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Perspective

Computational Modeling in Biological Systems

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DESCRIPTION

Computational modeling is the use of mathematics, physics, and computer science to create complex, dynamic models of systems based on multiple data points. The growth of advanced data acquisition technologies such as wearable sensors and internet-connected medical devices is part of the recent growth in this sector. Computer modeling has been applied in several areas such as weather forecasting, flight simulation, seismic simulation, and life sciences. Computer models currently in use can provide data about biological systems at multiple levels. This type of modeling is called multiscale modelling.

While running these simulations, scientists identify some laboratory experiments needed to solve the problem. This has several benefits, including highly controversial ethical issues, such as significant reductions in research costs and, in the case of biological research, the use of animal models. There are several ways in which computer science and biology interact. Computational Biology describes computer-aided modeling and simulation of biological processes. Bioinformatics is used to develop systems that automatically manage and analyze biological data. Biological computing explores how biological methods can help solve computing problems.

Developmental biology refers to the study of how organisms, especially plants and animals, grow and develop. This includes several biological processes such as cell differentiation, regeneration, asexual reproduction, metamorphosis, and stem cell growth and differentiation. Taking the multicellular organism itself as an example, it is a dynamic system in which both the value of a state variable and the set of state variables change over time. Multicellular systems are made up of individual cell lines, all of which are constantly developing and regenerating throughout the life of an organism. It is regulated by a complex process of progenitor cell proliferation, differentiation, and migration. The dynamics of each scale are determined by the collective activity of the units of the next scale. When the mother cell divides, two daughter cells are created. As soon as the mother cell divides, the entire topology of the system is adjusted. The connection between the mother cell and the rest of the organism is removed the connection is established between the daughter cell and inserted between the daughter cell and the rest of the organism. This gradually creates a large network of interconnected cells. This happens constantly throughout the life of an organism.

Pluripotency refers to the ability of a single cell to produce all cell lines of a mature organism. It is transient and limited to just a few epiblast cells of mammalian embryos, but is maintained in vitro by Embryonic Stem Cells (ESCs). Uncovering the molecular basis and understanding the process of pluripotency within these cells is of growing concern to modern medical science. There are a few factors in pluripotency that are central topics in stem cell research: how it is maintained in ESCs, how it is lost during lineage specification, and how it is reintroduced to generate new pluripotent stem cells are some of them. A multitude of computational studies has been published in recent years alongside conventional *in vitro* and *in vivo* experiments.

Complementary applications of computer-assisted techniques are becoming increasingly important for accurately understanding and explaining complex behaviors and interactions. For example, computational modeling approaches can define the dynamics and structure of gene regulatory networks. However, care must be taken in interpreting the study, as different structures encode similar or same biological functions. Network analysis is as important as structural identification. This is just one application of developmental biology in which computer modeling is used. In fact, there are many other application examples.

Computational modeling has fundamentally changed the way scientists collect data for clinical trials and provide knowledge about biological systems and processes. As data acquisition techniques advance, the field of computational biology will become more sophisticated in the future and may remain at the forefront of developmental biology for decades to come.

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