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The Engineering of a Microscale Niche to Test a Novel Anti-Cancer Agent

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Exploring Divine Providence through the Engineering of a Microscale Niche to Test a Novel Anti-Cancer Agent

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Abstract

Cutting-edge biomedical research often relies on innovative tools from the field of engineering. Some of these tools are designed to investigate or probe a niche, analyzing its characteristics and affordances. Other devices are engineered to create a niche in which a specific, unique interaction can take place, while the outcomes are carefully monitored. This paper will focus of the latter and, more specifically, the affordance structure behind production of a niche designed for cancer research that suggests a divine engineer behind the whole of creation and provides evidence of God. Preliminary research suggests that when maintained in close proximity to breast cancer cells, mushroom mycelia secrete compounds which trigger the programmed cell death of the cancer cells. Experiments are currently being conducted to assist in the development of an appropriate scaffold to facilitate this interaction. This experiment's use of affordances will serve as a template to understand complex interactions and to display an ingenuity that points to God.

Since niche construction can be viewed as the perception, utilization, destruction and creation of affordances,[1] it is proposed that affordance-based design and reverse engineering techniques will prove advantageous in this work. The specific design question being asked is: "What set of affordances is necessary to achieve a high success in the organism interactions, as well as ease of experimentation and repeatability?" As with all new innovations, there has been much trial and error. The process for engineering this device was to first create a setup that would allow for the most basic affordances, i.e. allows for both the mushroom and cancer cells to survive, and then to add on more unique affordances. At this point, a prototype has been fully constructed and the physical parameters are being adjusted to allow for ease and accuracy of analysis.

Affordance-based design allows for a more holistic understanding of the process and the created niche. The utilization of affordances in the understanding of any niche or system would allow for a greater interchange of information between disciplines, including Christian theology. As scientists continue to discover interdependent affordances at all levels of the natural realm, a picture of divine providence and exquisite engineering expertise comes into clear focus. While an individual affordance does not necessarily serve as an indicator of purpose or teleology, layers of interdependent affordances in both space and time point to the work of an engineer. This interconnectivity can be applied to understand how known cosmological constants afford the known universe and those who inhabit it; in essence, pointing towards an intelligent and loving creator. Thus, this concept of affordances can be used to understand such things as a biblical creation, or can potentially be helpful in describing how a Christian worldview is consistent with the fields of science and engineering.

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Introduction

In the world of biomedical engineering, there are many facets and avenues that are able to be explored. Each day, there are advances being made in medical technologies, making them smaller, smarter, and faster; however, in the area of medical research, biomedical engineering is seemingly often left out of the foreground. Medical research is soon approaching the point where not only are scientists being required to apply an immense amount of ingenuity, but the supporting engineering must also do the same in order to facilitate scientific advancements that are limited by existing equipment and technology.

A strong approach to the understanding of a theoretical biological niche that is to be facilitated by way of engineering is gained from an affordance-based analysis. An affordance is defined as a relationship that has the potential to result in an outcome for an end user. Affordances also have the ability to be nested in space and time. In more complex multi-part systems, intermediate, or part-to-part affordances may lead to an end-user affordance.[2] By the use of an affordance-based analysis, an understanding of the parameters necessary for the biological niche to be designed is achieved. In the current paper, this approach will be discussed in regards to understanding the necessary design to create a niche for mushrooms and cancer cells to destructively interact.

From a Christian perspective, a valuable feature of using an affordance-based analysis is the fact that the terminology is teleologically neutral and is acceptable in both Christian and scientific circles. No secular scientist will use terminology that would imply that something has a purpose or has been designed; however, with the use of affordance terminology, it is only implied that it has an ability, which is not necessarily its purpose.[3] This is an important step to showing the interconnectivity of all aspects of life, and through an in-depth analysis there is strong evidence of a transcendental intelligence in the universe.[4]

Creating a biological niche by understanding the necessary parameters through an affordance-based analysis provides an avenue for Christian engineers and scientists to celebrate the divine ingenuity of God. Through the process of determining the necessary scaffold of a biological niche for mushrooms and cancer cells to interact, the creativity and brilliance of the Creator is apparent. This paper will discuss the method of affordance-based analysis used in this specific instance and how this analysis leads to a fruitful interaction between science and theology.

Understanding the Problem

Mushrooms themselves are extremely resilient and are able to survive in some of the harshest environments on the planet; however, like all living things, there are necessary parameters in order for life to be sustained. Parameters such as food source, space to grow, surface area for gas diffusion, etc. are taken into account.[5] Cancer cells are more easily adapted to a lab environment by the submersion of the cells in a nutrient rich solution; while the provision of life affording parameters it straight forward, there are additional parameters that must be considered to avoid their unintended death or apoptosis. These parameters take into consideration such things as light, floating particles, air pollution, etc.[6] The crux of the problem

being faced is how to afford the survival of mushrooms while in the presence of cancer cells, and still affording the ability for them to interact. Thus, the primary focus of the analysis is:

"What biological environment needs to be engineered that would afford the ability for mushrooms and cancer cells to simultaneously survive and interact?"

Research into the subject of cancer cells and mushrooms sheds some light on what affordances are necessary for a successful and repeatable interaction. The primary problem set that was uncovered centers around the physical proximity necessary for an interaction to occur; however, this physical proximity threatens entanglement and death of the mushroom. Due to the nutrient solution that the cells are submerged in, the mushroom must be afforded the ability to grow into the solution to interact while maintaining a sufficient surface area outside of the solution to allow for gas diffusion. This same engineered part must also afford an ease of separation when removing the mushroom from the cancerous environment. The secondary problem set centers around the necessity of data collection and monitoring. The engineered environment, by definition, is a closed system, thus any type of data collection and monitoring is going to be intrusive. This problem set begs the question of what design will afford the ability to collect data and monitor with the least amount of intrusions.

Engineering Process

The engineering process began by creating an affordance matrix of what parameters were needing to be met or built through the construction of niche. This matrix allowed for the visualization of the necessary affordances needing to be established, as well as displaying the part-to-part and nested affordances that would be built into the experimental scaffold of the niche. The benefit of having this affordance matrix is that the initial design could be more efficiently and thoughtfully planned, which saves on both cost and timing. After the matrix and initial design was created on paper, SolidWorks software was utilized to create the prototype design.

SolidWorks software affords the ability to do a vast amount of technical visualizations and experimentations; however, the software is not sufficient to completely understand the biological niche that was created by the design in order to adjust and improve the affordances. To this end, an XYZ printer was initially utilized to establish a proof of concept; however, the XYZ was printing with PLA filament and thus not able to be used in biological experimentation. The PLA filament is technically biologically active and could interfere with the organisms utilizing the design. While this could be compensated for by the binding of proteins to the outer layer of the PLA, the PLA filament does not provide sufficient affordances beyond that of ABS that would make an argument for more extensive biological meddling of the design before experimentation.[7] Through this 3D printing process with the XYZ printer, the affordances became tangible and the part-to-part affordances were able to be manipulated and tested.

Once the proof of concept was established, the 3D printing was being done by an Object24 printer printing with ABS Verawhite material and supporting structures. This printer affords a more precise print that is also usable in biological experimentation due to the material; however, there was an unexpected limitation to this print. The film and supporting structures that

are needing to be removed before use left small particles that were seen in the electron microscope when viewing the cells. This is just one example of many where a new affordance had to be created when there was an unexpected consequence of the design or experiment process.

Currently, all aspects of the project are being restricted as proprietary knowledge due to the experimental process being in the patent process; and so, specifics and results are not available to be discussed at the current time. What can be stated, however, is that the design and experimental process has been quantifiable as highly successful and are proceeding forward with the current results.

Design Concept

The definition of completeness for this project is: To engineer an artificial niche that affords the ability to successfully force an evolutionary adaptation of the mushroom in order for it to kill and feed off of cancer cells in order to survive. The key for this to be successfully is the interface and niche in which the two interact. The end-user affordances that are essential to this successful interface are close proximity, ability to grow, and ease of mushroom manipulation. The end-user affordances that are essential to this successful niche are being a closed system, compatibility with other lab equipment, and being repeatable. In this case, the end-user is the scientist as well as the mushroom; while this may seem slightly odd, both are actively using the parts based upon their provided affordances. The mushroom, cancer cells, and design are all combined in multiple part-to-part affordances to produce the ultimate affordance of the release of an anti-cancer agent by the mushroom.

Affordances from a Christian Perspective

Christians hold the belief that God is in everything and it's one of their goals to display this fact in as many facets as is possible. The ingenuity of the Creator is displayed clearly by the recognition of the lengthy string of nested affordances to create a niche for a single interaction to take place, let alone the large number of niches that occur within nature. An affordance-based analysis of this biological interaction also reveals the divine thought involved in the creation of the mushrooms, and possibly cancer cells, depending on one's theological perspective of cancer. The mushroom mycelium affords a foundation for rapid growth and expansion of the organism that is necessary for the interaction to take place, while also having a biological makeup that affords the ability to break down its surroundings into a food source. Both of these affordances are fascinating; while Christians are able to point towards a design and Creator, secular scientists require the neutrality that the affordance terminology allows in order to discuss said abilities in regards to what permits them to be actualized in nature or a synthetic niche.

The affordances being discussed in regards to the experimental niche construction are all fairly straight forward; however, when combined into a product, the collective part-to-part affordances and end-user affordances provide a design concept that affords a successful interaction and repeatability. Each time the term affordance is utilized, as engineers, the terminology is visualized as indicating a purpose and design. This same interpretation can be applied as Christians to areas of knowledge such as cosmology, ecology, and biology. The same

terminology can be used by secular scientists in the same areas of knowledge without the teleological implications. Due to this, a neutral foundation established that affords the ability to exchange conclusions and data without compromising scientific integrity nor compromise on one's personal convictions.

An example of an affordance outside of strictly engineering, albeit rather broad, is the existence of life as it is currently known that is afforded by the four fundamental forces in physics. There is a common uncertainty in science as to why the fundamental forces seem to have "frozen" and became distinct mathematical forces. The use of affordances in discussing a topic such as the frozen nature of fundamental forces becomes valuable due to a lack any solid reasoning or understanding as to why they "froze" when they did.[8] With this use of affordances, Christians are able to articulate the evidence for a divine intelligence behind the existence and static nature of the forces, and the secular realm can agree that the forces are seen to provide the ability for life to exist as it currently does and not having to rely on any true supporting arguments to make an assertion. The caution that must be stated is that the terminology must remain consistent throughout any discussion in order to maintain the integrity of the science and neutrality of the discussion.

One clarification that is needing to be made is that this paper does not hold the purpose of furthering the fine-tuning argument, or any creation argument for that matter. The transcendental implications from the use of affordance terminology are derived by the ability to display the web of part-to-part and nested affordances that exist in niches. This display of interconnectivity allows for conclusions of divine providence to be asserted by the Christian perspective.

Conclusion

An affordance-based analysis is able to provide a unique framework for the understanding of complex biological interactions and the engineered designs that create the necessary niche for the interactions to take place. These affordances that have been used to understand the way in which the parts interact to provide a unique end-user affordance open the door for a discussion into the ingenuity of the artificial niche, which would consequently lead into the ingenuity found in all of nature. While Christians unveil the purposes of God through science, it is imperative to remember that this terminology can be a barrier to other scientists. Due to this, it is proposed that affordance terminology is used so that Christians can keep their spiritual integrity while also conversing in an academic and teleologically neutral discussion of science. While evangelism is not the goal of technical exchanges, Christian engineers and scientists can strive to lay bare the data and present the science in a way that will lead others to the divinity behind it all.

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