

Gabriel-Philippe de la Hire and the discovery of Hunter-Schreger bands

C. D. Lynch,¹ C. T. McGillicuddy,² V. R. O'Sullivan³ and A. J. Sloan⁴

IN BRIEF

- This paper provides an overview of how the modern understanding of enamel microstructure developed.
- It introduces historical figures important in the development of dentistry as an independent field of science and learning.
- After reading this paper, readers will be familiar with the presentation and nature of Hunter-Schreger bands.

Hunter-Schreger bands are an optical phenomenon observed in mammalian tooth enamel. Familiar to all current and former students of dental histology, this optical phenomenon appears as alternating patterns of dark and light bands when cut enamel is viewed under reflected light. The discovery of this important feature of mammalian enamel has been historically credited to two eighteenth-century investigators, Hunter and Schreger. A re-evaluation of the evidence would suggest that the bands were observed almost seventy years earlier by a French scientist, Gabriel-Philippe de la Hire, and subsequently confirmed by the famous French dentist Pierre Fauchard. This article reviews the contribution of de la Hire, as well as that of Fauchard, Hunter and Schreger, to the early recognition among the scientific community of what would now be referred to as 'enamel microstructure'.

INTRODUCTION

It has long been known that when light is reflected off the surface of enamel that has been sectioned or fractured in the longitudinal plane, an alternating series of dark and light bands may be visualised (Fig. 1).^{1,2} These features were named Hunter-Schreger bands (HSBs) in recognition of the first observers credited with reporting this curious phenomenon in the late 18th and early 19th centuries.^{3,4} Neither of those investigators could suggest a reason for the presence of the bands, thereby introducing a mystery that would intrigue experts in the fields of human and comparative dental anatomy for many years.^{3,4} One plausible but incorrect explanation was that the appearance of HSBs was caused by differences in calcification and hardness throughout enamel.⁵⁻⁸ In the mid-1960s it was shown that the

appearance of HSBs is an optical phenomenon related to the changes in the directions of enamel prisms as they pass through the body of enamel from the amelodentinal junction to the external enamel surface/tooth surface.⁹ The presence of HSBs and their packing density in the crowns of natural teeth has important implications for understanding the nature of clinical scenarios such as tooth wear, abfraction and enamel bonding.^{10,11}

As the years passed and the literature continued to expand after the observations of Hunter and Schreger were published, most workers have been content to quote the references at second hand. Few appear to have read the original reports and fewer still to have considered them in their proper context. Given the time that has elapsed, it would seem appropriate that a reappraisal of the early identification of HSBs is warranted. A recent search of the original sources has indicated that French investigators, Gabriel-Philippe de la Hire and Pierre Fauchard, had independently examined the microscopic detail of human enamel and identified HSBs before the works of either Hunter or Schreger were published. Exploration of the writings of de la Hire and Fauchard provides an interesting insight into how our understanding of the structure of human teeth has developed over the past few centuries.

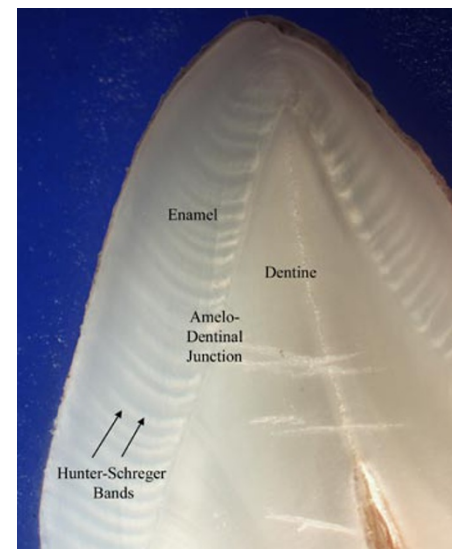


Fig. 1 Appearance of HSBs (alternate dark and light bands) viewed on a buccopalatal section made through the buccal cusp of a maxillary first premolar

GABRIEL-PHILIPPE DE LA HIRE

Gabriel-Philippe de la Hire (1677-1719) was born in Paris.¹² His father, Philippe de la Hire, began his career as a respected painter but is better known for his accomplishments in mathematics, surveying and astronomy. Gabriel-Philippe, the third of four children by Philippe's first marriage, had very broad interests in engineering and the sciences which extended into medicine and anatomy. Gabriel-Philippe was elected to membership of the Académie

¹Senior Clinical Lecturer and Honorary Consultant in Restorative Dentistry, ²Dental Student, ⁴Reader in Bone Biology & Tissue Engineering, School of Dentistry, Heath Park, Cardiff, CF14 4XY; ³Professor of Anatomy, Royal College of Surgeons in Ireland, Medical University of Bahrain, PO Box 15,503, Adliya, Kingdom of Bahrain
*Correspondence to: Dr Christopher D. Lynch
Email: lynchcd@cardiff.ac.uk

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Royale des Sciences in 1694, one of the youngest ever to attain that honour, and remained a member until his death in 1719.¹² Eighteenth-century France was regarded as the centre of learning and enlightenment in Europe, with membership of the Académie Royale des Sciences being considered a very significant accolade for any scientist.^{3, 12-14}

In an article that is usually cited as being published in 1699, Gabriel-Philippe reported a description of human enamel observed under primitive and low-powered magnification. He described how ‘... the enamel (*l’émail*) is composed of innumerable small filaments (*filets*), to which the dentine (*l’os*) is attached...’³ De la Hire included diagrams representing these *filets* (Fig. 2). An illustrative example of a longitudinally sectioned maxillary premolar reveals a pattern of *filets* similar to de la Hire’s drawings (Fig. 2). Given the relative accuracy of de la Hire’s description, it is evident that he observed what would become known as ‘Hunter-Schreger bands’ almost 70 years before Hunter, and 100 years before Schreger. The usual reference given for his work is: ‘De la Hire, GP. *Sur les dents*. Histoire de l’Académie Royale des Sciences, année 1699. 1702; 41-43’³ A fruitless search indicated that this reference was incorrect. A copy of de la Hire’s manuscript was recently traced to the library of the Royal Society of Medicine, London. The manuscript was published in the journal *Histoire de l’Académie Royale des Sciences, Année M.DC.XCIX Avec les Memoires de Mathematique et de Physique pour la meme Année*. It is recorded at the beginning of the volume that it should have been published in 1701-1702 but was delayed until 1732.

PIERRE FAUCHARD

Pierre Fauchard (1678-1761) (Fig. 3) is perhaps one of the most famous dentists of all time, being regarded as ‘the father of modern dentistry’.^{13,15} Following a career in the French Navy and some time working as a dentist in Western France, Fauchard established himself as a *chirurgien-dentiste* (‘surgeon-dentist’), the first practitioner to use this title, at the University Circle in Paris. Fauchard’s conscientiousness and abilities earned him a reputation as an outstanding dentist, attracting patients who travelled from all over France to see

him.¹⁶ In addition, Fauchard’s opinion was frequently in demand by some of the most accomplished contemporary surgeons in Paris.¹⁵

The practice of dentistry at the time of Fauchard was quite rudimentary, with the choices of practitioner being either an untrained ‘tooth-puller’ who attended village fairs and relied on the use of magic potions and spells to treat dental diseases and toothaches, or more reputable practitioners who had usually served an apprenticeship in surgery. There were no formal training courses or regulatory bodies in dentistry. Critically, the development of the profession had stagnated due to professional jealousy, with many skilled and competent practitioners guarding their knowledge and techniques as valuable property that was rarely revealed to colleagues.¹⁶ In a significant break with tradition, Fauchard published a textbook in 1728 entitled *Le Chirurgien Dentiste ou Traité des Dents* (‘The Surgeon Dentist or Treatise on the Teeth’).¹⁶ This comprised two volumes of over 800 pages and included many illustrations. In this way Fauchard shared his considerable knowledge and wealth of observations with other practitioners and students, describing his techniques with exceptional clarity and detail. Many of his suggestions were radical for the practice of dentistry in those days. For example, he advised the seating of patients for dental procedures, a novel departure from the custom of laying the patient on the floor which was current at that time. He demonstrated the presence of roots on deciduous teeth, something that was not readily accepted at the time.⁵ On examining decayed teeth with a magnifying glass, Fauchard confirmed the earlier observations of Leeuwenhoek^{17,18} and disproved another commonly-held belief that the presence of worms were the causative agent in dental decay. Fauchard’s openness was unprecedented. Subsequent editions of his textbook appeared in both French and German over the following years, but the first English translation was not published until 1946.

In his textbook, Fauchard makes several references to the structure of human enamel, noting that the outer layer of the tooth ‘...differs greatly from the inner layer [dentine]; it has scarcely a third of a line of thickness at the circumference of the

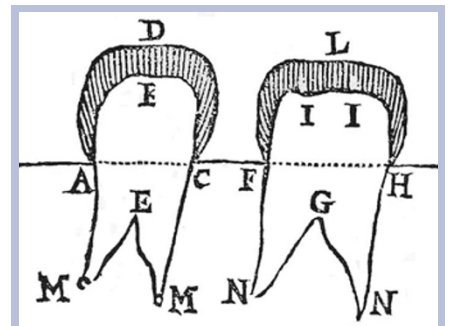


Fig. 2 Comparison of De La Hire’s illustrations of enamel filets with a contemporary image of Hunter-Schreger bands viewed in fractured enamel under low-power magnification



Fig. 3 Portrait of Pierre Fauchard (1678-1761), painted by Jacques Le Bel, 1725

body or of the crown and in proportion as it goes to form the extremity of the body or crown, it is thicker. It is very white and so hard that the drill and the file can only cut it with difficulty. This substance, which is called enamel, is formed before the eruption of the tooth, gets stronger and better



Fig. 4 Portrait of John Hunter, painted by Sir Joshua Reynolds, 1786, © The Royal College of Surgeons of England

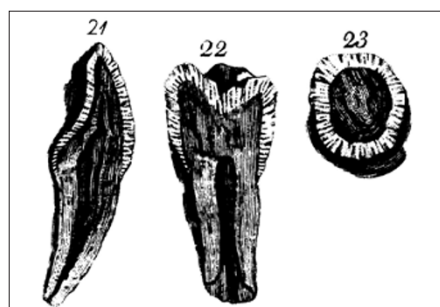


Fig. 5 Illustration of alternating dark and light bands in a vertical section through an incisor (21) and posterior tooth (22) from John Hunter's 'The Natural History of the Human Teeth'. '23' is an illustration of alternating dark and light bands in a horizontal section through a posterior tooth from the same text. While the illustrations '21' and '22' are anatomically accurate, the illustration in '23' is inaccurate cf. Fig. 6

up to the age of twenty years, after which time the enamel begins to wear away by friction...¹⁹

It is clear from other sections of his book that Fauchard used microscopes to examine the internal substance of teeth. For example, he reports how he had used microscopes purchased from M. Manteville to investigate the possible existence of worms as a causative agent in dental caries.¹³ He also used his microscopes to examine the structure of enamel and from his own investigations, Fauchard confirmed that de la Hire's descriptions of 'filaments' (HSBs) were correct.¹⁹

JOHN HUNTER

John Hunter (1728–1793) (Fig. 4) was a celebrated eighteenth-century surgeon and anatomist who played a major role in

laying the foundations of modern surgery. He and his elder brother William ran a school of anatomy for aspiring surgeons in London for many years in the mid-1700s where he worked enthusiastically as a dissector. Being fascinated with all forms of anatomy and pathology, Hunter filled his home with anatomical specimens of both humans and animals. Because of this he was feared by many Londoners and it is generally accepted that the author Robert Louis Stevenson based the setting for his novel *The Strange Case of Dr Jekyll and Mr Hyde* on Hunter's home in Jermyn Street.²⁰

Hunter practised dentistry with James Spence, a well-known and respected dentist, at Gray's Inns Lane, London in the mid-1760s. In 1768 he was appointed as Surgeon to St George's Hospital, London and enjoyed great popularity there. Some of his more famous students included Edward Jenner (1749–1823), who later discovered vaccination, and Everard Home (1756–1832) who, along with John Corse, is credited with an early description of cementum on the roots of teeth.³ In 1776 he was appointed Surgeon Extra-ordinary to the King.²⁰

John Hunter published *The Natural History of the Human Teeth: Explaining their Structure, Use, Formation, Growth, and Diseases* in 1771, in which he introduced the familiar terms 'incisors', 'cuspid', 'bicuspid' and 'molars', and described the banding pattern in enamel which now bears his name. What is often called the second edition was published in 1778, but this was a volume that included two separate books bound together: the original 1771 edition reprinted, and a reprint of another book he had published earlier in 1778 called *A Practical Treatise on the Diseases of the Teeth: Intended as a Supplement to the Natural History of those Parts*.²²

In *The Natural History of the Human Teeth*, Hunter describes the structure of enamel, noting: 'When it [enamel] is broken, it appears fibrous or striated; and all the fibres or striae are directed from the circumference to the center of the Tooth... This, in some measure, both prevents it from breaking in mastication, as the fibres are disposed in arches, and keeps the Tooth from wearing down, as the ends of the fibres are always acting on the food!'



Fig. 6 Accurate representation of the appearance and arrangement of HSBs in the horizontal plane drawn from a horizontal section through the cuspid tip of a maxillary canine cf. #23 in Fig. 5



Fig. 7 Tray 84 from the Hunterian Collection at the Royal College of Surgeons, London, UK, on which it is assumed the illustrations by van Rymsdyk in Fig. 5 are based. © The Royal College of Surgeons of England

Interestingly, Hunter was very accurate in what he perceived to be the function of these 'fibres' or HSBs when he associated them with the fracture and wear resistance of enamel. Hunter published three illustrations of the 'fibres' (Fig. 5). The first two illustrations show the teeth cut in longitudinal section, with alternating dark and light bands running from the ADJ (amelo-dental junction) to the EES (external enamel surface). The third illustration shows a transverse section through the crown of a molar, again showing alternating light and dark bands radiating from the ADJ to the EES. While the HSBs are correctly shown in the longitudinal sections (Fig. 5), their appearance as depicted in the transverse section is inaccurate. In that view (Fig. 5) they are shown as radiating bands whereas they should have been depicted as interlocking, but largely incomplete, concentric circles (Fig. 6).²¹ The reason for this error was identified following a visit to the Hunterian Collection in the Royal College of Surgeons of England. It was confirmed in discussion with the Head Curator that while many of the illustrations in Hunter's text were drawn from surviving displays or 'trays'

of real teeth, there was no tray of teeth that directly corresponded to the images illustrated to describe the Hunter-Schreger bands.²³ There is however a tray ('Tray 84') containing an arrangement of longitudinally sectioned teeth thought to demonstrate the Hunter-Schreger bands (Fig. 7). Colyer's authoritative text *John Hunter and Odontology* refers to this tray as the source for the illustrations of the Hunter-Schreger bands.²⁴ It is likely that the artist, Jan van Rymdyk, who drew those illustrations, created what he considered a suitable interpretation of fractured teeth based loosely on the specimens in Tray 84. This would explain why the horizontal section through the molar tooth incorrectly shows a radial arrangement of Hunter-Schreger bands rather than an arrangement of incomplete concentric circles.

SCHREGER

A paper was published in 1800 entitled *Beitrag zur Geschichte der Zähne* ('a contribution to the history of the teeth') under the name 'D. Schreger'. That paper describes the structure of enamel in both human and animal dentitions.²⁻⁴ In contrast to the often accepted idea that Hunter and Schreger worked independently and without knowledge of each other, Schreger's paper includes several references to, and criticisms of, Hunter's book.^{3,4} Schreger comments that he has 'been working for many years in this area [dental anatomy]', and that he will 'share some of his findings, though not all' with his readers. He criticises Hunter's descriptions of enamel, stating that Hunter's descriptions are incomplete, contain insufficient information, and are inaccurate. On these grounds he considers that publication of his own conclusions are warranted. The accuracy of Schreger's descriptions has been confirmed in recent years.⁹ Some examples where Schreger finds fault with Hunter's descriptions include:

- Schreger claims Hunter described the bands as being straight; Schreger states that the bands are curved. He writes: '...all of the bands run in arch shapes in human enamel, not – as Hunter says and illustrates – in straight rays. They course so that the concave surfaces are directed toward the crown and the convex toward the root of the tooth.'² In this, Schreger ignores Hunter's text because Hunter does mention the

curved appearance of his bands. In *The Natural History of the Human Teeth*, Hunter wrote: '...When [enamel] is broken, it appears fibrous or striated... the fibres are disposed in arches...'¹

- Schreger observes that Hunter's illustration of transversely sectioned enamel is erroneous, stating correctly that these bands should have been illustrated in concentric circles
- Schreger complains that Hunter included no description of the appearance of the bands in animal teeth.

Schreger reported on his own investigations into the appearance of the bands in animal dentitions and included some illustrations (Fig. 8).^{2,4} He examined the internal enamel structure in horses, sheep, and deer, among others. Schreger notes that the appearance of the bands in animal enamel is more complex and differs between animal species. The latter characteristic would later become accepted for the purposes of taxonomy where it is possible to differentiate between some mammalian species according to the HSB arrangements within their dentitions.²⁵

Nothing is known about the life of D. Schreger and doubt has been expressed over the accuracy of Schreger's first name. The 'D.' may be a misprint and some modern authorities^{3,4} identify him as Christian Heinrich Theodour Schreger (1768–1833). In that explanation, the 'D.' may have been a typological error for 'Dr'. An alternative possibility is that he may have been Bernhard Nathanael Gottlob Schreger (1766–1825), the older brother of C.H.T. Schreger. Both were anatomists and either could have written the paper. In that view, the 'D.' may have been a typological error for 'B.' and in the opinion of the authors this seems to be the most likely explanation.

CONCLUSION

It seems from the descriptions and illustrations provided in de la Hire's manuscript that he may well have been the first to describe what have become known as HSBs. Nothing resembling them is described in the earlier literature, including the first dental books published in German (Anonymous 1530),²⁶ Latin (Eustachius 1563),²⁷ French (Gilles 1621),²⁸ and English (Allen 1685).²⁹ The only account that comes close to that of de la Hire is that of Malpighi (1675),³



Fig. 8 Illustration of alternating dark and light bands in enamel specimens from human and animal teeth reproduced from *Beiträge zur Geschichte der Zähne* by D. Schreger (1800)

who described enamel as a skin-like material containing fibres or filaments, but his description of what he observed is vague and inconclusive.

Based on the information and records available, it would seem that 'Hunter-Schreger bands' were first observed by Gabriel-Philippe de la Hire and reported by him to the Académie Royale des Sciences in 1699, though his description was not published until 1732. De la Hire's description was further reported and confirmed by Pierre Fauchard in his textbook. This was followed by Hunter's descriptions in 1771 and 1778, and Schreger's in 1800. While Schreger was aware of Hunter's work, neither he nor Hunter mentions the writings of either de la Hire or Fauchard in their accounts. Gabriel-Philippe de la Hire made a fundamental contribution to the elucidation of enamel microstructure, the understanding of which has led to many of the advances we see in the contemporary practice of clinical dentistry.

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