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SUCCESS AND FAILURE OF XU GUANG-QI : RESPONSE TO THE FIRST DISSEMINATION OF EUROPEAN SCIENCE IN MING CHINA*

MAN-KEUNG SIU

1. *Introduction*

Joseph Needham, an acknowledged world-renowned expert on history of science, especially on science and technology in ancient China, raises many times the following fascinating and important query [26, p. 11]: "Why, then, did modern science, as opposed to ancient and medieval science, develop only in the Western World?" Many scholars have offered their in-depth critical analysis of this issue, ranging from factors of an intellectual and philosophic character to factors which are social, economic and historical in nature [17]. In this connection the late Ming Dynasty was a critical period which is worth studying. Four adverse factors marked that period: (1) autocracy and decadence of feudal despotism in the Ming Dynasty, (2) effort of the ruling class to shackle the minds of intellectuals, (3) opposition and impediment to the introduction of Western science and technology, (4) political and social upheavals [17, p. 370-380)]. Despite such adversity, some intellectuals of that period did expend their talent and dedication and make commendable efforts to developing science in China. Among them Xu Guang-qi[a]** (Hsü Kuang Ch'i) was a most prominent figure. Indeed, his life and career provide a synopsis of the adversity of his times, specifically of the four aforesaid factors. Hence, a study of his life and career affords one approach, albeit laterally, to answer the query of Needham.

The Ming Dynasty[b] (1368-1644), starting with her founder Emperor Hongwu, was on the whole dominated by a group of unscrupulous and wicked ministers or eunuchs who won the favour of emperors who were either atrocious or incompetent or both. Greed, corruption, fraudulence, nepotism, intrigue and brutality were the cult of the day. To the common people and to the good honest officials who did not go along with this cult, the period was "Dark Ages" during which freedom of speech and even of thought were suppressed, safety of lives and of

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** Small letter superscripts (a, b,..z; aa,....az;....) indicate proper names and Chinese terminology in Chinese characters, as listed in the Chinese Glossary (Appendix II).

properties were not guaranteed, human dignity was trampled on and the daily lives of the people were made unbearable. However, in spite of this dismal aspect of the political history of the Ming Dynasty, the country progressed in many fields including trade and industry, science and technology, philosophy and literature, mainly owing to the wisdom and effort of the people. The economic development was especially marked in the Yangtze Valley. It was therefore a natural consequence that figures like Xu Guang-qi and others appeared during this period of "Renaissance". This paper will give an account of his life and career, elaborating on two areas of his scientific work, mathematics and astronomy. (See also [8, 12, 15, 16, 24].) He led a long, but politically rather futile, ministerial life for a quarter of a century in the Imperial Court of the Ming Dynasty. It was also during these last decades of the Ming Dynasty that the Chinese first came into contact with European science through the Jesuits. The Jesuits were intent to spread the Catholic faith in the old Empire, and to win over the people they endeavoured to first gain the favour and the following of the educated class. As an expedient means they brought in various new technological gadgets and apparatus unknown to China, as well as scientific theories which were, though not all of them updated knowledge at the time in Europe, nonetheless of a sufficient novelty and attraction to some educated Chinese. Through the works of Xu Guang-qi in mathematics and astronomy one can also acquire an understanding of the events and moods surrounding this first dissemination of European science in China during the first few decades of the 17th century. His success and failure in this endeavour will reflect rather typically the response of the Chinese to this first dissemination. In this connection, it is worth the emphasis to repeat a perceptive viewpoint of Jami [23, p. 83]: "The analysis of this transmission of Western science to China as a failure relies on the implicit assumption that what China then needed or should then have been inclined to achieve was the reproduction of the European pattern of scientific development. This assumption, which is questionable, actually stems from the interpretation of 19th century history in terms of the Chinese incapacity to face Western intrusion for lack of appropriate military technology". Indeed, as suggested by Qian [10, p. 161], without the brutal intrusion of Western powers, development of the Chinese culture in the political, social and scientific arenas may achieve a totally different but harmonious existence. However, speculation does not reflect the reality, and one has to admit that by the 17th century, certain weakness within the Chinese culture was exposed, and that the stage was set for the interaction between the East and the West, for the better or for the worse. In this paper we will confine to what actually had happened.

2. *Childhood*

Xu Guang-qi was born into a small household of the free labourer class in Shanghai on April 24, 1562. From four essays he wrote later in his life about his ancestry [13, pp. 523-528] we can piece together a picture in broad outline which traces back to his great-great-grandfather, who was probably a well-educated small landlord that moved from Suzhou to settle at Shanghai. Heavy taxation in terms of both money and labour brought about bankruptcy in the family so that his great-grandfather ended up farming for a livelihood. His grandfather however gave up farming for business and thereby improved the family's financial situation considerably. It was therefore possible for Xu Si-cheng[c], father of Xu Guang-qi to devote his time to the study of classics in the hope of passing a series of state examinations that would make him a scholar-official some day. Were it not for peril and strife caused by Japanese pirates known as Wokous[a], Xu Si-cheng might have achieved this aspiration of most Chinese intellectuals of his days. During the period 1546-1564, inhabitants in the southeastern coastal provinces of China lived under constant fear of ravage brought about by the merciless and blood-thirsty Wokous who killed and plundered wherever they prowled. This went on until the Ming general Qi Ji-guang[e] eradicated the last remnant of the Wokous in 1564. Before reaching the age of 20, Xu Si-cheng was engaged in the defence of Shanghai against such raids by the Wokous while his family, headed by his wife, had to flee the city and to dodge about for safety in nearby villages. Xu Guang-qi was born at this tumultuous time when the financial situation of the family was fast deteriorating. After the plague of Wokous, when Xu Si-cheng returned to Shanghai with his family, he had to take up farming just like his grandfather did, while his mother and wife wove from morn till night throughout the year.

Xu Guang-qi grew up in this industrious small household under the loving care of his parents and grandmother, who had great expectations of this robust, clever and good-natured boy. Despite financial difficulty the family strove hard to provide the boy with a decent education in the hope that he would become a scholar-official some day. As we shall see, later events in the life and career of Xu Guang-qi indicate that indeed his childhood had exerted a significant influence upon his character development and future career.

Throughout his career Xu Guang-qi placed heavy emphasis on agriculture. He saw in it the key to the establishment of a strong and prosperous nation. Growing up in a farming household and taking part in agrarian production since childhood undoubtedly played a key role in the formation of such a viewpoint. Along with

this viewpoint, growing up in a city like Shanghai which saw from mid 16th century the emergence of capitalism in the form of trading and family handicrafts (such as textiles) generated in Xu Guang-qi an awareness of the importance and complementary effect of trade and industry besides agriculture. In some sense such an awareness helped to shape in him a "Renaissance-like" open mind in his other pursuits later. In his working habits, as any good scientist should, Xu Guang-qi placed heavy emphasis on carefully-planned experiments and accurate, detailed observations, and always kept an open inquisitive mind. The habit of working in the fields and learning from experienced farmers since childhood was maintained and extended in his later career.

Stories about the plague of Wokous told by elders, especially his parents, cultivated in the young Xu Guang-qi a sense of patriotism and drew his attention to issues on national defence. According to his own account [13, p. 527] his mother, witnessing the persecution and even execution of patriotic generals by wicked ministers and eunuchs and fearing that her son might one day meet the same tragic fate, concealed from him all books which mentioned military tactics or weapons. Despite that, in the years to come, Xu Guang-qi was twice charged with the duty of training troops and of defending Beijing, the state capital. Xu Guang-qi sympathized with and cared for the common people, and discerned their sufferings and hardships. Among officials in the Ming Dynasty this was an unusual frame of mind. His upbringing had made him a straight, determined and industrious man of high principles who led a simple and frugal life even after he became a high official.

3. *Struggle on the Road to Officialdom through Examinations*

In 1581, at the age of 19, Xu Guang-qi took his first successful step on a long and arduous road to become a scholar-official by passing the local examination, thus becoming a Xiucai[1] which meant literally "cultivated talent". With this title came the elevation in social status as well as the entitlement to do some tutoring both in public or in private. Xu Guang-qi could now earn a living by giving lessons while at the same time he continued his studies in preparation for examinations at a higher level. He got married the same year and a son was born to the young couple two years later. His wife was a skilful weaver who had the reputation of accomplishing triple the amount an ordinary worker could produce in one day. With this competent new addition to the family's labour force and with the small remuneration Xu received from his tutoring, the family income might have improved somewhat for a brief period. However, Xu's parents were getting old and could no longer take part in farming or weaving. Xu's

grandmother passed away in 1585. The family livelihood soon fell upon the shoulders of the young couple who had by then raised a family of their own. And in those years, the area they lived in was constantly plagued by disasters such as rain-storms, flood or drought. The family again lived in poverty. By one account written by his grandson [4, p. 51], Xu Guang-qi travelled to attend the triennial provincial examination held at Taiping (now renamed Dangtu in the Anhui Province) in 1588 during this poverty-stricken period. He did not have enough money to travel by boat all the way but had to walk on foot carrying his own luggage. The situation was made worse by a heavy downpour, so heavy that he could not discern where the narrow slippery cobbled path was leading. This path ran along a torrential river so that one slip of the foot would mean getting drowned. While he was laboriously groping on his way his family fared no better at home, for what little food or money they had saved up had been given to Xu for his trip. As a matter of fact, the account goes on to say that one day the family only managed to keep off starvation by means of a single gourd plucked nearby. The same biographer also gives an account of a long trip to southern China that Xu took with the Zhao family who hired him as a tutor in 1596. Dressed in shabby clothes covered with patchwork here and there, he frequently engaged himself at night in needlework to put even more patchwork onto the few shabby clothes he possessed [4, p. 58].

Xu Guang-qi led such a poverty-stricken life for quite some time, for he failed some four to five provincial examinations before he finally passed in 1597 and became a Juren 舉人 which meant literally "recommended man". Only then were his social status and financial situation improved so that he could devote more time to his study in preparation for further examinations. Counting from his first attempt at a provincial examination in 1582, one year after his early success at the local examination, fifteen years had passed! Were he living in a more well-to-do household so that he could devote more time to study, he might have attained the title of Juren at a much earlier date. And because he failed to attain this title he could not improve the family's financial situation which in turn delayed his attainment of the title. However, as we shall see later, poverty was but one factor, perhaps even a minor albeit related factor compared with others which thwarted such a brilliant scholar in getting the recognition he well deserved at an earlier date.

The title of Juren was not yet the destination on the long road to officialdom, but only a qualification that allowed one to attend the national examination held at the state capital. Xu must have attended several of these examinations and failed. He finally passed in 1604

and became a Jinshi [h] which meant literally "Qualified Official". At a subsequent Court Examination given to all three hundred and eleven Jinshis of that year Xu Guang-qi came fifty-fifth and was placed in the third grade. His ranking, as it stood, was not high enough to qualify himself for a further examination to select candidates for the Hanlin Academy[i] which was the training institute for prospective ministers of the state. By a fortuitous coincidence, his former teacher Huang Ti-renj was also among the successful candidates at the Court Examination and ranked higher to gain a place for the selection examination. Huang Ti-ren, who was already 63 years old by then and who always had a high opinion of Xu from the time Xu became his student at the age of 16, recommended this former student of his to take his place on the pretext that he was already too old for the selection. Xu took the examination and came fourth, thus he was selected as one of the twenty four to enter the Hanlin Academy. It was almost a quarter of a century since passing the local examination that the 42-year-old Xu Guang-qi for the first time felt the relief of having finished this long and arduous struggle that most Chinese intellectuals of his days went through.

Started in the Sui Dynasty [k] (581-618) and perfected in the Tang Dynasty [l] (618-907) and the Song Dynasty [m] (960-1279), a system of civil service examinations was introduced with the intention of selecting capable and cultured men of high intelligence to serve the ruling class in governing the country and presumably also of keeping the intellectuals under control. As a side effect, such a recruiting exercise made it possible for a common citizen to enter officialdom and created a high degree of vertical mobility as well as fluidity in social-political status. Families of peasant ancestry might gradually rise into the scholar-official class and then sink out of it again. In this sense, it helped to break the hereditary nature of governance, and when properly implemented could supply an efficient and capable administrative group. In the Tang Dynasty, civil service examinations were given in a relatively broad spectrum of expertise, but by the Ming Dynasty the syllabus was limited to the "Four Books and Five Classics" and even more restrictively to the interpretation of them by Zhu Xi [n] (1130-1200), a Song philosopher of the Neo-Confucian school of the 12th century. In the 15th century, even the style of writing was dictated by the authority. Known by the name of "eight-legged essay" this prescribed form was composed of eight paragraphs, no more and no less. Its strait jacket effect lay not so much with the style as with the content, which was to explain a passage taken from the "Four Books and Five Classics" according to the orthodox interpretation and not according to the opinion of the writer of the essay. As such, an "eight-

legged essay" was a neatly-packaged bag of clichés that adhered to strict rules of observance. It was a usual practice for candidates preparing for the examinations to commit to memory a large collection of essays written beforehand on different passages taken out from the "Four Books and Five Classics" in the hope that some would come up in the examination they took. Certainly, this kind of drilling would not cultivate independent and critical thinking. On the contrary, which was what the ruling class was aiming at, the minds of the intellectuals were shackled and inventiveness was stifled. Instead, a majority of scholars were channelled into thinking that officialdom was the sole purpose of life and every bit of effort should be spent in mastering the old sayings of the "Four Books and Five Classics" without time for paying attention to anything else. This frame of mind created an ironic state of "scholarship-ignorance" and was best described as pedantry. Many scholars literally spent their whole lives in taking these examinations without accomplishment of any other kind. However, some scholars felt the detrimental effect and chose not to conform with this system and thereby dissociated themselves from officialdom. Two illustrious names in the history of science of the Ming Period were Li Shi-zhen[o] (1518-1593) who compiled "Compendium of Materia Medica" [p] in 1578 and Song Ying-xing [q] (1587-?) who compiled "Exploitation of the Works of Nature" [r] in 1637. Both books are recognized as landmarks in the history of science and technology, but these authors were not accorded comparable recognition in their country in their time. While Li became a Xiucai at the age of 14 he failed thrice at the provincial examinations. While Song became a Juren at the age of 29, he failed five times at the state examinations. It was therefore not without vexation and bitterness that Song said at the beginning of his masterpiece: "Let the ambitious scholar toss this book onto his desk without a further glance, for it has absolutely nothing to do with the art of attaining fame and officialdom!" [17, p. 125]. Not only was the study of science and mathematics held in low esteem because it could bring no fame and officialdom, it was even despised by some as "evil tricks".

Xu Guang-qi took a path different from scholars of the two categories described above, but he paid a price by spending twenty three years on it! He differed from scholars in the second category in that he persisted in finishing the long and arduous struggle even though he was well aware of its detrimental effect. Years later in a letter to his son written in 1619 [13, p. 496] he told his son how his grandsons should prepare for the local examination, but he also finished by saying: "It is preposterious that our generation has spent our whole lives crawling along this rotten path!" In an official memorial addressed

to the emperor in 1629 he expressed concern at the uselessness of the "eight-legged essay" [13, p. 441], but as was to be expected the authority paid no attention to his concern. This feeling notwithstanding he was determined to attain officialdom through examinations, not because he wanted personal fame, wealth and power but because he was of the opinion that this was the only way to execute the plans he had in mind to build a strong and prosperous nation. His later career as an official bore out this noble intention, but it also indicated how a single person could hope in vain to improve a socio-political system which was basically hopeless and decadent. Because he viewed officialdom in a different light he was also strikingly different from scholars in the first category in that he paid much more attention to pursuits he valued, including agriculture, science, history, political science and the like, and looked upon "eight-legged essays" as a necessary chore. However, one should not be led into thinking that Xu Guang-qi was not a proficient writer of essays. On the contrary, as a youth he was already praised by many for his organized and resourceful essays which displayed critical thinking and broad knowledge.

However, true scholarship alone might not ensure success in examinations in those days. Despite measures to prevent fraud and favouritism these examinations were not completely free from the influence of wealth and power. To mention just one instance, which was unfair but which was not too deceitful compared with other more disreputable means, I shall cite the buying of a place to sit for the provincial examination at the province where the state capital was situated and where the selection was not as strict in favour of the candidates who came mostly from local wealthy and powerful families. A poor candidate like Xu Guang-qi was in no position to afford the sum of money to buy such a place even if he wished to do so. But after several attempts Xu might have tried this means with the help of a wealthier family whom he found in Zhao Huan[s]. One reason which led him to accept the offer of the Zhao family to become a private tutor for their son in the far away southern province of Guangxi was probably to secure an opportunity to accompany his pupil to attend the provincial examination at the province where the state capital was situated and to attend it himself as well. But even with that advantage there was still a problem concerning the examiners who were not always accomplished scholars themselves and, being brought up in such a system, valued orthodox clichés more than new ideas they were unaccustomed to. Indeed, in that examination of 1597, when the local examiners carried out the preliminary rating, Xu's papers were discarded as of inferior quality. Luckily one of the chief examiners that year was Jiao Hong[t], a true scholar worthy of his fame. He felt so frustrated at being unable to

select a top-ranking candidate that he decided to read even all the papers rejected by the local examiners. When he came to that of Xu Guang-qi he immediately recognized its value. Upon further reading he was so immensely impressed that he placed Xu Guang-qi first in the list of Jurens in that provincial examination of 1597 [4, p. 59].

Some may wonder whether a span of twenty three years is worth the waiting. But for Xu Guang-qi those twenty three years were not at all wasted. Although he lived most of the time in poverty, he studied hard. Even after he became a Juren he still lived on meagre meals of congee but feasted daily on academic discussion or relaxed in songs and poetry with his pupils and friends [4, p. 63]. When he was at home he also took part in the farming. When he travelled to other places he learnt from the local people about various topics. In this way his outlook was broadened and his knowledge increased. This long period of study proved to be of significant value in his career ahead.

4. *Career as an Official*

It is helpful to put things into perspective if we have a general picture of the Ming government before we go into an account of the career of Xu Guang-qi as an official. (See also [3, 11, 22, 28, 30].)

The founder of the Ming Dynasty, Emperor Hongwu,[u] whose name was Zhu Yuan-zhang[v]—but we shall follow the usual practice of referring to the emperor by the title of his reign, was a man of undoubted ability but also a man of cruelty and paranoia. He harboured distrust of his ministers and generals, including even those who had risked their lives to assist him in securing the throne, to such an extent that he purged them ruthlessly under any pretext, some of which were perhaps justifiable but most of which were tenuous or even groundless. The two most notorious cases of wide-spread execution were those involving Hu Wei-yong[w] in 1380-1390 and Lan Yu[x] in 1393. Hu was the prime minister at that time but had built up such considerable power and influence around himself that Hongwu wanted to put an end to it. Under an accusation of plotting against the emperor, Hu and his accomplices were put to death. Hongwu made use of this incident to execute a large number of officials, some of whom might only be remotely related to the group of Hu. To serve a stern warning to his subjects, he even ordered the execution of all offspring and relatives of those involved, resulting in the loss of some thirty thousand lives in a span of ten years. A similar purge was directed at military officials when General Lan Yu was executed for alleged treason, this time resulting in the loss of some fifteen thousand lives. Even some aristocrats who had by then died got implicated and their offspring were executed

in their places. Hongwu even had people executed on the suspicion of making puns with words regarding his person! He also started the inhuman and humiliating practice of public beating at the Imperial Court as a form of punishment to high officials who displeased him. It was said that during his reign officials bade farewell to their families each morning when they went to office and felt greatly relieved if they returned home safe and sound in the evening. To place his subjects under surveillance and to carry out large scale arrests and executions Hongwu set up his sect of secret police known as "Guards in Ornate Garb". But the one thing he did which inflicted even more far-reaching damage on the country, and ironically ultimately led to the demise of the rule of the Zhu's family, was the abolishment of the prime ministership and the Central Chancellery after the execution of Hu Wei-yong. He even prohibited any future proposal to restore the prime ministership by decreeing for posterity whosoever so proposed would be put to death! In place of the Central Chancellery, six ministeries, viz. of personnel, revenue, rites, war, justice and public works were established to assist the emperor in handling all administrative matters. The emperor would still need some scholars to act as secretaries to help him in going through the hundreds of daily official memorials and in the writing of imperial edicts. This led to the establishment of a Neige [y] which meant "inner cabinet", comprising a few Grand Secretaries. In the ensuing years of the dynasty, these Grand Secretaries gradually assumed more important status and became the chief officials of the Imperial Court. But at the beginning they were no more than what their titles suggested. Hence, all political and military power was even more centralized in the hands of the emperor. With the power also came heavy demands upon the emperor's energy and competence. A weaker emperor would then rely on his cabinet so that gradually the Grand Secretaries took on the role of a prime minister except that without the legally vested authority a prime minister possessed the Grand Secretaries could only derive their power and influence from the favour or trust of the emperor himself. Officialdom in the Ming Period was therefore marked with intrigue and court politics between different cliques. Worse yet, most emperors after the first few reign were under the influence of eunuchs who were closest to the emperor inside the place and might have even been in his company since childhood. By and by, even the Grand Secretaries could have no access to the emperor but had to depend on the eunuchs to maintain communication. Several emperors went so far as not to appear in their court to meet with his officials throughout his reign. Emperor Wanli [z], during whose reign Xu Guang-qi began his career as an official, did not meet with his officials throughout the forty eight years

of his reign! One can well imagine how little an honest dedicated official could do to right the wrong when the emperor was under the influence and manipulation of an unscrupulous wicked minister or eunuch that had risen to power. On the contrary, an honest dedicated official would as a rule fall victim to this reign of terror and decadence, sometimes even lose his life. The eunuchs set up their own organizations of secret police in the course of time, increasing to three in number by the beginning of the 16th century. Eunuchs were also appointed as tax supervisors sent to the provinces and as military supervisors sent to strategic cities. The whole country was thus under tight control in the hands of these powerful unscrupulous men who colluded with local officials or landlords of equally base character. Common people lived in misery in those times, hence it came as no surprise that the Ming Period was noted for numerous uprisings by peasants, some lasting for decades and covering large areas. Such uprisings coupled with invasion from the northeast by the Manchus who rose in power from the first decade of the 17th century finally brought the Ming Dynasty to its downfall in 1644.

Xu Guang-qi entered the Hanlin Academy in July of 1604. The Hanlin Academy was set up as a training ground and research institute for prospective high officials, more or less a reservoir of future heads of the six ministries and eventually Grand Secretaries. Candidates in the Academy studied under the tutelage of experienced senior officials for a period of three years during which they researched on political science and current affairs and prepared reports thereon. Some of these reports were in the form of mock official memorials addressed to the emperor advising him on how to deal with problems arising in the empire. Xu Guang-qi took this opportunity to point out in his mock memorials the inadequacy and mismanagement in the administration and laid out his well-thought plans. From these we can appreciate his deep concern for the well-being of his country, his analytical scientific approach in examining the issues, his wide range of knowledge and his courage in speaking out his mind. The three most noted mock memorials he wrote in this period concerned three separate but related issues: (1) on national defence in the northern frontier (1604 [13, pp. 1-10]), (2) on allowances for royal dependants (1604 [13, pp. 13-19]), (3) on transportation by canals (1607 [13, pp. 19-36]).

Besides studying at the Hanlin Academy, Xu Guang-qi spent a lot of time studying science and technology on his own, for he strongly believed in their worth in building a strong and prosperous nation. It was during this period that he assimilated a remarkable amount of Western science including mathematics, astronomy and hydraulics

from the Catholic missionaries, notably from Matteo Ricci (1552-1610), the most prominent Jesuit missionary in China in the Ming Dynasty. Ricci entered the Society of Jesus in 1571, studied at Collegio Romano from September 1572 to May 1578, and was soon afterwards sent on his China mission. He reached Macao, a port in southern China occupied by the Portuguese, in August 1582. Early contact with Europeans in the 16th century, the first being the Portuguese who came in double capacity of pirates and merchants, had left the Chinese people with a feeling of distrust and resentment. The brutal behaviour of other Europeans who followed, such as the Dutch, the Spaniards and the English, only aggravated this uneasy relationship. In 1557 the Portuguese gained a permanent foothold by occupying Macao which developed into a settlement and centre of trade. After the pirate-merchants came the Roman Catholic missionaries who used to enter China through Macao. To ease the hostile feeling the Chinese harboured against foreigners, many missionaries tried to learn the Chinese language, dressed in Chinese clothes and as far as possible adopted the Chinese way of living. Ricci, who adopted a Chinese name Li Ma-dou [aa], was a brilliant linguist, so he not only learnt the Chinese language but mastered it to such an extent that he could study Chinese classics. Coupled with his knowledge of Western science he soon impressed the Chinese intellectuals who came into contact with him as an erudite man of learning, thereby commanding their trust and respect. Xu Guang-qi first got to know Catholic missionaries in the southern coastal province of Guangdong, perhaps only incidentally. One day in 1595 when he was teaching at Shaozhou (now renamed Shaoguan) he strolled up to a Catholic church and met Father Lazzaro Cattaneo (1560-1640), whose Chinese name was Guo Ju-jing[ab] and with whom he engaged in pleasant conversation [4, p. 57]. He probably got to know Ricci through Cattaneo and actually met Ricci five years later at Nanjing. Xu was impressed by Ricci's exposition of religious and philosophic subjects which he found enlightening and also by Ricci's broad knowledge of Western science and technology which he found completely new. Brought up in the Confucian tradition Xu was well-versed in the Confucian philosophy but found the speculative and metaphysical ideas of Neo-Confucianism and Buddhism prevalent at that time unsatisfactory. While looking for a substitute he happened to come upon the Catholic missionaries who were at that time concentrating their effort on converting the highly educated elite class to Christianity. In January 1603 Xu Guang-qi was baptized under the Christian name Paul [4, p. 69]. He commented on his view of Christianity in the preface to his "Western Hydraulics"[ac] in 1612: "These Western scholars came to our country with their profound knowledge and high virtues. Soon after their arrival, they were able to win our

admiration. We all admire their sincerity, their proper conduct, their solid scholarship, and their trustworthy character. Their religious doctrine is based on the purification of human nature and the worshipping of God. Their religious regulations, which are based on absolute justice, can be observed by everyone. ...I believed that their religion can supplement Confucianism and replace Buddhism" [13, p. 66]. In the history of Catholicism Xu Guang-qi was hailed as the "greatest glory of Chinese Catholicism" [19, p. 67]. Without his support and assistance the missionaries could not have accomplished so much in spreading their faith in the Ming Dynasty. Together with Li Zhi-zao[ad] (1566-1630) and Yang Ting-jun[ae] (1557-1628), they were referred to as "three pillars of the Catholic church in China".

But during 1604-1607 when Xu Guang-qi visited Father Ricci whenever he got the chance his interest and attention lay elsewhere. He mentioned in the same preface referred to in the preceding paragraph: "Among the lesser teachings of these Western scholars are methods which enable people to understand the reasons for all kinds of things existing in this world or out of this world. ... Within this method of investigating and understanding things comes forth a science of numbers [mathematics] which can be applied to calendarial calculation and musical systems or to all objects with shapes and substances, and to all phenomena involving measures and numbers. Such applications are of utmost intricacy and refinement" [13, p. 66]. It was the "lesser teachings" he was after during those visits to Ricci, namely Western science and mathematics. The most significant accomplishment during this period was the translation of the first six books of Euclid's "Elements" into Chinese in 1606-1607. As far as the scientific career of Xu Guang-qi was concerned, this three-year period was an extremely intensive and fruitful continuation of the twenty three years of perhaps off and on scientific study. It is amazing how much new knowledge he had mastered in this short span of three years.

In April of 1607 Xu Guang-qi completed his studies at the Hanlin Academy and was appointed a Corrector of the Academy. Unfortunately his father died in May and according to tradition he had to resign his official position and return home (Shanghai) with his father's coffin to observe a three-year period of mourning. Xu Guang-qi turned those three years to good use by performing agricultural experiments in the fields while at the same time putting the finishing touches to his several works in mathematics. It is fair to say that these three years at Shanghai plus the preceding three years in the Hanlin Academy were the foundation years of the scientific career of Xu Guang-qi. He returned to Beijing in December 1610 to resume his office. In April of that year Ricci passed away and so Xu had lost his most esteemed

teacher and friend. But in place of Ricci came several missionaries who were even better trained as astronomers. Ricci had urged his superior as early as 1605: "I address to Your Reverence urgent prayers for a thing which I have for long requested and to which I have never received any reply: it is to send from Europe ... a Father or even a Brother who is a good astronomer. ... With our maps of the world, dials, spheres, astrolabes and other instruments which I have constructed and explained, I succeeded in acquiring the reputation of being the greatest mathematician in the world. ... Consequently, if this mathematician were to come to China, after we had translated our tables into Chinese, which would be very easy for me, we would undertake the task of correcting the calendar, and, thanks to that, our reputation would go on increasing, our entry into China would be facilitated, our sojourn there would be more assured and we would enjoy greater liberty". [18, p. 56]. These newcomers included Nicolaus Longobardi (1559-1654) with Chinese name Long Hua-min[af], Didaco de Pantoja (1571-1618) with Chinese name Pang Di-wo[ag] and Sabbathino de Ursis (1575-1620) with Chinese name Xiong San-ba[ah]. They were all brought to Beijing at that time at the suggestion of several officials who proposed to launch a large scale project of reforming the calendar owing to an erroneous calculation of a solar eclipse on the same day Xu Guang-qi resumed his office. For a brief period of two to three years there went on a series of semi-organized activities by supporters of the project including Xu Guang-qi and Li Zhi-zao and the Jesuit missionaries in translating and studying Western books on astronomy and making astronomical instruments. However, the project was never actually launched because Emperor Wanli never issued an official approval, perhaps out of neglect but presumably more likely owing to opposing views from some high officials. By and by, the proposed project came to nought. But the proposal and the activities had already offended those who opposed the introduction of Western science and technology and created ill-feeling between the two factions.

In 1613 Xu Guang-qi felt the pressure of such opposition from some officials in the Imperial Court, and also of reproach from Wei Guang-wei[ai] whom he offended during their assignments as examiners for the national examination that year. He took sick leave in October and spent another three years or so in performing agricultural experiments at Tianjin. He returned to office in July of 1616 only to get himself involved in another controversy, the Nanjing Persecution of Christians initiated by Shen Cui[aj] who was then Vice-President of the Ministry of Rites at Nanjing. According to a modern Jesuit scholar, the motives of this persecution, besides personal dispute, involve a deeper issue: "Whatever personal motives may have contributed to

Shen's hostility, his opposition had its roots in Sung orthodoxy. The persecution which he led represented the first large scale counterblow of the school of orthodox reactionaries against innovation". [19, p. 129]. Xu Guang-qi spoke out in the defence of the missionaries in an official memorial. He refuted the charges made by Shen against the missionaries, but to no avail, for Shen had the support of Fang Cong-zhe[ak] who was then Minister of Rites and concurrently Grand Secretary of Dongge. Even before the emperor signed any edict, Fang instructed Shen to have the missionaries arrested anyway. In February of 1617, Emperor Wanli issued his edict which reprimanded the Jesuits for preaching an unknown doctrine and for having, under the pretext of religion, troubled the tranquility of the people and conspired to incite an uprising against the state, and hence decreed that the missionaries were to be driven out of China. Many Jesuit missionaries including de Pantoja and de Ursis were banished to Macao and died there, but some remained in China under the shelter of officials who were converts such as Xu Guang-qi, for the persecution was carried out in earnest only at Nanjing. However, in this connection, transmission of Western science and technology was seriously hampered and for some time almost stopped. Perhaps as a measure to ease the tense situation within the Imperial Court, Xu Guang-qi was dispatched in July of 1617 to far away Ningxia to deliver the official title of Prince Qing to a royal prince. Following custom, the prince sent him a gift of two hundred tales of gold together with other valuable items, all of which Xu declined. To him, the much more valuable harvest of this trip was a study tour of agriculture and hydraulics in the northwestern part of the empire. But because of the long and exhausting trip he fell very sick after returning to Beijing in October. He was also at odds with a number of officials who were either jealous of his rising prestige or displeased with his support of the missionaries. Feeling fatigued, disappointed and frustrated he took sick leave again and resumed agricultural experiments at Tianjian.

However, he did not have a peaceful period of study this time, for Nurhachi [al], a Jurchen [am] chieftain who started as a commander appointed by the Ming emperor in charge of his tribe and who rose to power by uniting other Jurchen tribes and proclaimed himself Emperor of the Late Jin Dynasty[an] in 1616, launched his attack on the northeastern part of the Ming empire on the pretext of avenging the death of his father and grandfather killed in 1582. The Ming forces suffered heavy losses and several cities fell. Xu Guang-qi was ordered to return to the state capital because he was noted for his knowledge of military affairs. Xu had not completely recovered from illness, but as a patriotic duty he hurried back to resume office. (The

son of Nurhachi declared in 1636 the establishment of the Qing Dynasty[ao] in place of the Late Jin Dynasty, implying the creation of a new dynasty entitled to rule the whole of China. And in this connection he also declared the use of the name "Manchu"[ap] for "Jurchen" to erase a connotation of Chinese dominance. In our subsequent account we shall therefore refer to this rising power as the Manchus.)

Just as Xu Guang-qi was returning to Beijing, Yao Gao[aq] was appointed as Administrator of Liaodong to stop the Manchu invasion. Yang amassed a vast army of 80,000 men. But by an erroneous deployment which proved fatal, this vast army was completely shattered by the Manchu force which was only a quarter of its size. Extremely worried by such military performance Xu Guang-qi submitted three official memorials in succession to explain his plan of training troops. This led to his appointment as Junior Supervisor of Imperial Instruction and concurrently Censor of Henan and he was charged with the training of troops. On paper Xu was given *carté blanché* to request any of the six ministries for money or supplies, but in practice this seemingly generous permission produced the opposite effect. Since no particular office had been designated to support this mission of recruiting and training troops and since the official titles bestowed on Xu had little to do with military matters, his requests were seldom met or at best only met half-heartedly. Officials when asked tried to push the responsibility on someone else. Worse yet, most military officials were under the impression that Xu must have received considerable funds and so would come to him for help when they were turned down by the Ministry of War. In some instances Xu had to settle this out of his own pocket or ask donations of his friends! He was only provided with unqualified recruits and dilapidated armament despite his pleas. In one official memorial written in January 1620 he said: "These soldiers are not what I mean by soldiers; these provisions is not what I mean by provisions; this armament is not what I mean by armament. Looking back and looking ahead I am terribly frightened and feel so helpless". [13, p. 140]. He managed to get some money and started the training job again in April at Tongzhou. At that time he became aware of the superiority of Western artillery and wrote to his friends Li Zhi-zao and Yang Ting-jun in November, asking them to help raise funds to purchase Western artillery from Macao. Li and Yang did succeed in getting four Western cannons and dispatch them together with a small team of technical staff to Xu. But by that time Xu Guang-qi's health had deteriorated owing to over-work and frustration so that he had requested to be allowed to retire. Fearing that these cannons might fall into the hands of incompetent officials, Li and Yang decided to keep the cannons in store in the province of Jiangxi instead. Manchu

forces were on the move again and took several strategic cities. The 59-year-old Xu Guang-qi in poor health was summoned back from Tianjin in this time of emergency. He ordered those cannons sent to Beijing immediately and suggested that more should be manufactured based on these as models. In this way he introduced Western artillery into the Chinese army. But in July of 1621, disagreement with Cui Jing-rong,[ar] Minister of War, led to Xu's being censured and finally Xu requested to be allowed to retire to Tianjin once more. Thus ended in failure the first attempt of Xu Guang-qi to build up a strong army for the defence of his motherland. But it was reported that during later battles of defence, the troops that fought best and most courageously were those trained by Xu [13, p. 554].

During those years the Ming Dynasty saw a change of three emperors in a span of two months. Emperor Wanli died in August of 1620, succeeded by his son Emperor Taichang[as] who died in September and was succeeded by his son Emperor Tianqi[at]. It was during the first year of the reign of Emperor Tianqi that the most vicious eunuch in the Ming Period, by the name of Wei Zhong-xian[au], rose to power. Almost any honest decent official during this period was either fired, arrested or even executed. Persecution was particularly harsh upon a group of scholar-officials labelled as the Donglin Party[av] which started in the beginning of the 17th century as a group of scholars giving lectures at the Donglin Academy but gradually became a clique in the Imperial Court when some scholars in that group became officials and had their taste of power. A number of scholar-officials in this clique, some out of political contention but some out of righteous indignation, spoke out against fraudulence and corruption, in particular in opposition to Wei Zhong-xian and his followers. Many scholar-officials were thus arrested and executed with unspeakable cruelty. In attempting to retain a moral legitimacy which they never deserved Wei and his followers did try to arrange to have some respectable men appointed to office, especially those who did not belong to any opposing clique. Xu Guang-qi was a prime example. Many times he had expressed his abhorrence of clique politics: "Clique politics serves only to deplete the energy and talent of scholar-officials, but does nothing good for the well-being of the country and her people". [13, p. 474]. He was at that time staying at Shanghai on the pretext of sickness, but in February of 1624 he received an appointment as Junior Vice-president of the Ministry of Rites. Disgusted with Wei and his followers he refused to take up the post. This open display of contempt and non-cooperation angered Wei so that in June of 1625 Xu was censured by the Censor of Guizhou Zhi Ting[aw]. Of all things, the subject of reproach was the training of troops during 1619-1621. Zhi Ting accused Xu Guang-qi

of not only incompetence but fraudulence by claiming that in spite of his ignorance of military affairs Xu took on the job of training troops in order to direct funds and supplies into his own pocket, and as a result the troops so trained turned out to be totally useless. Zhi went on to accuse Xu of joining the Donglin Party in opposition to the administration and hence that he should not be allowed to stay in any post. Xu Guang-qi, in his usual logical and methodical practice, refuted Zhi's accusation point by point supported by solid argument and evidence in a proposed memorial which however he did not submit to the emperor, knowing too well the political climate of the time . At the end of this article he said, half in humour and half in bitterness: "Of all things said against me I find the invective referring to me as vicious and cunning so vague as not to warrant any defence on my part. I remember a well-known saying by an elder, that a cunning person is not dull-witted while a dull-witted person is not cunning. Now the reproach starts by saying that I am incompetent and pedantic but concludes by saying that I am vicious and cunning. Can the two persons be the same one"? [13, p. 217]. Perhaps it was just as well that Xu Guang-qi was penalized by being relieved of all posts so that he could stay away from the intrigue of the Imperial Court in those dark years. He spent his time in working on his monumental treatise "A Complete Treatise on Agricultural Administration"[aw] which was ultimately published in 60 volumes posthumously in 1639. (For Xu's contribution in agriculture, see [29, Section 6].)

Emperor Tianqi died in September of 1627, succeeded by his brother Emperor Chong-zhen[ay] who immediately eradicated Wei Zhong-xian and his followers and had those good officials previously fired reinstated. The 67-year-old Xu Guang-qi was certainly among those who returned to office. He was reinstated as Junior Vice-president of the Ministry of Rites and soon promoted to Vice-president of the Ministry of Rites the next year. In June of 1629 the Imperial Board of Astronomers which was under the Ministry of Rites miscalculated a solar eclipse. This incident caused the emperor great displeasure because in those days the ruling class placed heavy emphasis on rituals governed by calendarial reckoning. It led subsequently to the proposal of a large scale project on calendarial reform. Unlike what happened over fifteen years ago, the project this time was immediately launched since the directive came straight from the emperor. A Calendarial Bureau[az] was to be set up and put under the direction of Xu-Guang-qi. He enlisted the help of his friend Li Zhi-zao and two Jesuit missionaries Nicolaus Longobardi and Jean Torrenz (1576-1630) with Chinese name Deng Yu-han[ba]. Later with the departure of Longobardi and the death of Torrenz, another two missionaries, Gia-

como Rho (1590-1638) with Chinese name Luo Ya-gu[bb] and Johann Adam Schall von Bell (1591-1666) with Chinese name Tang Ruo-wang[bc], filled the vacancies as consultants.

Xu Guang-qi's work in the Calendarial Bureau was interrupted by a second Manchu invasion in the winter of 1629. The situation was extremely serious when the Manchus broke through the Great Wall and were at the doorstep of the state capital. In this time of emergency, Xu Guang-qi stepped forth once more to take up the job of defence although he was already 67 years old. This time he placed emphasis on Western artillery and its use in defending the city. If he was not sweating by the furnace supervising the casting of cannons he would be found at the rampart instructing and emboldening the soldiers "day and night, rain or storm, ignoring hunger or thirst" [4, p. 169]. In November of 1631 he detailed in an official memorial a plan to build up a strong army equipped with modern artillery and suggested that the plan could be put into practice by starting with the troops led by Sun Yuan-hua[bd], the Commander of Denglai who was his former student and was knowledgeable in Western mathematics and artillery. Unfortunately, in January of 1632 an officer under Sun Yuan-hua dispatched to Liaodong started a mutiny and struck back, even capturing Sun but later releasing him. This incident put an end to the second attempt of Xu Guang-qi to build a strong army. Furthermore it involved him in court politics. The chief official at that time was Zhou Ting-ru[be] and it was due to his recommendation that Sun Yuan-hua got his position as Commander of Denglai. Now that Sun Yuan-hua was facing trial for the mutiny (even though he was the victim of it) Zhou worked hard to rescue Sun from the death penalty. As the venerable Xu Guang-qi was the former teacher of Sun and his son, Xu-ji[bf], was Sun's father-in-law, Zhou tried to obtain his support. To lend him more strength, Zhou even arranged to have Xu become a Grand Secretary. In June of 1632, at the age of 70, Xu Guang-qi was appointed Minister of Rites and concurrently Grand Secretary of Dongge. The rescue of Sun came to no good and Sun was executed in September. The promotion of Xu to Grand Secretary did not provide him with any political authority in fulfilling his long-sought dream to make his country a strong and prosperous nation. For one thing he was old and not in good health. For another thing he was drawn into the "inner cabinet" through the one thing he had always been trying to avoid, namely court politics. Wen Ti-ren[bg], another Grand Secretary who was at the beginning patronized by Zhou, turned into a rival of Zhou, eventually ostracized Zhou and took his place in April of 1633. Xu Guang-qi could not escape the fate of being reproached as well. This deeply saddened Xu who by now must have

had lost all hope in the Ming government. His health was deteriorating fast. In December of 1630 during a night trip to the Observatory he fell down and hurt his back and knees seriously [4, p. 178]. In March of 1633 he suffered from serious illness and could hardly take his meals [4, p. 199]. Illness coupled with despair led him to submit an official memorial requesting retirement. Instead he was granted the additional title of Grand Guardian of the Heir Apparent and promoted to Grand Secretary of Wenyuange while at the same time keeping the post of Minister of Rites. However, those were empty titles as far as actual authority was concerned. In September of 1633 his illness got worse and he had to take leave and stay away from office to which he could never return. Politically he failed completely during those last two years of his life. In the Ming Chronicles[bh] it was said of him: "Guang-qi was a man of exceptional ability and aspiration for the well-being of the world. But when he was appointed to high office he was old and furthermore it was at a time dominated by Zhou Ting-ru and Wen Ti-ren, so he could not achieve anything". [13, p. 551]. During those last years he spent every bit of time, besides going through his daily routines as a chief official, on editing another monumental work of his, the "Chong-zhen Treatise on Astronomy and Calendarial Science"[bi]. According to two young scholars who visited him frequently to seek clarification in calendarial matters in those years, "the Master [Xu Guang-qi] was engaged busily in his writing in a small room with a single bed but no curtains, ... we have observed the Master in his calculation of latitudes, in such a meticulous manner that he did not stop until midnight" [14, p. 1]. Even when he was seriously ill during the last month, he still did his writing and reading of the astronomical treatise in his bed, for "industry had become part of his character as a result of hardwork since childhood, so much so that he was not even aware that his physical body was too weak to stand the work" [13, p. 559].

On October 31, 1633, he wrote an official memorial on his sick-bed to present the detailed calculation of a predicted lunar eclipse on February 15 of the next year. On the same day he submitted another memorial to report on the progress of the Calendarial Bureau and to recommend Li Tian-jing[bj] as his successor at the Bureau. On November 7 he wrote another memorial on his sick-bed to petition the emperor to reward his staff at the Bureau for their outstanding work, listing them one by one by name. On November 8 he wrote still another memorial to report the accounts of the Bureau and to hand over his seal and the imperial letter of appointment. On that same day this great man passed away without saying one word concerning himself and his family. When his family members went through his things

after his death, they found that he had practically no money left with only some worn clothes and lots of manuscripts in his possession. The blanket on his bed was worn through with a hole in it owing to water seeping out from the slightly cracked hot-water-pot he used for warming the feet in winter. When the news of Xu's death reached the emperor, he was grief-stricken and upon learning that Xu had left practically no money, he dispatched a high official in the Ministry of Rites to take charge of the funeral on his behalf, and he canonized Xu's as Wending[bk] [4, pp. 201-203]. (A brief chronicle of Xu Guang-qi is given in Figure 1.)

5. *Translation of "Elements" and Related Works*

In the years 1604-1607 Xu Guang-qi visited Ricci whenever time permitted him to do so. Topics of discussion shifted from Catholic doctrines to detailed study of Western science and mathematics, presumably on Xu's initiative. But this was in line with the tactics adopted by the Jesuit missionaries put clearly in Ricci's words: "whoever may think that ethics, physics and mathematics are not important in the work of the Church, is unacquainted with the taste of the Chinese, who are slow to take a salutary spiritual potion, unless it be seasoned with an intellectual flavouring. ... All this, what we have recounted relative to a knowledge of science, served as seed for a future harvest, and also as a foundation for the nascent Church in China". [27, p. 235, p. 332]. From Xu's point of view, Western science and mathematics held the key to the well-being of his country. Hence he was eager to learn as much as possible and as fast as possible, and furthermore to transmit such knowledge he had mastered to his countrymen. An expedient and necessary means would be to translate Western texts into Chinese. Xu Guang-qi must have conceived of the idea of translation when he first came into contact with Western science, and he continued to promulgate this idea in his later years. In the preface he wrote for "On Astrolabes"[bl] translated by de Ursis in 1611, Xu commented that Ricci once told him science progressed in the West through teaching and learning by generations of teachers and students for thousands of years so that each generation excelled the former; and he sighed for the situation in his own country where an eminent scientist appeared only every hundred years or so and only worked by himself; therefore he proposed that the large number of Western texts should be translated so that they could be accessible to a large number of capable scholars who would then assimilate in a matter of years the knowledge accumulated in three thousand years and thence would bring about development in science in China [13, pp. 72-74]. Years later when he was appointed in charge of the large scale enterprise of reforming

the calendar he organized another extensive exercise in translating Western texts. Of this he commented: "We honestly believe that if one wants to excel the previous system one must first understand Western astronomical works, and to attain a thorough understanding it is necessary to translate them". [13, p. 374].

According to Ricci's account: "Doctor Ciu Paul [Xu Guang-qi] had this one idea in mind: since volumes on faith and morals had already been printed, they should now print something on European sciences, as an introduction to further study, in which novelty should vie with proof. And so, this was done, but nothing pleased the Chinese as much as the volume on the Elements of Euclid. This perhaps was due to the fact that no people esteem mathematics as highly as the Chinese, despite their method of teaching, in which they propose all kinds of propositions but without demonstrations. The result of such a system is that anyone is free to exercise his wildest imagination relative to mathematics, without offering a definite proof of anything. In Euclid, on the contrary, they recognized something different, namely, propositions presented in order and so definitely proven that even the most obstinate could not deny them". [27, p. 476]. Ricci's comment on the complete absence of demonstration in Chinese mathematics indicated his lack of understanding of the ancient tradition in Chinese mathematics. However, he was not alone in this state of superficial knowledge, for even the Chinese themselves at that time did not realize the value of their mathematical legacy which by the Ming Dynasty was no longer preserved and nurtured in the way it should be [9, p. 120]. Xu Guang-qi was quite aware of this unsatisfactory state. In the preface he wrote for Li Zhi-zao's translation of Clavius' "Epitome Arithmeticae Practicae"[bm] in 1614, he said: "There are two main causes for negligence and dilapidation of mathematics in the past centuries. Firstly, scholars in pursuit of speculative philosophical studies despise matters of practical concern. Secondly, sorcery encroaches upon mathematics to turn it into a study filled with mysticism." [13, p. 80]. This perhaps explains why Xu Guang-qi was so attracted to the deductive logical approach of mathematics as exemplified in Euclid's "Elements". Ricci, who studied mathematics under Christoper Clavius (1537-1612), was trained in the classical tradition so that this ancient Greek masterpiece was to him the basis of any mathematical study on which he laid heavy emphasis. At first, Xu Guang-qi only suggested that Ricci should translate this important text with the help of some scholar paid for the job, but it did not work out well and Ricci told Xu that "only an intellect like yours is capable of bringing such an enterprise to a good termination" [18, p. 67]. Xu Guang-qi set himself to work and applied every bit

of spare time after his study at the Hanlin Academy to the job. He went to listen to Ricci's exposition of "Elements" every day in the afternoon and studied laboriously, and at night he wrote out in Chinese everything he had learnt [4, p. 81]. Ricci gave an account of this: "When he began to understand the subtlety and solidity of the book, he took such a liking to it that he could not speak of any other subject with his fellow scholars, and he worked day and night to translate it in a clear, firm and elegant style. ... Thus he succeeded in reaching the end of the first six books which are the most necessary and, whilst studying them, he mingled with them other questions in mathematics. He would have wished to continue to the end of the Geometry; but the Father being desirous of devoting his time to more properly religious matters and to rein him in a bit told him to wait until they had seen from experience how the Chinese scholars received these first books, before translating the others". [18, pp. 67-68]. Xu Guang-qi agreed, saying that he had at least started the project and if it proved worthwhile it did not really matter if he was the one to complete the project. However, when the translated version was revised and published in 1611 after the death of Ricci he wrote in the preface: "It is hard to know when and by whom this project will be completed". [13, p. 79]. Indeed, the completion of this project had to await two and a half centuries when the noted Qing mathematician Li Shan-lan[bn] (1811-1882) translated the remaining nine books of "Elements" with the collaboration of the British missionary Alexander Wylie (1815-1887) in 1856. (This long delay is a question which is worth investigating [6, 20]. The first Chinese translation by Xu and Ricci was based on the fifteen books of the Latin version of Euclid's "Elements" (believed to consist originally of thirteen books compiled at around 300 B.C.) edited by Clavius in 1574. It was the first Western text to be translated into Chinese. On the title page was written "dictated by Li Ma-dou [Ricci] and copied by Xu Guang-qi", which was a gross understatement of the labour and scholarship that this undertaking demanded. For Xu Guang-qi this was not just a translation job but a fruitful experience of fervent study which initiated him into the realm of Western mathematics. In a preface and a prelude to this translation published in 1607 he heaped words of praise on the book. Owing to limitations imposed upon him by his training and by the lack of knowledge of contemporary Western mathematics, which was not transmitted into China by the Jesuit missionaries, some of his comments sound like over-valuation, and in hindsight due to our knowledge of mathematics some of his comments were even incorrect. But judging by standard of his times and circumstances, his comments indicated a deep understanding of the crucial features of the book in particular

and Greek mathematical thinking in general, and they were not just empty words of praise. For instance, an unusual sensitivity to the postulational approach of mathematics, which was so foreign to the tradition of Chinese mathematics, was displayed in a passage: "As one proceeds from things obvious to things intricate, doubt is turned to conviction. Things that seem useless at the beginning are actually very useful, for upon them useful applications are based. It is no exaggeration to describe this study as the envelopment of all objects and phenomena, and the sea where all streams of study will converge." [13, p. 75]. (As pointed out by Engelfriet [20, p. 112], it was not Euclid but Clavius who was translated, and the true "spirit" of Euclid had not always been conveyed in these later European redactions. However, even in this version of "Elements" by Clavius Xu discerned the features of a postulational and deductive nature.) In the prelude he gave a critical review of the book commenting on the logical sequence of the propositions, the organization and the clarity of the exposition, the good working habits it would cultivate in the readers, and on some main points of merit [13, pp. 76-78]. It is particularly of interest to read what he said at the end where he parodied one verse of an old poem. The original verse was: "Though I present you with this beautiful needlework of mandarin ducks, I will never give anyone my golden needle." He said that the aim of the book was to do exactly the opposite, and rendered the verse: "Though I give my golden needle to everyone, I have not made anyone a needlework of mandarin ducks." With a golden needle one can make his own needlework of mandarin ducks, while if one can obtain the needlework easily from others nobody would learn to use the golden needle [13, p. 78].

Since this was the first Western text to be translated into Chinese, all mathematical terms in Chinese had to be coined, and this was no easy task since they had to convey the correct mathematical meaning and at the same time conform to the traditional use of Chinese words. In this Xu Guang-qi succeeded admirably so that many terms were adopted by later mathematical texts and are even in use now, almost four centuries later. It even exerted influence upon the coining of mathematical terms in Japanese and Korean in later years because of the influence of China upon those countries. Of particular interest is the modern Chinese term for geometry, namely "Ji-he"[bo]. In fact, the title of the translated version of "Elements" by Xu and Ricci was rendered "Ji-he Yuan Ben"[bp] meaning the "Treatise on the Elements of Ji-he". Some people interpret the term "Ji-he" as a transliteration of the Western word "geometry", but there are two reasons against this view: (1) the title of Clavius' edition of "Elements" is "Euclidis elementorum libri XV" where nowhere does the word "geo-

metry" appear, (2) Jesuit missionaries in those days were rather cautious about adopting anything "un-Chinese" and transliteration was considered to be such. Added to the intrigue is the fact that "Ji-he" means "how much" in Chinese, and that this term appeared very often in ancient Chinese mathematical texts. A possible explanation lies in the use of Xu Guang-qi of the term "Ji-he" in translating the term "magnitude" in Book Five of "Elements". We have to admire the care Xu Guang-qi exercised in choosing a right word for this central but difficult notion in Book Five which expounds Eudoxus' theory of proportion. Today we translate this technical term "magnitude" by "liang"[bq], which also carries the meaning of "quantity" in daily use. Xu Guang-qi preferred to coin a completely new term for it and settled on a term which frequently appeared in ancient Chinese mathematical texts. Moreover, he even selected this term as a key word to be put in the title of the book. Again we have to admire his perceptiveness in grasping the significance of this notion of "magnitude" in "Elements". Indeed, if one takes a look at Book Ten of "Elements" (of which Xu Guang-qi might not have had a chance to learn!) one will appreciate the significance even more. As times pass, the original technical meaning of "Ji-he" as "magnitude" gets forgotten. Instead, it acquires a new meaning as the subject "geometry" because the "Ji-he Yuan Ben" comprises of the first six books of "Elements" which deal with properties of geometric figures, what we now classify as geometry.

The method of translation by Xu and Ricci set a model for the means of dissemination of Western science in China in the ensuing two hundred and fifty years. It involved two men, one Chinese and one Westerner. The Westerner, who had to understand Chinese to some extent, would read the Western text in rough Chinese translation to his Chinese co-worker who did not understand any Western language. The Chinese co-worker would take down the rough Chinese translation and discussed with his Western co-worker points he failed to understand until those were clarified. When all queries were resolved, the Chinese co-worker would smooth out the rough Chinese translation and write it out in Chinese. This method, required both the Westerner and the Chinese to be acquainted with the subject matter, and in many cases the Chinese co-workers became well-versed in the subjects they helped to translate as a consequence. But the drawback is apparent, as such an indirect method of translation not only affected the accuracy in the translated content but also confined propagation of the disseminated knowledge to a small circle in a tardy pace.

After they finished translating the first six books of "Elements", Xu Guang-qi and Ricci collaborated in the same way to translate another text "Essentials of Surveying"[br]. Xu Guang-qi was interested in

surveying in connection with his concern about irrigation as early as 1603 when he laid out a plan of surveying river works. At that time he had not studied Western methods but relied on traditional Chinese mathematics. Now that he had learnt the Western methods and Greek geometry he tried to compare the two and actually supplied explanation by utilizing the knowledge he gained from "Elements". This new line of pursuit was carried out in an appendix he wrote for "Essentials of Surveying" and was titled "Similarities and Differences Between Chinese and European Surveying Techniques"[bs], published in 1608. A comparative study of similar nature was carried out for the very important central theme of "Gou-gu"[bt] in "Meaning of the Right Triangle"[bu] published in 1609. Many problems involving computation in a right triangle in the ancient Chinese text "Nine Chapters on the Mathematical Art"[bv] were given proofs in the deductive tradition of Euclidean geomerty, referring to propositions in "Elements". In the Qing dynasty, because of the availability of the Chinese version of "Elements" due to Xu more and more mathematicians were drawn to works of this kind. Several noted Qing mathematicians benefited from studying this translation of "Elements" and produced texts written in the same style [16, p. 44]. In this way, the translation of "Elements" by Xu Guang-qi contributed to the development of Chinese mathematics in the way he envisaged. However, it was much later—not until the beginning of this century—that Euclidean geometry found itself a part of the school curriculum in China, much later than Xu predicted when he said, "Few people study it now, but I surmise that everybody will study it a hundred years from now, at which time they will regret that they study it too late!" [13, p. 77].

It is amazing that one can succeed, like Xu Guang-qi, in coming to grips with such a large amount of mathematics presented in such a different style and approach to the mathematics one is accustomed to in such a short span of time. It is interesting to speculate how much Xu Guang-qi would have achieved as a mathematician if he had concentrated his effort on this one discipline; and whether or not, if he had known more about contemporary commentaries on "Elements" that he would have been drawn, like so many mathematicians in other parts of the world, to the controversial and far-reaching question concerning the Parallel Postulate that ultimately led to the discovery of non-Euclidean geometry. But of course he did not pursue along this line because he had in mind a more major programme which will become apparant in the next section.

6. *Calendarial Reform*

In the second period of his officialdom (1628-1633) Xu Guang-qi did not achieve anything in the political arena, but in the scientific

domain he accomplished a great deal in organizing a large scale enterprise of calendarial reform. Perhaps the satisfaction derived therefrom could compensate for his failure in politics. In the preface to his "Meaning of the Right Triangle" of 1611 he had commented that calendarial studies were not as urgent as waterworks and hence did not claim priority [13, p. 84]. Why therefore would he devote himself so enthusiastically twice to the proposal of calendarial reform, once during the reign of Emperor Wanli but which died a natural death, and once toward the end of his lifetime? We can try to find the answer in his official memorials addressed to this issue.

Since very ancient times calendarial reckoning was a major function of the Chinese government, which is usual for a nation based on agriculture as Needham says: "The establishment of the calendar by the emperor of an agricultural people, and its acceptance by all those who acknowledged allegiance to him, are threads which run continuously through Chinese history from the earliest time...." [25, p. 171]. The Ming Calendar, under the title of Da-Tong-Li [bw] meaning "Calendar of the Grand Unity" was actually a modification of the Shou-Shi-Li[bx] prepared by the great mathematician-astronomer Guo Shou-jing[by] (1231-1316) in the late 13th century. But for over two hundred years essentially no adjustment was made even though prediction of solar or lunar eclipses were often found to be erroneous. A prevalent conservative opinion in the Imperial Court opposed any change on the ground that what was handed down by the ancestors should be observed without alteration. Imperial astronomers had their own reason for fear of a reform in the calendar because their privileged positions were hereditary. Private studying of astronomy was prohibited by law so that no change could be initiated from outside the Imperial Court. By the early 17th century knowledge of the imperial astronomers was at best rudimentary and the reaction to any reform was even more hostile. Although there was a proposal for reform during the reign of Emperor Wanli, and for a time some preliminary work was carried out by Xu Guang-qi, Li Zhi-zao, de Ursis and de Pantoja, the project was finally abandoned owing to opposition, which subsequently even turned into opposition to Western learning in general.

In the West, the Julian Calendar in use since the middle of the 1st century was far inferior to the Da-Tong-Li when the latter was first put into use in the middle of the 14th century. But when the West changed to adopt the Gregorian Calendar in 1582, the out-of-date Da-Tong-Li in its turn looked inferior. Besides accuracy, the novel feature about Western astronomy and calendarial science which Xu Guang-qi found most attractive was its logical and theoretic exposition in the

spirit of classical Greek thinking. The Western astronomical system transmitted into China at that time by the Jesuit missionaries[z] was the Tychonic system which was a compromise between that of Ptolemy in the 2nd century and the revolutionary theory proposed by Copernicus in the second decade of the 16th century. In the Tychonic system, the earth was still at the centre and the moon and sun rotated round it, while the other five planets went round the sun in epicycles. Xu Guang-qi could not have known that this was not the most updated astronomical knowledge because the conservative Jesuits were at that time reactionary to this scientific revolution although ironically their missionary work relied on scientific work. It is another speculative question to ask: What would have happened if Xu Guang-qi had been taught the new scientific theory in astronomy of that time, and in general if he were to learn the new scientific knowledge which was not transmitted into China by the Jesuits? But even this version of Western astronomy already fascinated Xu Guang-qi and led him to say: "[not knowing that] there are theory, argument, method and calculation in it. Without understanding the theory we cannot derive the method; without grasping the argument we cannot do the calculation. It may require hard work to understand the theory and to grasp the argument, but it takes routine work to derive the method and to do the calculation. ... the more intricately we probe into it now, the more simplified it will become later. Our hard work will make it easy for others, so why should we be afraid of facing this challenge?" [13, p. 358]. Technically, he realized perfectly clearly why a logical deductive theory was preferable to an empirical approach. He said in an official memorial in July of 1629: "The Da-Tong-Li is actually the Shou-Shi-Li prepared by Guo Shou-jing in the Yuan Dynasty. For the past two hundred and sixty years calculation by imperial astronomers was based on values of astronomical constants that had never been adjusted one bit. It was not only because they did not dare to try to do so, but because they were not able to do it. If they thoughtlessly altered the values on their own, the result might become more erroneous than the original. The art of calendarial reckoning began with Tang Yao[bz] and had been passed on for four thousand years until now. The method had been developed from coarse to refined, and from erroneous to accurate. In the Han[ca] and Tang[cb] Dynasties there had been one or two days of discrepancy between theoretical prediction and actual observation, then later improved to only one or two hours of discrepancy. The Shou-Shi-Li by Guo Shou-jing had been exalted as a method of ultimate accuracy. However, this method of intermediate values basically could not exclude errors so that if we use this method there would be error as much as one or two quarters

of an hour, and sooner or later even errors more than that". [13, p. 319]. In an ensuing memorial written in September, he explained more clearly this point: "Although the motions of heavenly bodies obey certain intrinsic values, they cannot be represented by terminating decimals" [13, p. 333]. Therefore numerical constants in astronomy had to be determined from time to time to make them in accord with the observed heavenly phenomena. In this way, the very nature of the traditional method of interpolation made the calculation out-dated and discrepancy increased as time went on. Xu Guang-qi was therefore attracted to a theoretical approach in which "one should be able to calculate phenomena in the past and predict phenomena in the future without error; one should be able to predict solar and lunar eclipses and occultation of the five planets as precisely as possible; one should study thoroughly the original [Western astronomical] texts so as to write clear and concise exposition on them which can be easily understood at one glance". [13, p. 333]. He continued: "Hundreds of generations later, people will be able to follow the job and when confronted with small differences from the actual motion know how to correct the calculation". [13, p. 333]. He clearly saw the point that such a theoretical approach allowed improvement by later generations in a way far better than the empirical approach. In the preface to the "Chong-zhen Treatise on Astronomy and Calendarial Science" he put it this way: "Methods of today can be improved in future, hence later generations will definitely excel the present generation". [13, p. 377].

The other main reason for his enthusiasm in the project was the idea that the mathematics involved was not only useful for calendarial reform but could be applied to a lot of other areas. In the memorial of September of 1629 he said: "Furthermore, if the mathematics is understood, then it can be applied to many problems other than astronomy as a by-product. Such a wide-ranging task is what I hope to carry out but not what I am capable of doing alone, so I wish very much to secure cooperation from more people who will contribute their talent to this enterprise". [13, p. 333]. He even listed those "by-products"[cc] in ten categories [13, pp. 337-338]: (1) The ability to forecast weather conditions that could help prevent calamities caused by floods and drought, (2) better surveying methods that could solve irrigation and drainage problems, and facilitate the proper construction of dams, (3) proper methods of measurement that could help revise the muscial system for ritual purposes, (4) the improvement of military equipment with improved measuring techniques, (5) better accounting methods that could improve revenues for the government, (6) sturdier and more easily constructed buildings due to improved methods of

surveying and measuring, (7) the construction of labour-saving machines for the improvement of people's livelihood, (8) the collection of accurate data on the topographic conditions of various regions of the Empire, (9) the improvement in medical practices, (10) the ability to produce accurate timepieces for the masses, so that the common people could achieve a better concept of time and improve their productivity. We can see that these are in line with his usual attention paid to matters of practical concern.

In the aforeasaid memorial, together with a related preliminary memorial written half a month earlier, Xu Guang-qi laid out a detailed plan for the staffing, equipment and funds for the proposed Calendarial Bureau, and also of the projects to be carried out once the Bureau was set up. Besides the director, vice-director and two Westerners as official consultants, the Bureau was to consist of another three to four capable astronomers on secondment from the Imperial Board of Astronomers, up to ten senior staff-members and about fifteen research students. Recruitment for these staff-members and research students was to be done through a careful selection process [13, pp. 324-329]. The post of research students is of particular interest, for it shows that Xu Guang-qi had in mind some sort of an Academy of Science, which was in line with his idea of "by-products" from the project of calendarial reform. If he had been in good health to supervise the project for a longer period and if the political situation of the Ming Empire had not been deteriorating as fast, this dream might have had a chance of being realized. Unfortunately, even the new calendar was never adopted, not to mention the more encompassing plan of an Academy of Science. The "Chong-zhen Treatise on Astronomy and Calendarial Science" consisted of 137 volumes, presented to the emperor in five instalments from 1631 to 1635. The last two instalments were presented by Li Tian-jing after Xu's death. Of those sixty odd volumes, half of them had been carefully read and revised by Xu into their final form, while thirty to forty percent of the other half had been read and commented on by him. One can therefore say with all fairness that Xu Guang-qi saw it through to its completion. But already in 1632 he said: "Although we have completed the task and compiled the book, we fear that not too many people are willing to study it. We promulgate the knowledge but nobody responds. We transmit the knowledge but nobody learns. We fear that one day the book will be put away in some obscure corner and become useless!" [13, p. 415]. This dismal prediction was not too far away from the truth in his time. The treatise was to provide the instrumental, mathematical and astronomical basis for reforming the calendar, but opposition in the Imperial Court thwarted adoption of the new calendar for ten years. Finally, in 1644

the emperor decided to adopt it, but in that same year, the Ming Dynasty collapsed. When the Qing Dynasty took over, the Jesuit missionary Adam Schall von Bell was made the head of the Bureau of Astronomy of the new rulers. He changed the title of the treatise compiled by Xu Guang-qi to "New Western Methods in Calendarial Science"[cd] without changing the content. Based upon it he announced the new calendar which was adopted by the Qing Dynasty under the name of Shi-Xian-Li"[ce], which later became the "nong-li"[cf] (agricultural calendar), still in common usage in China today.

Now that we have seen why Xu Guang-qi devoted his time and energy so unreservedly in his seventies to fight his last "scientific" battle, so to speak, we should at least briefly give an account of what he had achieved in those four years. His plan in the first stage was divided into two parts: (i) translating and editing Western texts, (ii) observing and measuring astronomical phenomena. The former provided the instrumental and theoretical basis while the latter provided further data and lent support. He was prompt in using the telescope, which was newly invented in the West in 1608, in such observations. As Hashimoto puts it: "Hsü [Xu] tried hard to justify the extensive reception of Western astronomy for this urgent need by demonstrating the accuracy of the new method in comparison with the existing ones". [21, p. 50]. Although Xu Guang-qi valued highly Western astronomy, he did not worship it without a rational cause. In fact, he would like to have combined the best of traditional Chinese and Western astronomical knowledge, including the third school of Islamic astronomy that was introduced at the beginning of the Ming Dynasty. In the preface to "Chong-zhen Treatise on Astronomy and Calendarial Science" he said: "We honestly believe that if one wants to excel the previous system one must first understand and integrate Western astronomical works, and to attain a thorough understanding it is necessary to translate them. It is because books on the Da-Tong-Li are scarce but Western techniques are available in detailed explanations. Furthermore, those that were developed during the last decades were ten times improved over those available to previous astronmers. As the Chinese saying goes: [a pupil outshines his teacher] like indigo colour excelling blue colour from whence it is derived, and ice colder than water from whence it is formed. ...When the Western works are translated and studied, we will be able to clarify the Da-Tong as well. Those who understand the meaning of astronomical methods can then investigate and compare; melt the material and substance of Western astronomy and cast them into the mould of the traditional Chinese Da-Tong". [13, p. 374].

Xu Guang-qi knew that this was an enterprise of immense magnitude and its success depended on the collaboration of a large number of people working incessantly for a long period of time. To facilitate working he mapped out the general plan, classifying the proposed content of the book into six subjects and five categories. The six subjects were: the motion of the sun, fixed stars, the motion of the moon, solar and lunar eclipses, the motion of the five planets, occultations and conjunctions of the five planets. The five categories were: theories in astronomy, astronomical tables, mathematical methods, astronomical instruments, conversion and comparison between traditional Chinese calendar and Western calendar. This comprehensive planning laid the foundation to ensure successful completion of the enterprise. Although Xu Guang-qi failed in his job as a minister of the state, partly owing to his own submissiveness in the political arena but which however was not entirely due to his fault, we see here that in fact he was an exceptionally competent and inspiring organizer and leader in a scientific endeavour on a scale as large as this. Besides introducing Western astronomical knowledge (though not the most up-dated version), clarifying certain queries in the old calendarial reckoning and introducing some novel ideas to improve astronomical calculation, the project contributed to mathematics by introducing in a systematic way Western trigonometry and spherical geometry.

7. *Scientific Thought of Xu Guang-qi*

It would be far from complete if we fail to mention a most important contribution of Xu Guang-qi, namely the scientific thought which permeated his life and works. It may not be too unfair to say that he was a man ahead of his place and times!

Xu Guang-qi possessed an open, receptive but at the same time sceptical mind. He would not accept any piece of knowledge, handed down by tradition or authority, without giving it critical thought or going through actual observation and experiment. His son said of him: "He liked to investigate things ancient or modern, and consulted widely, asking questions of anyone he encountered and in any place he went to. After getting an answer he would write it down. When he was investigating something he would not stop till he got to the bottom of it". [13, p. 560]. But he welcomed new viewpoints and ideas, as can be seen from his fervent study of Western science and mathematics. A main thread running through his scientific career was the effort to combine the best of Western and Chinese science and of ancient and modern science, in his own terms "understand and integrate"[cg] [13, p. 338].

He placed heavy emphasis on "the study of measure and number"[ch]. This was apparent in his writings at the time he collaborated with Ricci in translating mathematical texts and was reiterated when he was advanced in years. He believed that "all objects with shapes and substances can be explained in terms of mathematics" [13, p. 338]. He realized that mathematics can be applied in exploring physical phenomena because it affords a quantitative description, usually to such a detailed extent that one has the feeling of a qualitative understanding. In this respect he should perhaps be ranked with contemporary giants in the history of science such as Galileo Galilei (1564-1642) and Isaac Newton (1642-1727), in thought if not in accomplishment.

Although Xu Guang-qi stressed the theoretical basis of scientific pursuit, he was equally noted for his emphasis on the experimental aspect. This was apparent in his agricultural pursuit when he "worked with agricultural implements in the fields, tasted plants and herbs, collected information all the time, interviewed local peasants and compiled the knowledge he gathered into a book" [14, p. 5]. It was equally apparent in his astronomical studies. During 1630-1632 he led his astronomical team to predict and watch five lunar eclipses and one solar eclipse. In the Western world, people usually ascribe the inductive approach to science through systematic observations and experiments to Francis Bacon (1561-1626), who happened to be an exact contemporary of Xu Guang-qi. In this respect not only should Xu be ranked with Bacon, but he surpassed Bacon in that he combined this approach with that of another contemporary of his, namely René Descartes (1596-1650) who advocated the deductive mathematical method for seeking knowledge. It was a true pity that these giants in East and West, though living in about the same period, did not have the opportunity to exchange their ideas and views! Although the Jesuits had their contribution in transmitting Western science into China in the Ming Period, they were also to blame for not transmitting the new ideas and theories in Western science which were then starting to flourish.

Xu Guang-qi was perceptive and far-sighted in realizing that scientific pursuit is a collective activity. In the ancient Chinese tradition, scientists and mathematicians usually worked alone by themselves individually. Perhaps with his administrative background Xu Guang-qi was a capable organizer of a scientific team. He was good at collaborating with other scientists and he regarded educating the next generation of scientists an important task. In this respect he was unusual, considering that he was a man of the 16th century. The majority in the officialdom during this period of the first dissemination of Western science did not feel the urgency (or even opposed it), very

unlike the situation during the period of the second dissemination of Western science in the second half of the 19th century after the two Opium Wars. Only a small group of scholar-officials were attracted to Western science through their strong hope of using it to improve the well-being of their countrymen. Xu Guang-qi, besides being a leading figure in this endeavour, was also the most far-sighted promoter in that he realized the importance of education in the nurturing of scientific thought, not just the transmission of techniques and knowledge [1, p. 146]. Promulgation of this far-sighted vision can be found throughout many of his writings [13]. Again, this ranks him higher than the promoters during the second dissemination of Western science who predominantly had their eyes on "learning the techniques of the foreigners to deal with the foreigners".

All scientists understand full well the scientific method of first collecting data and evidence by observations or experiments, then analyzing such data and evidence to arrive at certain basic laws, then proceeding to draw conclusions from such basic laws by deduction, finally applying these conclusions to solve problems on hand or to make predictions and plan accordingly. But not all scientists, however, are as good as Xu Guang-qi in carrying out these procedures in domains other than science. His many official memorials exhibited this scientific trait which rendered them farseeing and thoughtful. It was a great pity that he lived at a time when the country was run by people with a total disregard for learning and knowledge.

Just as Bacon had said: "Knowledge itself is power", Xu Guang-qi shared the same conviction that science held the key to the well-being of his countrymen. His uppermost aspiration was to build a strong and prosperous nation and to improve the livelihood of his people. He was a pioneer in this noble attempt. What he did not realize was the fact that science cannot flourish by itself but requires the soil of an open-minded society to support its healthy growth. In the socio-political climate of the Ming Dynasty, his dream had no chance of being realized, no matter how hard he tried. He earned our respect in that he, perhaps even knowing full well that he would never succeed in this, still attempted to do his part and succeeded admirably within the harsh constraints imposed upon him by his times and circumstances.

8. *Response to Dissemination of European Science*

In spite of the effort and accomplishment of intellectuals as typified in the person of Xu Guang-qi, the gain during this first dissemination of European science in China seemed momentary and passed with the downfall of the Ming Dynasty. Looking back we can see its long-term influence, but at the time this small window which opened

onto an amazing outside world was soon closed again, only to be forced open as a wider door two hundred years later by Western gunboats that inflicted upon the ancient nation a century of exploitation and humiliation, thus generating an urgency to know more about the Western world. This was not yet the case in the time of Xu Guang-qi so that in the clash of two great cultures, one of which was accustomed to being in the centre of civilization, it was difficult for the Chinese culture to embrace the other alien culture. Even with people as open-minded as Xu and his colleagues, this superiority complex showed up unintentionally in the method of translation. Unlike their Japanese counterparts, the interpreters during the period of Rangaku ("Dutch Learning") in the 18th century, all major figures who played important roles in the transmission of Western learning in China during the 17th century did not understand any Western language. One may speculate what would happen if Xu Guang-qi had mastered Latin just as Ricci had mastered Chinese, and even speculate what would happen if Xu had the chance and the inclination to pay a visit to Europe and return with what he experienced there? Unfortunately, besides this cultural obstacle, there were at the time adverse social and political factors that did not work in favour of this first dissemination of European science in China. Ironically, the ready acceptance of Western science by this small circle of open-minded scholar-officials, as exemplified by Xu Guang-qi, also turned out to be a reason for their failure, for in the eyes of the conservative ministers and the general populace, this small group of converts were over-enthusiastic about the alien culture. They lacked the support of the host culture, so to speak. It will be a meaningful task to try to trace the "mental struggle" of China in the long process of learning Western science, from the endeavour of Xu Guang-qi, to the resistance best portrayed by the vehement opposition of Yang Guang-xin[c], to the promulgation of the theory that "Western science had roots in ancient China"[o], to the self-strengthening movement, and finally to the "naturalization" of Western science in China [31, p. 12]. It is a complicated story embedded in a complicated cultural-socio-political context. (See [2, 5, 6, 7]).

As a foremost scientist-intellectual of his time, Xu Guang-qi deserves to be better known to all people other than just Chinese. However, sad as it may sound, I see in this man the image of a typical Chinese intellectual who transcends ages in that he gives so selflessly and sincerely for the betterment of his motherland, irrespective of how the ruling class behaves and how he is treated in return; he attempts to carry the whole world on his shoulders, so to speak. On the negative side, some may see in this a trait of docility and misplaced loyalty,

or at the least a lenience and forbearance that border on foolishness. But if one views this over and above the temporal scenario one will see the true value embodied therein. Power can crumble and wealth can vanish, but the good a man did to the people will forever become part of the world's cultural heritage. This paper is humbly dedicated to all those who have thus devoted their life-long work to their high ideals.

I have attempted to show what a patriotic upright scientist-intellectual faced and experienced in the late Ming Dynasty. I have described how he chose to lead his life, and in what way he succeeded and in what way he failed. Success or failure aside, he left his imprint on the history of science, and perhaps more are still to walk in his footsteps. I wish to end with a saying in Xu Guang-qi's "A Complete Treatise on Agricultural Administration": "What our posterity will see in us so had we seen in our ancestors."[ck] [14, vol. 35, p. 963].

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* See Appendix I for the first seventeen references in Chinese characters.

Appendix I

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Appendix II

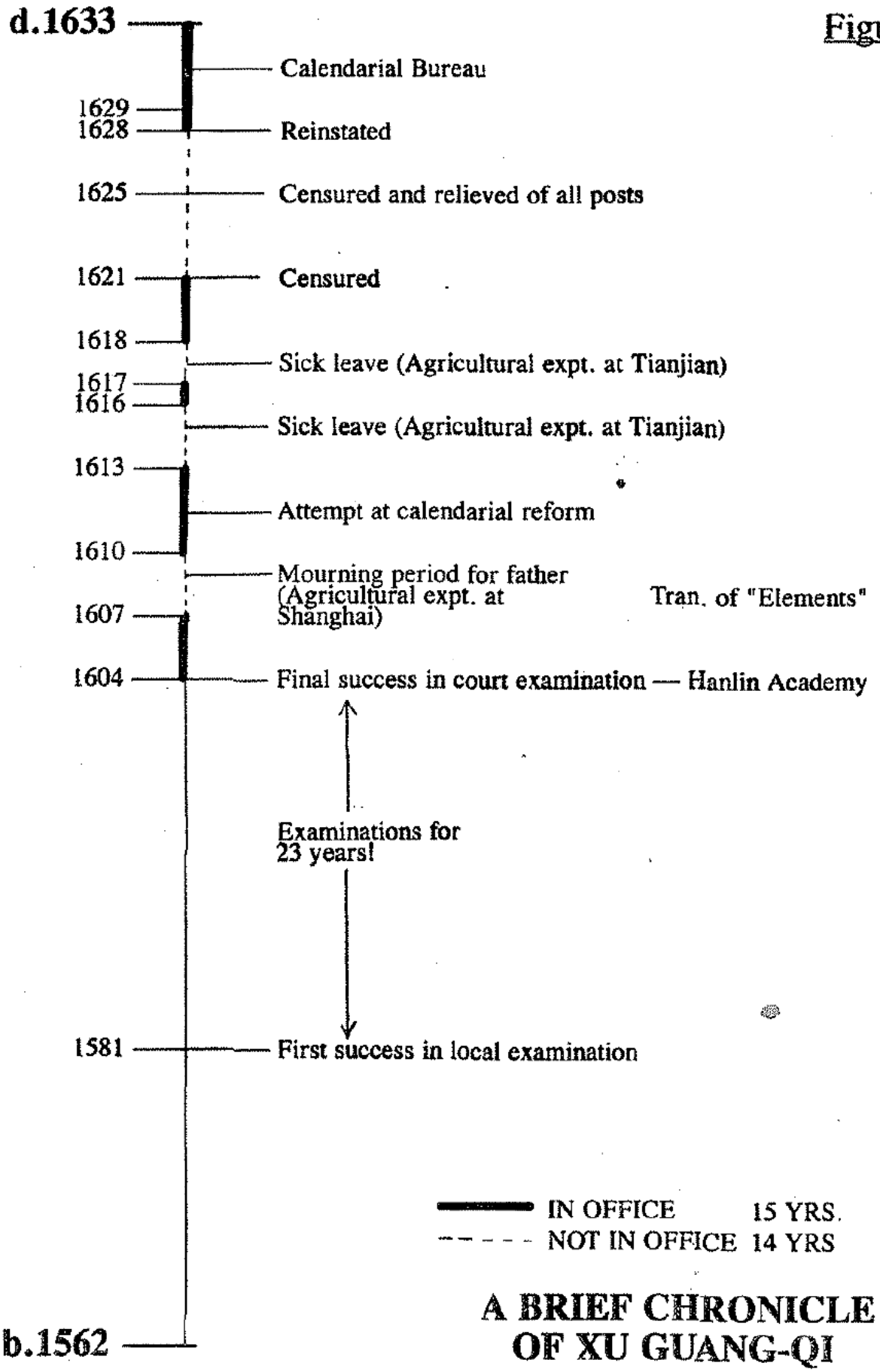
CHINESE GLOSSARY

a	徐光啟	aa	利瑪竇
b	明	ab	郭居靜
c	徐思誠	ac	泰西水法
d	倭寇	ad	李之藻
e	戚繼光	ae	楊廷筠
f	秀才	af	龍華民
g	舉人	ag	龐迪我
h	進士	ah	熊三拔
i	翰林院	ai	魏濬徵
j	黃體仁	aj	沈潅
k	隋	ak	方從哲
l	唐	al	努爾哈赤
m	宋	am	女眞
n	朱熹	an	後金
o	李時珍	ao	清
p	本草綱目	ap	滿
q	宋應星	aq	楊鎬
r	天工開物	ar	崔景榮
s	趙煥	as	泰昌
t	焦竑	at	天啟
u	洪武	au	魏忠賢
v	朱元璋	av	東林黨
w	胡惟庸	aw	智鋌
x	藍玉	ax	農政全書
y	內閣	ay	崇禎
z	萬曆	az	曆局

ba 鄒玉函
bb 羅雅谷
bc 湯若望
bd 孫元化
be 周廷儒
bf 徐驥
bg 溫體仁
bh 明史
bi 崇禎曆書
bj 李天經
bk 文定
bl 簡平儀說
bm 同文算指
bn 李善蘭
bo 幾何
bp 幾何原本
bq 量
br 測量法義
bs 測量異同
bt 勾股
bu 勾股義
bv 九章算術
bw 大統曆
bx 授時曆
by 郭守敬
bz 唐堯

ca 漢
cb 唐
cc 旁通眾務
cd 西洋新法曆書
ce 時憲曆
cf 農曆
cg 度數之學
ch 會通
ci 楊光先
cj 西學中源
ck 後之視今，猶今之視昔也

Figure 1



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1. *Al-Qānūn fi'l Ṭibb* (Canon of Medicine), by Ibn Sīnā (980-1037 A.D.) known as *Avicenna* in the West.

   (a) Arabic text and critical edition sponsored by Hakeem Abdul Hameed:

   Book I : *On Principles of Medicine*
   Book II : *On Simple Drugs*
   Book III : *On Particular Diseases of Human Organs* (in two parts)
   Book IV : *On the Therapy of Fevers, Crisis, Poisons, Cosmetic Defects and Coaptation etc.*
   Book V : *On Pharmacopoeie*

   (b) English translation of Book I, the rest in press.

2. *Islamic and Comparative Law Review*—a bi-annual Journal, edited by Prof. Tahir Mahmood, Honorary Professor of law, Jamia Hamdard, New Delhi-110062.

3. *Proceedings of the First International Conference on Elements in Health and Disease*, New Delhi, 6-10 February 1983, first edition, 1984.

4. *Introduction of Modern Western Astronomy in India During 18-19 Centuries*, by S. M. Razaullah Ansari, with a Foreword by Hakeem Abdul Hameed, New Delhi, 1985.

5. *R. & D. of Indigenous Drugs*, Editors: P.C. Dandiya & S.B. Vohora, first edition, 1989.

6. *New Horizons of Health Aspects of Elements*, Editors S.B. Vohora and Jan. W. Dobrowolsky, first edition, 1990.

7. *Indian Alchemy or Rasayana in the Light of Asceticism & Geriatrics*, by S. Mahdihassan.

8. *A Catalogue of Arabic and Persian Manuscripts*, compiled by S.A.K. Ghori, Tazeemuddin Siddiqui and S.A. Ali.

9. *Exchanges between India and Central Asia in the Field of Medicine*, by Hakeem Abdul Hameed, with a Foreword by Saiyid Hamid, New Delhi, 1986.

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