Advanced Techniques in Biology and Medicine

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Perspective

Cellular Molecular Signaling Through DNA Nanotechnology

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DESCRIPTION

In life science, cells have evolved over millions of years to have the most successful functionality. Therefore, research on cells certainly broadens our comprehension of living systems and adds some predesigned functionality to them. Scientists have created a variety of artificial cell-like systems to simulate cellular molecular signaling in order to test the viability of artificial cells. A minimum of three essential elements are needed to create an artificial cell: (i) a metabolic apparatus that gathers resources and energy for cellular life; (ii) a membrane component that maintains the stability and isolation of the living thing from its surroundings; (iii) an information-processing and information-transferring genetic system.

A genetic molecule called DNA has a lot of potential for use in nano and molecular engineering. Dynamic DNA nanotechnology, which is based on DNA hybridization and chain displacement reactions, demonstrates precisely molecular processes with nanomachines including DNA logic gates, motors, computers, and reaction networks. Watson-Crick base pairing has been used to create topological nanostructures for structural DNA nanotechnology, including DNA dendrimer, DNA framework, DNA hydrogel, and DNA origami. We created an artificial cell using DNA engineering in the last ten years as a result of developments in DNA nanotechnology. HeLa and HepG2 cancer cells that had been separated earlier in time were used to create a biomimetic large vesicle that kept the host biological characteristics. To understand cell membrane biology, researchers typically used synthetic phospholipid bilayer membrane models. Our huge vesicle, in contrast to the synthetic phospholipid vesicle, has host cell membrane characteristics and maintains cellular size. We created the strategy of creating artificial cells through DNA nanotechnology based on such cell-mimicking large vesicles. On a surface simulating a cell, we used DNA hybridization and DNA strand displacement response to accomplish reversible regulation of Nano prisms, and to simulate cellular adaptivity, a DNA cascade reaction was built on a surface that mimicked a cell. To transfer information and provide feedback on external stimuli, a signaling system is necessary for the equilibrium of living organisms. The encapsulated system requires logical interaction from surface molecular engineering.

CONCLUSION

In the natural world, a biomolecular signalling network controls many biological molecules to maintain live creatures through a sequence of spatiotemporal and organized chemical processes. The design and construction of a logical integrated functional module to control the cascade of molecular events is a significant problem in the engineering of molecular signaling systems. Building a prototype cell that can execute preprogrammed actions and uses an artificial response network as its computational core is therefore appealing.

The new techniques for creating artificial cells using DNA nanotechnology are based on our large vesicles, which imitate cells. Our biomimetic large vesicle, generated from a mammalian cell, was used to build an artificial molecular signalling system based on DNA. On a membrane, a switchable Nano channel was created for the transport of materials and information. To communicate data between the outside and the interior of the vesicle, designers built an ATP-responsive DNA Nano gatekeeper that traverses the membrane. Adenosine Triphosphate (ATP) is a canonical energy molecule that activates cellular machinery and drives metabolic reactions in physiological and pathological reactions. Afterward, we built an encapsulated data processing system. The rational design of the DNA cascade network was intended to imitate cellular signaling pathways. The entire system mimics the reception, transmission, and response of biological signals using an encapsulated DNA signaling network and on-membrane DNA nanostructure.

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Received: 08-Sep -2022, Manuscript No: ATBM-22-20580; **Editor assigned:** 12-Sep-2022, PreQC No: ATBM-22-20580 (PQ); **Reviewed:** 26-Sep-2022, QC No. ATBM-22-20580; **Revised:** 03-Oct-2022, Manuscript No. ATBM-22-20580 (R); **Published:** 10-Oct-2022, DOI: 10.35248/2379-1764.22.10.383

Citation: Pui SV (2022) Cellular Molecular Signaling Through DNA Nanotechnology. Adv Tech Biol Med.10:383