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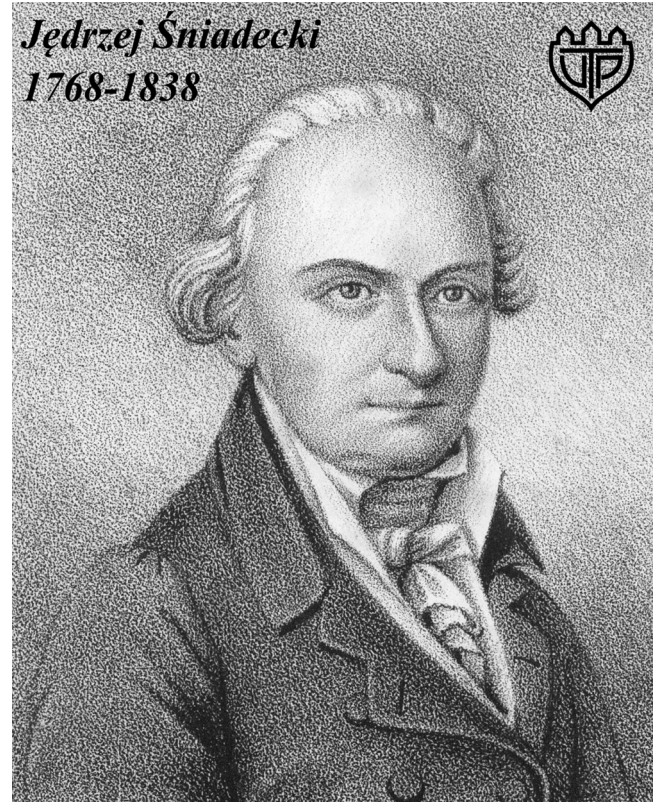
Editorial

Spatiotemporal models in biology and the health sciences



Living systems are out of thermodynamic equilibrium. As a result, unceasing activity and energy dissipation are required for such systems to stay alive. Cells, tissues, organisms, and ecosystems, furthermore, are not spatially homogeneous. There are concentration gradients, barriers, and anisotropic structures. Therefore, biological systems commonly exhibit variation both in time and in space. Such systems pose interesting challenges in the modeling and in the mathematical analysis. Coupled nonlinear partial differential equations are notoriously impenetrable. A researcher who is seeking a quantitative understanding of a biological system commonly finds her- or himself walking a tightrope. On the one hand, the model needs to quantitatively account for the observed phenomena. On the other hand, the model has to be kept sufficiently simple for it to be understood and analyzed. A variety of spatiotemporal biological models is presented in this Special Issue.

On June 4–5, 2018, a Biomedical Workshop focusing on Spatiotemporal Modeling in Biology and Medicine was organized, thanks to a special support by the marshal of Kujawsko-Pomorskie voivodeship, at the UTP University of Science and Technology in Bydgoszcz, Poland. The workshop celebrated the 250th anniversary of the birth of Jędrzej Śniadecki (1768–1838), see picture/lithograph, a native of the Bydgoszcz region who became a prominent professor of chemistry and medicine at the University of Vilnius. He is known, among other things, for having first described how rickets can be related to a lack of sunlight (cf. W. Mozołowski, *Nature*, No. 3612, Jan 21, 1939). It is worth noticing that his famous book “Theory of Organic Beings” has very recently been translated from Polish (versions from the years: 1838 and 2018) into English, and compiled then by B. Railiene and B. Baranauskas (Vilnius 2018, limited edition sponsored by Thermo Fisher Scientific) to commemorate the aforementioned anniversary.



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Most of the 18 articles in this Special Issue stem from the presentations at the workshop; they are the solicited written accounts that presenters provided. Other articles were invited. What follows below is a short outline of each article.

Subdiffusion is diffusion that is slower than normal diffusion due to random trapping. It has been a much researched area over the last few decades and it has become ever more clear that many biological mediums are actually subdiffusive. Kosztolowicz and Lewandowska consider a medium with normal diffusion that is connected to a subdiffusive medium. Surprisingly, it turns out that concentration patterns in the medium with normal diffusion can reveal whether absorption takes place in the subdiffusive medium.

Models for how proteins turn chemical energy into mechanical motion have customarily assumed that the diffusive motion in a cell is normal. As the prevalence of subdiffusion is now firmly established, it has become necessary to reconsider these models. Goychuk considers motor-protein-mediated transport of subdiffusive cargo in a viscoelastic cytosol.

The numerical simulation of partial differential equations associated with diffusion in an inhomogeneous 3D environment is very time consuming. Honary, Nitz, Wysocki, and Wysocki propose a much simpler queueing-networks model and compare results of their approach with the more traditional approaches.

Granules that are growing because diffusing or subdiffusing particles remain stuck to it are found in biological systems and also occur in biotechnological applications. Gadoski investigates the processes and factors that control the shape and size change of the growing granule.

Though gallstone disease is common and much researched, little is known about the exact mechanism of the formation and growth of the responsible cholesterol crystals. Siódmiak presents physical models for the different stages of the growth.

Low-density lipoproteins can form dangerous plaques on the inside walls of the coronary artery. Jesionek and Kostur present computer models for the transport and accumulation of such low-density lipoproteins.

Complex spatiotemporal patterns are commonly found in ecological systems with interacting species. Vázquez-Medina, Ledesma-Durán, and Aragón consider a system with one predator-species and two prey-species. They investigate how mutualism between the prey species affects the dynamics.

Is it advantageous for a group of prey animals to aggregate when facing a predator? The answer to this question appears to crucially depend on the environment in which prey and predator operate. Filippov, Guillermo-Ferreira, and Gorb analyze the situation on the surface of a cylinder. The numerical simulations realistically describe predation on a tree trunk.

Outbreaks of infectious diseases like the measles are still hard to predict. For an outbreak to occur, it is necessary that the number of susceptibles exceeds a certain threshold. However, for a real community both the threshold and the number of susceptibles are generally hard to estimate. Lisowski, Yuvan, and Bier endeavor a quantitative analysis and conclude that the city of Warsaw, Poland (not far away from the Bydgoszcz region), may be close to a measles outbreak.

Na_v1.5 is a voltage gated sodium channel that is the subject of much pharmacological research. Grzywna and Borys discuss the channel's

ball-and-chain inactivation mechanism on the level of amino-acid residues and relate it to cancer metastaticity.

The ATP-sensitive potassium channel appears to play a key role in insulin release. It is currently not well understood how and why certain mutations that affect the channel lead to diabetes while others lead to hyperinsulinism. Szewc-Walczewska and Nowak attempt to solve the problem by studying the 3D structure of an important subunit of the channel.

Understanding the electrical activity of the muscles of the anal sphincter can be important for understanding colorectal cancer. Trybek, Nowakowski, Salowka, and Machura explore these electrical signals and establish what information they carry.

Understanding uterine contractions in early pregnancy is important for understanding, and possibly preventing, miscarriage. Domino, Domino, and Gajewski take the electromyographic signals from uterine muscles of pregnant pigs and do extensive statistical analysis on these signals.

Release of inflammatory and oxidative agents from the intestines into the body is one of the responses to heat stress. Sławinska, Mendes, Dunisławska, Siwek, Zampiga, Sirri, Meluzzi, Tavaniello, and Maiorano administered a prebiotic to chicken eggs and checked whether this would later lead to chicken intestines with better barriers against the influx of the toxic agents.

Joints need to stay lubricated with a fluid that has the right viscoelasticity. Wierzcholski and Miszczak discuss the involved chemistry and physics and review the current state of knowledge.

Osteoarthritis occurs when cartilage degrades and joints are no longer properly lubricated. The results of Pawlak, Mreła, Kaczmarek, Cieszko, and Urbaniak show how phospholipids are crucially involved

At the surface of a joint there is a subtle interplay of hydrophilicity and hydrophobicity. Mreła and Pawlak present new results on the bioelectrochemistry of joint functioning.

Severe bone damage is nowadays commonly treated with the use of synthetic, 3D-printed, porous bone material in combination with tissue engineering methods. Andrzejewska examines mechanical properties (tensile strength, Young modulus, etc.) of the ensuing products.

Finally, this special issue would not have been possible without the efforts of the reviewers of the manuscripts. BioSystems' editor-in-chief, Gary Fogel, gave invaluable advice and direction as we were putting together this Special Issue. We are, furthermore, very grateful to the staff of Elsevier for their help and guidance in the process. Last but not the least, a travelling grant by Santander Bank – Polska for a visiting researcher from Spain, lecturing at the workshop, is acknowledged.

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