Biomaterials Science: Education for UK Undergraduates

Report of a meeting hosted by the Institute of Materials, Minerals & Mining (IoM^3) on 18th September 2003

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Foreword

Biomaterials have been used to replace and repair human tissues for centuries. Pioneering work in the 1960's led to the development of "breakthrough technologies" such as the joint replacement and prosthetic heart valve that have had a dramatic impact on healthcare. Biomaterials are now in the front line of our battle against human disease and disability, and are the basis of a multi-million pound global industry where the UK is an acknowledged leader. The interdisciplinary subject of biomaterials science has matured over a similar period, and we now have a greater understanding of the interaction of living tissues and materials than ever before. Today it not only informs the development of advanced medical devices, but it is one of the principal technologies behind emerging therapies in tissue engineering and regenerative medicine.

Several UK universities have a long history in biomaterials research, and they have become recognised international leaders in the field. Not surprisingly, given this track record and the importance of the subject, a number these institutions have developed biomaterials education at an undergraduate level. These programmes have become an important source of graduates for industry and universities (particularly as higher degree students).

There are other perceived advantages in the development of biomaterials degrees. Many traditional engineering disciplines, including materials science, have found it increasingly difficult to attract sufficient numbers of good quality applicants to their single subject degrees. The provision of interdisciplinary programmes, particularly those with a medical dimension, has attracted increased interest from A-level students. Not only has the size of the pool of potential applicants been increased, but for the first time these degrees have attracted students with a biological interest and background. Departments have therefore recruited staff that contribute not only to interdisciplinary teaching but also stimulate interdisciplinary research. However, the new opportunities presented by biomaterials at a degree level have been accompanied by new challenges. For example, some students who arrive at

university with a “biological” background lack A-levels in mathematics or physics. Engineering departments have had to address this deficiency with new introductory or “balancing” courses.

The development of interdisciplinary degrees by universities has presented problems for other organisations including the professional bodies. The IoM^3 (and formerly the Institute of Materials) has traditionally been associated with materials science at an undergraduate level, offering support and ultimately routes for accreditation. My impression is that, while the IoM^3 welcomes the development of modern degree programmes that take materials science forward to contribute to wider fields of scientific endeavour, interdisciplinary biomaterials science degrees can at the same time challenge the traditional methods used to maintain high standards.

Towards meeting the challenges presented by biomaterials at a degree level, the Biomedical Application Division of the IoM^3 asked me to organise a workshop to consider the state of undergraduate biomaterials science teaching in the UK, and to investigate the relationship between the Institute and the UK academic biomaterials community. This included the contribution of materials science to biomaterials degrees, the accreditation of interdisciplinary degrees, and to identify opportunities for the IoM^3 to support these degree programmes and biomaterials education generally. To meet these objectives, we first held a one day working party meeting in 2002, followed by a full workshop in 2003 to which representatives of all the principal providers of degrees with a significant biomaterials science content and other interested parties were invited. This consensus report summarises the collective response of these UK academics to the IoM^3, and I am very grateful for the hard work and immense enthusiasm of all the contributors. It should serve not only to assist the IoM^3 in developing its support for biomaterials education, but also stimulate debate in the UK community regarding our aspirations for this exciting subject.

Professor Paul V Hatton
Workshop Leader

1. Executive summary

Many UK universities provide valuable training in biomaterials science as a part of an interdisciplinary degree programme. There is no doubt that the development of biomaterials science-based degrees has brought tremendous benefits, improving the quantity and quality of applicants to Engineering faculties as well as increasing the numbers of female undergraduates in an area traditionally dominated by males. Significant numbers of graduates from these courses make an important contribution to national R&D, either by studying for higher degrees and/or entering industry. The workshop on biomaterials degrees in the UK identified not only differences between institutions but also common themes. The latter included a desire to deliver excellent undergraduate programmes that offered the best learning experiences, and to attract bright and enthusiastic students in sufficient quantities to sustain our degrees. Towards these aims a number of opportunities were identified for consideration by the UK biomaterials community and IoM^3:

- The UK biomaterials community should consider developing agreed key learning objectives or benchmarks for biomaterials science degrees.
- Cooperation and support in area of recruitment and marketing of biomaterials science is considered a high priority.
- We could benefit immensely from cooperation with the Whitaker Foundation in the US, and the IoM^3 should consider ways to promote or support this.
- The IoM3 should sponsor or organise further meetings and workshops. Activities directed at the development of biomaterials education in the UK should also engage (and be carried out in collaboration with) other groups as appropriate. These would most likely include the Medical Devices Faraday Partnership, the UKSB, and other professional bodies.

While this report focuses on the potential for involvement of the IoM^3, it also recognises that there are many important stakeholders in biomaterials education. Of these, the UK Medical Devices Faraday Partnership is the most significant, particularly in the area of identifying the needs and aspirations of the UK biomaterials and medical device industry with respect to degree programmes.

2. Biomaterials science for undergraduates

2.1 UK degree programmes

The identification of biomaterials-based degrees is more complex than might be imagined, with a wide variety of titles and significant overlap with other branches of bioengineering. For the purposes of identifying appropriate degrees, the following were not included even though some programmes had a biomaterials (or medical device) component: Medical Physics, Medicine, Dentistry, and Bioengineering. Fourteen undergraduate degrees with a significant biomaterials science component were identified in the UK. Thirteen academics representing 11 of these degrees have provided contributions to this report, either through the 1st working party meeting, the full workshop, or both events (see Section 4). Additional contributions came from the Irish Republic (University of Limerick), industry, and IoM^3. The following points were noted:

- While some degrees were established pre-1994, the majority had started within the last 10 years. The modularisation of degrees was identified as a significant factor accounting for the relatively recent development of several interdisciplinary programmes, as was the apparent popularity of a “medical” component.
- Degree titles differed significantly between courses, with wider aspects (e.g. marketing) influencing title as much as content.
- While the programmes generally combined subjects from materials science and human biology to effectively produce a common “core curriculum”, the specific content often differed markedly between institutions. Some progress has been made to date in identifying such a core, but further work is needed. The most significant differences between degrees were encountered in the final year, generally reflecting the strengths and interests of any given institution.
- Despite the differences noted above, the degree programmes presented all had strong foundations in both materials science and human biology. This impression was reinforced by the involvement of staff who were well known for their biomaterials research and related professional activities. While the

apparent strength of the programmes described at the working party meeting and workshop was encouraging, some concerns were expressed that it might be possible for less scrupulous departments to develop a degree that claimed to deliver a biomaterials programme without these essential ingredients.

Recommendations / issues for further consideration: (1) The UK Biomaterials community should consider the development of key learning objectives for biomaterials science-based degree programmes. These could be based on existing QAA benchmarks in materials and biological sciences (and possibly developed into a new QAA benchmark for this field). While desirable in that they would reduce the risks of poor quality degrees being launched, it is also acknowledged that there is a tension between the potential benefits and the desire to maintain the individual characters of existing degrees and a broad curriculum. (2) The above is a challenging task, and the IoM^3 might consider ways of supporting activities designed to develop a consensus on key learning objectives for biomaterials science.

2.2 Accreditation

Brian Knott kindly provided an overview of the IoM^3 accreditation scheme for UK materials science degree programmes. It was clear following presentations and discussion (reported under 3.1 above) that not all degrees were suitable for accreditation, and that the decision to develop an accredited or non-accredited course was taken early in the design of the programme. Indeed, re-working of an established degree to fit an accreditation scheme might be detrimental in some cases. Additional key points were as follows:

- Recognition of biomaterials and relevant human biology subjects in accreditation would be welcome, but might not result in significant changes to degree market. Mixed response from medical device industry re: value of accreditation (see Section 3.7).
- Chartered scientist status might yet be more useful to many of our graduates than an accredited degree, although the latter was clearly still valuable for certain professions and career paths.

Recommendations / issues for further consideration: The IoM^3 should consider revising its approach to the accreditation of biomaterials-based degree programmes in the UK if it wishes to increase its stake and repuation in this interdisciplinary field.

2.3 Recruitment & outreach

Effective recruitment of students is essential for the success of any degree. While it might be assumed that biomaterials science was a relatively attractive subject for sixth formers, most academics reported that recruitment remained a challenge. Indeed, not all the degree programmes represented consistently met their targets for undergraduate numbers, and this did not appear to be related to the quality of the degree or the reputation of the institution. Additional points included:

- While it was not always possible to fill a biomaterials or related degree course, the provision of such a degree frequently provided useful flexibility in meeting faculty-wide targets for recruitment.
- Significantly more female students were attracted to biomaterials science-based degrees than traditional engineering disciplines (including materials science).
- Recruitment targets differed between institutions, although optimum first year intake was generally for between 10 and 25 students. All degrees had at times experienced difficulties in recruiting students, although this was not considered to be a major problem.
- Recruitment was most likely hampered by the lack of exposure of sixth formers and their tutors (especially careers advisors) to materials science and biomaterials, and a lack of awareness of the subjects being offered at degree level. Most universities had developed some form of advertising or outreach programme (often at a Faculty level) to address this, but with no consensus on the effectiveness of these initiatives.
- The standard A-level offer to potential students differed between institutions, but it was generally very high. The lowest offers tended to be around CCC, with the highest standard offers being BBB. The precise entrance requirements also differed with respect to which subjects were specified. Most

universities had at times accepted lower A-level grades when necessary to fill the course, but this was balanced against the observation that many students exceeded the minimum entry requirements.

Recommendations / issues for further consideration: (1) Institutions with reputable degree programmes should consider pooling their resources in developing a recruitment and "outreach" strategy. While this might be wider than for biomaterials degrees alone, we submit that the unique nature and appeal of these merits their playing a central role in any broader strategy for engineering faculties. (2) The IoM^3 should consider their role in supporting outreach activities to schools and sixth forms that promote biomaterials science.

2.4 The US experience

Sally MacArthur provided an overview of the attitude to biomaterials science at degree level in the US within the wider context of "Biomedical Engineering". The US certainly appeared to have several advantages with respect to the stronger identity of biomedical engineering as a "discipline" in its own right, most likely due to the strong influence of the Whitaker Foundation (see http://www.whitaker.org/index.html). While the US appears to have several advantages, it is interesting to note that they are also considering many of the same issues at this time (e.g. a biomaterials curriculum). The two White Papers on the US biomaterials curriculum are currently available on-line (http://summit.whitaker.org/white/biomat1.pdf & http://summit.whitaker.org/white/biomat2.pdf). Despite their apparent lead, we should remember that the environment in the UK (and Europe) differs to that in the US. The adoption or adaptation of US materials for use or dissemination in the UK should therefore be undertaken with care by appropriate individuals.

Recommendations / issues for further consideration: (1) IoM^3 (or a suitable alternative) could be approached to consider supporting early dialogue with the Whitaker Foundation to identify potential for collaboration or assistance for the UK. At the very least, support should be sought to send UK representatives to appropriate events in the US and disseminate information to the wider home community. One

example of a potentially useful and certainly significant event is the forthcoming "Biomedical Engineering Educational Summit" (March 3-6, 2005). All interested parties are encouraged to read the information on the Whitaker Foundation web site.

2.5 Potential for sharing educational resources

Some discussion of the potential for sharing or developing new educational resources took place. While all agreed this could be beneficial, it was also acknowledged that (a) all academics involved with the delivery of biomaterials education were very busy already and (b) there was relatively little funding to support sharing and development of new resources. This might be one potential subject for a dedicated future meeting, perhaps centred on "good practice" in biomaterials education with some exchange of teaching materials developed by recognised centres of expertise/excellence.

Recommendations / issues for further consideration: (1) The IoM^3 (and/or an appropriate Society or organisation) should consider sponsoring a UK meeting to share educational resources, and assist in the dissemination of the results of such an event.

2.6 "End user" perspectives

2.6.1 Graduate destinations. Not all the institutions were able to provide data on graduate destinations. However, the consensus was that a significant proportion (25 to 50%) of undergraduates went on to study for a higher degree by research, with most institutions reporting recruitment of their graduates by the medical device or related healthcare industry. Longer term follow up of destinations, particularly for postgraduates, could be very useful. It was widely suspected that the development of postgraduate scientists with a biomaterials science first degree was having a positive impact on industry and academia, but no data was currently collected to support this.

2.6.2 The view from industry John Egan presented a summary of information gathered by the Medical Device Faraday Partnership survey on industrial training needs. More detailed information is available on the Medical Device Faraday web site. He reported that industry saw undergraduate degrees as part of an ongoing

process of personal and professional development that could include postgraduate and/or company-based training. Industry was generally most impressed by courses where tutors had an appropriate scientific background and a good knowledge of the medical device industry. In addition to a good scientific training, industry was keen on development of transferable skills in IT and project management. While the above views were held by a significant proportion of respondents, in other areas it was more difficult to identify a consensus. For example, many industrialists claimed that they wanted to recruit good interdisciplinary scientists, but at the same time favoured graduates from single-discipline degrees. Not all industrialists, particularly those in SMEs, recognised added value in recruiting students from accredited degree programmes. During discussion it was acknowledged that this might be a deficiency of parts of the industry rather than universities or the IoM^3.

Recommendations / issues for further consideration: In general, this was seen as an area where collaboration with the UK Medical Devices Faraday Partnership would be very useful. (1) Universities should further improve links with the medical device industry, and in turn use these links as a resource to improve the content of their degrees. (2) Universities should remain alert to the possibility of adapting appropriate undergraduate teaching material to short courses for industry (3) The IoM^3 might want to communicate better the value of an accredited degree, particularly to SMEs and the medical device sector.

2.6.3 The undergraduate-postgraduate interface. Andrew Lloyd presented a stimulating overview of the qualities we sought in our postgraduate students, and connected this to the benefits and disadvantages presented by undergraduate degree programmes. The delegates were all of the opinion that good biomaterials science undergraduates were an important component of the UK postgraduate community in this subject.

Recommendations / issues for further consideration: (1) The annual UKSB Postgraduate Meeting might be a suitable event to estimate the proportion of current UK higher degree students with a first degree in biomaterials science. This should be put before the Council of UKSB.

4. Contributors

1st Working Party meeting (Sheffield, May 2002)

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Apologies: Brian Meenan (University of Ulster), (University of Hull), Irene Turner (University of Bath), and Peter Davies (IoM^3) sent their apologies.