Schools Affiliate Schemes

Newsletter

Issue 7: Spring Term 2001.

The Armourers and Brasiers Scholarships 2001

The Worshipful Company of Armourers and Brasiers are launching a new scholarship scheme to encourage students in the sixth form to find out more about the discipline of materials science & engineering, with the final aim of them going on to study a related degree programme at university. The awards will not made on the basis of academic merit; rather, the judges will be looking for a genuine interest in the subject area and enthusiasm for finding out more.

10 awards of £250 plus £50 of materials related books will be made to students in their final year at school or sixth form college and if a recipient goes on to study a materials related course at an approved university the award will continue at a level of £250 per year under the banner of the Armourers and Brasiers Scholarship. The approved universities are, at present, Birmingham, Imperial, Leeds, Loughborough, Manchester, Queen Mary & Westfield and Swansea.

In order to apply for an Armourers & Brasiers Materials Scholarship students must be studying post 16 courses suitable for continuation on to a materials related degree programme and must also be considering reading the subject at university. Students should apply for a scholarship at the end of Year 12, the closing date for applications is 12 September 2001, and the recipients will receive their awards at a ceremony at Armourers Hall inDecember. Flyers will be distributed to schools in March, however, if you would like to know more about the scheme please contact: Diane Talbot, Armourers & Brasiers Scholarships 2001, School of Metallurgy and Materials, University of Birmingham, Edgbaston, Birmingham, B15 2TT. Telephone 0121 414 5188, fax 0121 414 5232 or e-mail D.Talbot.1@bham.ac.uk

What's inside

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CAREERS: - How to gain a solid qualification.

Materials are essential to our well being. We simply could not do without them. Just about everything we do involves them. And when we use them we need them to be reliable and perform well so that they do just what we want. We don't want them to crack, melt, snap or bend just when it is inconvenient. Safety is essential and we must be able to use appropriate materials with confidence. "Everything is made of something," says Tom Hutchinson from Liverpool University, who was a materials science student of the year 1999, " there will always be a need for materials scientists."

Materials can be conveniently divided into several different classes such as electronic materials, aerospace materials, textiles, optical materials and building materials. Mixing one material with another can change its properties in ways that are beneficial. For example, iron rusts but combining it with other materials, making an alloy, we make stainless steel, which doesn't rust. Problems that arise in practise often concern several materials at the same time. Most things, like hi-fi sets and computers, cars and aeroplanes, are made up of a lot of different materials each with a function of its own.

Take the apparently mundane example of a hair dryer. Even this involves a good deal of work for the material engineer. There are the various parts – the plastic fan, the copper wiring, and the motor – that must all be made to work in harmony. The material engineer must ensure that the dryer is safely insulated electrically, and is sufficiently robust that if you drop it the dryer will not break. The whole item must be made economically for a price that the customer is prepared to pay. Finally the casing has to look good in texture and colour so the customers will want to buy it. It is a tall order for something so simple, but that is where the materials scientists come in.

Range of courses. Just over 20 universities offer accredited degree studies in materials science, covering the broad range of materials. They have a variety of different names that generally give good indication if there is a bias towards one particular material or type of materials. UMIST for example offer several courses including a degree in materials science, one in paper science and another in polymer science. Leeds University and UMIST are the leading places for those who wish to study textile technology. Most other courses involving textiles are concerned with design and fashion whilst these are more biased towards production and management.

Sheffield has always been a major force in the steel industry, so it is no surprise to find a course in metal science offered at Sheffield University. But it also offers a degree in glass science engineering and another in ceramic science. Advances in medical science have led to surgical procedures that leave various materials within the human body, such as hip joints and braces to support the spine. At Birmingham and Manchester Universities it is possible to study Biomaterials science or specialise in this subject as an undergraduate.

Choosing science or engineering. Whilst some degree courses are called materials science, others have titles that include the word "engineering". Generally this indicates a slight difference in emphasis. Materials science courses tend to be more concerned with scientific investigations and analysis of materials, whilst those in materials engineering focus more on the application of materials in real engineering situations. However, much of the ground covered by these courses is the same. In any case, all the course which call themselves materials science or engineering start off with a study of the fundamentals. What are materials? What are their structure? How are they made? Why do differently materials behave differently and have different properties? How are materials investigated? You learn how to examine materials in many different ways and the laboratory techniques for testing such as properties as their strength, hardness, resistance to cracking and electrical properties.

It is often possible to do an optional course or project in one of the specialist areas such as biomaterials, optical materials or electronic materials in the final year of study. Manchester Metropolitan, North London, Staffordshire and Sunderland universities are amongst those that offer HND studies in the subject. Some offer courses that allow you to specialise in one particular type of material. These include electronic materials, biological materials, biomedical materials, composite materials and aerospace materials. For those whose qualifications are not adequate for an immediate start on the first year of a degree course, some universities run a foundation course.

Some universities offer sandwich courses that include a year of industrial training. Most of these placements take place after the second year of study and are organised during that year. They can be in a variety of different contexts including research and development, testing and production departments, and in a range of industries – from materials producers to the manufacturers of goods. Several universities offer placements abroad, where knowledge of another European language is an asset.

Most materials science departments are in the engineering faculties and groom their students for a BEng or MEng degree, though a few degree courses lead to a BSc. If your career objective is to become an engineer, you should note that an MEng or equivalent is required if you wish to reach the top professional grade of Chartered engineer, whilst a BEng leads to Incorporated Engineer status. Often the decision about which degree you will obtain is taken during the course rather than before you start, that MEng taking a year longer than the BEng and being restricted to those students who are particularly successful during their first two years.

Making the conversion to materials science. Some students convert to materials science after having graduated in another subject. This is especially true of physicists and chemists but graduates in electrical and mechanical engineering sometimes take this option. A graduate electronic engineer, for example, may want to specialise in electronic materials. There are several advanced postgraduate courses that can provide the means of transferring into a materials science career at a later date.

Careers available in materials science. The prospects are good for graduates in materials science and related subjects. Although it is true that a few employers recruit materials science graduates in large numbers, their skills and knowledge are essential in a very broad range of manufacturing industries. New graduates in materials science typically earn in the region of £17,000 to £21,000pa, which varies between different industries and locations. Those in the oil electricity and car industries tend to earn the highest salaries.

Work in manufacturing industry may involve working in production, or advising on process changes to improve the product. Other roles include advising customers on material use, and discussing materials for a particular application. When a product fails during use, the manufacturer may be held liable and materials scientists will examine the reasons for failure and suggest how these may be overcome.

The ministry of Defence laboratories, including the Defence Evaluation and Research Agency (DERA), is another important employer. MODF scientists liase with the armed forces about their equipment needs and any failures that have occurred in action. They make recommendations for changes in the materials used and liase with manufacturers of equipment to ensure that designs are improved.

Materials scientists employed by car, aeroplane or electronics manufacturers work with designers on the best choice of materials. They also have to monitor problems that arise when the product is in operation. A fracture in an aeroplane wing are car axles could be catastrophic so this is very important work.

Other employers include oil companies and those providing offshore oil facilities. These are difficult environments for any material but these scientists have to investigate which systems and methods will work and what materials to use in these particular circumstances.
Numerous organisations undertake contract research for particular industries and employ materials scientists to do so. Occasionally they are to be found in forensic science, as assessors or loss adjusters dealing with disasters (often caused by the failure of materials) in the insurance industries.
Additionally the skills of materials scientists are highly respected by numerous other employers. If graduates decide not to become materials scientists, then teaching and lecturing, information technology, accountancy, banking, marketing and sales are amongst the occupations which attract most.
Case Study 1. At British Energy, the firm that runs Britain's nuclear power stations, the failure of materials could have disastrous consequences. Materials scientists are employed to make sure that the power stations are operated effectively, economically and above all safely. Mark Hartley joined British Energy after a BSc and a PhD in materials science at Bath University.
"During my BSc I spent a year at Phillips Research Laboratories, investigating electronic materials and especially ultra-high definition liquid crystal displays," says Mark. "I also did some service work on materials problems in waveguides and medical systems. British Energy (then Nuclear Electric) sponsored my PhD, which was an investigation of the mechanical properties of graphite. Advanced Gas Cooled Reactors, the type of nuclear reactor that is most used in British Energy, use graphite in their core. As a project manager my role is to understand the properties of the graphite and develop an ability to predict how it will behave in the future. This is important because we want to extend the safe and useful life of our reactors.**"**
Case study 2. "I chose to study materials engineering because it was something different," says Tom Hutchinson, who recently graduated with a master in engineering (MEng) degree from Liverpool University. "I had little interest in quantum theory or chemistry. Instead I chose materials engineering at Liverpool. It is a very broad course where you learn so many different but related things. Just one of the courses I studied, on the microstructure of materials, included a little thermodynamics and chemistry, alloying, microscopy, electron and x-ray diffraction. It gave me a broad perspective.
"I spent six hours every week in the laboratory. I also completed two projects and wrote dissertations on both of them for my final MEng degree. Whilst the first years provide an introduction to the subject there are many choices from the third year onwards. Those who gain higher than 60% at the end of their second year can take a Master of Engineering (MEng) degree rather than the bachelor of Engineering (BEng).
I took a year out to gain some experience in industry. Working for Raychem in Swindon I developed a sensor which, when inserted into the car engine, detects when the oil needs changing. I also looked into sensors that would turn on the heating when required in a wing mirror to keep it providing good visibility. Many of my colleagues have gone to jobs in firms such as Corus, Jaguar, Roll-Royce and British Aerospace Systems. I have decided to research for a PhD

This article was originally published in the Spring issue of the membership magazine of the Independent schools Careers Service.

The Role of Materials Science in Sculpture Conservation

Pedro Gaspar, The Sculpture Conservation Section, The V&A Museum. (p.gaspar@vam.ac.uk)

David McPhail, The Materials Department, Imperial College. (d.mcphail@ic.ac.uk)

Research in the field of sculpture conservation is part of the current collaboration between the Victoria and Albert Museum's Conservation Department, the Royal College of Art and the Materials Department of Imperial College of Science Technology and Medicine. Conservation involves not only the study and preservation of artworks, but also the development of new treatments and techniques to be used in the preservation of our cultural heritage.

This study combining art and science engenders the need for a common vocabulary that deals with art-related concepts, for example how the visual perception of surface texture can be translated into a scientific terminology. Finding a common language that allows scientists and arts conservators to communicate effectively with one another is, undoubtedly, a fascinating task.

For the last few years, the surface studies group of the RCA/V&A Conservation Section has been developing a collaborative research program with the materials department at ICSTM to determine the effects that cleaning treatments may have on the surface texture of sculptures. This involves the topographical investigation of statuary surfaces and the assessment of the effects of various cleaning treatments used in sculpture conservation. These treatments are used not only for aesthetic reasons but also for the prevention of further deterioration. They vary from older methods like abrasive cleaning and steam cleaning to the use of chemical solvents and state of the art technology like laser cleaning. The analytical techniques used to investigate the surfaces must, wherever possible, be air-based and non-contact. Scanning white light interferometry (Zygo) and Atomic Force Microscopy (Quesant AFM) have proven themselves very useful, the more so since they both produce digital height maps. SIMS, a more destructive technique, has been used on special test samples to establish the effectiveness with which surface contaminants are removed

Our research aims to assess important conservation treatments and thus to provide more information to the conservators who use them and also to establish closer links between art and science. For more information please contact Pedro or David.

The National Bureau of Standards (now the NIST) constructed the 12-metre-long by 4-metre high outdoor wall in Washington, DC, in 1948. The long-term purpose was to answer questions concerning the durability of common American building stones used in monuments and commercial and government buildings. Most of the wall's 2,300 stones had been taken from samples collected and displayed at the 1876 Centennial Exposition in Philadelphia. For comparative purposes, the National Bureau of Standards also stored unexposed specimens of the same stones.

The 32 tonne wall was moved intact to NIST's Gaithersburg, Maryland, campus in 1977. For 52 years, it has illustrated the weathering effects of frost and acid on individual stone types as well as degradations due to thermal and moisture expansion and shrinkage.

Now the long-running experiment has gone high tech. Users can now access the 'virtual' NIST Stone Test Wall and a growing database on the individual stones it holds. The plan is to expand the database with detailed petrologic studies that relate each stone's mineralogical and texture attributes to its weathering and durability performance. Pictures of well-known buildings constructed with specific stones will also be available. http://stonewall.nist.gov/Default.htm

Streets ahead for Materials.

The wheel is often stated to be the single most important item that distinguishes us from other primates. If asked to name a second, it would perhaps be the humble seat. Over the centuries, like the wheel, the seat has appeared in a number of different product forms varying from the aesthetic to the functional and from the simple to the technically complex.

Table 1 lists some of the different markets for seating technology.

Table 1 – Markets for seating.
Outdoor: (Street/ Forest furniture)
Transport: (auto, rail, areospace)
Office.
Community: (schools, halls, churches)
Domestic.

The design and manufacture of seating is a regular project in technology studies. One of the attractions is the freedom in both design and the selection of materials. However, cost and the service environment always influence our choices, and seating is no exception. Table 2 lists some design parameters.

Table 2 – Design parameters.

Cost	Stiffness
Strength	Comfort
Degradation resistance: (outdoor)	
Usage/vandalism	Weight
Production volumes	
Environmental sustainability.	

Outdoor seating – street furniture – provides a relatively simple case study in product design and the selection of materials. Products can range from traditional designs (made from wood and cast iron - Figure 1) to more modern creations in aluminium or stainless steel (Figure 2). Data on some of the different materials used in the manufacture of street furniture is provided in Table 3, along with comments on design considerations and methods of ensuring protection from the environment. An informative web site on this subject is provided by a Swansea-based manufacturer of street furniture, Streetmaster Products (see www.streetmaster.co.uk).

If you want an insight into just how technically complex seating has become, take a look at this web site: www.atalink.co.uk/mira2000/html/p208.htm. It illustrates how the production of polyurethane foam may be controlled to affect the structure and properties of the foam. Of interest to the authors is the dampening of automotive vibrations to increase the comfort of the car driver. This is a subject of on-going research.

Table 3 Design considerations and environmental protection

Material	Specific gravity	Stiffness (GPa)	Design considerations	Typical weight	Environmental protection
hardwood and softwood	0.6	1	Timber section sizes vary depending on robustness required. Slatted backs particularly at risk from vandalism.	25-40 kg	Timber from sustainable forests. Normal exterior wood stains applied.
mild steel	8	200	Use rectangular hollow sections and perforated sheeting to give stiffness with minimum weight. Strength and toughness ensures high vandal resistance. Cold to sit on!	75 kg	Painting required to prevent rusting. For best protection (eg seaside locations), galvanise then add a primer and top coat.
stainless steel	8	200	Strong, stiff, tough, corrosion resistant - and expensive. The ultimate seating material!	75 kg	No need for protective coatings. Minimal maintenance and suitable for seaside locations.
cast iron	8	200	Elegant but rugged. Potential to incorporate plaques and crests. Iron is normally restricted to frames-seating boards may be wood, steel or polyboard.	90 kg	Normally made from grey iron, but ductile iron is selected for areas prone to vandalism. Finished in primer plus top coat to prevent rusting.
aluminium	3	70	Lightweight and hard wearing. Extruded hollow sections for frames and perforated sheets for seating. Brackets can be die cast.		Anodised for corrosion protection - painting optional.
polyboard	1	0.5	Made from recycled polyethylene. Metal frames required to provide stiffness.	60 kg	Durable, water & rot resistant. Knot and splitter free. No painting or maintenance required.

What is Materials Science?

Do you know any students in Year 12 who might be asking this very question? If you do (or know any that already have an interest in materials), why not suggest that they apply to attend a four day residential course to find out more.

The School of Metallurgy and Materials at the University of Birmingham is running a taster course entitled "What is Materials Science?" from Monday 2nd to Thursday 5th July 2001, during which students will have the chance to investigate materials first hand and sample student life. This highly successful course involves a series of lectures laboratory classes and problem solving exercises covering topics such as biomedical, sports and aerospace materials, materials processing and materials testing. The main focus of the course is to encourage students to find out more about materials in a fun environment and past participants have found the experience very enjoyable (and educational!). The participants stay in on of our Halls of Residence, which provides the opportunity to sample student life and Hall food. All other meals and entertainment are provided and the course is free.

If you would like to know more please get in touch with me, Diane Talbot, at School of Metallurgy and Materials, University of Birmingham, Edgbaston, Birmingham, B15 2TT. Alternatively you can contact me on 0121 414 5188 (phone), 0121 414 5232 (fax), or e-mail D.Talbot.1@bham.ac.uk

A Taste of Materials Science and Engineering.

Two–day Residential Courses for Lower Sixth Form Students

10th/ 11th & 13th/ 14th July 2001

These courses are sponsored by the industrial partners who work with the Department so that students only have to pay for their travel to and from the University. Each group visit is arranged to:

- Allow interaction with existing students
- Provide information about the exciting subject of Materials Science and Engineering
- Carry out laboratory and computer experiments
- Experience some of the magic of student life

Applications for the course can be made on-line, or the application form down-loaded and sent by regular mail. For further information and postage of either the competition or course application forms, please write to:

Dr. Belinda Hulm
Undergraduate Admissions Tutor
Department of Materials Engineering
University of Wales Swansea
Singleton Park
Swansea SA2 8PP

e-mail: b.j.hulm@swansea.ac.uk
Tel: 01792-295867
Fax: 01792-295244

UCAS CONVENTIONS

Last years UCAS conventions were very popular and this year they are running again. There are many events scheduled for venues up and down the country and further details can be found through the UCAS website, or by contacting UCAS direct at the address given below. They will provide you with a timetable of events so that you can plan a visit the one most convenient for your school. If you require further information on UCAS/The Guardian Education Conventions contact: **UCAS Education Conventions, Rosehill, New Barn Lane, Cheltenham, Gloucestershire, GL52 3LZ. Email: conventions@ucas.ac.uk Tel: 01242 544803 Fax: 01242 544806**
For general enquiries, please contact enquiries@ucas.ac.uk or try their website at www.ucas.ac.uk
The Institute of Materials will be present at five of the larger ones and the dates and locations of these are listed below.

London:	Business Design Centre Islington	15/16 March
Manchester:	Manchester Evening News Arena	27/28 March
Bath:	The University of Bath	26/27 April
Sheffield:	Sheffield arena	3/4 July

Birmingham: Aston University 5/6 July

These are very helpful events for your pupils and we would recommend that you encourage them all to try to attend at least one.

POLYMER STUDY TOURS - Unique Opportunities for Teachers

Polymer Study Tours are free, four day, industry awareness courses for school teachers involved in science and design technology. They are designed to bring teachers up to date with the latest developments in the world of polymers, as well as providing information for school leavers on career opportunities within the plastics and rubber industries. The courses have been running since 1987, with over 1000 teachers benefiting so far.. The format of the courses has changed recently. They all have a common core and will run from Sunday 4pm to Wednesday 4pm. Further details can be obtained from Mike Morgan at PAINTO (Tel: 01952 681852; Fax: 01952 582065; E-mail: mikem@bpta.co.uk). Courses will be run in 2001 at three centres as shown below.

Napier University 24th - 27th June
Manchester Metropolitan University 1st - 4th July
Trowbridge College 8th - 11th July

Teachers go back to School at Birmingham.

In September this year 14 A-level physics and chemistry teachers went back to school at the University of Birmingham to find out more about materials. The teachers, from the Derby, Bristol and Birmingham areas, attended a 2-day Materials Master Class in the School of Metallurgy and Materials, sponsored by Rolls-Royce and the Worshipful Company of Armourers and Brasiers. This was followed, a couple of weeks later, by a visit to Rolls-Royce in Derby where they saw materials in action.

During the course the teachers got hands on experience of some of the tests used by materials scientists and engineers and also developed ideas for making materials more fun in school. The activities ranged from using polystyrene balls to represent crystal structures to building loudspeakers using very powerful magnets.

Plans for a KS4 course next year were also discussed so watch this space!! Finally a big thank you to all those who helped run the course and the participants (I hope you are reading this!), without whom it would not have been possible.

Stones are materials too!

The Stone Test Wall was constructed to study the performance of stone subjected to weathering. It contains 2352 individual samples of stone, of which 2032 are domestic stone from 47 USA states, and 320 are stones from 16 other countries. Over 30 distinct types of stones are represented, some of which are not commonly used for building purposes. There are many varieties of the common types used in building, such as marble, limestone, sandstone, and granite. The web site presents the existing data and pictures for each particular stone.

Architects, construction companies, builders, and civil engineers can now access a 'virtual' Stone Test Wall at the US National Institute of Standards and Technology (NIST) in order to gather data of the effects of weathering on different types of building stones. The new website brings a 52-year experiment in stones and cement into the digital age.

New Interactive Science Centres.

In the first issue of the SAS newsletters we highlighted the Interactive Science Centres around the country. Now thanks to Lottery money there are several more including four really big ones in Bristol, Birmingham, Belfast and Glasgow. Below is a list of details of the new ones.

Name	Location	Cost*	Opening	Web Address
Discovery Centre Millennium Point	Birmingham	£112m	Autumn 2001	www.discoverycentre.org.uk
Explore/Wildscreen @Bristol	Bristol	£97m	July 2000	www.at-bristol.org.uk
W5 at Odyssey	Belfast	£90m	Spring 2001	www.w5online.co.uk
Glasgow Science Centre	Glasgow	£75m	Spring 2001	www.gsc.org.uk
International centre of Life	Newcastle	£68m	May 2000	www.centreforlife.co.uk
Wellcome Wing Science Museum	London	£48m	July 2000	www.nmsi.ac.uk/science_museum_fr
National Space Science Centre	Leicester	£46m	Spring 2001	www.nssc.co.uk
Magna	Rotherham	£36m	April 2001	www.magnatrust.org.uk
Our Dynamic Earth	Edinburgh	£34m	July 1999	www.dynamicearth.co.uk
The Big Idea	Irvine	£14m	April 2000	www.bigidea.org.uk
Sensation	Dundee	£4.7m	July 2000	www.sensation-dundee.co.uk
Making it	Mansfield	£3.77m	Summer 2001	

- in some cases the project involves more than just the interactive science centres.

Although these centres cover more than just the Materials sections of the National Curriculum and exam syllabuses, they are excellent for enthusing pupils about science and engineering generally. It is very rare for anyone to attend and not have a great deal of fun as well as learning something. Additionally they provide a range of examples of materials “in action”. So often we find that children do not realise exactly what materials science and engineering means and so overlook it as a career despite the fact that they are already interested in a subject which relies heavily on materials and the latest materials technology.

Materials in the Millennium Competition

Department of Materials Engineering, University of Wales Swansea

1st Prize: £1000 - £500 for you, plus £500 for your school/college*

2nd Prize: £400 - £200 for you, plus £200 for your school/college*

(*for the purchase of equipment)

After the great success of the Materials in the Millennium Competition run in 2000 by the Department of Materials Engineering, University of Wales Swansea, a new challenge has been set for this year's lower VI formers.

Last year, Gillian Warrick won £500 both for herself and her for school (Amman Valley School) with Jim Mason of Bishop of Llandaff High school scooping the second prize with their interesting outlooks on how materials science and technology will influence future developments in transportation. This year's tie-breaker question asks "*How will materials recycling technology improve our environment?*" The competition has been sent to schools across the UK and is also available on the Department's website: www.swan.ac.uk/mateng/competition/competition.html. Forms can also be obtained by contacting the Undergraduate Admissions Tutor, Dr. Belinda Hulm at the address below.

Lower VI formers who are keen to find out more about Materials Science and Engineering can apply for the extremely popular residential course in the Department of Materials Engineering, University of Wales Swansea.

SPOTLIGHT on Materials at the Olympics.

Strength, determination and years of intensive training to qualify for the ultimate sporting event. And as the torch entered the Olympic Stadium one thought was foremost in the athletes' mind: winning. With improvements in performance becoming ever more slight in some sports, many experts believe that today's sportsmen and women are approaching some kind of physical limit. It is not surprising therefore, that athletes are increasingly turning to science and technology in their quest to run faster, jump higher and throw further.

Technology is used to improve sports performance in two ways: by helping to perfect the athlete's technique or refining the equipment used. Nike and Speedo spend millions of dollars on research to develop the footwear and swimsuits that could help shave milliseconds off world records. Sport is not however meant to be a test of who has the best equipment, but an even match between all athletes. The sports governing bodies keep careful watch on technological developments to make sure that the ability and skills of the athlete count.

The technology available to top class sprinters is limited to lighter running shoes, Lycra bodysuits and improved track surfaces. Even with these developments, the winning times for the 100 metre sprint at the Olympics appear to be levelling off. Sprinting remains a test of raw speed. Not all changes to sport equipment improve performance however. By the mid 1980's athletes were almost able to throw the javelin the full length of the sports stadium, putting spectators lives at risk. The international ruling body decided that the javelin had to be redesigned to underperform!

It is a different story for pole-vaulting. The sport literally reached new heights in the early 1960's when lighter stronger glass-fibre poles replaced the bamboo that had been used since the 1900's. Pole-vaulters have even changed their technique to take advantage of the new technology. Now they can bend the pole much further to extract as much of the strain energy as possible, turning upside down as they propel themselves over the bar. Although the winning heights are beginning to level off, researchers are continuing to develop new composite materials and designs that could add an extra few centimetres to the winning height.

The rules for pole-vaulting that are set by the International Amateur Athletic Federation (IAAF) – the sports governing body -are extremely liberal. There is no restriction on the length of the pole, the materials from which it is constructed or its energy storage capacity. The only stipulation is that poles should be generally smooth and not covered in too much adhesive tape. Poles were originally made out of solid wood, probably hickory. Slightly more flexible bamboo poles were introduced in the early 1900's, mostly by American vaulters, who dominated the sport at the time. Basic mechanics states that the highest stresses occur on the outside of a bent beam, and that a symmetrically bent object, such as a pole, actually has a zone down the middle, where the stresses are very low or even zero. There is therefore no need for a pole to has any mass down the centre. Bamboo is naturally hollow, is much lighter per unit length than a solid pole and yet can provide the same maximum stress. This enable the athlete carrying a bamboo pole to either take a faster run up or use a slightly longer pole.

The use of bamboo poles led to steady increase in the winning height of the Olympic pole-vaulting competition. However, the improvements started to level off by the mid 1950's and in the early 1960's bamboo began to be replaced by glass-fibre poles. This led to a dramatic increase in the winning heights. Glass fibre poles consist of long filaments of glass fibre – ranging from 3-20μm in diameter – embedded in a matrix of less stiff polymer resin. The material can be fabricated into different shapes and has a high stiffness to weight ratio. Essentially pole-vaulting involves the conversion of the kinetic energy of the running athlete to the potential energy of the jump using the strain energy stored in the pole (the energy stored in elastic deformation). An athlete running at 10 m s^{-1} (i.e. as fast as the 100 m sprinters) should be able to jump just over 5 m. ($\frac{1}{2} mv^2 = mgh$) However in reality, most pole-vaulters can jump heights of nearly 6 m. So where does the extra energy required to propel the athlete to these greater heights come from?

It turns out that the extra energy comes from the athleticism of the vaulter bending the pole. Energy is stored in the pole as it is bent or strained by the athletes muscles and returned to the vaulter as the pole recoils. The strain energy comes from the work done by the muscles of the athlete as he or she takes off, carrying out work on the pole as it is bent. The maximum strain energy of the pole is relative to its failure stress, density and Young's modulus. Bamboo has a relatively low Young's modulus and density and a moderate failure stress. Glass fibre also has a low Young modulus and density, but a much higher failure stress than bamboo. In fact, the maximum strain energy that can be stored in a glass fibre pole before it breaks is about 2500 J, compared with just 100 J for bamboo. One consequence of this is that glass fibre poles can be bent through much larger angle before breaking, which is why athletes can use them to jump gymnastically over the bar. If we assume that the efficiently of the glass-fibre pole is 50% then when converted into potential energy, a 80 kg athlete could jump a further 1.5 m.

The current advances in pole-vaulting are certainly not as good as they were in the 1960's. That has not however, stopped researchers from searching for further improvements, which have included introducing carbon fibres to make the pole stronger and lighter and allowing the pole to vary in thickness along its length. During a jump the greatest bending moments and therefore the greatest stresses are at the middle of the pole, whilst the lowest stresses are at the ends. In other words the ends of the pole can be narrower and hence lighter without compromising the poles performance. Pole-vaulting is an example of a sport in which technology has been used to improve athletic performance. As the Olympic winning heights in the discipline level off it will be interesting to see if our ingenuity can provide another technological leap to allow pole-vaulters to jump even higher.