

## Biomechanics – is the paradigm changing?

Patrick J. Prendergast, Trinity College Dublin, Ireland

President of the ESB

*The Structure of Scientific Revolutions* is a very influential book in the philosophy of science. The author, Thomas Kuhn, proposed the idea that scientists are a social group with a set of rules which they obey for conducting investigations in their field; he used the word “paradigm” to describe the dominant accepted set of rules and theories. Scientists accept the paradigm as the appropriate framework for solving problems. Using the paradigm to solve such problems, or puzzles, is doing what Kuhn termed doing “normal science”. However, as time passes anomalies in the accepted theories turn up. Initially these anomalies are patched up, or brushed under the carpet, but it eventually becomes obvious that normal science no longer achieves solutions to the problems of the day. What happens next, according to Kuhn, is a scientific revolution where the vast majority of scientists switch allegiance to a new paradigm, except for some stubborn adherents to the old paradigm.

Kuhn’s classical example of this was the Copernican Revolution. Before Copernicus the accepted paradigm was the Ptolemaic theory with the earth at the centre of the universe whereas Copernicus proposed instead that the planets, including the earth, rotated around the sun. In biomechanics we have theories too; for example, theories to explain bone remodelling, stability in gait, arteriosclerosis, mechanical behaviour of cartilage, kinematics of the knee joint, and many more.

In my own area of interest (tissue mechanics), biomechanical theories were postulated based on the

axioms of continuum mechanics – we are Engineers (mostly) so it is natural for us to proceed in this way. Therefore problems relating to the response of biological systems were formulated as problems in mechanics, and the approach has helped to uncover the mechanisms behind diseases (such as arthritis or instant restenosis) – but have we exhausted the possibilities of the mechanical approach if we want to engineer methods to prevent and treat these diseases? These subjects that biomechanicians studied were also of interest to biologists who were attempting to find their own solutions using the concepts and tools of molecular biology. Their research did not originate in mechanics, but rather aims to understand the mechanisms of disease in terms of, among other things, genomics and proteomics.



*Nikolaj Kopernik (Copernicus)*

Ask the person-on-the-street what scientific revolution is happening now. The answer will probably be the genetic or molecular biology revolution. Is the molecular biology revolution passing the biomechanics community by? Have we expended the possibilities of precise mathematical formulations with detailed constitutive modelling when it comes to solving problems in healthcare problems of our day?

In discussing this Editorial with the Editor Dr Hans Van Oosterwyck he suggested that combining the paradigms (continuum mechanics and constitutive modelling + molecular biology) is the way forward, and such an approach is certainly discernable – we will see it at ESB2004 in The Netherlands. The extent

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of the work still to do is, perhaps, behind the remark of Professor Telega about ESB2002 where he critiques the situation where the “biological, descriptive methodology prevails” (page 2 of the April 2003 issue of the ESB Newsletter). To evolve the new paradigm will require advances in mechanics that allows

biomechanics to be applied closer to the cellular and molecular level. It is a fascinating challenge.

P.J. Prendergast  
Dublin, October 15, 2003

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## ESB 2004 approaching rapidly!

ESB invites you to the 14<sup>th</sup> Conference of the European Society of Biomechanics, held in ‘s-Hertogenbosch, The Netherlands, from July 4-7, 2004. By now you should all have received an e-mail of the organising committee of the Eindhoven University of Technology, reminding you of the abstract submission

deadline of November 1, 2003. Notification of abstract acceptance is due February 1, 2004. Early registration deadline is March 15, 2004. More information can be found on the Conference website ([www.esb2004.tue.nl/](http://www.esb2004.tue.nl/)). We hope to welcome you all in ‘s-Hertogenbosch!

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## Why I am a strong supporter of the European Framework Programs...

Marco Viceconti, Istituti Ortopedici Rizzoli, Italy

### EC Liaison for the ESB Council

**IOR** As most of you know the European Commission manages various funding programs for research and technological development. Most of them are organised under a quadrennial Framework Programme. Projects financed under the Fifth Framework Program (FP5) are still running, while the Sixth Framework Program (FP6) just started. My opinions are largely based on the experience I had with FP4 and FP5, as FP6 first projects will start only in the fourth quarter of 2003. Being a researcher in the area of medical technology, I have been involved with projects mostly in the information technology and the life science domains. I also had some experiences with actions related to the training and the mobility of students and researchers and with actions aimed at technology transfer towards small and medium enterprises. I served as evaluator for proposals and as reviewer for running projects. During all these experiences I worked with many project officers working for many different Commission units. Thus, while I do not consider myself an “expert of European Projects” as some consultants like to call themselves, I had my share of experience, some positive, some negative, but nevertheless all together it made me a strong supporter of the framework program.

I am the co-ordinator of a small research unit on computational biomechanics inside a large Italian

research hospital, with a status similar to the NIH hospitals in the USA. For many years our main funding source was the Italian Ministry of Healthcare and other national funding bodies. However, over the years the level of national funding did not increase, and to a certain extent it even decreased. It became more and more difficult to find money for research at the national level. My first proposal in a framework program was submitted in the BIOMED II action of the FP4. It was rejected, but the overall impression was very positive. The evaluation seemed fair and the comments made by the reviewers indicated true weaknesses in my proposal. Even more important, it was clear that the only metrics was the scientific quality of the proposal. Nobody asked me how visible was my institution, who was my boss, if I was a full professor in the local university, my political orientation, who were my friends. For me, as for many other colleagues, it was a breath of fresh air. I started to look more seriously to these calls for proposals, and in collaboration with our local supercomputing centre, CINECA, I submitted a second proposal for a technology transfer project, which was accepted under the umbrella of the so-called Technology Transfer Nodes. During this first project we developed a complete software environment for the design and the validation of custom-made total hip replacements for an Italian manufacturer of orthopaedic prostheses. It was a very good experience, which gave us a lot of

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new ideas, some of which concretised later in the Hip-Op© surgical planner.

Then, FP5 started. The bad news was the absence of any key action on biomechanics or biomedical engineering, but the good news was a lot of opportunities for information technology applications in biomedicine. Together with some foreign colleagues with different expertise, I wrote various proposals, some of which were accepted. This gave an incredible momentum to my work and to my career. I was finally able to pursue important research objectives, to give my co-workers a three-year contract with a decent salary, and to become more independent from the local lobbies who controlled the national funding. This was the start of four fantastic years.

Beside the injection of funding, EC projects gave me the opportunity to work closely with colleagues from other research fields. I found this interdisciplinary collaboration very instructive and in many cases synergistic. If the international consortium works well, it becomes a very powerful work group, where for any problem there is somebody able to provide an effective solution. The fact that the partners work in different domains, publish in different journals, and aim at different communities ensure collaboration without competition. You have to learn how to work in large, geographically distributed groups, under precise deadlines and well-defined milestones. You do more and better science, and you learn new ways to approach and tackle a problem. With the right partners and a sufficient dose of enthusiasm, participating in a European Project makes you a better scientist.

These four years were also an amazing opportunity for my personal growth. You are forced to travel a lot more all over Europe, you deal with the European Commission bureaucracy, and you have to maintain very close collaboration with people from many different member states. Cultural gaps must be painstakingly overcome; differences in procedure, law, administration, and organization between the various countries require continuous adjustments. And in the meantime, you learn a lot more about Europe, its

institutions, its member states and its citizens. It is both a professional and human experience. Because of the project you end up working and meeting these people quite frequently and with some of them you start to talk about the various local economical, political and social issues. You end up knowing much more on the situation in the other countries. This intense relational work teaches you how to separate the few true cultural traits of a country from the many prejudices we all develop toward foreigners. I discovered that Spaniards are hard workers, French are humble, Belgians are smart and not all Germans are good organisers. In a word, I believe working in European Projects made me a better citizen of Europe.

Of course, not everything is positive. Running an EC project is also hard work. There is no free lunch with EC funding. You are continuously under pressure, the paperwork is huge, and you must develop managerial skills. Also the experience of being part of an international consortium is not easy. Cultural differences, different institutional aims, a certain amount of opportunism by some of the partners made the co-ordination of a project consortium a quite heavy and sometimes distressing job. But the point remained valid: if you are good, and if you are motivated, here there are opportunities for you.

In conclusion, my experience with EC projects has been totally positive. This does not mean that everybody should necessarily participate. If you are happy with your national funding system, stick to it. Trying to get money through the European Commission is going to be much harder, and it requires you to spend a lot of your time dealing with administrative and managerial issues. But if you are unhappy of how the research funding is managed in your country, if you are looking for new professional growth opportunities, if you are attracted by multinational and multidisciplinary initiative, you should give a serious look to the next framework program.

More information can be found on [www.cordis.lu/](http://www.cordis.lu/).

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## ESB GOSSIP

As was already announced through our ESB\_Forum mailing list ([esb\\_forum@yahoo.com](mailto:esb_forum@yahoo.com)), a column on "ESB Gossip" is introduced in this issue of the Newsletter. Obviously, we do not intend to comment on romantic adventures or love affairs of our members – although this may also attract quite some attention – but to put the spotlight on the scientific accomplishments of our members (grants, promotions, author of a new book, etc.). We would like to thank all

the people that already responded and at the same time we hope that others will be encouraged to send in information on their achievements (there is absolutely no reason to be too modest!). Please send this information to:

[hans.vanoosterwyck@mech.kuleuven.ac.be](mailto:hans.vanoosterwyck@mech.kuleuven.ac.be).

**Dr. Clive Lee** (Royal College of Surgeons, Dublin, Ireland) was elected as President of the European

Society for Engineering and Medicine (ESEM) during the 7<sup>th</sup> Conference of ESEM in Halle, Germany (see also page 6 of this issue).

Together with a team of European researchers, **Prof. Ralph Mueller** (Swiss Federal Institute of Technology in Zuerich, Switzerland) has recently been awarded 8.5 million Euro for their Integrated Project "GENOSTEM", one of the new funding vehicles in the Sixth Framework Programme of the European Union to support large-scale pan-European research. For the next four years, the consortium will investigate how adult mesenchymal stem cells can help in the treatment of connective tissue disorders.

**Prof. Arturo Natali** (University of Padua, Italy) has recently published a book on "Dental Biomechanics". The book covers a wide range of aspects, relevant to the biomechanics of natural teeth, dental implants and orthodontic treatments and explores the possibilities of both computational and experimental methods. Clinical and materials aspects are addressed as well (see also page 8 of this issue).

**Prof. Patrick Prendergast** (Trinity College Dublin, Ireland) was awarded the "Parsons Medal" in Engineering Sciences from the Royal Irish Academy. The award lecture, which was delivered on October 8, 2003, was entitled "Life and limb: the bioengineering of prostheses and implants".

**Prof. Jos Vander Sloten** (K.U.Leuven, Belgium) was elected as secretary-general of the interim Executive Board of the new European Alliance for Medical and Biological Engineering and Science (EAMBES)

Elections for the first regular Executive Board will take place during the MEDICON 04 conference in Ischia (Italy). This election will be by the interim council of EAMBES, to which also **dr. Marco Viceconti** (Istituti Ortopedici Rizzoli, Italy) has been elected. Further information about the alliance can be found at [www.eambes.org](http://www.eambes.org). The first meeting of the interim council was held in Brussels on October 17 and 18 in the premises of the Royal Flemish Academy of Belgium for Science and Arts.

In November 2002 **Dr. Maurice Whelan** received the Young Scientist Award for Scientific Innovation from the European Commission DG - Joint Research Centre (JRC), Ispra, Italy (see [www.jrc.org](http://www.jrc.org)). The award was in recognition of his work in applied optics and biomedical imaging. Dr. Whelan is currently head of the Photonics Sector of the Institute of Health and Consumer Protection (IHCP) at the JRC, Ispra. His research interests focus on optical methods for molecular and morphological imaging of cells and tissues, *in vivo* and *in vitro*, and optical waveguide devices for biosensing.

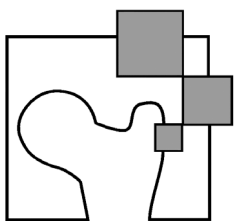
**Prof. H.-J. Wilke, A. Rohlmann, S. Neller, F. Graichen, L. Claes and G. Bergmann** (University of Ulm and Free University of Berlin, Germany) received the ISSLS Award 2003 from the International Society for the Study of the Lumbar Spine for their paper entitled "A novel approach to determine trunk muscle forces during flexion and extension: a comparison of data from an *in vitro* experiment and *in vivo* measurements (see [www.issls.org/](http://www.issls.org/)).

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## Significance of Musculo-skeletal Soft Tissue on Pre-Operative Planning, Surgery and Healing

### February 2003, Charité, Berlin

**Georg N. Duda, Charité - University Medicine Berlin, Humboldt-University and Free University of Berlin, Germany**



In conjunction with the European Society of Biomechanics (ESB), the German Research Council (DFG), and the Association for the Study of Internal Fixation (AO/ASIF Foundation), the Research Laboratory of Trauma and Reconstructive Surgery at the Charité, Humboldt-University of Berlin organized a symposium specifically dedicated to the topic of the „Significance of Musculo-skeletal Soft Tissue on Pre-Operative Planning, Surgery and Healing“. The goal of this

symposium was to initiate a discussion between researchers from the fields of physiology, biology and orthopaedics with clinicians, and to report the current understanding of the significance of the soft tissues surrounding bone.

Growing clinical and experimental evidence suggests that the difficulty in treatment of complex injuries, as exemplified by fractures with severe open or closed soft tissue trauma, is related to the damage of the soft tissue and not to the injury of the bone. Concomitant soft tissue trauma plays a pivotal role in the treatment of complex injuries as it guides fracture management,

significantly influences bone healing, and dictates patient prognosis. Extensive soft tissue injury and subsequent biomechanical instability frequently precede delayed fracture repair, possibly leading to non-union and long-term skeletal muscle dysfunction. Furthermore, poor soft tissue management or muscular balance during joint replacement can have detrimental influences on joint function and lead to lasting pain. At the present time these problems are still not solved. Apart from several classification systems and scores, clinical management and reconstruction of soft tissues following trauma relies purely on empirical evidence. In addition, muscle activity is a determinant for the overall loading of bone. It is known that the musculo-skeletal loading history significantly influences both healing and tissue differentiation, and soft tissue trauma may therefore lead to altered bone remodelling processes in the longer term. Although clinically appreciated, the biomechanical, microvascular and cellular mechanisms accounting for this phenomenon are poorly understood.



*Charité Campus Virchow Clinic*

It is now becoming increasingly clear that clinical management and long-term outcome of complex

injuries will benefit considerably from approaches that involve selective targeting of biomechanical, vascular and cellular pathways that evolve after severe muscle trauma. We suspect that the key to understanding the healing response and improving the return of function lies in understanding the roles that the soft tissues play in providing both the predominant extra-osseous blood supply and coverage of the bone itself and also as actuators in restoring the biomechanical balance.



*Symposium participants*

During the two days of the symposium the invited speakers from both clinical and research backgrounds in orthopaedics and physiology were asked to address the current knowledge and latest results concerning the importance of muscles during pre-operative planning, the changes in soft tissue biology after trauma and the influence of musculo-skeletal biology and loading on tissue healing. The speakers were asked to focus on the clinical relevance of their findings and identify ways in which the results will affect clinical practice, understanding and teaching. The majority of presentations led to publications, which are presented in an issue of Langenbeck's Archives of Surgery (No 5, 2003).

## **7<sup>th</sup> Conference of ESEM September 2003, Halle, Germany**

**Hans Van Oosterwyck, K.U.Leuven, Belgium**

The 7<sup>th</sup> Conference of the European Society for Engineering and Medicine (ESEM) was organised from 18-21 September, 2003 in Halle (Saale), Germany. The meeting was organised in cooperation with the European Society for Artificial Organs (ESAO) and was endorsed by the European Society of Biomechanics. Specifically, a number of ESB Satellite Symposia were dedicated to the following topics (coinciding with the different ESB focus groups):

- Tissue Engineering and Mechanobiology
- Implant Fixation
- Ultrasound and Bone Biomechanics
- Biofluid Mechanics
- Dental Biomechanics

The scientific programme was characterised by a high diversity of topics, covering almost the entire area of biomedical engineering: head-and-neck-surgery, ultrasound, bioinformatics, scanning electron

microscopy, medical sensors, medical imaging and biopolymers are only a few of the topics that were addressed in the parallel sessions of the conference. This diversity clearly is a strong point of the ESEM conference: while other conferences may cover only a limited number of topics, here the participant can “taste” from totally different subjects, which may hardly be related to his or her primary research field, but which can be quite successful in broadening someone’s view on biomechanics and biomedical engineering. An obvious drawback of this concept is the lack of focus.



*Martin Luther University, Halle*

In accordance with current trends, cell and tissue engineering was one of the most prominent topics in the scientific programme. Again, a large diversity of related aspects were addressed, like stem cell technology, gene therapy, bioreactor technology, rapid prototyping techniques for scaffold design etc. The prominent position of tissue engineering was further emphasised by two keynote lectures on the subject:

- Prof. Augustinus Bader from the Biomedical-Biotechnological Centre at the University of Leipzig (Germany), who focused on the use of bioreactors for regenerative medicine.
- Prof. Edwin Horwitz from St Jude Children's Research Hospital in Memphis (USA), who focused on the clinical applications of bone marrow-derived mesenchymal stem cell.

The third keynote lecture was delivered by Prof. Jos Vander Sloten from the Division of Biomechanics and Engineering Design (K.U.Leuven, Belgium) on the use of computer-integrated surgery for improved patient care. Apart from scientific contributions, Mr. Olivier Le Dour from the European Commission gave a lecture on the key aspects of the 6th EC-Framework

Programme and focused on the opportunities for biomedical engineering projects within FP6. He gave an overview of the different funding mechanisms and stressed that opportunities for biomedical engineering – related projects are present in different work areas. Nevertheless, he insisted on the importance of awareness rising with political decision makers about the impact of biomedical engineering upon health care and society as a whole. Noteworthy is also the election of dr. Clive Lee from the Royal College of Surgeons in Dublin (Ireland) as the new President of ESEM for the next term. We congratulate dr. Lee with this election and wish him success with his new function.



*Winners of the “Tim De Dombal” student award (from left to right): Jess Snedeker (1<sup>st</sup> prize, ETH Zuerich, Switzerland), Johannes Dietrich (2<sup>nd</sup> prize, TU Ilmenau, Germany), Daniela Eyrich (3<sup>th</sup> prize, University of Regensburg, Germany)*

Clearly, the scientific programme was not the only factor that turned this conference into a successful one. The city of Halle with its historical buildings, narrow streets and enjoyable pubs formed a beautiful background for the conference, which was appreciated by all participants.

Finally, the most important factor for the success of the conference was of course the organising committee and the conference chairman Dr. Hans-Joachim Hein, who succeeded in bringing together a very attractive conference programme –both the scientific and the social programme. The collaboration between three different European Societies – ESEM, ESAO and ESB – has clearly proven to be a success story. It may be regarded as an example of similar joint conference organisations on biomedical engineering in the future.

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# International Congress on Computational Bioengineering (ICCB) September 2003, Zaragoza, Spain

Triona Lally, Trinity College Dublin, Ireland

The ICCB2003 was launched on September 24<sup>th</sup> to 26<sup>th</sup> last. I had the pleasure to be one of the delegates at this newly established conference in the beautiful setting of Zaragoza, Spain.

The objective of this congress was “to create a new forum for the discussion and diffusion of the recent advances in Computer Bioengineering with special emphasis in the Iberoamerican context, trying to detect common areas of potential collaboration between America and Europe, and especially between Iberoamerican community, as well as to contribute to the development of the Health industry and services in these countries”. This was achieved by presentations on mathematical modelling and computer simulations for the study and prediction of biological processes with bone and tissue remodelling being a key topic in the conference. There were also a significant number of presentations on the development of suitable constitutive models for biologic materials. The conference was held in the University of Zaragoza and the total number of delegates attending was about 130. The conference began with a plenary lecture given by Prof. Steve Cowin from the New York Centre for Biomedical Engineering entitled 'The Plumbing of Long Bones'. The lecture began with an overall description of blood and interstitial fluid flow in living bone tissue and of the factors that drive these flows. Prof. Cowin introduced a computational model to explain why large strains are required for osteocyte signalling *in vitro*, whilst physiological strains on the bone surface due to mechanical loading are much lower.

This highly stimulating plenary talk started the conference on a high note and the quality of the presentations was maintained at a high standard throughout. The structure of the conference was a plenary lecture each day followed by 3 parallel sessions, the session topics ranging from modelling of biological tissues, medical imaging and design of devices to computer methods. All of the sessions were very varied in content and covered a wide range of applications for similar computational methods.

The first of two plenary talks given on the second day of the conference was delivered by dr. Marco Viceconti entitled 'The Living Human Project' and

dealt with the issues involved in generating computational models from CT scans. This lecture was followed by a mini-symposium on the Visual Human project. There was a lot of interest in this aspect of the conference with computational models becoming increasingly more complex as computer resources no longer limit the use of anatomically realistic geometries in computational models. The second of the plenary lectures, given by Prof. Miguel Cerrolaza was entitled “Recent advances in the design and manufacturing of biomedical devices for traumatology and neurosurgery’ and outlined many of the uses of computer techniques in the manufacture and design of new medical devices. The final plenary talk was delivered by Prof. Jean Louis Coatrieux and was entitled ‘Coupling biosignal and image analysis and integrative models’. Overall the ICCB conference content was broad in its application but the overall common computational theme meant that there was a great deal that could be learned from other peoples experiences and research.



*The Pilar Basilica in Zaragoza*

The social side of the conference was also well organized and very enjoyable. On the first evening of the conference a guided tour of the *Aljaferia* Palace, an ancient palace which had examples of Spanish Muslim, Mudéjar and Catholic architecture and art, in Zaragoza was the beginning of the cultural experience that the conference also offered. This was followed by a welcome reception at the five star “Meliá Corona” hotel where beer and wine flowed freely and there was excellent opportunity to talk to the other conference delegates.

Each day lunch was allocated a very generous two hours where traditional Spanish dishes such as seafood paella were served. The lengthy lunches added to the

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relaxed and friendly atmosphere and encouraged a lot of discussion on the conference topics.

The conference banquet at the Aragonese restaurant “El Cachirulo”, an old Spanish villa, was another wonderful cultural and social occasion where entertainment in the form of traditional Spanish gypsy dancers and singers ended the night. The final evening of the conference involved another guided tour of the main monuments in central Zaragoza, the Pilar

Basilica and the Cathedral of San Salvador. This tour showed the spectacular art and architecture in Zaragoza that has spanned many centuries and it was the perfect finish to what had been a thoroughly enjoyable conference, both academically and culturally. Although for many of us who remained in Zaragoza on the last night of the conference, the night was only young and the lively city bars and restaurants still remained to be discovered!

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## Announcements

### New books

**Computational Models in Biomechanics**, E.B. de Las Casas, D.C. Pamplona (eds.), CIMNE, Barcelona, price: 49€, 235 pp., ISBN: 84-95999-26-9 (see also: [www.cimne.upc.es/](http://www.cimne.upc.es/)).

**Dental Biomechanics**, A.N. Natali (ed.), Taylor & Francis, London, price: £65, 304 pp., ISBN: 0-415-30666-3 (see also: [www.tandf.co.uk/books](http://www.tandf.co.uk/books)).

**Functional Tissue Engineering**, F. Guilak, D.L. Butler, S.A. Goldstein, D.J. Mooney (eds.), Springer, New York, price: 160€, 426 pp., ISBN: 0-387-95553-4 (see also: [www.springeronline.com](http://www.springeronline.com))

### Journals

**European Cells and Materials** is a free access, on-line journal ([www.ecmjournal.org](http://www.ecmjournal.org)). The journal is not new, but since this year it is also indexed on Medline. As indicated by its title this peer-reviewed journal focuses on the interaction between cells and biomaterials and related issues, like cell and tissue engineering, biomaterials and tissue characterisation. Dr. Geoff Richards from the AO Research Institute (Davos, Switzerland) is Editor-In-Chief of ECM.