

Chapter 2

Natural Scientists from the Last of the Medici (1694) to the Period of the Museum of Physics and Natural History (1775–1807)

By the end of the 17th century in Europe the new experimental method that eventually became central to the discipline of chemistry was in its infancy. Within a few decades, it passed with giant steps into the 18th century and became well-established thanks to the ideas, inventions, discoveries, intuition and theories of Antoine Laurent Lavoisier (1743–1794).

In documenting the roots of chemistry in Florence, it is essential to mention the patronage of the Medici and Lorraine, Lords of Florence, who supported it in many forms: costly chemical reagents (such as gems and diamonds) and fine scientific instruments built by skilled craftsmen. The most significant event in this period was the rise of the first great chemical industry in Italy—the manufacture of sulfuric acid. Other industries followed later such as sugar extraction from sugar beets, serving to tie chemistry irrevocably to industrial development.

But surely, one of the most auspicious events in Florentine scientific history was the burning-lens experiment by Giuseppe Averani and Cipriano Targioni that revealed the true nature of diamond. It also set the stage for Lavoisier's more famous demonstration a century later that demolished the phlogiston theory and replaced it with his theory of combustion.

In Tuscany, the area of pharmaceutical chemistry flourished, and in Florence, the Museum of Physics and Natural History was established. Opened in 1775 by decree of Peter Leopold of Tuscany (1747–1792) and under the direction of the abbot, Felice Fontana, it underwent substantial changes at the hands of the next director, chemist Giovanni Fabbroni, in 1805. In fact, Fabbroni took control of a situation in Florence that most would consider untenable. There were no analogous institutions in Tuscany similar to those in the great cities like London and Paris where scientific ferment gave rise to prestigious research publications and concomitant financial support. So Fabbroni undertook to transform the museum into a scientific institution that he hoped would function as a “quasi-university.” However, with a change in government in 1807, officials appointed by the former government, such as Fabbroni, were removed.

Fig. 2.1 The Burning Lens used by Averani and Targioni. Donated by its maker, Benedikt Bregans of Dresden, to Grand Duke Cosimo III in 1690. *Courtesy Museo Galileo, Florence; Photography Franca Principe*



2.1 Giuseppe Averani (1662–1738) and His Experiment with Cipriano Targioni (1672–1748)

Giuseppe Averani was born on 20 March 1662 in Florence. He completed his degree in law at Pisa in 1684 and was appointed to the Chair of civil law there in 1687, where he remained until his death in 1738. Although he was renowned for his interpretation of Roman law, and was a member of many prestigious regional and international academies, his interests were very broad: theology, geology, astronomy, geometry, and, above all, experimental physics. In 1694 the Grand Duke Cosimo III Medici commissioned Averani, together with Cipriano Targioni (1672–1748), with the task of using a burning lens (Fig. 2.1)¹ to investigate whether diamond was, indeed, combustible.

Conventional wisdom, dating back to the opinion of Emperor Rudolf II's physician, Anselmus De Boodt (1550–1632), and affirmed by Isaac Newton (1642–1727), asserted that it was not. Their conclusion was a hypothesis unsupported by experiment. And so the great experiment of Averani and Targioni, the results of which reverberate to the present day, demonstrated that the nature of

¹Donated to the Grand Duke by its maker, Benedetto Bregans, the lens is now housed in the Galileo Museum.

diamond, that most precious and hardest of stones, was pure carbon. They reported their findings in the following words [1]:

Diamond, thought by all...that no force could break it, resisted the power of this fire less ably than other gemstones. So where the others were hardly consumed, this [diamond] completely disappeared.

Averani and Targioni, in demonstrating the combustible nature of diamond, as well as determining its nature, debunked the belief that this gem was absolutely unassailable: diamond exists in a form that is thermodynamically unstable at ambient conditions. The chemistry laboratory of the Museum, with its advanced scientific tools, became a research center of considerable importance for the naturalists of the time. For example, the aforementioned burning lens was used again in 1814, by Humphry Davy (1778–1829), when he came to Florence with his valet and laboratory apprentice Michael Faraday (1791–1867), to complete further research on the chemical nature of diamond.

Averani was a friend of the most learned men of his time. King Victor Amedeus II of Savoy (1666–1732) invited him to the faculty of the University of Turin, but he refused. In his honor in 1721, his scholarly associates struck a medal with his effigy. At his death in Florence on 24 August 1738, he left his belongings to the poor and his library to the University of Pisa.

2.2 Giovanni Targioni Tozzetti (1712–1783) and His Family

The Targioni Tozzetti family has been, for more than two centuries, an important point of reference in Tuscany's scientific and cultural life. The history of this family and of its familial relationships allow us also to understand the social climb of a complex familial nucleus motivated to maintain intact a patrimony consisting of a rich collection of manuscripts, books, herbaria, and other natural collections amassed over the course of decades by various family members.

The most well-known naturalist in the family is certainly Giovanni Targioni Tozzetti (1712–1783), physician, botanist, and naturalist, who probably inherited his passion for science from his paternal uncle, Cipriano Antonino Targioni (1672–1748). In 1747, he married Brigida Dandini, descendant of the famous family of painters. Their son, Ottaviano (1755–1829) followed in the footsteps of his father, becoming a physician, botanist, and professor at the University of Pisa and director of the Medicinal Plant Garden. Ottaviano in his turn married Vittoria Campana; they had two sons: Antonio (1785–1856) and Giovanni (1791–1863). Antonio continued the family tradition, studying medicine and becoming famous for his chemical discoveries and his botanical work. Giovanni, Ottaviano's other son, did not become a scientist, but one of his sons, Adolfo (1823–1902), completed his degree in medicine and later became professor of botany, zoology,

Fig. 2.2 Portrait of Giovanni Targioni Tozzetti. *Courtesy Museo Galileo, Florence*



comparative anatomy, and entomology at the Institution of Higher Studies at Florence. He was the last scientist in the family.

Son of Benedetto Targioni and Cecilia Tozzetti, Giovanni Targioni-Tozzetti (Fig. 2.2) was born in Florence on 11 September 1712. His childhood was dominated by a passion for all things natural, and above all for plants and fossils. The great botanist Pier Antonio Micheli was a frequent visitor to his home and with Micheli he explored the mountains and plains of Tuscany. In 1730 he went to study at Pisa and received his degree in medicine and philosophy in 1734.

The year 1737 marked a turning point in the history of Florence and also in Giovanni's personal life. On 2 January, Pier Antonio Micheli (1679–1737) died. On 7 January, Targioni was immediately appointed his successor as Director of the Garden and Reader in Botany at the Studio Fiorentino. On 12 March, he participated in the translation of the remains of Galileo to the church of Santa Croce; on 12 July, Francis Stephen of Lorraine (1708–1765) became the new Grand Duke of Tuscany starting the Lorraine dynasty, which reigned for more than 120 years. Subsequently, numerous studies on Tuscany's natural resources, needed to improve the living conditions of the people and to advance the economy, were undertaken.

Commissioned by the Lorraine Government and by the Botanical Society, between 1742 and 1745, Giovanni conducted scientific expeditions all over Tuscany, observing and cataloguing the natural resources in each area. Between 1751 and 1754, he published the first edition, entitled “*Viaggi fatti in diverse parti della Toscana per osservare le produzioni naturali e gli antichi monumenti di essa*,” in six volumes, and the second edition in 12 volumes, with much more information, including the report of Micheli’s 1732 expedition, appeared between 1768 and 1779.

In 1763, Giovanni compiled a 12-volume manuscript catalog of the natural-products collection in his private museum. The catalog and the greater part of the samples described therein are presently held by the Museum of Natural History of Florence. It contains descriptions of animals, fossils, rocks, and minerals. The basis and details of the mineral collection are fully described in the 2007 work, “A Contribution to the Mineralogy of the 18th Century” [2].

Targioni’s work was a milestone in the advancement of Tuscan science and its economy. For example, his publications contained the first scientific description of the borax-bearing zone, destined to become world-famous for the production of boric acid and the utilization of the subterranean steam arising from the famous boric acid fumaroles, used for production of electrical energy.

In 1754 he published his “Prodromo,” an encyclopedic work describing Tuscany’s physical topography and explanations of all aspects of its natural history, something he never could have accomplished without making use of his close relationships and friendships with scholars and intellectuals of the area. This monumental work has never been published as a single work. It is collected in 17 hand-written volumes under the title “Collected information pertaining to the origin of progress and improvement of the physical sciences in Tuscany (for the use of Doctor Ottaviano, his son).”

In addition to his scientific studies, throughout his life, Giovanni continued to practice medicine. In 1750 he worked at the Santa Maria Nuova hospital for incurables (syphilitics). In 1756, he administered smallpox vaccinations, the first in Italy, at the Spedale degli Innocenti (Foundling Hospital); the gratifying results were published by the press in 1757. His successes earned him great esteem as well as an appointment to the medical staff of the court, but this left him with little time to do scientific research and exploration.

After great famines that afflicted Tuscany in 1764 and 1766, the problem of agriculture became ever more serious and research for solutions involved all the great brains of the country, with Targioni Tozzetti always at the front line, thanks to his profound knowledge of the territory. In 1767 he published “*l’Alimurgia*,” an enormous volume on how to minimize famine’s effects. Of its 367 pages, almost 200 are devoted to weather-related causes of famine. The last part, based on his microscopic observations, addressed grain rust, a fungal infection that affected the nutrient quality of wheat.

Also in 1767 he published a prescient volume on the Arno River, calling it a vital element for the city’s life, and, at the same time, a very dangerous one. According to Giovanni, the frequent and ruinous flooding was not due to natural

causes, but to human activity: excessive deforestation, urbanization all along the river, and factories that choked up the river bed with detritus. He actually proposed that the course of the Arno be diverted and that its trench be filled in and used for streets, businesses, and markets.

Targioni devoted the latter years of his life to getting his private museum in order—finds and samples coming from his own explorations and those of Micheli. The entire collection was bequeathed to his son Ottavio, who reclassified it on the basis of new scientific discoveries. In 1829, Baron Bettino Ricasoli acquired the mineral and fossil sections, but when he married in 1838, these sections went to the Museum of Natural History [3]. The botanical section remained with the Targioni family until 1845. It consisted of about 19,000 plant samples coming in large part from Tuscany and other parts of Italy.

Giovanni Targioni Tozzetti, member of numerous domestic and international scholarly academies, died on 7 January 1783, and his renown earned him a well-deserved burial place in the church of Santa Croce.

2.3 Felice Fontana (1730–1805)

Felice Fontana was born at Pomarolo, Trent, on 15 April 1730. Anatomist, physiologist, chemist, and naturalist, he was one of the most famous Italian scientists of the 18th century [4–7]. Beginning his studies in mathematics, he studied histology and physiology at Padua and then Bologna. Among Fontana's earliest physiological experiments were those in which he used static electricity to examine the behavior of nerve and muscle tissue [8]. The stimuli that he produced using the electrical instruments of the time gave small quantities of electricity at very high voltages (about 10,000 volts or more). Fontana claimed that the way in which an organism reacted to external stimuli was an expression of its internal force and organization, independent of the external force and nature of the stimulant, an idea that was initially attributable to the Swiss physiologist Albrecht von Haller (1708–1777) [9]. He and his colleagues frequently borrowed the laboratory facilities of Laura Bassi (1711–1778) [10] and her husband for their work, which preceded the experiments of Galvani by several decades.

In 1766 he was appointed court physicist by Grand Duke Peter Leopold and was a driving force in establishing the Royal Museum of Physics and Natural History (founded in 1775) and which he directed until 1805. He also collaborated with Clemente Susini (1754–1814) in the preparation of the renowned anatomical wax figures presently held at the Museum of the Observatory.

From 1775 to 1780, Fontana traveled in different parts of Europe to cultivate relationships with major scientists of the day, e.g., Lavoisier and Joseph Priestley (1733–1804), accompanied by his student and future successor, Giovanni Fabroni. During this period, he studied the chemistry of poisons and also pneumatic chemistry. He published two papers with the Royal Society of Chemistry on the latter topic. He also became, in studying the anatomy of venomous reptiles, one of

the world's foremost microscopists. In these studies, he did tissue staining to facilitate his work: he was a true precursor of modern histological techniques. One result of his work was the discovery of a new canal in the eye and hitherto unknown spaces near the anterior chamber of the eye, now called respectively Canal of Fontana and Fontana Spaces.

His other chemical research was directed at what was then called nitrous air (nitric oxide) and dephlogisticated air (oxygen). In 1779 he observed that oxygen's solubility in water is greater than that of air, and in 1780 he determined the nature of water gas (a mixture of hydrogen and carbon monoxide). In 1777 he discovered carbon's ability to absorb gases.

Felice Fontana died in Florence on 20 March 1805.

2.4 Giovanni Fabbroni (1752–1822)

Giovanni Valentino Mattia Fabbroni, born in Florence 13 February 1752, was a naturalist, economist, agronomist, chemist, and Italian politician with a wide cultural background. As Felice Fontana's assistant, he helped found the Museum of Physics and Natural History and was its provisional director from 1805 to 1807. He wrote works on soil fertility, the use of fertilizers, and coal.

During the reign of Ferdinand III of Tuscany (1769–1824) he became a member of the International Commission for the Reform of Weights and Measures and, in 1800, he became not only Director of the Florence Mint, but also a member of the Commission for the Institution of the Metric System during the Napoleonic occupation. After the Restoration, he became responsible for the mines of the Grand Duchy of Tuscany.

Although he was a polymath, his major scientific contributions were in the area of chemistry. He adopted Lavoisier's theory of combustion and had it broadly disseminated in Tuscany. He used Alessandro Volta's newly-invented "pile" to conduct important electrochemical research. But perhaps what made him famous in his time was his intervention of 1801 at the Academy of Georgofili, when he entered into the debate that took place years earlier between Alessandro Volta (1745–1827) and Luigi Galvani (1737–1798) relating to so-called "animal electricity." Fabbroni expounded the theory according to which the muscle contraction of a skinned frog connected to the conductors is due to the interplay of the two metals placed in contact in the presence of a solution. From this memory sprang the chemical theory that would explain the generation of electromotive force in Volta's "pile."

Fabbroni died at age 70 on 17 December 1822.

His works were collected into one volume and published in 1848 under the title "Writings on Public Economy." Fabbroni was a versatile man of science and his scientific eclecticism was well recognized not only in Tuscany but abroad. When the Soviets, starting in 1959, succeeded in photographing the dark side of the moon, the International Astronomic Union decided to name one of its craters after him.

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Chemistry and Chemists in Florence

From the Last of the Medici Family to the European
Magnetic Resonance Center

Fontani, M.; Orna, M.V.; Costa, M.

2016, XI, 123 p. 30 illus., 11 illus. in color., Softcover

ISBN: 978-3-319-30854-8