DISCOVERY OF MODERN ANAESTHESIA A SHORT SUMMARY OF SCIENTIFIC DEVELOPMENTS LEADING TO DISCOVERY OF ANAESTHESIA

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INTRODUCTION

On the fateful morning of Saturday 15th April 1854, the US senate was debating *"The Appropriation Bill"* to recompense the *'discoverer'* of practical anaesthesia, the reward was US$ 100,000. The candidate was William Thomas Green Mortan, a self-educated dentist from Massachusetts, whose previous three petitions to US Congress (1846, 1849 and 1851) for financial recognition has been unsuccessful but was very hopeful of recognition by the US senate. Mortan, himself not present in the senate but was represented by his friends, who were confidently awaiting the results, when Senator Dawson from Georgia, arose and said that he had received a letter from Dr Charles Thomas Jackson, in which he acknowledged that a certain Dr Crawford William Long, a general practitioner from Jefferson Town Georgia, had a more valid claim for the reward and had undoubtedly used the Ether for anaesthesia long before the demonstration of etherisation by Morton on 16th October 1846 at Massachusetts general hospital. Mr Dawson further clarified that he himself appointed Dr Jackson to investigate the claim by Dr Long, made by the later in his letter to Senator Dawson in March 1854. Although, there were many other contestant, who claim priority for discovery of practical anaesthesia but Mortan had been able to subdue them all but Dr Long emerged as the most formidable claimant and this announcement by Senator Dawson fell like a thunderbolt and was the last nail to the coffin. Morton lost all his hopes of gaining a reward and passively allowed the bill to die.

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Although, the US senate didn't accept Morton's claim, however, the debate continued for decades in the professional and public circles about who discovered modern anaesthesia. In this article, I have attempted to summarise the important scientific developments which directly or indirectly contributed towards the ultimate *Discovery of Modern Anaesthesia.* It is a brief account of such developments and not a detailed description of historical events, for which reader may refer to a range of books on history of anaesthesia.

THE BEGINNING

Ancient Times

"....when the dreadful steel was plunged into my breast cutting through my veinsarteries-flesh-nerves needed no injunctions not to restrain my cries. I began a scream that lasted unintermittingly during the whole time of incision - & I almost marvel that it rings not my ears still! So excruciating was the agony...."[1]

Fanny Burney Novelist

Although, the excruciating pain felt by Fanny Burney during her operation by Napoleon's Surgeon-in-Chief, Dominique-Jean Larrey on 30th September 1811, was experienced by most of the patients who were forced to have operation at that time but the characterisation of the era before 1846 as an absolute "age of agony" where the surgical patients have no choice but to submit and bear the suffering is not completely accurate.

There is no doubt that from the earliest times attempts were made to relieve the pain of surgical intervention by the oral and rectal administration of herbal medicine, by physical methods like local application of ice or cold water and pressure on nerves.

The principal herbal drugs, capable of relieving pain or inducing amnesia or mental detachment were ethyl alcohol, opium (*papaver somniferum*), cannabis (*cannabis satvia*), mandrake (*mandragora offcinarum*), poison hemlock (*conium maculatum*). These had been used for centuries by the Greeks, Romans, Arabs, Chinese and Eygyptians[2]

Hippocrate (460 357 BC) recommended a draught of mandragora juice mixed with wine before surgery. Pedanios Dioscorides, chief surgeon to the armies of Nero (54 -68AD) had described the use of mandragora in combination with extract of hemlock. Avicenna (9791037), an Arab philosopher, advocated the use of mandragora extracts in wine for alleviation of pain of any cause. Chinese surgeon Hoa T'o (190 A.D.) employed Cannabis indica mixed with wine to alleviate pain during surgical procedures. The ancient Chinese had also used opium as a means of stopping pain. Theodoric De Lucea (1205 - 1298), an Italian practitioner, used a sponge soaked in hot water and a mixture of mandrake, hemlock and opium to relieve pain during difficult surgery.

The word pain is derived from the Greek *Poine* meaning penalty via Latin *Poena* meaning punishment[3] and from the earliest times and through the middle ages, pain has been regarded as a punishment inflicted by the Almighty for some misdeed, which can be reduced by divine intervention as an act of redemption and atonement. This was especially true of the mysterious pathological pain, for which there was no visible aetiology except the imposition of divine will as oppose to traumatic pain, especially the battle or surgical wounds for which the cause was all to obvious.

The Renaissance

The renaissance in the fourteenth and fifteenth centuries heralded the age of enlightenment and scientific investigations. Humans since then begin to regard themselves as master of their own environment. Scientific investigations began to be regularised and developed into an independent discipline. The active treatment of pain was now considered as humanitarian act with or without religious overtones.

As the first anaesthetics were administered by inhalation of gases and vapours, therefore, evolution of anaesthesia would have never been possible without the comprehensive knowledge and understanding of the existence of identifiable and variously distinctive materials that exist in gaseous state. Scientific investigations, which began in 16^{th} century to explain the human body functions and how they interact with the environment, were to continue in the later centuries and in a faster pace.

THE EVOLUTION

Airs and Gases

As the first anaesthetics were administered by inhalation of gases and vapours, therefore, evolution of anaesthesia would have never been possible without the comprehensive knowledge and understanding of the existence of identifiable and variously distinctive materials that exist in gaseous state.

Use of term *"air"* to designate any gas is legacy from the old Greek concept that universe is made of four elements (Earth, air, fire, water). Van Helmont (1579-1644) was the first person that coin the word *"gas"* for the aeriform substances that are liberated from other materials by chemical means but the term *"gas"* enjoyed little popularity or standing until it was introduced into English dictionary by the chemist James Keir in 1777, till than the term *"airs"* was used in the English dictionary to designate all substances that exists in gaseous state.[4] Van Helmont, observed the effervescent reaction produced by the action of vinegar on calcium carbonate and suggested that smokes derived from various sources were different and their characteristics depends upon the substances they originated from and that they are different from the '*ordinary air*'. Robert Boyle (1627-1691) coined the term '*factitious air*' for any chemically derived air.

Joseph Black (1728-1799), a Scottish physician and chemist, while studying at Edinburgh thoroughly studied properties of magensia alba and lime water as subject for his thesis to be sumitted for his MD degree. In his thesis (1754) he observed that heating limestone and magnesia alba results in liberation of a type of air which is different in charcateristics than the ordinary air. He called his discovery '*fixed air*' and concluded that the fixed air was not breathable because it extingguised flame and killed mice. He also recognised that *'fixed air'* is produced during respiration, fermentation, burning charcoal and action of acids and heat on chalk.

In 1756 Black described how quicklime became more alkaline when they lose *'fixed air'*, whereas the taking-up of *'fixed air'* reconverts them. His other acheivements were discovery of magnesium and carbon as an element (1755) and development of theory of "latent heat" (1763) on which his scientific fame chiefly rests.

In 1766 Henry Cavendish (1731-1810) described that when zinc, iron and tin were treated with either vitriolic acid (sulphuric acid) or spirit of salt (HCl) a new type of air was liberated which was highly flammable but only in the presence of *'fixed air'* and named it the *'inflammable air'*.

Daniel Rutherford's (1749-1819), a student of Joseph Black continued to invesigate the relation ship between *'ordinary ai'r* and *'fixed air.'* He experimented that if an animal is allowed to breath in a confined environment, a contraction in volume of *'ordinary air'* occured despite production of *'fixed air',* and observed that if *'fixed air'* is removed from the mixture, the remaining air did not support life. He named it *'Noxious air'* (1772).

Phlogiston Theory

Phlogiston theory[5] developed during the early 16th century and remained in fashion until it became inadequate to explain behaviour of gases and was finally abandoned at the turn of 19th century. Phlogiston was considered a "fire substance" contained in combustible matter and is released when that mater is burned. Phlogiston theory was the first general theory of chemistry and was invoked to explain many observed natural phenomena: combustion of substances and oxidation of metals involved loss of phlogiston to the atmosphere, highly combustible materials contained large quantities of phlogiston and a metal oxide could be changed to the original metal by heating with a substance rich in phlogiston.

Discovery of *'fixed air'* by Joseph Black was an important step in the history of chemistry as it helped people to realize that air was not an element and was actually comprised of many different things, which finally lead to the discrediting of the belief in the actions of the fiery principle called phlogiston.

Combustion And Respiration

Leonardo da Vinci (1452-1519) was the first to describe and demonstrate the mechanism of inflation and deflation of lungs and that air consisted of two portions, one supporting combustion and respiration while the remainder did not.[6] The Belgian scientists, Andreas Vesalius (1514-1564) in his book 'De Humani Corporis Fabrica' observed that blowing of air into the lungs of an animal with an open thorax is essential for continued effective beating of heart.[6]

17th century witnessed the progress in the understanding of the process of combustion and physiology of respiration. The main credit goes to group of scientists from Oxford University who were also the founding members of the Royal Society of London (1662). Among these the most remarkable were Robert Boyle (1627-1691), Robert Hooke (1635-1703), Richard Lower (1631-1691), Thomas Willis (1621-1675) and John Mayow (1641-1679). The greatest scientific advances of 17th century in respiratory physiology included[7];

a) Definitive description of circulation of the blood by William Harvey (1578-1657) in 1616.

b) Hooke's demonstration that the essential requirement in respiration is a constant supply of fresh air to the lungs (1661).

c) In 1662 Boyle published his work describing the inverse relationship between volume occupied by a sample of gas and pressure applied to it The Boyle's Law.

d) Marcello Malphigi (1628-1694), the founder of microscopic anatomy was the first to see capillaries and discovered the link between arteries and veins that had eluded William Harvey. In his book *De viscerum structura exercitatio,* (1666) he described the relationship between membarnes surrounding the air spaces in the lung and the blood circulating through cappilaries in these membranes.

e) Richard Lower, first Western scientist ever to perform a blood transfusion, in his major work *Tractatus de Corde* (1669), noted that the change in colour of blood during its passage through the lungs occurred secondary to uptake by blood some substance from the air.

f) John Mayow, a medical practitioner from Bath, published his results in 1674 after a series of experiments, established that both combustion and respiration consumed a substance from the atmosphere and the remaining portion of atmosphere neither supports combustion nor life. He also suggested that something noxious was given out by blood on expiration or released during combustion.

The Gas Maker And Colleagues

The life of Joseph Priestley (1733-1804), born on March 13th, son of a Yorkshire handloom worker, a strict non-conformist theologian, a dissenting clergyman and a self taught scientist occupies a pivotal role in the evolution of modern anaesthesia.

He began his career as a minister than became a school master and wrote immensely on politics, theology, philosophy, education and language but later turned to the study of physics, electricity and chemistry. He began scientific work in 1765 and published *"History of electricity"* in 1767 and *"History of optics"* and *"Directions for impregnating water with fixed air"* in 1772. In 1780 Priestley relocated to Birmingham, set up his own laboratory and library and became a member of the Lunar Society. He was a Unitarian, an atheist, staunch supporter of French revolution and had to pay dearly for his religious and political views. His Aryan religious beliefs (doubt in the validity of trinity) contributed immensely for his unpopularity in Birmingham, and consequently led to the destruction of his house, laboratory and library by the mob during 1791 riot. After the riot, he emigrated to Pennsylvania United States (1794), where he died on February the 8th.

For anaesthesia, his contributions came from his work in pneumatic chemistry. He is credited for the discovery and characterisation of at least ten *'factitious airs'*. Knowledge about some of these gases played a cornerstone role in the development of modern anaesthesia.

Joseph Priestley resolutely followed the phlogiston theory as reflected by the Nomenclature he used to describe his *'factitious airs'*. During his time, three *'airs'* were identifiable as distinct entities; *'ordinary'*, *'fixed'* and *'inflammable'*. Priestly strong motivation to study *'airs'* is attributed to the plentiful supply of *'fixed air'* generated over fermenting liquor in a brewery close to his residence in Leeds.

Priestley used several different tests to identify the properties of individual gases. He analysed their appearance, odour, and taste, their reaction with lime, whether or not they burned or supported combustion and how long a mouse could survive in the gas. He also observed the characteristic of flame and electrical sparks in the gas.[9] He began his work by studying the properties of gaseous oxides of nitrogen. He prepared *'nitrous air'* (nitric oxide) by treating metals with nitric acid (1771) and described its poisonous nature.[10] While experimenting his newly discovered gas, he prepared another gas by exposing iron filing and brimstone (sulphur) with *'nitrous air,'* over water (1772) and named it as *'dephlogisticated nitrous air'* in 1773, he described its properties of supporting combustion but not supporting life.[10] In 1771 Priestley obtained a gas by heating saltpeter (potassium nitrate) and noted the ease with which candle burned in this new gas[11] but he did not investigated the gas further at this time, later in August 1774 he produced the same gas by heating mercuric oxide and red lead oxide.[12] He named the gas in 1775 as *'dephlogisticated air'* and demonstrated that the new gas is breathable and superior to ordinary air for sustaining life. He established that the air which had been vitiated by animals could me made breathable again by growing plants with in it.[13]

Priestley also noted that *'fixed air'* prevented putrefaction and suggested that its inhalation might be used to treat diseases and his proposition that soda water prepared from *'fixed air'* should be used to prevent scurvy among sailors on long voyage, was recommended to he Royal Navy by the College of Physicians.

Antoine-Laurent Lavoisier (1743-1794), the "*father of modern chemistry,*" was Priestley's contemporary in France, demonstrated in 1783, the production of water by burning the *'inflammable air'* which he named *hydrogen* (Greek for water-former), in the presence of *'dephlogisticated air'*, which he renamed in 1778 as *Oxygene*[13] (Greek for acid-former). He demolished the phlogiston theory by correctly delineating the process of combustion and demonstrated that burning involves the combination of a substance with oxygen. He also explained the active role of oxygen and Black's *'fixed air'* and passive role of Rutherford's *'noxious air'* in animal and plant respiration.[14] He also stated the first version of the '*Law of conservation of mass*', introduced the *Metric system*, developed the first '*periodic table*' and helped to reform chemical nomenclature leading to renaming of *'dephlogisticated nitrous air' as* nitrous oxide, *'fixed air'* as carbon diaoxide, '*noxious air*' as Nitrogen.

Although, Joseph Black might have prepared nitrous oxide before Priestley in 1766 but had neither published nor identified it as a unique gas. Same applies to Karl Wilheim Scheele's (1742-1786), who recorded the existence of Oxygen in 1772 but failed to publish his results until 1777.[13]

The Gas Factory

"....We know that some of the forms of disease that affect the viscera of the thorax, do depend on an imperfect oxygenation of the blood and it is perfectly reasonable to suppose that the administration of this gas I in such cases, might be a source of relief and perhaps eventuate in a complete return to health."[17]

Thomas D Mitchell (1819)

Priestley certainly was the first person to suggest that the newly discovered gases should be used medically and the therapeutic inhalation of these gases heralded the begining of pneumatic medicine and the evolution of inhalation anaesthesia is deeply rooted in the pneumatic medicine. Various physicians followed up Priestley's suggestion for ailments as diverse as fever, diarrhoea, carcinoma of breast and gall stones,[14] like Thomas Percival (1740-1840) who used carbon dioxide with air in the treatment of tuberculosis and Eramus Darwin (1731-1802), administered oxygen, nitrogen and hydrogen for asthama,[15] but the credit to develop pneumatic medicine as an established branch of medicine to treat diseases goes to Thomas Beddoes and surely he stands in the first rank of those individuals who set the stage for the introduction of clinical anaesthesia.

Thomas Beddoes, a man of conceptual intuitions and great conviction, was born in Shifnall, Shropshire on 13^{th} April 1760. In 1776, he was enrolled in Pembroke College of Oxford University, where he studied and become proficient in French, German, Italian and Spanish and awarded Bachelor of Arts degree (1781). At Pembroke, he also studied botany, geology, pneumatic medicine, with which he remained obsessed for the next 25 years, and completed his Masters in Arts (1783).[16] He began studying medicine in Edinburgh but completed his MD from Oxford (1786). He began his career as Lecturer in chemistry at Oxford (1787). Displaying his linguistic skills, he translated into English the scientific works of Spallanzini (1784), Berrman (1785), Scheele (1786) and published his dissertation on Mayow's work (1790).[5]

Beddoes published his first major treatises on pneumatic medicine *"Observation on nature and cure of calculus, sea scurvy, consumption, catarrh and fever"* and performed his initial trials of gas inhalation in patients in 1792 but the equipment for generating, storing and administering the gases were crude and imperfect, consequently, he conceived the idea to establish a pneumatic institution and began soliciting support and financial help from his brother Joseph, William Reynolds a landowner from Shropshire and Davies Gilbert (1767-1839), his pupil in Oxford. He also developed acquaintances and friendship with many members of Lunar Society of Birmingham, like Eramis Darwin, James Watt and Richard Edgeworth and requested them to solicit support for him in scientific circles.

Beddoes chose *Hotwells Spa* at Clifton in Bristol to establish his Pneumatic Institution. Medical activities began in May 1793 that soon flourished into a successful practice, treating despairing patients suffering from incurable diseases including cancer and tuberculosis, known in eighteenth century as pulmonary consumption, and used oxygen, hydrogen, carbon dioxide and impure carbon monoxide and fumes produced by burning of feathers and charred meat to treat such ailments.[15] In his work, Beddoes was assisted by James Watt (1736-1819) in the designing and development of equipments and apparatuses for generation, storage and administering of gases and together they published *"considerations on the medicinal powers of factitious airs"* in five parts between 1794 and 1796.[5]

In December 1793, Georgina, the duchess of Devonshire visited the pneumatic institution[15] and highly impressed, she suggested Beddoes to found a medical institution, replacing the outpatient facility with a hospital. Beddoes began to work on the idea in 1794 and by 1797 had collected sufficient funds from donations and subscriptions to found such institution. Members of Lunar society of Birmingham contributed significantly in the launching of the Pneumatic Medical Institution (1799).[5]

In reality, the vision of Thomas Beddoes to revolutionise medicine through pneumatic medicine came to nothing with closure of the institution in 1802 yet the influence of his work on gases and vapours was to prove seminal in the development of inhalation anaesthesia. Together with Watt he designed and built an apparatus which was capable of delivering gas in measured volumes. He neither conceived that pain of surgery can be alleviated nor considered the use of gases for such purpose but his appointment of Humphry Davy, on the advice of Davies Gilbert, as superintendent of Pneumatic institution in October 1798 would prove to be a mile stone in the road to development of modern anaesthesia. The historical importance of the Pneumatic institution doesn't lie in its achievements but in the extensive researches carried out by Humphry Davy at the institute. Beddoes died on Christmas Eve 1808.

THE EXPERIMENTS

The Laughing Gas

Humphry Davy (1778-1800), famous for his invention, the *Miner's lamp,* came from a family of craftsman in Penzance, Cornwall, became an apprentice to local surgeon, Mr Borlaise, when he just 16, after finishing his education at local school. Although, he didn't attend a University but he developed amateur interest in Nature and became a self taught chemist and acquainted himself to Beddoes through Gilbert, who himself was Cornish and Gregory Watt son of James Watt, who visited Cornwall to recuperate from pulmonary consumption.[5] Davy became interested in nitrous oxide after reading *"considerations on the medicinal powers of factitious airs"* by Beddoes and Watts, in which they quoted Samuel Mitchill (1764-1831) assertion that *'dephlogisticated air'* was contagion, responsible for the spread of plague.[15] Davy began experimenting with nitrous oxide firstly on animals and than on self and sent his results to Beddoes, inferring that nitrous oxide was not contagion for plague. Impressed by his work and on Gilbert's advice, Beddoes appointed Davy as his superintendent at the newly opened Pneumatic Institution.[16]

Davy worked at the institute from 1799 to 1801 during which he experimented with all the available gases but his main interest remained nitrous oxide. He established its specific gravity, solubility in water & blood and measured the rate of uptake of nitrous oxide by his own body, using a spirometer specially designed for him by William Clayfeild (1772-1837) a pupil of Watt and also measured the capacity of his own lungs by inhaling hydrogen. He studied the effects of nitrous oxide on small animals and observed that the progressive reactions in animals preceding death from breathing pure nitrous oxide were very different than those killed by privation of *'ordinary'* air. He described these reactions as *'Struggling, Repose, Convulsions and resuscitation'* if the animal is subsequently allowed to breathe pure air.[15] These *Reactions* are very similar to those described in 1937, as the Stages of anaesthesia by Arthur Guedel (1883-1956).

By breathing nitrous oxide, he discovered that the gas relieved pain in his sore gums and had pleasurable, euphoric and exhilarating effects and probably coined the term *laughing gas* and later became addicted to the gas. In January 1800 he published his book, *'Researches chemical and philosophical; chiefly concerning nitrous oxide or dephlogisticated nitrous air and its respiration'* in which he noted;

> *"...As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place."*[17]

Its Irony that despite discovering the analgesic effects and suggesting its use during surgery, Davy never pursued to use nitrous oxide for surgical analgesia and contemporary surgeons of his era also failed to realise the significance of the discovery. However, Davy had opened the door that led to the discovery of modern anaesthesia.

Suspended Animation

The first deliberate effort to produce surgical anaesthesia through inhalation route was attempted by Henry Hill Hickman (1800-1830), a general practitioner from Shropshire but the gas he used was carbon dioxide. Hickman identified the state of '*suspended animation*' as a near death condition, resulting from asphyxia, observed in individuals who had survived drowning, strangulation or suffocation and individuals could be resuscitated from the state by allowing them to breathe atmospheric air. He recognised that '*suspended animation*' could also be created by breathing carbon dioxide. He performed his experiments on small animals and described his results in a letter to Thomas A Knight, a Fellow of the Royal Society and a close associate of Humphry Davy, in hope that the results would be presented at the Society. However, either due to the lack of interest or fear of risks attached to such experiment on humans, they both ignored Hickman letter.

Hickman than published a pamphlet in August 1824 stating,

"I feel perfectly satisfied that any surgical operation might be performed with quite as much safety upon a subject in an insensible state as in a sensible state, and that a patient might be kept with perfect safety long enough in an insensible state, for the performance of the most tedious operation.."[18]

After disappointment from English colleagues, Hickman wrote to King Charles X for an audience before French Royal Academy of Medicine.[26] A committee was set up to consider his claims but only Baron Larrey (Napoleon's Surgeon) showed any interest. Unfortunately, Hickman died in 1830 and matter didn't go further.

Although, Hickman's work didn't contribute directly to the development of modern anaesthesia but he was the first to promote the new age of humanitarian attitude to pain during surgery. As Cartwright rightly said

".....the first of all men, set out to banish pain by means of experimental investigation."[15]

The Sweet Slumber

Although, Raymond Lully (1234-1314) a Majorcan, might be the first to prepare *ether* but Paracelsus (1493-1541) and his pupil, Valerius Cordus (1515-1544), who published the first '*modern*' pharmacopoeia, claims are more widely accepted.[19] They obtained a distillate in 1544, from the interaction of alcohol and vitriol (sulphur) and named it '*sweet oil of vitroil*'. The preparation was later used orally as an anodyne and called as '*Hoffman's drop.*'[19] Paracelsus fed these drops to hens and caused temporary state of deep sleep and described its soporific properties. The name *ether* derived from Greek '*aether*' meaning burnt brilliantly given to the distillate by Frobenius (1638-1775), who prepared it on scientific basis.[19]

Mathew Turner (1725-1790), a surgeon and chemist from Liverpool described its medicinal use in a pamphlet *"An account of the extraordinary medicinal fluid called aether"* published in 1761.[16] Thereafter, it had been used as a cold surface application for headaches and migraines, as a anti-spasmodic for colic or flatulence and nasal applications for fits and nervous diseases. By the end of seventeenth century it was being used by inhalation route, first in pneumatic medicine as a putative cure for phthisis, asthma, whooping cough and other lung diseases and then as '*analgesic*' during examination of sensitive ears and to relieve distress in pulmonary inflammation.[20] Although there is some doubt but Michael Faraday (1791-1867) is accredited as first to describe the anaesthetic effects of Ether, similar to those caused by nitrous oxide.[21]

Ether Frolicks

Surprisingly, despite the discoveries that the '*laughing gas*' and *sweet slumber*' had analgesic properties, medical professionals remained oblivious or ignorant to such scientific discoveries and no serious attempts to translate these observation into surgical practice followed. However, it was the recreational drug culture of first half of 19th century that took notice euphoric potential in these gases and began their public and private demonstration of exhilarating effects of these gases. Because of difficulty in storage and administration of nitrous oxide, its use remained limited by showman and medical professionals and many renowned scientist of that time became habituated to it, Beddoes, Watt, Humphry and Clayfield are few examples.[12] However, because of the ease of preparation, storage and administration, ether became a very popular gas among recreationalists and was frequently used to enliven private parties notoriously labelled as '*Ether Frolicks*'.[16] A parallel practice to drink ether as alternative or mixed with alcohol also existed.

Failures & Setbacks

On December 1844 at Hartford, Connecticut, Garden Q Colton (1814-1898), a medical student turned itinerant chemist, was giving a public demonstration of the exhilarating effects of nitrous oxide. For him it was business as usual but in the audience was sitting Horace Wells (1815-1848) a local dentist, who noted that a local shopkeeper, Samuel Cooley, had banged his shin and made it bleed during the inhalation but experienced no pain. Wells, who had a sore wisdom tooth persuaded and arranged for Colton to administer nitrous oxide while that tooth is extracted by his partner John Riggs (1810-1835). It was a big success, Wells realised the great potential of his discovery and proclaimed;

'A new era in tooth pulling'.[13]

Wells learnt from Colton the technique about, how to make nitrous oxide and then successfully administered it to fifteen patients for pain free extractions. Once convinced, Wells decided to demonstrate and announce his discovery to a larger audience of medical students of Harvard medical School, Boston. He co-ordinated with leading surgeon John C Warren (1778-1856) and eminent physician and chemist Charles T Jackson (1805-1880) of Boston and in January 1845 gave a demonstration of tooth extraction, while nitrous oxide is inhaled. Unfortunately, patient cried out before the extraction was completed, the entire affair ended in a fiasco and Wells was hissed out of the room amidst cries of *'hambug'*.[23]

Frustrated and heartbroken, Wells developed severe depression, became addicted to chloroform and was sent to prison for throwing sulphuric acid at a prostitute, where he committed suicide by cutting his femoral artery. He was just 33 years old.

THE DISCOVERY

The Chosen One

A certain named William Thomas Green Morton (1819-1868), ex-apprentice of Wells turned medical student, took a keen interest in Wells failed demonstration. Born at Charlton, Massachusetts, Morton began his career as a clerk later went into business but ended in failure. He became an apprentice of Horace Wells in 1841 but later set up his own practice at Connecticut initially and later in Boston however maintained his partnership with Wells in Hartford till January 1844. Morton's practice at Boson prospered, however, rendering teeth extractions painless prior to insertion of dentures or fixing of crowns remained a problem.

In March 1844 Morton joined Harvard medical school, got married and became acquainted with Jackson as his lodger. Probably, Morton discussed the problem of dental pain with Jackson, who suggested direct application of ether to gums and also brought attention of Morton to intoxicating effects of inhaled ether.[13] Apparently, after Boston fiasco, he discussed with Wells the possible use of ether as alternative to nitrous oxide.[24] Wells himself might be considering the option[24] but probably was reluctant to take the initiative because of prevalent consensus of opinion that prolonged inhalation of ether would inevitably result in death. However, Morton became seriously interested in the possibilities of producing stupor through inhaled ether for painless tooth extractions. He first experimented on insects, worms and on a dog, and then made himself and his apprentices to inhale ether but instead of loosing consciousness they became excited.

Morton realised he need advice from someone who has superior knowledge of chemistry and Jackson was the obvious choice and visited him on 30th September 1846.[25] During the interview, Morton purposefully didn't disclose his experiments with ether but suggested that he intend to use nitrous oxide. Jackson condemned use of nitrous oxide and cautiously recommended the trial with ether and instructed to purify before use the commercially available impure ether. Opportunity arise on the same evening, when an emergency patient Eben Frost called on Morton for tooth extraction, which he carried out while frost inhaled ether from a handkerchief.[26] On the following day, in the *Boston Daily Journal,* Albert Tenney reported this success.

"Last evening..............an ulcerated tooth was extracted from the mouth of an individual without giving him the slightest pain."[27]

The Ether Day

"......the patient being prepared for operation, the apparatus was applied to his mouth by Dr Morton for about three minutes, at the end of such time he sank into state of insensibility. I immediately made an incision about three inches long through the skin of the neck, and began dissection among important nerves and blood vessels without any expression of pain on the part of patient."[28]

John C Warren 16th October 1846.

Henry Jacob Bigelow (1818-1890), the newly elected surgeon at the Massachusetts General Hospital read the report and was sufficiently impressed to invite Morton to demonstrate its use at the hospital. Morton conscious of Wells failed demonstration, instructed Chamberlain, an instrument maker, for an apparatus consisting a glass globe to hold a sea sponge with inlet port to pour ether and outlet port, a simple tubular spigot for breathing to and fro.[29]

Morton gave the demonstration at the Massachusetts General Hospital on 16th October 1846, now remembered as Ether Day. The surgeon was John Collins Warren, who removed a congenital tumour from underneath the left jaw of Edward Gilbert Abbot, without producing any pain. At the conclusion of operation, Warren turned to the audience and uttered;

"Gentlemen, this is no Hambug"[30]

THE CONTROVERSY

The Patent

Morton wishful to gain the full financial benefit and to claim sole credit for the discovery, wanted to apply for a patent under the synonym *'Letheon'* to conceal the identity of ether. However, Jackson, who was not present at the demonstration, approached Warren and proclaimed himself as true discoverer of anaesthesia, who suggested to Morton to use ether and that later had acted only under his instruction. Later he pestered Morton to include his name in the patent application and a joint application was made on 27th October and issued on 12th November 1846 but Morton never succeeded in enforcing his patent.[31]

The Dispute

Wells visited Morton on 25th October and learned about the joint patent, furious, he argued that Morton's discovery was nothing new and pursued rather ferociously for his claim to priority for discovery of anaesthesia through communications to both scientific and public press.[23] By December 1846 *Letheon* arrived and administered in London and by January 1847 it was used in Paris and other European capitals. In June 1847, ether was adopted in Australia and soon in every country in the world.[32]

On 1st December 1846 Jackson wrote his version of the events leading to discovery of anaesthesia to French Academy of Sciences in Paris in which he excluded the name of Morton altogether but Morton's written rebuttal of Jackson's claim also reached Paris that resulted in division of Montyon Prize of 5000 francs, by the French academy, between Jackson for *'observation and experiments regarding the anaesthetic effect of ether'* and Morton for its *'application.'*.[13]

In 1849, an article *'An account of the first use of sulphuric ether by inhalation as an anaesthetic in surgical operations'* was published in the *Southern Medical Journal,* by Crawford W Long, a general practitioner from Jefferson Town, Georgia claiming that he had used *Ether* on at least eight patients since his first use on 30th March 1842, when he removed a tumour from the neck of Mr James Venable.[33]

Uncertainty still persists about why did Dr Long, delayed publication of his groundbreaking innovation? Probably he might not have realised the full importance of his discovery till it became an accepted fact and he was anxious only for his claim for priority to be recognised, but had no financial interests.[34]

The Petition

Being unable to capitalise his *discovery,* Morton made three submissions to US Congress for financial recognition (1846, 1849 and 1851), well supported by the trustees and staff of MGH. Unfortunately, all three petitions were opposed and then blocked by Jackson and Wells and later by Wells widow.[31]

In March 1854, Long wrote to his Congressman and Georgia's Senator about his claim. Senator Dawson appointed Jackson to investigate the claim. Jackson interviewed Long, on 8th March and examined evidences for the claim and left Long's residence that evening well convinced about the validity of the claim and his support for Long led to rejection of *"The Appropriation Bill"* debated in the US Senate to recompense the *'discoverer'* of practical anaesthesia.[34]

By now Morton was a broken man, who exhausted all his finances in trying to establish his claim to priority. He died of cerebral haemorrhage in New York City on 15h July 1968.

THE HONOUR

"In science, the credit goes to the man who convinces the world, not to the man to whom the idea first occurred."

Sir William Osler (1849-1919)

The capability to perform surgery with out pain has been regarded as one of the most important advances in the history of medicine. Anaesthesia has been voted as the third most important medical advance by the BMJ medical milestone poll. The word *'discovery'* is often ambiguous in science and leads to misunderstandings.[29] Morton was neither a genius nor a scientist, not even a qualified dentists but still his contribution towards *Discovery of Modern Anaesthesia* is beyond description. Morton did not *"discover"* anaesthesia as such, he was not the first person in the history who relieved or attempted to relieve, surgical pain nor the first who used ether through oral or inhalation route but it was his personal inspiration and professional conviction which led to successful administration of the *right agent* before the *right audience* in the *right place*, at the *right moment* of history that ensured rapid spread of the news of his success around the world that brought a revolution in the practice of surgery.[31]

For this unimaginable contribution to modern science and medicine he rightly deserves the inscription on his tombstone in Mount Auburn Cemetery, Boston, the Morton's monument, composed by Henry J Bigelow that reads;

"....William T G MORTON, Inventor and Revealer of Anaesthetic Inhalation. BEFORE WHOM, In all time Surgery was Agony, BY WHOM Pain in Surgery was averted and annulled. SINCE WHOM Science has control of pain....."[30]

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