Immunogrid - The European Virtual Human Immune System Project

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Motivation

The immune system is a complex and adaptive learning system which has evolved to defend the individual against foreign invaders. It has multiple levels (molecular, cellular, organ and tissue, organism, and organism-to-organism) and is also combinatorial in nature with a large number of products; there are typically > 10^15 antibodies and 10^12 immune system cell clones in a single individual. The function of the immune system depends on both the genetic composition and the previous exposure, i.e. the experience of the organism. Immune intervention, such as vaccination, is the most effective method for the control of disease and the greatest achievements include eradication of smallpox, near-elimination of polio, and savings of some 170 million person-years. Vaccination has been used in the control of over two dozen diseases by the 50 or so successful vaccines which have been developed to date. These vaccines largely protect against infectious diseases, although recent vaccine developments offer great hope for treatment for a broader range of diseases. Large-scale studies of the immune system, also known as immunomics, is the key factor driving the current wave in vaccine development. These include genomics and proteomics, analysis of the diversity of pathogens or complexity of the human immune system, high-throughput screening or immunoinformatic tools for the management and analysis of vast quantities of data. Computational models are becoming increasingly important in immunomics: Experimental approaches are expensive and it is impossible to perform systematic experimental studies of immune processes in humans. Because of ethical issues, there are stringent limitations as to what experiments can be performed in humans. The usefulness of computational approaches to the study of immune system has been demonstrated, but computational models that encode the natural-size immune system have not been developed because of the past limitations of computational infrastructures.

Methods

In order to overcome the limitations of current immune system models the ImmunoGrid project was created. This initiative is a three year project which has been funded by the European Union and involves a consortium of leading European institutions from Italy, France, UK, and Denmark and also from Australia. The outcome will be a Virtual Human Immune System simulator that can be used as a computational tool for preclinical/clinical applications of vaccine development and immunotherapy. The project will address all aspects of immune system models including integration of standardization concepts and information on molecular, cellular and organ levels for the description of immune system processes and function, while the simulator itself will be validated by pre-clinical mice models. The key feature though will be the use of Grid technology to provide the necessary computational resources (CPU time and data storage) in order to cope with the natural complexity of the human immune system.

Results

The project officially started on the February 1st 2006 and has begun by addressing improvements in the current simulation models. A prototype of the Virtual Human Immune Simulator will be available within 18 months of the start of the project. The set of tools developed will be validated with experimental data and then provided to support clinical applications for the development of immunotherapies in cancer and chronic infections and disseminated to users such as vaccine and immunotherapy researchers and developers.

Availability: http://bioinfo.cineca.it/immunogrid

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