Journal of Heat Transfer

# Guest Editorial

## Special Issue on Heat and Mass Transfer in Biosystems

The involvement of the heat transfer community in the research related to heat and mass transfer in biosystems increases rapidly and covers a wide variety of applications. While the past involved mainly topics of cryogenics and other related fields the current involvement is substantially wider and covers diverse biological fields and applications. The present special issue dedicated to heat and mass transfer in biosystems captures only a portion of this wide topical potential for biosystems research. The objective of this special issue is to report the state of the art on some of the research conducted in this field and motivate the heat transfer community, which is uniquely qualified to make a valuable contribution in providing fundamental understanding of transport of heat, mass, and momentum occurring in biological and biologically inspired systems, to become more involved in this field of research. In particular, applying the engineering way of thinking can be especially useful in developing the fundamental understanding, the governing principles, mechanistic explanations, and predictive modeling for functioning of biological systems. Application of the engineering point of view (through identification, formulation, and solution to bioengineering problems as well as designing machines and systems based on fundamental conservation laws) can usefully complement many biological research efforts and lead to new breakthroughs in this area. Among the topics covered in this special issue are targeted drug delivery, heat generation in nanoparticles with potential application to cancer treatment, tissue engineering by using irreversible electroporation to minimize tissue damage due to Joules heating, temperature distribution in cryosurgery, facilitating transdermal drug delivery via skin electroporation, modeling of microorganism growth including the lag phase, human eye response to thermal disturbances, modeling of bioheat transfer, formation of organelle traps in an axon providing a mechanistic explanation of the onset of Alzheimers disease, the use of micro-cantilever biosensors for detection of microorganisms, and the application of the constructal theory to biophysical systems.

The issue starts with a general topic of applications of the constructal law (this law postulates that the direction of systems evolution is such that it obtains easier access to currents that flow through it) in a paper by Bejan and Lorente. The paper considers applications of the constructal law to various biophysical systems. A novel method of targeted drug delivery (of an anti-cancer drug for example) to lung sites via utilization of a new smart inhaler system is then introduced by Kleinstreuer and Zhang. A correlation between the heat generation rate in nanoparticles (due to applying an alternative current at a specific frequency to a water-cooled coil, which thus generates an alternating magnetic field) and the density of the micro-CT images is presented by Attaluri et al. This correlation is important for understanding basic issues of using nanoparticles for cancer treatment. Evidence that parameters for irreversible electroporation can be chosen in such a way that minimizes the damage due to Joule heating to the tissue is demonstrated with the help of numerical modeling by Phillips et al.. Shitzer presents a comprehensive review of analytical and numerical studies on temperature distributions in cryosurgery; in vitro and in vivo experimental data used for validating these results are also discussed. The situations involving both surface application as well as insertion of cryoprobes are analyzed. Results of analytical modeling of biological media or heat management devices with a nonuniform geometry as a combination of convergent, uniform, and/or divergent configurations is presented by Mahjoob and Vafai. Kuznetsov develops a new model for the formation of organelle traps in an axon with regions where microtubule polarity has been reversed by the formation of microtubule swirls. Biological data link the formation of such microtubule swirl regions to traffic jams in axons that lead to various neurological disorders, such as Alzheimers disease. The developed theory demonstrates how the reversal of microtubule polarity results in the formation of organelle traps for both newly synthesized and used organelles, thus providing a mechanistic explanation of the onset of Alzheimers disease. Vadasz and Vadasz present a generic theoretical mechanism for microbial growth, including the lag phase that reveals the profound impact of the metabolic process on the growth. The theoretical model provides excellent matching to experimental data of microbial growth. Systematical reviews of four existing models of a human eye response to thermal disturbances are presented by Shafahi and Vafai. The physical phenomena included in the models, strengths and limitations of the models in simulating eye thermal response to various ambient conditions, blood temperature, and various thermophysical and biological parameters are discussed. Different models of bioheat transfer are introduced by Wang and Fan. Different approaches for obtaining constitutive relations for the heat flux, including Fourier law, Cattaneo −Vernotte theory, and dual-phase lagging theory are presented. The strengths and limitations of various bioheat models, including Pennes, Wulff, Klinger, Chen and Holmes, dual-phase-lagging, as well as some other models are discussed. A comprehensive overview of existing mathematical models of skin electroporation, which is a promising technique of causing a structural alternation in the uppermost skin layer, the stratum corneum, with the aim of facilitating transdermal drug delivery is presented by Becker. Special attention is given to developing a thermodynamic model of electroporation, which is based on the idea that a large current density through the pore causes lipids composing the stratum corneum to undergo a phase transition. Application of microcantilever biosensors for detection of microorganism is investigated experimentally by Tzeng et al. They explored the use of specific carbohydrate receptors for the functionalization of nanoparticles and demonstrated their binding specificities and their ability to mediate aggregations of targeted bacteria.

We would like to extend our special thanks to the authors of the special issue and to the reviewers for helping to elevate the quality of the papers. We are also thankful to the Editor, Professor Yogesh Jaluria, for providing this forum to discuss this emerging field. Special thanks to the Editorial Assistant, Shefali Patel, for the help in organizing this special issue.

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