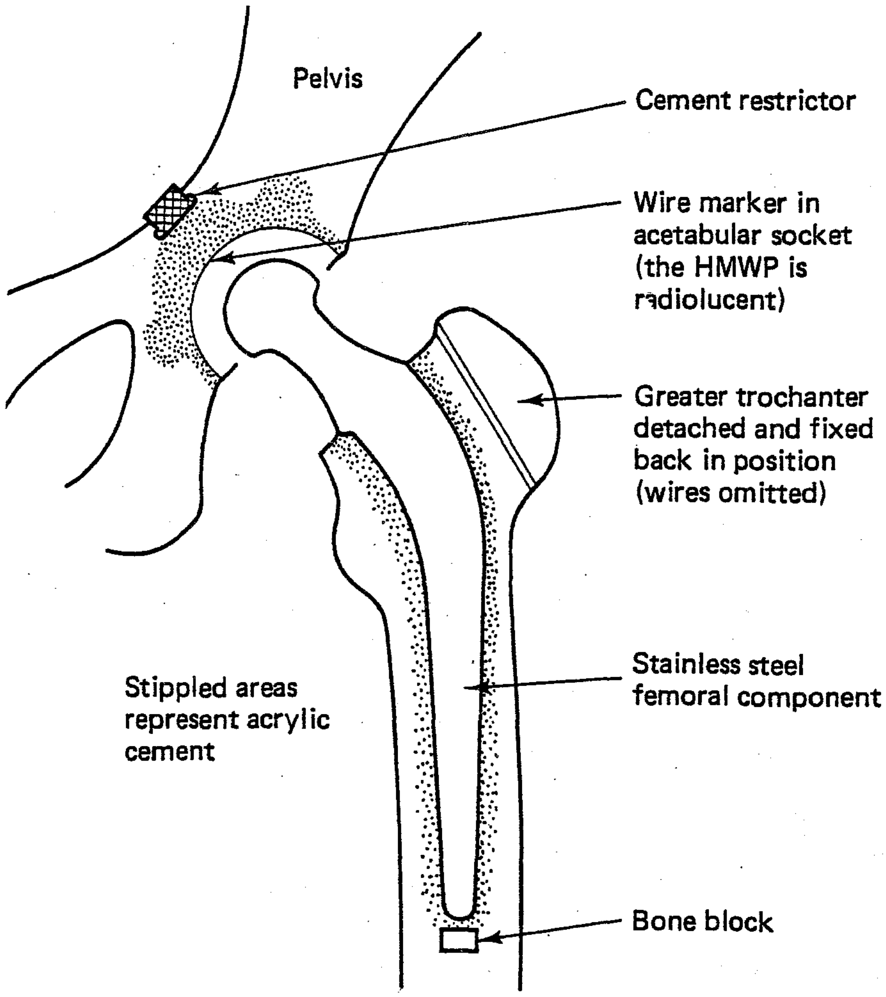
Historical Medical Equipment Society London



Outline sectional drawing to demonstrate Charnley hip prosthesis cemented into the acetabulum and femoral canal respectively (c. 1965)

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NEXT MEETING Venue: GLENSIDE PSYCHIATRIC MUSEUM BRISTOL Date: SATURDAY 24TH APRIL 2004 Organiser: DR TONY BENNETT Programme to be organized.		

EDITORIAL, HMES BULLETIN
NOVEMBER 2003

Following our instructive meeting at the Charnley Institute for Hip Surgery, Wrightington Hospital, Wigan in October, this Bulletin is heavily weighted towards the speciality of orthopaedic surgery. This was not anticipated but our meeting report is reinforced by an additional summary of a paper I gave at the Thackray Museum meeting in Leeds some 18 months ago. However, it occurs to me, there may be an advantage in producing similar speciality Bulletins from time to time? The Editor and I would be pleased to have your views and suggestions.

In defence of orthopaedic surgery, it is now considered a major and expanding branch of the surgical tree which touches the lives of most of us at some stage, especially those with traffic and sports injuries, and older citizens with fractures and arthritis. At the same time, it is also one of few specialities which treat patients from the cradle to the grave. As a former orthopaedic surgeon, I can report that examination of a new-born infant with a severe club foot sets up an immediate conditioned reflex asking one's self, "How do I treat this infant to prevent it becoming a crippled adult?" Further, in the same instant, one reflects that treatment and further review may well last many years, indeed extending into adult life. Modern orthopaedic practice also involves a vast array of instruments, orthoses, prostheses and implants, as my paper will remind you. Of course, these cost the nation enormous sums of money, although, currently, endoscopic methods reduce expensive hospital stays whilst investigation of more physiological solutions continue. However, I doubt whether the total bill will ever diminish with our ageing population and the undoubted benefits of orthopaedic interventions which solve many painful crises and, at the same time, restore most victims to full-independent activity. For example, consider the 'unsolved' fracture of the femoral neck (noted in my paper) whose numbers will increase annually and for whom surgical solutions will change little, in the foreseeable future; these injuries will continue to need beds, operating theatre time, orthopaedic equipment and convalescent facilities, and therefore expanding financial resources. Nonetheless, in the spirit of Sir John Charnley, we anticipate funding for further research efforts and ultimately, the discovery of more sophisticated solutions.

Finally, do not forget the Editor is very happy to receive your accounts, however brief, of unusual instruments or equipment, of museums and collections visited or indeed any topic relevant to the Society. This edition is being edited by Belinda Heathcote who has kindly stepped into the breach due to the temporary absence of Sisir Majumdar.

Many, many thanks to Belinda and a Happy New Year to you all.

John Kirkup

ORTHOPAEDIC ORTHOSES, PROSTHESES & IMPLANTS

HMES, Thackray Museum, Leeds

John Kirkup, 27th April 2002

Introduction

These terms are often a source of confusion and deserve clarification. At its origin. ortho-paedic (straight-child) surgery described the correction of children's deformities such as club foot, dislocated hip, scoliosis, etc. Today it encompasses all musculo-skeletal deformities of both child and adult, predominantly the latter. For the adult, the better term would be 'ortho-surgery', that is straightening by surgical means, and would return orthopaedic to its original use, hopefully to eliminate ridiculous terms such as 'paediatric orthopaedics', sadly now established in some quarters.

Ortho-ses, singular ortho-sis (straightening) refer to appliances or equipment worn externally to the limbs or body to straighten or strengthen the part in order to correct deformity or weakness. Orthoses aim to assist and improve function but can always be removed for adjustment or replacement.

Pros-theses (to apply or add) refer to apparatus or devices introduced to replace lost or removed parts of the body on a permanent basis. These can be external, as in the case of artificial limbs or internal, such as joint replacements or ligament substitutes. Im-plants (in-sert) are foreign materials implanted temporarily, to stabilize fractures or to achieve joint arthrodesis, until natural healing takes place when the implants no longer have further function. This communication will emphasis the development of implant material.

Orthoses

Bandaging is the earliest form of orthosis for deformity and was the basis of the Hippocratic method for controlling fractures. Originally, reeds or suitable leaves were employed, followed by textile bandages, perhaps strengthened with resins and wax but now replaced by crepe bandages, elasticated supports and, for fractures, plaster-of-Paris bandage casts. The majority of orthoses are rigid, and include simple wooden or metal splints for fractures, and later more complex supports such as the Thomas calliper (fig. 1), originally designed to relieve knee tuberculosis. Other callipers fitted into special shoes or boots, often with a spring device to hold up a drop foot or other mobile deformity or complete paralysis, especially due to poliomyelitis. Other orthoses include corsets, spinal supports and neck collars.

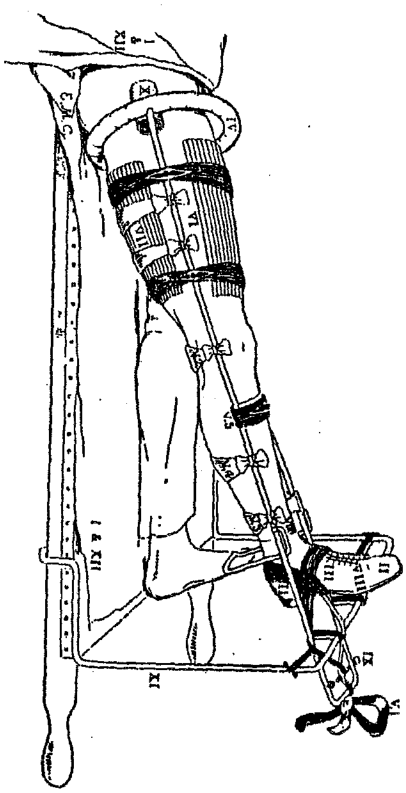

Fig. 1

Prostheses

External prostheses to replace amputated limbs go back at least to Roman times but were relatively crude until the late 19th century. Current designs are so sophisticated and comfortable that observers may not detect an amputee's disability. Internal prostheses could not be inserted safely before the development of aseptic surgery just over a century ago. However, the discovery of materials, fully compatible with human tissues, apart from gold, silver and mercury amalgam, did not develop much before the mid 20th century; these include chrome-cobalt alloys (fig. 2), certain grades of stainless steel and plastics (see cover illustration), titanium and carbon figure. Now large sections of arthritic joints or malignant bone tumours are excised and replaced by these foreign materials, without reaction or infection.

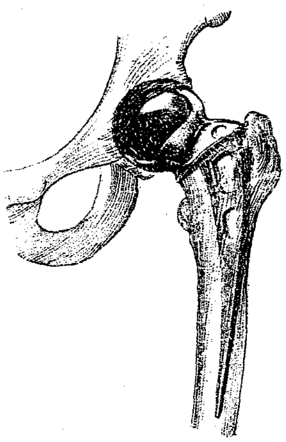

Fig. 2

Implants

Effective mechanical fracture fixation by implantation commenced in the mid 19th century, with the percutaneous external fixation methods of Malgaigne, employing a clamp to hold patellar fractures (fig. 3R) and a nail on a hoop for tibial shaft fractures. Lister developed this further using square-section steel and beef bone pegs. Later, Lambotte and Parkhill employed screw location above and below the fracture, attaching the protruding screws to an external bar. Curiously these methods were not pursued significantly until Hoffman introduced sophisticated universal ball joints to control external bars in 1948; since external fixation has proved effective in treating fractures of the face and pelvis, and also by the Ilizarov apparatus in controlling club foot deformity and leg lengthening procedures. Charnley's compression arthrodesis clamp is another form of external fixator of bone (fig. 3S). All external fixation devices are removed once fractures have consolidated, arthrodeses fused or deformities resolved.

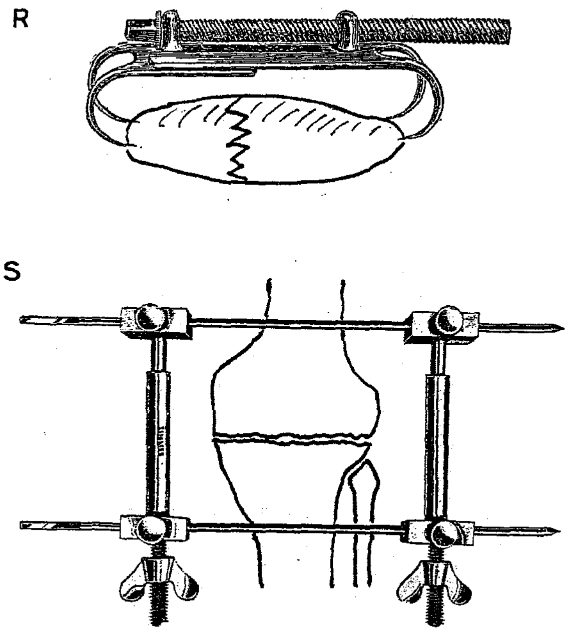

Fig. 3

Internal fixation of fractures probably started with the application of gold wire around the teeth for jaw fractures. Occasionally, compound long bone fractures were reduced with copper, silver or steel wire, somewhat hazardously before antiseptic surgery diminished infective complications. Lister was one of the first to claim good results employing silver wire for patellar and olecranon fractures. However, the opening of closed long-bone fractures was not seriously attempted until aseptic methods were established. The pioneers were Lambotte and Lane who initially inserted screws across oblique fracture lines but later added plates combined with screws in the near cortex. Today screws are inserted through both cortices to gain maximum stability. Hey-Groves in 1916, the Rush brothers in 1927 and Kuntscher in 1940 developed intramedullary nail fixations for long bones which remains popular, now often combined with cross-screws for greater rigidity (fig. 4R).

Fractures of the hip region are of two types. Firstly, the 'unsolved fracture' or subcapital fracture which if little displaced may do well with a trifin nail inserted under Xray control (fig. 4S). If significantly displaced, the threat of necrotic collapse of the femoral head is high and many surgeons remove and replace the head with a metal prosthesis (fig. 2) or even undertake total hip replacement with femoral and acetabular prostheses. Secondly, the trochanteric fracture has an excellent prognosis, even without surgery, though usually a nail and plate is inserted to mobilise the patient quickly (fig 4T).

Apart from prostheses which replace excised bone permanently, implants have temporary function limited to the period of fracture healing and can be removed; however, many are reluctant to return for a further operation. I have personal experience of removing plates and screws surviving in a femur for 68 years and only precipitated by a new fracture. Today research is directed towards biodegradable implants which can be absorbed by the body as their function diminishes. One excellent biodegradable material is beef or ox bone, highly suitable for temporary fixation of an arthrodesis, as I can confirm after much experience. However, animal bone implants, especially from cattle, are no longer acceptable in the human frame.

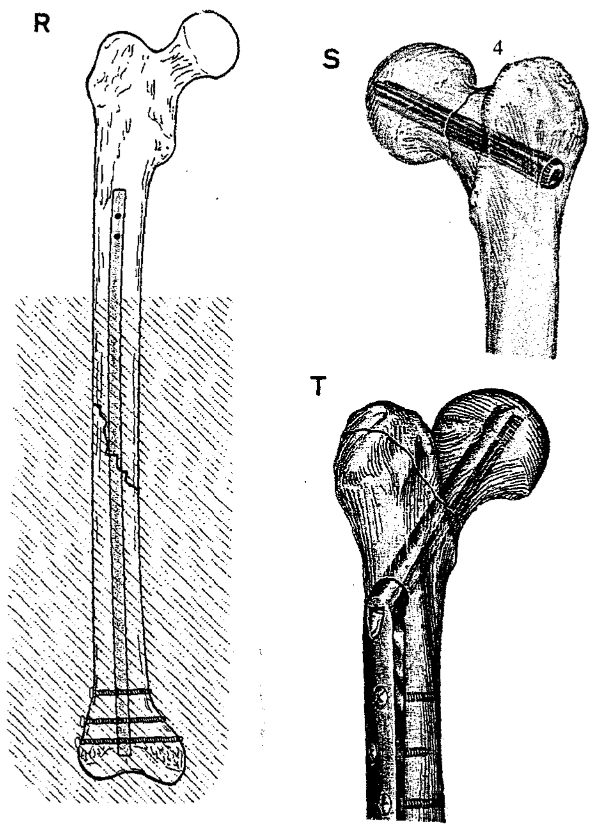

Fig. 4

<u>Figure Captions</u>

1. Thomas knee splint adapted for emergency treatment of a fractured femur during World War I; the soldier's boot is retained for temporary traction (c. 1917).
2. Austin-Moore chrome-cobalt femoral head prostheses, replacing the head of the femur after a subcapital fracture (devised c. 1952).

3R. Malfaigne's hooks applied through the skin to immobilise a fractured patella; the screw is turned with a key to facilitate reduction (devised c. 1847);

3S. Charnley's compression clamp to promote fusion of the knee joint after excision for arthritis or disease (devised c. 1948).

4R. Intramedullary nail with cross screws at both extremities, for fixation of femoral fractures within the shaded area (devised c. 1985);

4S. Tri-fin nailing for subcapital fracture of the femoral neck (devised c. 1931);

4T. Tri-fin nail-plate with cross screws for inter-trochanteric fracture of the femur (devised c. 1941).

VISIT TO THE WORKSHOP AND CHARNLEY MEDICAL MUSEUM

Before John Charnley started hip replacement operations, he established a biochemical workshop and appointed a resident engineer; this was quite unique for an orthopaedic hospital in 1958, at least in Great Britain. Although the workshop is no longer in use, the original machines for testing the wear of materials, especially stainless steel on various plastics, remain in situ and we were privileged to see one of these put into action.

In the adjacent Charnley Medical Museum we examined displays outlining the historical development of Charnley's low friction hip arthroplasty, as well as unique equipment, instruments and many specimens demonstrating various setbacks experienced with Teflon cups and non-cemented cups. The displays included: -

1. Acrylic Cement 1958. Self Curing acrylic cement was used in dental, plastic and intracranial surgery before orthopaedic surgery. However, no-one before Charnley denuded cancellous bone thoroughly to insert large masses of cement to fill the femoral cavity and significant portions of the pelvis, in order to embed the prosthetic components securely and rigidly against compact bone; this was his vital masterstroke.

2. Lubrication of Animal Joints. Charnley's study of joint lubrication was published in 1959 and persuaded him to use Teflon because of its very low coefficient of friction. His work on lubrication also influenced him to select a small spherical head for the femoral prosthesis.

3. Teflon Arthroplasty 1959-61. This records the failure of acetabular cups made of this very slippery plastic, due to abnormally rapid wear and penetration by the steel femoral head, necessitating the revision of some 300 hip arthroplasties.

4. Wear of Plastics in Vitro and HMWP in Vivo. Many wear tests were conducted and, by chance, high molecular weight polyethylene was examined and demonstrated to be very resistant after three weeks continuous movement; HMWP became the plastic of choice for cups and remains commonly in use.

5. Sockets Without Cement, 1963-65. Acrylic cement often showed a line of demarcation at its junction with bone which, initially, Charnley interpreted as ominous. Thus he introduced a press-fit acetabulum to use without cement for alternate patients; after some 300 cases he found cemented cups were best and abandoned press-fit prostheses.

6. Frictional Torque. Dislocation. Attachment of Trochanter. These were other topics investigated by Charnley who always divided the greater trochanter to gain free access to the hip and then re-attached the bone with wire by various methods.

As these displays reveal, part of the success of Charnley's hip arthroplasty was due to the continuous, detailed and brutally frank assessment of every stage of his work.

DEVICES AND DESIGNS : A HISTORY OF HIP REPLACEMENT

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Total hip arthroplasty is one of the most successful surgical procedures of the 20th Century. While surgeons such as Sir John Charnley are credited with devising and perfecting hip replacement surgery, innovation and research throughout the 1980's and 1990's have continued to improve both implants and techniques.

Different materials have been used to develop new types of implant. Contemporary materials such as titanium, improved stainless steels and high density cross-linked polyethylene have all been developed for use in hip replacement. One of the most important innovations of the post-Charnley period was the cementless hip replacement. The Ring prosthesis was one of the first cementless implants developed in the UK and also one of the first hybrids, as some were cemented on the femoral side. In the United States, fully cementless implants with a porous coating to encourage bony ingrowth were developed by Harris and Galante for the Zimmer Company in the early 1980's. Other companies have used different types of methods including sintered beads, titanium wire mesh and Hydroxyapatite in order to encourage the bone to grow into the prostheses and improve stability. The benefit of cementless components was that they allowed revisions more easily which was beneficial to the increasing numbers of patients who were receiving implants at younger ages, particularly in the United States.

While ceramic is not a new material, it has been used in Europe since the 1970's, there have been specific problems associated with it. Manufacturing processes were not as sophisticated as they are now which meant the heads tended to be rough causing catching and breaking. Higher quality ceramics have been developed and manufacturing techniques improved, reducing the risks associated with the earlier forms. Metal on metal implants have experienced a renaissance. With new manufacturing techniques, heads can be polished to a near-perfect sphericity using computers in the forming and polishing process.

Sometimes it was biology, rather than device manufacturers, which solved the problems relating to hip replacement. A major problem with orthopaedic surgery was the loss of bone stock. The use of morselised bone allograft began in the 1980's and has become the accepted method to help with the problem of osteolysis.

Modern technology has also improved surgical techniques. One of the most recent developments has been minimally invasive surgery. This consists of one, or in some cases two, very small incisions with specialized equipment such as guidance systems being used to ensure that the surgeon can monitor the surgery effectively. The benefits are small scars and a shorter period of hospitalization and recovery.

The future promises even more innovation and invention with hip replacement becoming more and more a matter of technology. Either way, the 40,000 or so patients in the NHS who receive implants every year will continue to benefit from this extremely important procedure.

THE FIRST INSTRUMENT DESIGNED FOR VACCINATION?

Unfortunately in his article on vaccination instruments in Bulletin No. 8 July 2000, John Kirkup could do no more than hint at the wide variety of instruments designed for this simplest of operations. We share an interest in this subject, but unknown to us both until recently is the description of what must surely be the first instrument specifically designed for vaccination.

This is a spring-loaded lancet illustrated by Luigi Marchelli in his short monograph "*Memoria sull' inoculazione della vaccina* ..." published in Genoa in 1801. This was very soon after the appearance of the Latin (1799) and Italian (1800) translations of Jenner's *Inquiry* of 1798. Marchelli himself is briefly mentioned in Crookshank's *History and Pathology of Vaccination* (1889). However, Marchelli's monograph has not been cited in any work on smallpox and vaccination of which I am aware, and his work deserves to be better known.

Marchelli's engraving (Figure) shows the complete lancet, and also exploded views to show the individual parts and their assembly. From this it appears that the spring mechanism was not designed to inject the vaccine; this would perhaps cause too much trauma. Apparently the lancet blade, with an integral needle guide (drawings 2,3) was inserted beneath the skin first. Then the needle (part 16) was pushed into the skin against the compression of the spring (drawings 4,6 and 5,8). The design ensured that the needle could not penetrate deeper than the blade, (drawings 5,8); again, this would reduce trauma to a minimum. When the compression of the spring was released the needle would return to its original position.

Although an ingenious device, it would seem to offer no real advantage over the ordinary bleeding lancet skillfully used. Also, even in an age unaware of the need for aseptic precautions, there would be problems with cleaning and maintenance.

Marchelli's monograph also includes an engraving showing the act of vaccination again probably the first such depiction. Ironically the instrument used is the ordinary bleeding lancet.

At present, we do not know how many of these lancets were made, nor whether they were used outside Italy, nor whether any have survived in museums or private collections. However, an American patent (No 12,636) was granted to Henry Mellish in 1855 for an instrument very similar to Marchelli's. Any information on these items would be most welcome.

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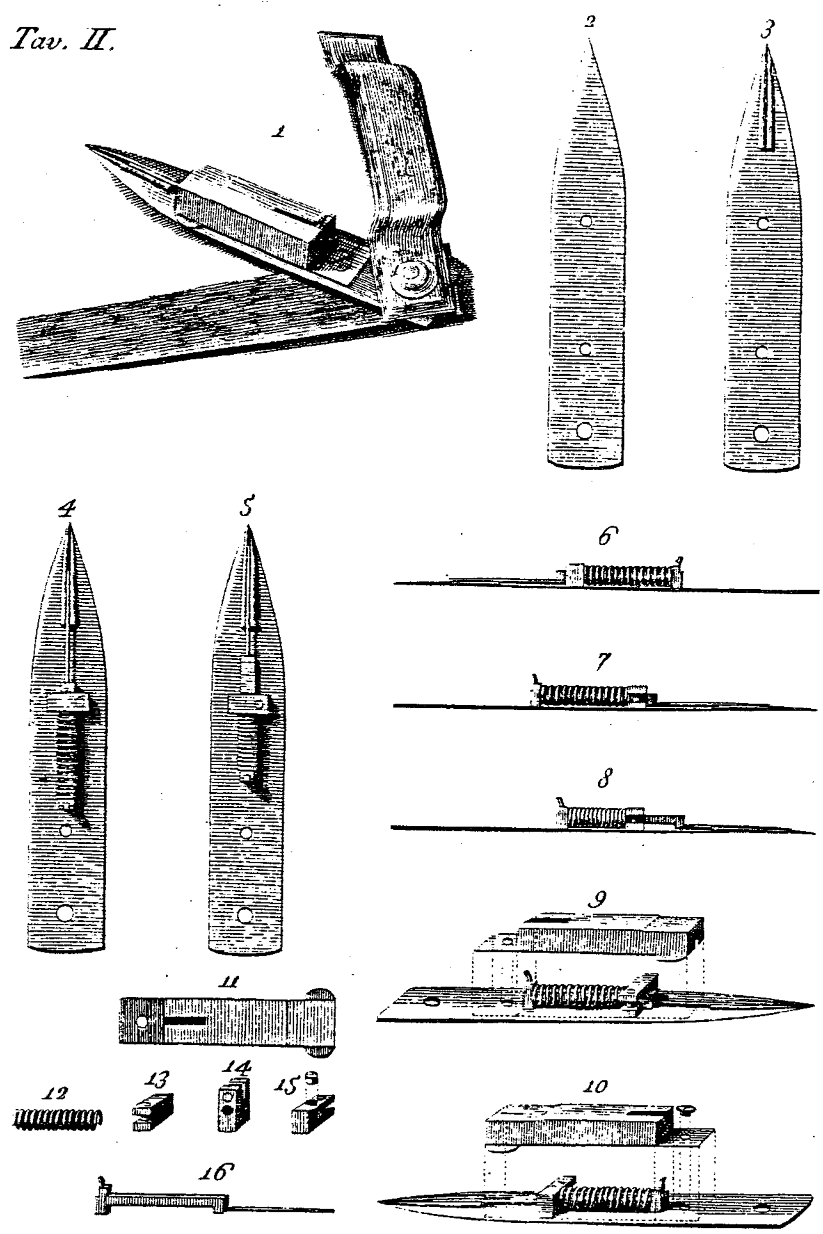

Plate 2 from Marchelli's monograph, showing the design and
Construction of his spring-loaded vaccination lancet, 1801

MUSEUMS IN ODD CORNERS

Belinda Heathcote

Since turning a corner in the very old part of Bratislava some years ago, and having my son say "Something for you, Mum" led to visiting one of the most interesting museums of pharmacy I have seen, sited in the premises of the oldest pharmacy in the city. I have been prepared to peer at anything which looks remotely "medical museum". However, even I was surprised when, having a spare day before a Meeting in Leipzig, I decided to visit the (in)famous Colditz Castle and wandering into the courtyard found myself looking at what seemed to be a "mechanical man". Further investigation revealed it was an advert for a Museum of Dental History. Unfortunately it was closed the day I was there, but a member of the "Friends of Colditz Castle" told me the history. Apparently, it is the work of one man, Andreas Haesler, who had the wit to realize that political changes in East Germany meant a rush to modernize in every field, resulting in "old-fashioned" equipment being thrown out en masse. He just grabbed everything that came his way and now has the 5th largest collection of dental artifacts in the world. Unfortunately, he does not have a museum but Colditz Castle has 600 odd rooms to use up. After the Castle disgorged its famous inhabitants the East Germans used it as a prison for landowners, and other undesirables, for a couple of years and then turned it into a hospital. In the 1990's it was emptied, in a parlous state of neglect, and while renovation has started they are still trying to find a use for it, hence space for Herr Haesler's collection. The next visit will have to be at a time when it is open. For those interested, opening hours are 09.00 – 17.00hrs, Monday to Friday, and 10.00 – 17.00hrs Saturday and Sunday. Entry is only E2.00. There is a web-site at www.dentalmuseum.de for those with computers.

Another clue to be followed came earlier on this particular journey. Arrival in Leipzig was the end of a very interesting, and packed trip round former East Prussia, now split between Poland and Russia. One stop was in Frauenberg (Polish, Frombork) where Copernicus did his most famous work. Naturally, Copernicus' observatory, the cathedral and a concert from the fantastic organ took priority on the short visit and to fill in the gaps I bought a book to read when I returned to the train. One picture is of the former Hospital of the Holy Ghost and the Chapel of St. Anne which is currently a "Museum of Medicine" – which we did not see. Something else which must be investigated. Eastern Europe has been closed for so many years, how many more treasures are to be found in odd corners? A case of 'keep your eyes open'.

THE MUSEUM OF MEDICAL HISTORY IN UPPSALA, SWEDEN

Uppsala is a university city full of historical and scientific interest. Its most famous son is Carl Linnaeus 1707-1778, the father of taxonomy. His influence is noticeable throughout the city in museums, parks and public gardens where there is meticulous and accurate naming of plants.

There are numerous museums and other buildings of interest. The anatomical theatre of 1663 in the Gustavianum Museum is particularly impressive.

The large medical museum is housed in an old psychiatric hospital and was opened to the public in 1995. It is run by a retired professor of surgery and his wife, a retired paediatrician. They are assisted by a nurse and a pharmacist. Throughout the professor's working life the portering services were under strict instructions that nothing was to be thrown away until he had scrutinised it.

Uppsala University Medical School has always been at the forefront of medical research and the collection reflects this. For example there is an early prototype Einthoven ECG apparatus, an original Laennec stethoscope from 1820 and an original Celsius thermometer. Celsius himself worked in Uppsala. In the thermometer on display the boiling point of water is marked at 0 degrees and the freezing point at 100 degrees. This was reversed a few years later.

The main exhibition room contains twelve operating tables from the 1840's onwards each with its corresponding anaesthetic apparatus. There are large collections of surgical instruments arranged on a speciality basis. There are also rooms devoted to pharmacy, radiology, respiratory care, internal medicine, pathology and nursing.

The museum is open Thursday 1.00 – 5.00 pm and the fourth Sunday every month 1.00 – 5.00 pm. It is closed July and August. Guided tours are available on request. Contact 00-46-(0)18-66-26-10.

Tim Smith (visited June 2003)

THE GIFTS OF PHYSICS TO MEDICINE

SISIR K MAJUMDAR

Advances in medical science have been, and always will be, dependent on progress in the basic sciences. However, basic science is not always easily converted to applied science, it depends on both continual advances in technology and the innovation of craftsmen. Together with these, physics in particular has made a unique contribution to medicine.

Discoveries of physicists like Wilhelm Conrad Röntgen, winner of the Nobel Prize for Physics in 1901, Albert Einstein, Nobel Prize for Physics in 1921 and Georg von Bekesy Nobel Prize in Physiological Medicine 1961, contributed much to the development of many machines now used in medicine. Niels Ryberg Finsen and Willem Einthoven were two other physicists who won Nobel Prizes, in 1903 and 1924 respectively, whose contributions aided the development of both therapeutic and diagnostic tools.

X-Rays

X-Rays are invisible electro-magnetic radiation with a shorter wavelength than light. Discovered by Wilhelm Röntgen in 1895, they were originally called Röntgen rays, until anatomist Rudolf von Kőlliker, the subject at a demonstration held by Röntgen, proposed they be called X-rays. The value of X-rays in medicine is that different components of the body absorb X-rays to a different extent, but enough radiation passes right through to register on a photographic plate. Röntgen produced the world's first X-ray image with a picture of one of his wife's hands, showing all the bones and her wedding ring. Shortly afterwards, on December 28th 1895, he sent a report of his findings to the Medico-Physical Society in Wűrzburg in a paper entitled "Uber eine neue Art von Strahlen" ("On a new form of rays"). His second communication was presented in Berlin on January 13th 1896, in the presence of Kaiser Wilhelm II. He spoke on the subject for the last time in Wűrzburg on January 23 1896, when Kőlliker again allowed his hand to be used for a live demonstration.

Röntgen published two more papers on March 9th and 10th 1897, but news of his discovery was already spreading fast. On January 2nd 1896, he sent a reprint of his report of December 28th 1895, to scientific colleagues, including Franz Exner in Vienna, Friedrich Kohlrausch in Gőttingen, Henri Poincaré in Paris and Arthur Schuster in Manchester. Exner passed the paper to Ernst Lecher, son of the editor of the Vienna "Freie Presse", resulting in the first publication of the discovery of X-rays being made in a local newspaper on Sunday, January 5th 1896. Other European mass-circulation papers followed it up and the first English announcement was made in the London "Daily Chronicle" on Monday January 6th. The first report of Röntgen's discovery in a scientific journal, was in the New York "Electrical Engineer" on January 8th 1896, entitled "Electrical Photography through Solids". On January 11th 1896 the medical press caught up, with the same information being published in both the New York "Medical Record" and the London "Lancet".

The tentative applications of X-rays marked the beginning of diagnostic radiology. Its value was increased shortly after Röntgen's discovery by the discovery of "radio active" materials that generate rays spontaneously, by Antoine Becquerel and the husband-wife team of Pierre and Marie Curie, who jointly won the Nobel Prize for Physics in 1903. Radiotherapy began with Becquerel's observation that radium carried in his pocket caused a burn. Marie Curie, the only holder of a Nobel Prize in two different subjects and the first woman to be awarded a Nobel Prize, was awarded her second Nobel Prize for Chemistry in 1911, for the discovery of Polonium (named after her mother country) and Radium.

The discovery of many other kinds of rays, like gamma rays, has followed Röntgen's monumental break-through as well as the discovery of particles like neutrons and electrons. In the future many more forms of rays could be seen in the service of medicine. The latest, electron beam tomography is now being used to assess the vascular condition of the heart.

Ultra Sound

Medical ultra-sound originated in the work on marine SONAR (SOund NAvigation and Ranging) during WW1. Ultra-sonics is the branch of physics dealing with theories and applications of ultrasound, i.e. sound waves occurring at frequencies too high to be heard by the human ear (above 20KHz). During the 1930's experiments were carried out into the possibilities of using high-frequency sound waves for medical purposes. The frequencies used in medical devices normally lie in the range of 1-10MHz. At these ranges, sound can be focused in the same way as light and, despite the high frequencies, is still conducted as mechanical vibrations within the tissues, thus free of the dangers of ionisation present in X-rays. The strength of the echo is proportionate to the density at the interface with the tissues and, as sound travels at a constant speed in soft tissue, echoes coming from deeper structures take longer to return to the surface, allowing the depth and direction of any tissue creating an echo to be determined by appropriate electronic apparatus.

Echo aortography is the application of ultrasound techniques to the study of the aorta. Echo cardiography uses ultrasound to examine the heart and to diagnose cardiovascular lesions, mitral disease, pericardial effusion etc. Doppler ultrasonography techniques are used to augment 2-dimensional echocardiograms, allowing velocities to be registered within the echo cardiographic image. Echo encephalography uses reflected ultrasound in the diagnosis of inter-cranial processes.

Tomography in Nuclear Medicine

Tomography is a technique using X-rays combined with ultra-sound to achieve a clear image of bodily structures in a single plane. It is sectional röntgenography taken with the X-ray tube in a curvilinear motion synchronous with reciprocal film motion, while the patient remains still. The selected plane for imaging remains stationary on the moving film while structures on all other planes have a relative displacement and are obliterated or blurred.

Computerised axial tomography (CAT) is a method of obtaining a 3 dimensional view of the interior of an object by building up a series of sectional views. Positron Emission Tomography (PET) is tomographic imaging of metabolic and physiological functions in tissues, the image being formed by computer synthesis of data transmitted by positron emitting radionucleides, often incorporated into natural biochemical substances which are administered to the patient. A computer traces the path of photons and produces a composite image representing the metabolic level of the bio-chemicals in the tissues. Single Photon Emission Computed Tomography (SPECT) is the imaging of local metabolic and physiological functions in tissues, the image being formed by computer synthesis of data transmitted by single gamma photons emitted by radionucleides administered to the patient.

Magnetic Resonance Imaging (MRI)

Electrons in motion produce a magnetic field. MRI is a technique using the magnetic field to cause resonance within atoms which produces an image. The patient lies inside a powerful electro-magnet, whose field is of the same frequency as hydrogen, the most common element in living tissue, but the concentration of which varies from tissue to tissue. The variations are detected, stored in a computer, analysed and formed into a computer graphic. A 3-dimensional image is obtained by changing the direction of the magnetic field and taking a series of pictures.

Magnetocardiograhpy measures the magnetic field of the heart using the same ionic currents which generate electrocardiograms and showing the characteristic P, QRS, T and U waves. Magnetoencephalography records the brain's magnetic field. Magnets are also used in therapy, magneto therapy.

MRI makes use of the nucleus of a single atom which has its own natural frequency. Because every type of atomic nucleus resonates to its own unique frequency, the frequencies become signatures of the atomic elements in a mixture. By adding a strong magnetic field the composition of substances can be analysed, allowing assessment of the physiological and biochemical functions of different organs, with the great advantage that MRI is harmless to patients.

Lasers

Laser (Light Amplification by Stimulated Emission of Radiation) is a system of coherent application of energy producing infrared or ultra-violet radiation with special properties. Atoms absorb energy in well-defined amounts, raising electrons to excited states, after which they quickly return to the original level, releasing energy as a photon of light. A photon is the quantum or particle of light which transmits the energy in ~X-rays and other forms of electro-magnetic radiation. Laser action depends on special atomic systems for which an energy supply can raise large numbers of atoms to excited states, ready to emit photons if stimulated. Mirrors at either end reflect light inside the "laser~" to maintain the action. A mirror at one end has a transparent area which allows a portion of the light to escape, forming the laser beam. Laser has multiple uses in medicine because the waves can be focused to a microscopic point, are sterile and cause minimal bleeding and scarring.

Electrocardiography

Willem Einthoven devised the electrocardiogram (ECG) by attaching electrodes to the skin and recording the voltages between various pairs of electrodes on sensitive machines. It has become an important diagnostic tool, rated by many, as second only in importance to Röntgen's discovery of X-rays.

Fibre-Optic Endoscopy

The accurate conduction of light was a serious problem in early endoscopes. It was solved when transmission along aligned bundles of flexible glass fibres was achieved by H H Hopkins and N S Kapany in 1954, creating an efficient replacement for the train of lenses which had been the only alternative in earlier an instruments. Endoscopes are now used extensively in both diagnostics and therapeutics, some in conjunction with electronic devices like videos and further developments like high magnification endoscopy are being worked on.

Microscopes

Microscopes are used to produce enlarged images of small objects and range from simple single lens magnifiers to complex electronic instruments. Simple and compound microscopes just use light waves and are called optical microscopes, but they can only magnify to c. x2.000, after which images become blurred. Higher magnifications are achieved by the use of electron beams. These electron microscopes have ring-shaped electromagnets to act as lenses, with beams of electrons spreading them out into cones with images invisible to the human eye. Visibility is achieved by forming the images on a glass screen coated with material which glows in the dark when struck by electrons. Both types, transmission and scanning electron microscopes, can achieve magnifications up to and beyond x1m.

Spectroscopy

Spectroscopy studies energy levels in atoms or molecules and is often used to identify the structure of unknown substances or to detect the presence of known substances, drugs, etc. It is widely used in clinical chemistry.

The Finsen Lamp

Niels Finsen was a Danish doctor who realised the possible value of various light rays on diseases like Lupus. He developed methods of using concentrated light radiation in special lamps. He is regarded as the father of modern photo-dynamic therapy and was awarded a Nobel Prize in Physiological Medicine in 1903 as a recognition of his pioneering work.

The Audiometer

An audiometer, which can be operated by the patient, was designed by Georg von Bekesy, a Hungarian scientist. It is based on his discovery of how sound is analysed and communicated in the cochlea. His research led to the construction of two cochlea models and other highly sensitive instruments that made it possible to understand the hearing process and differentiate between different forms of deafness. He was awarded the Nobel Prize in Physiological Medicine in 1961 for his work.

The Ophthalmoscope

Ophthalmoscopes are used for illuminating the retina of the eye. For normal vision the ophthalmoscope consists of a small hole to look through and a source of illumination, with the light being reflected into the eye by a mirror while the observer looks directly through the hole in the centre of the mirror. In the middle of the 19^{th} century Hermann von Helmholtz, a German physicist and physiologist, first demonstrated there were three essential elements for an ophthalmoscope to work effectively; a source of illumination, a reflecting surface to direct light and a means of correcting an out of focus image. Modern ophthalmoscopes vary little in principle from his first inventions.

The Future – Nuclear Medicine

The use of radioactive tracers in medicine has been widespread since 1971. This new speciality was recognized by the American Medical Association through the establishment of the American Board of Nuclear Medicine and nowadays about one in three patients in any modern hospital will have had a diagnostic procedure performed in which radioactive tracers have been employed. Physics will continue to have the greatest influence on medicine for the simple reason that the human body is a physico-chemical consortium and almost any advance in physics can be applied to gaining further knowledge of this complex structure.