LIFE of CHRISTIAAN HUYGHENS: Brief Notes

Christiaan Huygens was born on 14 April 1629 in den Haag (the Hague), the second child of the poet and statesman Constantijn Huygens and his wife, Suzanna van Baerle. The Huygens family held important positions in the administration of the house of Orange (stadholders of the Republic's provinces). Christiaan's father was one of the best-known poets and authors of the Netherlands, and Christiaan was taught at home by his father and private tutors. According to the stories, Christiaan began composing music at the age of 9, and soon thereafter was fluent in Dutch, Latin, Greek, French, and Italian, and could play the lute, viola, and clavichord. At the age of 14 he apparently became interested in mechanics, and built himself a wood-turning lathe, which he used to make models of many mechanical systems. At the age of 15 he began studies in mathematics.

In May 1645, Christiaan and his brother Constantijn began their studies at Leiden university, the oldest university in the Netherlands. Following the wishes of their father, they enrolled as Law students, but also took some of the standard liberal Arts courses. This involved the study of Classical authors and their writings on history, philosophy, and science, including mathematics. Christiaan took courses from Franz van Schootens, the best known mathematician in the Netherlands at that time, and a friend of (and prominent exponent of the ideas of) Descartes. Descartes lived and worked in the Dutch Republic for most of his adult life, between 1628-1649, and Christiaan Huyghens would have met him several times, when he visited the Huyghens family. At university Descartes became completely familiar with Descartes scientific and philosophical ideas. However, after 2 years at Leiden, Christiaan was transferred in March 1647 by his father to the new Illustrious School at Breda, recently founded by Prince Frederick Henry (William II) of Orange, to continue his legal studies. This decision was motivated by the simple consideration that with legal training one could aspire to attain a high administrative position in the Republic. Thus, in the same way as Galileo, Huyghens was forces to choose between a safe carreer, or to go against the wishes of his father and follow his interest in science and mathematics. Huyghens followed his legal studies for another 2 years, but he remained in contact with van Schootens during this time.

However in 1650 Frederick Henry died, and the western provinces of the Dutch Republic decided to dispense with the stadholder. The influence of the House of Orange and of its supporters such as Constantijn Huygens was thus considerably reduced. This blocked the way for Christiaan to take up a a government position- but it opened the way for him to continue with studies of science. This he did, learning both from acquaintances and by his own studies, while living and working at home in den Haag- the family fortune permitting him to work uninterrupted. A pivotal event in his career was a visit to Paris in 1655, when he met a number of the most important French mathematicians, and participated in the many salon discussions taking place about contemporary work in science and the arts. He became friends with the poet Jean Chapelain and the astronomer Ismael Boulliau.

During the years 1650-1660, Huyghens made a number of important discoveries, some of which he published during this period, and others which were not to appear until much later. In mathematics one of the best known of his achievements was to help found the mathematical discipline of probability, in his studies of games of chance; he was responsible for a number of other important mathematical advances during this time. Apart from mathematics, Huygens was fascinated by scientific devices and instruments. In 1656-57, he published a short description of his pendulum clock- the first published description of this device, which was crucila for the subsequent evolution of time-keeping, navigation, and astronomy. With his brother, he designed and built lenses, using them to make telescopes and microscopes. Behind these designs lay his theoretical treatment of lenses, which however remained unpublished at that time. He did, however, publish his astronomical discoveries. In 1656 he announced that his discovery of Titan, the largest moon of Saturn, and in his '*Systema Saturnium*' of 1659 he published the solution to the puzzle of Saturns remarkable and always changing appearance: the planet is surrounded by a ring. With these discoveries Huyghens achieved international fame. His thoughts on more fundamental mechanical problems the theory of collisions, and his ideas on centrifugal force remained unpublished at this time. In this his career followed the same path as Galileo and Newton, both of whom achieved initial recognition for their astronomical work, long before their work on more fundamental problems was published.

By the 1660's Huyghens had achieved international recognition as a scientist in European circles. In 1660-61 and 1663-64, he again went on journeys and spent several months in Paris and London, and in 1666 the French 'Sun King', Louis XIV, invited him to Paris to be the director of a scientific academy the King wished to found. This was a great honour, which was also extremely lucrative- he was promised a yearly salary of 6000 livres, a quite enormous sum in those days. The new 'Acadèmie Royale des Sciences' was not the first scientific academy in Europe- indeed, the English Royal Society antedated it by 6 years, and doubtless its creation helped motivate Louis to found a French version. The idea of a scientific academy also fitted well with Louis's desire to to enhance the role of a central government, based around his extremely lavish court. He therefore gave it more than adequate financial resources. In consequence it was the first academy where something approaching professional science was practiced- the Academicians were able to work fulltime on their scientific pursuits. There was however another side to this; the academy depended very much on the whims of the King.

In Paris Huygens was able to do important scientific work, as well as setting up the new Academy. He was also an important figure in Parisian social and scientific circles. The period from 1666-1681 was for the most part productive for Huyghens, although he had occasional health problems, and was twice forced to return to den Haag, from Sept 1670-June 1671, and then again in 1681. Among his most important works during this time was the '*Horologium Oscillatorium*' of 1673, dedicated to Louis XIV, wherein he treated the dynamics of the pendulum and proposed an improved pendulum clock. Huyghens's positions was not affected when Louis declared war on the United Dutch Provinces in 1672, even though members of his family occupied important positions in the administration of the new Dutch stadholder, Prince William III of Orange. However in the 1680's the religious climate in France became less tolerant. This trend culminated in 1685 with the revocation of the Edict of Nantes, and the expulsion of the Protestant French Huguenots (a move which France would later have cause to regret). On the advice of friends Huygens, in den Haag because of illness since 1681, finally decided in 1685 not to return to Paris.

For the rest of his life, Huygens remained in the Netherlands, living initially in his father's house in den Haag, and then from 1687, after his father's death, to the family country house in Voorburg (the same town in which Spinoza had lived), continuing his research and publications, and living off the family's resources. During this period, Huygens further improved his pendulum clock, hoping to adapt it for maritime use. He also continued to elaborate his work optics, work which culminated in 1690 with his most important work, the '*Traité de la Lumière*'. This theoretical work described light in terms of wave excitations, giving a mathematical treatment of wave dynamics. With this theory, Huygens could explain both the motion of light waves through lenses, and more subtle phenomena such as the puzzle of the 'birefringence' of crystals like Iceland spar (calcite). The theory of Huyghens was not in favour during the 100 years following its publication, because it contradicted Newton's ideas, but in 1801 its essential correctness was demonstrated in experiments by Thomas Young in England. After this it was adopted as orthodoxy by the scientific world, until the discovery of quantum mechanics led to a fundamental revision of the whole of physics.

It was in this last period of Huyghens's life that the fundamental new work of Newton and Leibniz appeared, in the late 1680's. In 1689, Huygens once again visited England, where he had a number of discussions with Newton, with whom he had fundamental philosophical and scientific differences (although records indicate that their relationship was very cordial, with respect on both sides). Huyghens never fully reconciled himself to Newton's mechanics, continuing to follow Descartes in some of his ideas. On the other hand Newton was never able to accept Huyghens's wave theory of light

In 1695 Huyghens's health began to deteriorate rapidly, and on 9 July 1695 he died, leaving his papers to the university of Leiden. His instruments and telescope lenses remained in the possession of the Huygens family until 1754, when it was sold at auction.

Huyghens was well known amongst scientists and philosophers during his own lifetime, but like his rough contemporary Spinoza, his reputation was eclipsed in the 18th century. This eclipse was largely due to the eclipse of the Netherlands as a political power. In physics, the ideas of Newton became supreme, to the extent that some even followed them dogmatically; and in philosophy, Spinoza was treated by French and German writers as merely a footnote to Descartes, in a curious rewriting of history. In both cases a serious revision of views took place much later on. In the case of Spinoza, too revolutionary for his own time, a complete change in the European political climate led 20th writers such as Einstein, Russell, and Santayana to revive interest in his work- he is now regarded as a remarkable pioneer. In the case of Huyghens, the verdict of experiment came down in his favour just over a century after his death- as described below, his wave theory of light was vindicated by Thomas Young and Augustin Fresnel at the beginning of the 19th century.

In retrospect one can see that Huyghens was a rather profound thinker. This is not only clear from his very extensive scientific work, but also from his more general reflections on the nature of the scientific enterprise, and the methodology of science. For Huyghens the hypotheses of science were only rendered *probably* correct by experimental confirmation- they could not be *proved* in this way, no matter how many confirming experiments had been performed. How probable? His answer appears in the "*Traité de la Lumière*" in 1678:

"*One finds in this subject a kind of demonstration which does not carry with it so high a degree of certainty as that employed in geometry; and which differs distinctly from the method employed by geometers in that they prove their propositions by well-established and incontrovertible principles, while here principles are tested by the inferences which are derivable from them. The nature of the subject permits no other treatment. It is possible, however, in this way to establish a probability which is little short of certainty. This is the case when the consequences of the assumed principles are in perfect accord with the observed phenomena, and especially when these verifications are very numerous; but above all when one employs the hypothesis to predict new phenomena and finds his expectations realized.*"

Thus, according to Huyghens, in many cases a theoretical hypothesis is not derived from observational data. Rather, the hypothesis is advanced, and its observational consequences are deduced or inferred. Then these "predictions" are

compared with the results of experiments. The experimental confirmations that are most convincing are those in which new, hitherto unexpected or unknown phenomena or results are found, as consequences of the theory.

These views of Huyghens were only properly discussed and elaborated in the 20th century (when they were appropriated by other authors). The 20th century philosophers of science were and are particularly influenced by some of the more dramatic predictions of Einstein's theoretical work in gravitation (which depended very little on any previous observations or experiments). Certainly Huyghens's understanding of the relation between experimental and theoretical work was far more sophisticated than that of Newton, whose ideas of 'Experimental Philosophy' were largely molded by his reading of Francis Bacon, and for whom all 'hypotheses' were merely inferred from observation.

Thus Huyghens remains one of the most remarkable theoreticians in the history of physics, neglected by historians of science, ahead of his time in one crucial regard (the understanding of light), but nevertheless destined to play a central role in a drama which is still unfolding.