THE TWENTY-THIRD ANNUAL GENERAL MEETING AND SIXTY-EIGHTH ORDINARY MEETING

The Society meet at the Royal College of Surgeons of Edinburgh on 23 October 1971 for its Annual General Meeting. At the Sixty-Eighth Ordinary Meeting which followed, Mr. David Mackenzie, Product Manager of Ethicon Ltd. gave a paper entitled:

THE HISTORY OF SUTURES

The title of this paper should more correctly be 'A Short History of Surgery with particular reference to Sutures' for the two subjects are inseparable. May I also clarify the word 'Sutures' in the title, for I mean both sutures which hold a wound together until it has healed, and ligatures which are used to tie off a vessel such as an artery.

Somewhere between 50,000 and 30,000 B.C. eyed needles were invented and by 20,000 B.C. bone needles were of a standard unsurpassed until the Renaissance. It is reasonable to assume that these needles were used to sew wounds together, for Neolithic skulls have been found, showing that during this period trepanning was successfully carried out. Bone growth inward from the edge of the hole shows that the patient was not only alive at the time of the operation but survived for a considerable period afterwards.

Primitive men in backwaters of the modern world give some indication of how early surgery was performed. North American Indians used cautery. East African tribes ligate blood vessels with tendons and close wounds with acacia thorns pushed through the wound with strips of vegetation wound round the protruding ends in a figure-of-eight. A missionary, Robert Felkin, described a caesarean section he saw performed in Uganda in 1879. It was skilfully performed using cautery and a skewer-like means of closure. A South American method of wound closure uses large black ants which bite the wound edges together, their powerful jaws acting in a similar manner to Michel clips. The ant's body is then twisted off leaving the head in place.

Returning to ancient times, about 1900 B.C. Hamurabi, king of Babylon, codified the laws and engraved them on a temple pillar. Some of these laws related to surgical practice. One stated that, 'If a physician shall make a severe wound with an operating knife and kill a patient or destroy an eye, his hands shall be cut off.' Although these laws show that surgery was performed, it also indicates why Babylonian medicine

eventually declined to the stage where the sick were carried to the market square and left so that passers-by who had previously suffered from the same illness might offer advice.

The Mesopotamian civilizations are known to have been in regular communication with India and, although the chronology of Indian history is notoriously difficult, one of the surgical texts written by an Indian, Susruta, is the great storehouse of early Aryan surgery. Susruta lists detailed accounts of how to perform repair of anal fistulae, tonsillectomy, caesarean section, amputation and rhinoplasty. Rhinoplasty was a popular operation since cutting off the nose of an offender was the punishment for adultery. Intestinal obstruction was relieved by surgical intervention. The intestines were opened and any obstruction removed, they were then washed out with milk, lubricated with butter and sutured with ant heads in the manner described previously. Nerves were not just repaired but divided to relieve pain. To perform these surgical feats, 125 instruments were described in detail, including triangular, round-bodied, curved and straight needles. Sutures were made from flax, hemp, bark fibre or hair. Training for surgical skills was stressed: gourds, melons and animal bladders were used to practise incisions, animal skin for suturing and lotus stems for ligating. Anatomy was taught but dissection was limited to the bodies of children under two years of age as above this age cremation was mandatory. It is obvious from these and the other texts available that Indian surgery was considerably ahead of any other early civilization and we must assume that much of Egyptian, Babylonian, Greek and Arabic surgery originated in India.

Egypt was invaded by the Babylonians who ruled for several centuries, but about 1600 B.C. a popular revolution created the New Egyptian Empire. It is from this period that the Edwin Smith papyrus dates. This papyrus, which may be the earliest book known to man, is an obvious attempt to codify the knowledge of previous generations, and is scientific in its approach. It contrasts with the other famous papyrus, the Ebers, which shows a strong propensity amongst Egyptian physicians to add dung to every possible prescription. The treatment for a gashed shoulder makes the first reference to sutures—'thou shouldst draw together for him his gash with stitching. Thou shouldst bind it with fresh meat the first day. If thou findest that wound open and its stitching loose thou shouldst draw together for him the gash with two strips of linen.' From other references it is learned that the linen strips were coated with an adhesive mixture of honey and flour thereby creating the original skin closure strips. Anatomy is not much referred to and many of the treatments appear to have been purely empirical. Even mummification did little to enlighten them, for usually only the intestines were removed through an incision in the side, the brain being removed by probing and syringing through the nostrils.

Egyptian surgery never attained the heights reached in India but it did much to initiate the move to a scientific approach which culminated, of course, with the Golden Age of Greece, when the separation of religion and medicine was finally completed. Previously, civilizations had arisen around a major physical feature such as a river, but Greece was a new concept being a collection of cities separated by physical features but united by an odd combination of heroic poetry and a four-yearly athletics contest.

Asklepios is the first name to appear in Greek medicine but what is truth and what is fable about him is impossible to distinguish. His success rate in curing disease was, however, so high that Pluto is supposed to have complained that hell was losing all its new recruits. Later, when the healing temples of Asklepios were in full swing the priests maintained this remarkable record by hurriedly removing all dying patients to the nearby woods. The employment in the temples of lay assistants who were responsible for healing led eventually to the founding of medical schools in the seventh century B.C. and for the first time medicine became a science. In 460 B.C. Hippocrates, son of a lay healer, was born. His writings do not make much reference to surgery but where they do, the basis is one of ensuring that the healing powers of nature were fully utilized. Dry wounds were known to heal quickly and well if the edges were kept closely approximated, although cautery was used to achieve haemostasis. Hippocrates' main contribution to surgery lies in his clinical descriptions and the discarding of treatments founded on tradition or wishful thinking rather than on rationality.

Although a tenuous link exists between Greek and Indian medicine by way of Crete, Egypt and Babylon, a concrete connection was established by Alexander the Great, who, having conquered Egypt and built Alexandria, marched on Babylon in 331 B.C. Alexandria became a great cosmopolitan centre which continued even after the death of Alexander and the break-up of his empire. Ptolemy I did much to establish it as a centre of learning with the creation of the great library, but, unfortunately, we know little of the medical school which was founded at the same time.

Now begins the rise of the Roman Empire, although its medicine was always Graeco-Roman. Pliny notes that a physician could not succeed in fashionable practice unless he spoke, or pretended to speak, Greek. The first century A.D. was one of consolidation and advance in technique and was the culmination of Greek medicine.

It was a Roman and a medical journalist, Aurelius Cornelius Celsus, who wrote *De Re Medicina* about A.D. 30. This encyclopaedic work stands as a monument to Graeco-Roman medicine. Celsus tells us that sutures were of ancient origin and should be 'soft, and not over twisted, so that they may be more easy on the part'. Whether he was referring to linen or wool is uncertain. He also described fibulae or small metal clips similar to the Michel clips of today. He is credited with the first substantiated mention of ligating by recommending that if ordinary means fail to arrest haemorrhage, the vessels which discharge the blood are to be taken hold of and tied in two places about the wounded part. Another means of obtaining haemostasis is described by one of Celsus' younger contemporaries reporting on a hernia operation. 'We ligature the larger vessels but as for the small ones we catch them with hooks and twist them many times thus closing their mouths.'

Galen of Pergamon, *c* A.D. 150, gained a reputation by treating and sometimes suturing the severed tendons of gladiators, giving them at least a chance of recovery where previously they could only expect paralysis. Galen became the Colossus bestriding the medical centuries ahead. His importance is not, however, merely as the progenitor of inviolate medical truth. In his work, *De Methodo Medendi*, he comments: 'Moreover let ligatures be of a material that does not rot easily like that of those brought from Gaul and sold especially in the Via Sacra.' Presumably he was referring to linen or celtic thread. He continues: 'In many places under Roman rule

you can obtain silk, especially in large cities where there are many wealthy women. If there is no such opportunity, choose from the material where you are living, the least putrescible, such as thin catgut which quickly falls from the vessel.' This is the first reference to catgut although Galen makes it plain in other passages that it was known to the ancients. Catgut made from the twisted intestines of herbivorous animals is still used today and, indeed, accounts for nearly half the usage of all sutures and ligatures. Although its most important characteristic is that it is absorbed or digested by body enzymes this fact was not discovered until the eighteenth century. The ancients used it because it was strong and easily available from any musician. The origin of the word 'catgut' is obscure and all we can say definitely is that it never had anything to do with cats! One suggestion is that it is a corruption of 'kitgut', the kit being an early form of musical instrument.

While not authoritarian by nature it was not Galen but following generations who must be blamed for embalming his words and theories as immutable laws of the universe and even worse, giving the same weight to misinterpretations of his ideas. Such a misinterpreter was Aetius of Amida (sixth century A.D.). Particularly remembered for his treatment of aneurysms he should more properly be arraigned as one of the originators of the theory of 'laudable pus'. Both Hippocrates and Galen recognized two types of wound—one dry and clean which healed by first intention, the other dirty and requiring drainage before healing took place. Aetius confused these doctrines by disregarding dry clean wounds and insisting that in all wounds the poison should be removed and that pus was a necessary process of healing.

By the fifth century A.D. the western part of the Roman Empire had crumbled but Byzantium still stood and as a bastion of Christianity. But it was a religious schism which drove a group of Christians from Constantinople to seek refuge in Persia. This group, the Nestorians, set up a medical school which nurtured Greek surgery until the great Arabian conquest and the consequent dissemination of the knowledge the Nestorians had brought to their home of refuge. Never did conquest spread so fast and soon the empire of the one true faith stretched from Persia to the south of France.

The first great Arabian, known by the latinized name of Rhazes, was born near Teheran in A.D. 852. Having started life as a minstrel and storyteller he turned late in life to medicine. Of particular interest to us is the use made by Rhazes of catgut for suturing the abdomen. This would, of course, be the natural material for a lute player to choose. Another great figure of the Eastern Caliphate was Avicenna, born some fifty years after the death of Rhazes. He, too, did not start his career in medicine but as a religious scholar who could repeat the Koran by heart by the age of ten. Having turned his attention to medicine he soon established himself as a medical authority. He still had time, however, to write extensively on philosophy, natural history, mathematics, law and, of course, medicine and this all by the age of twenty! Small wonder he was called the Prince of Physicians and that his writings should suffer something of the same fate as those of Galen. Avicenna's contribution to suture development was his realization that traditional materials such as linen thread, when used in the presence of gross infection as in the repair of anal fistula, tended to break down rapidly. In search of more suitable material he turned to pigs' bristles and so invented the first monofilament suture.

Avicenna may have been the Prince of Physicians but the Prince of Surgeons was undoubtedly Albucasis, born in A.D. 936 near Cordova in the Western Caliphate. In his first book he recommended the indiscriminate use of the cautery but in his second he described operations in which cutting instruments and sutures were used instead. He also described a double suture, a technique still used today.

With the decline of Islam, we return to Christendom. During the eleventh century A.D. the medical school of Salerno was fast becoming the first university. Said to have been founded by four men—a Jew, a Greek, an Arab and a Latin, the school certainly grew out of the many cultures of the Mediterranean. The first great surgeon to arise from this school was Roger of Palermo. His texts became standard works and did the disservice of spreading and establishing the theory of laudable pus as an inviolate rule of wound healing. His advocacy of strips of bacon as drains fitted conveniently into this theory. He introduced the seton as a counter-irritant or as a drain, and minimized the difficulties of repairing intestines by suturing them over a hollow tube of elderwood. While Roger was laying the foundation for centuries of laudable pus, the Church was reacting against the increased involvement of priests and monks in surgery, by the Edict of Tours and subsequently in 1215 by the fourth Lateran Council forbidding all burning and cutting by the clergy.

Salerno was by now not the only university nor was it the only one with an important medical school. In Bologna, William of Salicet was preaching the reintegration of surgery and medicine. His theories were also in advance of these of Roger of Palermo in that he recommended a knife instead of the cautery as a means of removing an organ or growth. He dressed wounds with a mild balm of egg white and rose water; he sutured nerves and tendons together; distinguished between arterial and venous bleeding; and claimed to have treated hydrocephalus by draining off the excess fluid through a hole in the skull.

Almost contemporary with William Saliceto at Bologna was Hugh of Lucca. Unfortunately none of his writings survived but his son, Theodoric, published a book in 1266 much of which he attributed to his father. Theorodic was one of the few who cried out against the theory of laudable pus when he wrote: 'No error can be greater than this.'

Another graduate of Bologna and a pupil of William Saliceto was Lanfranc who carried his master's teachings to France. There also Henri de Mondeville (1260–1320) took up the preaching of dry wounds at Montpellier, stressing the error of laudable pus, and recommending that all needles be kept sharp and clean lest they infected a wound. He was no respecter of persons, nor even the great Galen, of whom he wrote: 'God did not exhaust all his creative power in making Galen.' Henri is also remembered for his concern for his patients, recommending music and good food to keep up their spirits. He even proposed forged letters bringing good news as psychological therapy. Henri demanded greater attention to anatomy and in 1316 his plea was in part answered when Mondino de Luzzi wrote the first anatomical manual. Yperman. another Frenchman, introduced a new method of cautery which was more apposite to the real job of haemostasis. It consisted of a metal shield pierced with different sized holes through which a blood vessel could protrude and be burnt without damaging surrounding tissues.

French leadership continued with the greatest surgeon of the fourteenth century, Guy de Chauliac (1300–67). His memory is perpetuated today in many hospitals for he invented the overhead chain by which patients can pull themselves up. He wrote much on hernia and was particularly concerned that quacks and itinerants should not be left to carry out such operations. In suturing intestines he condemned the use of ants' heads, preferring furriers' stitches. This stitch is one that inverts the edges of the join allowing the fur to be brushed back over it thereby camouflaging the junction. In suturing the intestines an inverted stitch presented a larger surface for healing and helped to prevent leakage.

In England medicine was beginning to awaken. St. Bartholomew's Hospital was founded in 1123 and St. Thomas's some years later. The first English surgeon of note was John of Arderne (1307–90). He learned his craft at Montpellier and on the battlefield. He was at Crecy when the English archers were reputed to have carried little boxes of cobwebs which they used to stop bleeding. John of Arderne made his reputation and his fortune with an operation for anal fistula for which he charged the equivalent of £400 plus a £400 annual pension for life. It says something for his skill that he was paid what he asked. His status, too, was high and he described himself as a surgeon amongst physicians which is a sad commentary on the standing of surgeons in England at that time.

The Renaissance had a dramatic effect on surgery. Human dissection had not been practised on any scale since the days of the Alexandrian School. Since the decline of that school animals had been used and it was not until 1308 that human dissection was eventually reintroduced in Venice. This consisted of the teacher sitting on a raised platform reading from the works of Galen whilst below him his assistant dissected the cadavar. The more liberal of the academics would occasionally point vaguely from their elevated position in the general direction of some organ described in the venerable text. The fact that Galen's treatise was based on the anatomy of the pig was not allowed to interfere with the proceedings. Should any militant dare to object to the obvious divergence of text and body he was informed that the human body had changed since Galen's day. The dissections were carried out in public and became an even greater social event than an execution!

The Italian artists were more tenacious than their medical colleagues and by securing bodies for themselves they rewrote anatomy for the first time in 1200 years. Leonardo da Vinci produced over 750 chalk drawings of the human body which, if they had been published, would have made him the father of modern anatomy. It was left to a young Belgian, Andreas Vesalius, born five years after Leonardo's death, to spark off the revolution by publishing his immortal work at the age of twenty-eight.

A Frenchman born some four years before Vesalius was also to fight against the reactionary attitudes now entrenched in the European universities. Ambroise Paré, born in 1510 of poor parents, received his early education from the parish priest before journeying to Paris to work in the Hôtel Dieu. At twenty-seven he decided to become a military surgeon, a decision which was to change not only his life but the fate of many others. Paré's introduction to his chosen profession shattered any illusions he might have had about the grandeur of war. Entering the newly captured city

of Turin he found grievously wounded soldiers propped against a wall. An old soldier asked if there was any hope for them and receiving a negative reply, gently cut the wounded men's throats, telling Paré that he hoped when his time came someone would render the same service to him.

Paré's first appointment was at the Chateau de Villane where he had to treat gunshot wounds, now common due to the use of the arquebus. Anxious not to make any mistakes in his first job, Paré followed the then established method of wound treatment. Such wounds were thought to be poisoned by gunpowder and were treated by wedging open the wound with a piece of wood and ladling in boiling oil and treacle. To his horror the supply of oil and treacle became exhausted and he was forced to use an egg and rose-water mixture in an attempt to soothe the troubled flesh. Imagine his relief and surprise the next morning when he found his patients who had had the soothing balm much better than those who had had the boiling oil treatment. So began a one-man campaign, in his own words to 'abandon this miserable way of burning and roasting'.

Much of Paré's contribution lay in the reintroduction of methods used by the ancients. This may be surprising since he was not versed in Latin, a failing his academic opponents frequently pointed out. He was careful to enlist the opinions of Hippocrates, Galen, Celsus and Avicenna in his fight to reintroduce ligatures as a means of haemostasis in place of the cautery. To grip the artery or vein he used a crow's beak type instrument 'to pull the vessel forth that it may the more easily be tied.' Of sutures, he used them only if the wound was large or if muscle had been cut transversely, thereby pulling the wound open. He also warned against the dangers of leaving dead space in a deep wound by suturing too shallowly. His triangular needles obviously had some difficulty in penetrating for he used a hollow tube to hold the wound edges whilst the needle was forced through. He also described a method of dry suturing for wounds of the face. This consisted of sticking strips of plaster down each side of the wound and then sewing the strips together. The object of this indirect stitch was obviously cosmetic. Paré cared for humanity and practised humility as exemplified in his 'I dressed him, God healed him'.

In the meantime surgery in sixteenth-century Britain had progressed to the stage where bodies were, by law, given to the barber-surgeons of Edinburgh and London for dissection purposes. Both James IV of Scotland and Henry VIII of England influenced medical progress. The former was wont to pay his lieges for the right to practise surgery and dentistry on them while the latter, having constant need of surgeons, is depicted in Holbein's famous painting granting an Act of Union to the barbers and surgeons. A less well-known fact is that almost the entire needle-making craft in England was centred at a monastery in Worcestershire. When Henry perpetrated the dissolution of the monasteries the needle-making monks merely girded their habits and moved to the nearest town, Redditch and there they stayed. Today, Redditch is the home of eyed needle-making, although the city of London made one early attempt to wrest it from the town.

The seventeenth century was not one of particular note in surgery. A Swiss surgeon tells of a lady called Susanna who had lost a nose but had had it restored by surgery. He comments, 'The marks of the operation are hardly visible but in winter when it

is very cold the tip turns a little blue.' Whether the Hindu version of a forehead flap or the Sicilian forearm method was used is not stated. The Sicilian method had been described in 1597 by Gaspare Tagliacozzi and is reputed to follow a procedure devised in the first half of the fifteenth century by a Sicilian family known as the Brancas.

In England the leading surgeon was the Royalist Richard Wiseman (1622–76) whose accounts of naval gunshot wounds and their repair make astonishing reading. While not a surgeon the leading medical figure of the century was, of course, William Harvey. When he eventually published his little seventy-two page book on the circulation of the blood there was little room for argument with him although many stubbornly refused to believe his theory pointing still to the authority of Galen. Harvey's importance to us is that his work enabled surgeons to use ligatures rationally for the first time.

A great surgical figure of the eighteenth century was William Cheselden (1688–1752). He brought fantastic skill and dexterity to surgery and particularly to the operation of lithotomy. First trying the abdominal approach he gave it up for the traditional perineal approach which it was claimed he could perform in fifty-four seconds. His speed and skill reduced shock and bleeding to such an extent that his mortality rate was far below anything previously known. Quacks and charlatans abounded in Britain during this century and one whom Cheselden met was Martin Butchell who, when his wife died had her body embalmed and placed in a glass case and introduced all his visitors to his 'dear departed'. The man who performed this remarkable feat of preservation was William Hunter (1718–83) who used glass eyes and carmine injections in lips and cheeks to add the finishing touches. Coming to London in 1740 from Scotland, Hunter revolutionized the teaching of anatomy to such an extent that the whole concept of modern medical training on the subject stems from his influence.

In 1748 William Hunter was joined in London by his younger brother John (1728–93). Never close to each other, a rift eventually arose between the two which was never to be healed. John Hunter is too large a personality to deal with in this paper; suffice it to say that he was the founder of experimental surgery and surgical pathology. His opinion of sutures was that they were basically undesirable, but if needed they should be interrupted sutures. He preferred where possible to bandage or use sticking plaster across the wound. Possibly John's greatest contribution to medicine and surgery was as a teacher of teachers and his true worth was not to be recognized until his pupils themselves rose to fame.

In the surgical field three of these pupils were the most famous. John Abernethy (1764–1831) ligated vessels never attempted previously. Philip Syng Physick (1768–1837), an American who had trained in Edinburgh before coming to London and studying under John Hunter, became the first professor of surgery at the University of Pennsylvania. Following Hunter's preference for adhesive strips to close or assist in the closing of a wound Physick experimented with adhesive strips made of leather. He noticed that these strips were dissolved after contact with fluids discharged from the wounds and it occurred to him that ligatures which would eventually dissolve in the body would be of considerable benefit. He then experimented on a horse with a ligature of buckskin which proved successful. He followed this by trying kid, parchment, varnished leather, tendon and catgut, but found that catgut did not dissolve

easily enough. His experiments were historic, for no one had previously considered the possibility of an absorbable suture which would perform its function and then disappear. As mentioned earlier, catgut had been used previously because it was strong and readily available, although Galen came near the truth when he advocated its use as a material which caused less pus than many others.

Astley Cooper (1768–1841) was a great interpreter of Hunter. While Hunter was considered a somewhat eccentric theorist Cooper translated his ideas into practical and easily grasped lessons. Although politically a radical, he was not an originator, his best work being on repair of hernia and amputation of the leg at the hip joint. His most famous operation and another example of putting John Hunter's theories into practice was the first attempted ligation of the aorta. What ligating material Cooper used we do not know. Waxed thread had recently been replaced by silk as the material of choice, but Physick's work was already known and Astley Cooper had already successfully ligated the popliteal artery with catgut.

Following Cooper's death, the scene shifts to Edinburgh where two great friends, Robert Liston (1794–1847) and James Syme (1799–1870) were the great exponents of surgery. The two men were in fact cousins, both trained at Edinburgh and both became outcasts together when the medical establishment in the city turned against them for what can only be described as the heinous crime of being too successful too young. But even the establishment could not continue to disregard their success. Unfortunately a typically violent Victorian quarrel broke out between the two and Liston went to London. Liston, apparently the more successful in his time was a man of powerful physique who clamped the leg with one hand and sawed off with the other. His speed and strength became legendary and stories that he cut off a leg, two fingers of his assistant and the tail of a frock coat in one stroke are typical. Syme on the other hand was relatively slight in build, thoughtful and a conservative in the best sense of the word. Liston cut off a limb faster than anyone else. Syme took longer but often saved the limb.

Fortunately, Liston and Syme once again became good friends long before Liston's death. Liston performed the first major operation in Britain using the remarkable new substance, ether. Syme, in his last lecture, told a sceptical audience that the greatest advance since anaesthesia had been made by a house surgeon, Joseph Lister. The birth of antisepsis had been heralded by Oliver Wendell Holmes in America and Semmelweis in Vienna but a mother could still exclaim, when asked permission to operate, 'It's easy to give consent but who's going to pay for her funeral?'

By 1867 Lister had formulated and published his answer and now the long 'Carbolic Crusade' began. But Lister's scientific acumen was not limited to antisepsis. Two years later he published an article, 'Observations of ligature of arteries on the antiseptic system'. He was aware of Physick's work and had himself noticed that fragments of glass or needles inadvertently left in a wound did not give rise to suppuration. He conceived that harmful bacteria must lie within the interstices of the silk and if they could be killed a ligature could be left in the body. Up to that time the ends of a ligature were left long, protruding out of the wound. After a while the tightly tied end of the artery or vein necrosed and sloughed off from the healthy tissue to be withdrawn with the ligature when it was pulled out of the wound. With

such a system the chances of the dreaded secondary haemorrhage were, of course, high. With his new antiseptic ligature Lister hoped that he could cut the ends of the ligature short and leave it implanted, either to be absorbed like dead tissue or encapsulated like the lead from a fowling-piece.

In 1867 he tested his theory on a horse. Six weeks later the animal died but dissection showed that the carotid artery had not weakened at the point of ligation. Lister next used his antiseptic ligature (soaked in an aqueous solution of carbolic acid) on the external iliac artery of a fifty-year-old woman suffering from femoral aneurysm. Conveniently for medical science the patient died some ten months later as the result of another aneurysm and Lister was able to determine that his ligature was surrounded by a small cavity of fluid. His faith in antisepsis unassailed, he concluded that the most likely cause was mechanical irritation of the tissues. His next step in retrospect seems obvious—an antiseptic ligature which would be absorbed. In Christmas week of 1868 he tried two types of sutures, one of ox peritoneum, the other of fine catgut. Both ligatures were soaked in a carbolic acid solution and then used to tie the carotid artery of a young calf. After thirty days the calf was killed and to Lister's disappointment the ligatures appeared completely unchanged. Depressed at his failure he continued his examination and suddenly realized that the ligatures had been completely absorbed and replaced by the calf's own tissue. This was the historic discovery so nearly missed. He next tried treating catgut with a mixture of olive oil and carbolic acid and found that it could be stored in an aqueous solution without further swelling. This was the carbolized catgut ligature which was soon in use everywhere.

Lister had one further contribution to make to the manufacture of surgical catgut. He had by this time returned to London in the hope of swaying the surgical world there to join the rest of Europe in the antiseptic revolution. In an attempt to delay the absorption of catgut so that wound and blood vessels would have longer to heal in safety, Lister turned to the leather trade and found they used chromic acid to tan leather. This he incorporated into his formulation.

Not everyone was happy about carbolized catgut especially when in 1881 Koch declared that carbolic acid in oil was not an effective antiseptic. At the same time Kocher of Berne discarded catgut altogether and sounded the first blasts of a campaign against catgut and in favour of silk, an argument that still continues though with but little virulence now. In 1885 Neuber of Kiel developed the principle of asepsis. This concept was advanced by Halsted when he introduced thin rubber gloves at the Johns Hopkins Hospital in 1890 and by William Hunter in London when he adopted gauze face masks in 1900. Halsted is still remembered for his rules of surgery advocating gentle handling of tissues, meticulous haemostasis, and interrupted silk sutures. These historic events all occurred before Lister's death in 1912.

By 1900 the catgut industry was firmly established in Germany due to the use of sheep intestines in their sausage industry. Many methods of sterilizing were used but the introduction of iodine sterilization by Claudius in 1902 established what was to become the standard method of preparation for nearly half a century.

Becoming parochial for a moment, let us use the suture industry in Edinburgh as typical of the industry as a whole. With the advent of World War I, Britain was left

in the embarrassing situation of having little or no catgut industry. Some far-sighted Edinburgh surgeons, realizing the problems, requested a local pharmacist, George Merson to undertake the commercial manufacture of this material. This he did in an old manse at St. John's Hill in the Pleasance, Edinburgh, and by the end of the war the business was well under way. About this time Merson began to sell eyeless needled sutures where one strand of suture material is attached into the butt of the needle. These patented products were called 'Mersutures' and greatly reduced the tissue damage caused by pulling through a double strand of material. Of the many technical advances in suture manufacture little more need be said other than to mention the introduction of sterilization by irradiation in 1960 using a Cobalt 60 isotope. This allowed sutures to be sealed in their final package and then sterilized, thereby eliminating the dangers and difficulties of aseptic transfers. This revolutionary development was a breakthrough which brought in its wake many improvements in packaging.

G. F. Merson had by this time become Ethicon Ltd. and although the development of these businesses is a fascinating story, it was felt that the early history of suture was of more general interest. Finally, a brief description of Ethicon today. The suture industry is, it is suggested, much bigger than many imagine. In Edinburgh alone we employ over a thousand people, use the intestines of 26,000 sheep per day and manufacture enough suture and ligature material in a year to stretch three-quarters of the way round the Equator. These materials comprise catgut which accounts for nearly half of all sutures and ligatures, the remainder being mainly non-absorbables such as silk, linen, steel wire and synthetics such as polyester, nylon and the newly developed polypropylene. Several years ago a reconstituted absorbable collagen suture was introduced and last year a suture company marketed the first absorbable synthetic. These new synthetics, absorbable and non-absorbable, are obviously the forerunners of new generations of sutures which, with other means of coating tissue such as physiological glue, indicate an exciting prospect for this unusual industry whose history has been touched on in this paper. Guy de Chauliac, writing in 1350, said, 'We are children sitting on the neck of a giant—we can see all he sees and something more besides.'