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How is Biomimicry Used in Medicine and Medical Research?

Thesis Statement: Biomimicry contributes to the developing process of medical advances within our American society; based off of the design, materials, structure, and systems modeled to replicate biological entities and processes in life.

Introduction: Biomimicry (a system modeled to replicate biological entities and processes in life) has initiated a variety of human innovations, designs, and medical advancements; made to solve global problems. [1] " From spider silk-made artificial skin to lotus leaf-inspired self-cleaning materials, biomimicry endeavors to solve human problems"- Department of Biomedical Engineering; The University of Akron; Akron, OH USA. In the recent years, biomimicry has significantly contributed to biomedical research and medical advancements. [2] For instance, using polyacrylamide gel electrophoresis (a separation of biological macromolecules, a molecule consisting of a large number of atoms, such as a protein, nucleic acid, or synthetic polymer) are according to their electrophoretic mobility. Using polyacrylamide gel electrophoresis is important since, it mimics the elastic modulus of different biological tissues within the brain, muscles, and bone precursor osteoid; using biomimicry to supplement the various tissues sections of the brain acts as a medical advancement to operational processes and enhancements contributing to neurological research.

[3] "Disher's lab has directed mesenchymal stem cell (MSCs) differentiation into specific lineages. They have shown that soft substrates mimicking the elastic modulus of brain tissues (0.1~1 kPa) were neurogenic, substrates of intermediate elastic modulus mimicking muscle (8 ~17 kPa) were myogenic, and substrates with bone-like elastic modulus (25~40 kPa) were osteogenic"- Pennsylvania Muscle Institute, University of Pennsylvania, Philadelphia, 19104, USA. This work is essential since it represents the influence on biomimicry through stem cell research and medical advancements.

Body: Biomimicry achieved different levels through the requirement of structure, design, and replication of the process in life to contribute to the developing process of medical advances within our American society. For example, mimicking nature form or function, imitating natural processes, and emulating natural systems are products of the different levels of biomimicry. However, simulating structures, functions, biological entities and processes are hard to achieve efficiently.

[4] "Mimicking form or function is the most common bio-mimetics seen in biomedical research. A recent example can be drawn from cardiac research, where the field is poised for new breakthroughs. Published in Biomaterials, Dr. Parker's group used micropatterned surfaces to build 2-dimensional engineered cardiac muscle from neonatal rat ventricular myocytes with distinct architectures that mimic in vivo hierarchal structures and electromechanical function of heart"-Steven Cramer MD. The data collected from the testing of cardiac muscles show that as stress in the engineered cardiac tissues increase it correlates with the increased sarcomere, a structural unit of a myofibril in striated muscle, alignment. This study is critical because the results show that heterogeneities, a word that signifies diversity, can maintain muscle and cardiac tissue

function; the structural organization of the sarcomere and cytoskeletal alignment are critically crucial for maximizing peak force and providing stabilization of the brain.

Biomimetics, a word originating from the Greek words “bios” (life) and “mimesis” (to imitate), is the study of a system modeled to replicate biological entities and processes in life underlying mechanisms; obtaining methods and ideas from nature and applying those concepts into science, engineering, and medicine. More specifically, biomimetic is a form of technology that imitates nature to improve human lives. Examples of biomimetic studies include the reduced skin friction fluid drag in the turbulent-flow regime swimsuits inspired by the riblet structure of shark’s skin, production of Velcro fasteners based on the locked formation of burdock burr, shape of aircraft developed from the construction of birds, and stable building structures copied from the backbone of turban shells.

An essential biomimetic invention contributing to medical research is the High-Strength Carbon Nanotubes. [5] "Mussels do not detach easily from rocks even when hit by powerful waves because they have high adhesive strength, which is due to byssi. A byssus pad with a radius of 2 mm is capable of lifting weights up to 12.5 kg. The adsorptive power of byssi is greater than any adhesive found in nature. The structure of byssi is composed of the crosslinking of collagen fibers and a protein known as Mefp-1, which is more durable than any fiber"-Lee BP, Messersmith PB. Cultured Carbon Nanotube (CNT) fibers, as well as cross-linked macromolecule adhesives, act as collagen, main structural protein, and Mefp-1 protein. As a result, this led to the development of High-Strength Cultured Carbon Nanotubes (CNTs). The properties of byssi, tough silky filaments that mussel, as well as some other bivalves, adhere to rocks

and other objects, have also led to the use of Biomimetics in medicine to create advanced ways of stitching wounds and to utilize them in surgery.

While mimicking forms, functions, biological entities and processes in life will likely lead to medical breakthroughs in research as well as novel treatments, it is harder to achieve but will result in a more significant impact is achieved. For example, Dr. Elvassore's researched the Micro-Arrayed Human Embryonic Stem Cells-Derived Cardiomyocytes for In Vitro. [6] In this study, "Dr. Elvassore's group developed for the first time an in vitro cardiac tissue assay using human cardiomyocytes (hCMs) and micro-technologies. hCMs were cultured onto a poly-acrylamide hydrogel with tunable tissue-like mechanical properties and organized through micropatterning in a 20 × 20 array"-Industrial Engineering Department, University of Padova, Padova, Italy.

This observation this important since it provides the understating of why the surviving cells in damaged heart tissue do not integrate with the damaged host tissues. Overall the human cardiac, Micro-Arrayed Human Embryonic Stem Cells-Derived Cardiomyocytes for In Vitro essay, acts as a cardiac system that takes a closer look at the expanded knowledge of cardiac diseases and treatment. Most importantly it overlooks upon the concept of the mimicking of functions being hard to achieve since the research conducted poses a possibility of the invention to work instead of actuality. However, with further improvement, it could have a significant impact on drug development and medical research by replacing animal models used for drug screening.

Conclusion: Biomimicry, a word originating from the Greek words "bios" (life) and "mimesis" (to imitate), is the study of biological entities and processes in life. As a result, biomimicry is used replicate and mimic those process and apply those concepts to

science, engineering, and medicine. However, based off of the design, materials, structure, systems modeled to replicate biological entities and processes in life, it comes with the possibility of being harder to achieve but it will result with a significant impact if accomplished.

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