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Computational modeling in the biomechanics of cells

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The computational modeling is an effective tool in biomedical engineering helping in the interpretation of experiments and simulation of various diseases as well as their treatments at the molecular, cellular and tissue levels. We will discuss several examples of the computational modeling in cell biomechanics developed in close interaction with the experiment. Hair cells are sensory cells in the organs of hearing and balance. They have a bundle of stereocilia that sense, respectively, sound pressure and head acceleration. This cell's mechanotransduction is centered at an ionic channel located in the membrane at the tip of the stereocilium. The experiment has shown the involvement of this membrane but its exact role has not been clear. We have developed a computational 3-D model of the channel inside the membrane and used triangulation and a Monte-Carlo method to compute the local forces that determine the open probability of the channel. An important feature of the mammalian (human) ear is the second type of hair cells that provide the amplification and frequency selectivity in the loop of sensing the sound. We have proposed a computational electro-viscoelastic model to explain the experimentally observed features of the active forceproduced by these cells under acoustic-frequency conditions. The mechanisms of stem cell differentiation are crucial to their use for various therapies, and we have analyzed the fat-based stem cell differentiation into skeletal muscle cells using an experiment-supported kinetic model of cell progressing through several stages characterized by different protein expression and cell morphology.

Biography

Alexander A Spector received his BS and MS degrees in Engineering Mechanics from Moscow State University and his PhD from the Russian Academy of Sciences. In 1991, he received the highest academic degree of the Doctor in Mathematics and Physics from Russian Academy of Sciences. In the last twenty years, he has been at Johns Hopkins University where he currently is Research Professor in Biomedical Engineering and Mechanical Engineering. He is also on the faculty of the Institute of Nanobiotechnology and Center of Hearing and Balance. In 2010, he was elected as a Fellow of the American Society of Mechanical Engineers.

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