquid. This was the first experimental proof of the existence of the molecules, which Ernst Mach had regarded as no more than theoretical constructs.
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> **On a Heuristic Viewpoint Concerning the Production and Transformation of Light**, drew on Max Planck's observation that the spectrum of black-body radiation

corresponded to the spectrum that would be expected if the emission of light resulted from discrete events, Einstein postulated that light is composed of individual quanta, in addition to exhibiting wave-like behaviour – a revolutionary approach to resolution of the seemingly inexplicable contradiction between Planck's observation and the accumulated mass of theory explaining optical phenomena on the basis of wave propagation. In the light of subequent history it is often forgotten that it was Einstein who made the quantum revolution, despite the fact that he would later maintain fundamental disagreements with the mainstream proponents of quantum mechanics.

On the Electrodynamics of Moving Bodies put forward what became known as the Special Theory of Relativity (special because it did not consider accelerated bodies, but only bodies in constant or “inertial” motion). Physics had been struggling with the contradictions arising from the Michelson-Morley experiment which demonstrated that the speed of light from the Sun measured on the surface of the Earth did not depend on the motion of the earth towards or away from the Sun, or through the “ether”. Lorentz had worked out that if the length of a body increased or decreased by a certain ratio according to its speed through the ether, then the result could be explained, but there was absolutely no rationale for such a dilation. Einstein's approach was entirely novel. Rather than questioning the results of the experiment or postulating new properties for the ether to explain the result, or calling into question Maxwell's laws of electro-dynamics which

were only a few decades old, or even Newton's laws which were 200 years old, he assumed that all these laws were true and in fact postulated that all the laws of physics were *invariant with respect to transformation between inertial frames of reference* – i.e. the laws of physics were unaffected by movement through a co-called ether, and called into question Euclid's 2,000 year-old geometry. He subjected to painstaking, meticulous examination, the practice of measurement of time intervals and distances on which our conception of time and space are based. Through a series of "thought-experiments" he demonstrated that Lorentz's transformation was a simple, geometric result of the measurement process. The chief result was therefore to show that space and time had to be conceived in terms of the measurement processes they were associated with, rather than as entities which could be grasped by pure reason, something which everyone from Euclid to Kant and beyond had taken to be the case.

Does the Inertia of a Body Depend Upon Its Energy Content? was an addendum to the Special Relativity paper which observed that the famous $E = mc^2$ followed from the theory. The equivalence between energy (E) and mass (m) knocked yet another fixture away from the physical conception of the world, and would of course later have the most profound effect on world politics with its application to the production of nuclear energy and the atom bomb.

These papers were quickly recognised by physicists around the world for the revolutionary achievements that they were. He left the patent office and by 1914 was at the University of Berlin, continuing research towards

his *general* theory which would deal with accelerated motion and, what amounted to the same thing in Einstein's theory, gravitation, with only occasional requirements to lecture. His wife and two sons were trapped in Switzerland by the outbreak of the War and divorce followed a few years later. Mileva Maric was also a physicist and being married to the greatest physicist of all time was not an easy thing. While continuing with his work, Einstein distributed some pacifist literature to sympathisers in Berlin.

Einstein published the highly readable **Relativity: The Special and General Theory** in 1916, written for the general public and without complex mathematics, and *later* published the **The Foundation of the General Theory of Relativity** in which the approach he had developed in dealing with uniform motion was applied to accelerated motion. If you were falling in a lift, under the influence of gravity, then the appearance would be “weightlessness”, but you would be falling faster and faster, and despite the fact that you can see nothing other than the lift which is falling with you, you can *feel* the falling. In other words, not only are the laws of physics *variant* with respect to accelerated motion, but acceleration is interchangeable with a gravitational field. The mathematical tool which allowed Einstein to deal with the complexities of this analysis was Riemann's Tensor Calculus – a “solution waiting for a problem”. This allowed Einstein to express the fundamental laws of physics in an entirely new way. The “forces” which had dominated 18th and 19th century physics were no longer present – only forms of movement expressed in equations of incredible simplicity, from which Maxwell's and Newton's laws cold be derived as special cases. It was Minkowski who later showed that they also allowed for the conception of a “4-dimensional distance”, in which time figures as a 4-th dimension but only by combination with the square root of minus one! Thus arose the mind-bending conceptions of “curved space-time”

The idea of large masses causing space-time to be curved could be verified by observing the bending of light rays during a total eclipse and

in November 1919, the British Royal Society announced that an expidition which had been launched while the war was still raging had observed a solar eclipse and verified Einstein's predictions.

Despite the deteriorating political situation in Germany, Einstein continued to attack nationalism and militarism and spoke out against anti-semitism. Einstein toured around the world lecturing on his theory while under constant attack by Nazis at home. He was awarded the Nobel Prize in 1921.

During the 1920s, quantum mechanics continued to develop with Niels Bohr and Werner Heisenberg among those at the centre of this work. The formal character of the relativity theory and the quantum theory were very different and it was difficult to see how the two lines of development could be unified. Einstein continued to seek a resolution through a Unified Field Theory (the first attempt at which he published in 1929), and this kind of approach continues to this day though the terms have changed considerably. However, Einstein retained up to the time of his death reservations about the interpretation of the Schrödinger Wave equation, which determines the *probabilty* of quantum events. Einstein never accepted that such an interpretation could be regarded as a complete description of a physical system, that events could be fundamentally without cause.

Further Reading on this matter: **Bohr's Report of his Discussions with Einstein** and **Einstein's Reply**.

As the world situation deteriorated, Einstein spent more and more effort in promoting pacifism including the establishment of a War Resisters' International Fund. In a famous exchange of letters with the Austrian psychiatrist Sigmund Freud, Einstein speculated on the psychological basis for the war and fascism he saw around him. In a discussion of epistemology with the Indian poet, Rabindranath Tagore, Einstein

defended basic philosophical materialist positions and in particular indicated support for the Pantheism of Spinoza.

When Hitler came to power in 1933, Einstein renounced his German citizenship and emigrated to England, moving to the U.S. in 1935 for a position at Princeton where he lived for the remainder of his life. From this time, Einstein urged Europe to arm and prepare for the inevitable war with Hitler. Most Western nations at this time regarded Hitler as a good anti-communist and Einstein's advocacy of war was given as little heed as had his pacificism.

In 1939, Niels Bohr, told Einstein of Lise Meitner's success in splitting the uranium atom, and speculated on the prospect for the creation of an atom bomb. Though Einstein was sceptical, he was persuaded to write to President Roosevelt to begin atomic-bomb research. He was not included in the team that worked at Los Alamos and did not learn that a nuclear bomb had been made until Hiroshima was razed in 1945. He then joined those scientists seeking ways to prevent any future use of the bomb, his particular and urgent plea being the establishment of a world government under a constitution drafted by the US, Britain, and Russia.

By 1937, after years of failure advocating peaceful attempts to change the world, Einstein became involved with Communism. For the remainder of his life he would be a member, sponsor, or affiliate of at least 34 Communist organisations; and chaired three Communist organisations. Einstein spoke out against capitalism, and it's concentration of power into the hands of the few, and stressed the need for a revolutionary overthrow of capitalist governments. Such ideas did not go unnoticed: the FBI began documenting his activities and speeches, and filed claims against his "communist-anarchist" politics, ammassing into a 1,427 page report by the time of his death. In 1949, Einstein's agitation gained wider attention when he wrote **Why Socialism?**, explaining that the only way for humanity to rid itself of the evils of capitalism is through the adoptation of Socialism. Einstein did not fully approve of Stalinist Socialism; arguing

on several points in letters to Soviet scientists that freedom is necessary for Socialism to work.

The rejection of his ideals by bureaucrats on both sides did not break him, however, because his prime obsession still remained with physics. He published his new version of the unified field in 1950, a most meticulous mathematical essay that was immediately criticised by most physicists as untenable.

Compared with his renown of a generation earlier, Einstein was virtually neglected and ostracised in his later years; he said that he felt almost like a stranger in the world. His health deteriorated to the extent that he could no longer play the violin or sail his boat. On April 18, 1955, Einstein died in his sleep at Princeton Hospital.