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What We Have To Do in Immunology and Virology

-OPINION-

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Mathematical modeling, which at one time was essentially ignored by the experimental immunology and virology communities, has in the last 15 years become an important tool to aid biology. In fact, almost all of the major scientific disciplines are now collaborating with a theoretical immunologist, with the exception of Japan. This is because mathematical modeling has provided several quantitative insights which cannot be obtained by experimental and clinical studies alone, especially, in the fields of human specific infectious disease such as HIV, HCV and influenza infection [Nature, 1995, 373, 117-122: X. Wei et al. & 123-126: DD. Ho et al., PNAS, 1996, 93, 4398-4402: MA. Nowak, Science, 1998, 282, 103-107: AU. Neumann et al.]. Mathematical modeling is also improving our understanding of lymphocyte dynamics and the quantitative events that underlie the immune response to pathogens [Science, 1998, 279, 1223-1227: H. Mohri et al., JEM, 2001, 194, 1277-1287: H. Mohri et al., JV, 2006, 80, 7590-7599: P. Baccam et al., PNAS, 2008, 105, 6115-6120: N. Vrisekoop et al.].

Unfortunately, there are few research collaborations between immunologists, virologists and theorists in Japan. This is because theorists have not been trained in handling mathematical models in the fields of immunology and virology, resulting in extremely few opportunities for experimental researchers to associate with a modeling study. It is essential to establish a unique and original environment in Japan for creating opportunities which are distinct from the American and European countries, in which experimental researchers and theorists approach and cooperate with each other. These types of collaborations will provide us with novel insights in several immunological fields.

Our knowledge of immunology and virology is derived from various fields of study (medicine $\Rightarrow$ chemistry $\Rightarrow$ cell biology $\Rightarrow$ molecular biology). Which study will help pioneer the next generation of exploration? We are now generating and obtaining enormous

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volumes of data more than ever before by using the know-how of current technology to constantly develop higher throughput technology. However, the methods used to analyze these enormous amounts of data are extremely limited and lag behind the pace at which the data can be produced. "A Merger between Immunology, Virology and Mathematics" is a new challenge for answering our future needs to analyze various time course data mathematically, computationally and statistically, and is a key factor needed in the current field of immunology. In fact, collaborating efforts in immunology, virology and mathematics recently enabled us to analyze many complex immunological phenomena including immune cell migration [Nature Rev. Immunol., 2009, 9, 789-798: JB. Beltman et al.], immunologic memory, and interactions between virus and immune cells (one of my PRESTO projects), amongst others.