

# 2009 Departmental Seminar

Thursday 1 October 2009

3.00 pm

Mechanical Engineering Seminar Room – E547

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## **The Challenge of Multiple Scales in the Biological Sciences: Applications in Cerebro-vascular Perfusion**

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### **Abstract:**

In line with architectural advances in supercomputing science and engineering have each been posing more and more complex problems which are defined on complex geometric physical spaces. These physical spaces are themselves defined over vast ranges of scale lengths. In order to solve problems whose scale lengths vary substantially there are two possible solutions. Either discretise down to the smallest scale with the possibility of producing such large data sets and numbers of equations that the memory requirements become too large for the machine or divide the problem into a subset of appropriate length scales and map these discretised sub-domains onto appropriate machine architectures. The definition of "appropriate" here is determined on a case-by-case basis at present.

There are a significant number of problems that exhibit a large range of physical scales but none so prominent in the 21st Century as that exemplified within the biological sciences. In the major arterial networks the blood flow dynamic scales are of the order of 1mm (cerebral vessels) up to 25mm (ascending aorta). Downstream of any major vessel exists a substantial network of arteries, arterioles and capillaries whose characteristic length scales reach the order of 10-20 microns. Within the walls of these cylindrical vessels lie ion channels consisting of proteins (100 nanometers and smaller) folded in such a way as to allow only certain molecules through the membrane. One can now of course ask the question as to why all these scales should be integrated into a single model.

To investigate the way in which the brain responds to variations in pressure and yet maintains a virtually constant supply of blood to the tissue numerical models need to be able to have a representation of not only the vascular tree but also a dynamic model of how the small arteries constrict and dilate. Simulating this phenomenon as a "lumped" connection of arteries is insufficient since different parts of the arterial tree respond differently. Thus we have a range of scales from the major arteries down to the arteriolar bed. The combination of a 3D model taken from MR data coupled with an autoregulation model with a fully populated arterial tree able to regulate dynamically remains a relatively unexplored field. This particular talk will outline the reasons for investigating multiple scales and their particular constraints with special reference to the autoregulation of blood in the cerebro-vasculature and outline a possible solution.

All are welcome!