Molecular Science is Central to a Sustainable Future

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Our lives seem so dominated by solid-state electronic devices, and the software they contain or have access to, that molecule and molecular science can seem less important than in the past. But a few moments' reflection shows that this is far from true. Humanity faces no more pressing problem than that of climate change and the need for sustainable economic development. No better way of storing the sun's energy than in chemical bonds has yet been discovered. But converting sunlight, water, and CO_2 into a fuel with cheap abundant materials remains a tremendously challenging problem in catalysis, surface and interface science, electrochemistry and much else in the domain of molecular science. Developments in battery and fuel cell technology are heavily reliant on molecular science and may lead to a great expansion of electronic vehicles and a reduction of greenhouse gas emissions. If hydrogen is to become a viable energy source for transportation (in, for example, fuel cells) the problem of storing hydrogen effectively and safely must be solved. Climate change will bring challenges of resilience and adaptability as a result of increasing frequency of extreme weather events. The creation of resilient and even self-repairing materials can help prepare societies as climate change appears, regrettably, to be on a course which current international agreements such as the INDCs (National greenhouse gas reduction targets) for COP-21 in November 2015 are inadequate to halt.

Many other pressing problems of humanity depend on molecular science for their solution. The widespread and continued availability of clean water, for example, depends on cheap and effective desalination or removal of dangerous natural pollutants such as arsenic. The redesign of major chemical processes to reduce their environmental impact (green chemistry) or the bottom-up construction of functional devices with capabilities currently found only in living systems require profound developments in molecular science. The development of artificial cells or the effective combination of hard and soft matter in devices with new functions not found in nature is likely to represent one of the most exciting areas of molecular science over the next decade. Perhaps the greatest scientific challenge of all in the coming century is to understand cognition and the workings of the human brain. Here again, molecular science is of vital importance in developing characterization tools. It emerges that, while it has been conventional to characterize the function of neurons by their appearance in a microscope, their chemical signatures at synapses play a crucial role in function and may vary greatly for similar-looking neuron types. As precision and personalized medicine develop, treatments will be matched to an individual's own chemical and genetic makeup. We do not yet understand the relative roles of environment (the 'exposome') and genetics in disease. Fully characterizing the environmental molecules and their functions – both positive and negative – in disease remains a tremendous challenge.

Of course this wide range of opportunities, imperatives, and challenges for Molecular Science must be complemented by the creation of new tools, new facilities, and new theories and computational methods. With the quality of the faculty, the new collaborative programs developed over the last six years and the new faculties, IMS is well placed to contribute importantly to the basic molecular science that will underpin the vital challenges and opportunities incompletely sketched above.

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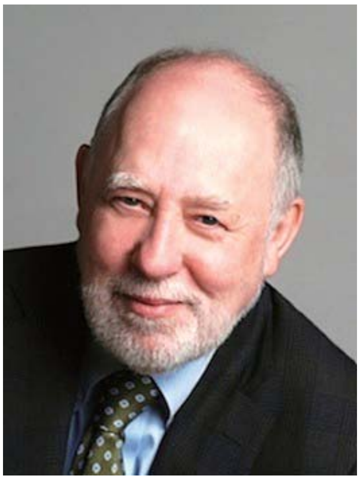

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Professor Fleming is the Melvin Calvin Distinguished Professor of Chemical Biodynamics in the Department of Chemistry. His research group develops and uses advanced multidimensional ultrafast spectroscopic methods to study complex condensed phase dynamics in systems such as natural photosynthetic complexes, and nanoscale systems such as single-walled carbon nanotubes and organic photovoltaic systems. Experiments conducted in the Fleming group indicated the importance of quantum electronic coherence in disordered biological environments, and set off a burst of research and collaboration examining the role of quantum dynamical processes in biological energy harvesting systems. He is a member of the National Academy of Sciences, a Fellow of the Royal Society, a member of the American Philosophical Society, a Fellow of the American Academy of Arts and Sciences, and a Foreign Member of the Indian National Science Academy.

Professor Fleming was born in Barrow, England. He earned his Bachelor's of Science degree from the University of Bristol in 1971, and his Ph.D. in chemistry from the University of London in 1974. He joined the faculty of the University of Chicago in 1979. There, he rose through the academic ranks to become the Arthur Holly Compton Distinguished Service Professor. At University of Chicago, he also served as the Chair of the Chemistry Department. In that role, he led the creation of University of Chicago's first new research institute in more than 50 years, the Institute for Biophysical Dynamics. In 1997, he came to University of California Berkeley as a professor of chemistry, and he started and directed a new division of physical biosciences for Berkeley Lab. He was also the founding director of the Institute for Quantitative Bioscience (QB3) at Berkeley, and (with two colleagues) led the plan to create the new Stanley Hall and became that building's first director. Fleming has served as Deputy Laboratory Director of Lawrence Berkeley National Laboratory and Vice Chancellor for Research at UC Berkeley. He is currently Chief Scientist and Chancellor's Principal for International Research Collaborations at UC Berkeley.