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Biomimicry and Forced Connections to Inspire Innovation

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Biomimicry and Forced Connections to Inspire Innovation

by

Bernadine Murray

An Abstract of a Project
in
Creativity and Change Leadership

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

May 2023

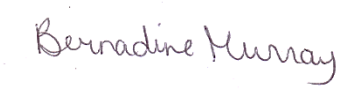
Buffalo State University
State University of New York
Department of Creativity and Change Leadership

ABSTRACT OF THE PROJECT

Biomimicry and Forced Connections to Inspire Innovation

The purpose of this project was to explore biomimicry and integrating forms of nature to generate unique ideas and possible solutions to problems. Four key components of this project were biomimicry, brainstorming, forced connections, and innovation to answer the question: What can I learn about imagination, forced connections, process, mindset, and innovation by copying aspects of nature or being inspired by nature? A *Biomimicry and Forced Connections Design Journal* contained conceptual designs based on nature or a challenge-to-nature searching for solutions. A *Reflective Learning Journal* included prior experiences and working on this project that contributed to my knowledge and insights. The findings of this project revealed that using the forced connections tool and unrelated images uncover novel and wild ideas. As a result, innovation occurred in the outcomes, throughout processes, and using skills such as curiosity, awareness, determination, and perseverance developing the mindset of an innovator.

Keywords: biomimicry, brainstorming, forced connections, innovation



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April 30, 2023

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SECTION ONE: BACKGROUND TO THE PROJECT

Purpose and Description of the Project

The purpose of this project is to explore biomimicry and integrating forms of nature to generate unique ideas and possible solutions to problems. The two outcomes of this project are a *Reflection Learning Journal* and a *Biomimicry and Forced Connections Design Journal*. A *Reflection Learning Journal* will include knowledge and insights gained throughout the process when creating nature-inspired designs. A *Biomimicry and Forced Connections Design Journal* contains conceptual ideas of bio-inspired designs (biology-to-design) and using nature to solve a problem (challenge-to-biology). The process work and reflections may highlight the importance of forced connections that inspire groups during brainstorming sessions.

The *Reflection Learning Journal* entries will be comprised of knowledge learned and documented from prior readings or experiences. Reflection is way to become aware, report, and make meaning during and after the experience. Schön (1983, 1987) described two types of reflection that facilitate learning: reflection-in-action and reflection-on-action. He described reflection-in-action to be occurring during the activity and restructured while working. Reflection-on-action happens following an activity or when the activity is interrupted. There is retrospective thinking about the experience.

The creativity concepts and skills that are relevant to this project are divergent thinking, idea generation, imagination, brainstorming, and forced connections. During the divergent thinking phase of the *Creative Problem Solving* (CPS) process, brainstorming is used to generate numerous ideas for a challenge or problem. In group brainstorming sessions, guidelines and tools are used to keep the ideas flowing. Osborn (1953) explains about the guidelines for group sessions. He states:

> Idea-producing conferences are relatively fruitless unless certain rules are understood by all present, and are faithfully followed. Here are four basics: (1) Judicial judgment is ruled out. Criticism of ideas must be withheld until later. (2) "Free-wheeling" is welcomed. The wilder the idea, the better; it is easier to tame down than to think up. (3) Quantity is wanted. The greater the number of ideas, the more the likelihood of winners. (4) Combination and improvement are sought (p. 300-301).

Forced connections is a tool used to combine items that are unrelated to create unique ideas or wild ideas. Images are used to trigger responses during the brainstorming session. The images evoke new combinations of ideas and solutions to a problem. The ideas are wild, untamed, combined, and not judged during idea generation. In fact, Osborn (1953) commented about the importance of combinations, synthesis, and questioning. He stated:

> Most ideas are by way of combinations—so much so that synthesis is generally regarded as the essence of creativity. To project imagination into this field, we can ask ourselves questions like these: "What ideas can be combined?" . . . "How about an alloy?" . . . "What about a blend?" . . . "Combine units?" . . . "Combine purposes?" . . . "What about an ensemble?" . . . "How about an assortment?" "What materials could I combine?" is an idea-starter which can lead to endless alternatives (p. 280).

The reflections, insights, and information gathered will fulfill the project goals to include: (1) applying knowledge and inspiration from nature to create bio-inspired designs (biology-to-design) and to solve a problem (challenge-to-biology); (2) using forced connections as a tool to inspire the designs and solutions; (3) gaining insights and understandings about innovation in outcomes, mindset, process, and skills; and (4) developing a biomimicry lens by asking the questions: What would nature do? How can this improve that I am doing? How can

organizations benefit and learn by using aspects of nature to solve problems? These goals demonstrate the process that I will take in this project and demonstrate the knowledge that I will gain from the research and writing. Using the biomimicry design approach means that I will: (a) use creative problem-solving skills and techniques such as forced connections to position or reframe the challenge; (b) search for inspiration and solutions in nature; and (c) apply sustainable solutions to design.

Rationale for Selection

I have twenty-seven years of teaching experience in higher education. My expertise was in apparel product development from conceptual designs, research proposal, competitive analysis, product development, and industry presentations. In my academic position in higher education, I taught courses such as color theory, draping, visual studies, fashion design, merchandise analysis, and research methods. My academic focus included teaching, research, and service. I developed a research agenda that included creativity, design, and learning. I felt a need to understand the creative person, process, product, and press.

After retiring from the position, I had a desire to further my knowledge and skills in creativity and problem solving. I enrolled in the Master of Science for Creativity and Change Leadership at *Buffalo State University*. The department of *Creativity and Change Leadership* hosted a workshop called *Lifelong Learning Days: Biomimicry and Creativity.* My introduction to biomimicry was provided by the staff from *Great Lakes Biomimicry (GLB)* and *The Buffalo Zoo*. I was intrigued by the experience and learning about the sloth, bird, and snake at that workshop. I was interested to know more about learning from nature to solve problems.

For my project, I accepted this new path to explore different areas of creativity. The main elements of my project include biomimicry, brainstorming with forced connections, and

innovation. I began searching for excellent resources such as workshops, books, researchers, associations, and websites. I thought about the project and how to incorporate the elements together. This project enriches my learning experience and provides me with new knowledge that could be used in any discipline. Business owners, staff, students, and educators may benefit from the knowledge on innovation and sustainable practices. The documentation from this project may provide guidance for those people who strive to find solutions to problems both personally and professionally.

This project is important because biomimicry can be used as a source of inspiration for designers, engineers, and scientists who are motivated to learn about sustainable solutions from nature. It is an innovation framework that enables new ways of thinking and perspectives. Using the biomimicry framework disrupts traditional ways of designing, making, and using products and services. Innovative products are developed using patterns, functions, structures, and behaviors from nature.

SECTION TWO: LITERATURE REVIEW AND RESOURCES

Keywords: biomimicry, brainstorming and forced connections, innovation

Pertinent literature and resources for this project include seminal or current work that have informed my thinking. The resources are valuable sources of information that are relevant to the topic and include websites or key scholars. Four key components of this project are biomimicry, brainstorming, forced connections, and innovation to answer the question: What can I learn about imagination, forced connections, process, mindset, and innovation by copying aspects of nature or being inspired by nature?

Biomimicry and Imitating Nature

Biomimicry has been developing as a science since the 1950s (Mazlan, 2020). Biomimetics and bionics originated within the engineering fields but have since moved into other disciplines. “Biomimicry is one of several ways to innovate bioinspired forms, processes and systems into the human world and is underpinned by the premise that life creates conditions conducive to life” (Rowland, 2017, p. 102). Three essential elements of biomimicry include: “Looking to nature as a model for inspiration (reconnecting with nature directly); a mentor to learn from (emulating nature’s strategies for survival); and a measure for sustainability benchmarks (biomimicry ethos with a sustainability mandate)” (Rowland, 2017, p. 103).

“Biomimicry means to imitate life or to put it another way design inspired by nature this is an approach that can be used by any discipline from manufacturing to art to agriculture.” (Hunt, 2020, 0:59) and “Biomimicry is the ability to combine strategies from different organisms.” (Hunt, 2020, 16:44). Learning to solve problems using nature creates sustainable innovative practice. Rowland (2017) takes this further by saying that biomimicry serves as a model for “inventions in human systems” (p. 102). Nature has learned how to solve challenges

and problems. It enables us to shift our perspectives while using nature as a guide to help solve the challenges that we face in the world. Biomimicry helps us to ask: How does nature solve those challenges or problems and what can we learn from the solutions?

Nature to Inspire Innovation

Biomimicry teaches us to "how to become an integral part of the natural world" (Hunt, 2020). It teaches us how to look for sustainable and natural solutions to human problems. Nature has figured out patterns, behaviors, and strategies for survival. Organizations that adopt such practices are inspired by what they learn in managing problems and developing solutions. According to The Biomimicry Institute (2022), "We are the bridge between biology and design, advancing the adoption of nature-inspired strategies to help solve the most pressing problems of our time" (p. 1). Nature is a valuable resource to use for organizations because the patterns, behaviors and strategies have helped to solve numerous problems. Humans learn that nature is the expert using this way of thinking about problems to develop innovative solutions.

Nature-inspired Design Versus Learning from Nature

Nature-inspired design, also known as biomimetics, allows creators to design and develop products drawing from the characteristics in nature. The innovation process is a process of discovery, design, and development (PDMA, 2015). Leonardo da Vinci was a master inventor who used nature-inspired design to create several inventions including an airplane that used the wing structure of a bird in the design. He had the ability to observe, identify, and integrate nature into new inventions. Learning from nature requires that we examine patterns, behaviors, and structure from nature that help to solve complex problems. Biomimicry can be used as a method to resolve material, architectural, and general design problems by emulating species that have developed elegant solutions with low environmental impact (Our Changing Climate, 2018).

Rowland (2017) commented that the process may take one of the following paths: (1) biology-to-design process begins with an inspirational biological insight that is applied to a design; and (2) the challenge-to-biology process is when a particular design challenge has been identified for which a bio-inspired solution is pursued. Biology-to-design is also referred to as nature-inspired design. Challenge-to-biology is aligned with learning from nature. The biomimicry thinking design process for the challenge-to-biology approach has four phases: (1) scoping phase; (2) discovering phase; (3) creating phase; and (4) evaluating phase (Rowland, 2017).

Connecting Biomimicry with the Outcomes, Process, and Mindset

Designers, engineers, thinkers, and inventors have approached human problems in design and technology by returning to nature and the processes. Reeves and Fuller (2021) discussed imagination and why businesses need to adopt new ways of thinking and foster imagination in various ways. Biomimicry provides inspiration, fosters imagination, and new ways of thinking about the outcome. It also changes our mindsets and processes for working independently and with a team of people.

Chirazi et al. (2019) outlined key factors of success, overarching topics, and aspects that facilitate the BID process: “Clear research objective and specific goals, mandatory interdisciplinary thinking, open-mindedness, commitment, flexibility, environment for collaboration, willingness to learn from each other, reciprocal respect, endurance, deep understanding of biology, advising experts and impartial referees” (p. 11). Factors or behaviors in the previous list provide clear directions and a commitment to work with others.

Brainstorming and Forced Connections

Divergent thinking tools provide individuals or teams with opportunities to generate a number of ideas and solutions to solve problems. The benefits of using the problem-solving process and tools lead to improved products or services because ideas are combined into something new (Vogel, 2014). The tools allow designers to see the minute details as well as having the ability to see the big picture. Four guidelines are considered throughout the divergent thinking process including deferring judgement, striving for quantity, seeking wild and unusual ideas, and building on other ideas (Firestien, 2020; Michalko, 2006; Miller et al., 2011). With the guidelines in mind the individual or team defines or clarifies the problem, analyses the cause, generates ideas, develops solutions, takes a plan of action, and evaluates the success of the actions or development (Firestien, 2020; Serrat, 2009).

Creative thinking techniques such as brainstorming enable individuals the ability to defer judgement and search for new and unique possibilities. Ideas flow without any criticism or praise. This method of thinking provides opportunities to generate numerous options and alternatives. All options are accepted even when some ideas are wild. In brainstorming sessions, the individual does not worry whether the ideas are accepted. The aim is for uniqueness or originality by being playful. Wild options can lead to new possibilities and alternatives. One idea leads into another as new combinations connect to create new ideas. Osborn (1953) described basic rules that should be introduced informally during the brainstorming session such as judgment is ruled out, wild ideas are welcome, strive for quantity, and combine ideas.

Firestien (2020) and Miller et al. (2011) described the *Creative Problem Solving* (CPS) process as a simple and repeatable method for individuals or groups who are taking on new challenges to achieve breakthrough solutions. The CPS process includes four steps: (1) clarify

the problem; (2) generate ideas; (3) developing solutions; and (4) plan for action (Firestien, 2020). Brainstorming enables the individual or group to generate numerous ideas with better solutions to the problem. Forced connections are an idea generating technique and enable the group to create the wild or unusual ideas. According to Firestien (2020), “Forced connections is the essence of creativity; the practice of combining ideas that don’t appear to be related in a new way. This method helps you get ideas flowing when you're stuck” (p. 81). Michalko (2006) says that it forces a connection between two items. He states, “Generates ideas by forcing a connective link between common attributes and your challenge” (p. 150).

Miller et al. (2011) stated that forced connections “…works well with other divergent tools such as brainstorming and brainwriting. The unusual ideas that result often help get the group’s mental wheels turning again” (p. 30). When using the forced connections technique, the two objects are unrelated. Several examples of using biomimicry and aspects of nature to create unrelated objects from The Biomimicry Institute at AskNature (2021) include:

- reversible electrocatalyst inspired by hydrogenase enzyme;
- efficient wind turbines inspired by insect wings;
- anti-reflective film inspired by moth eyes;
- effective ground sampling device inspired by sea urchin mouths;
- flexible surgical sealant inspired by slug slime;
- lightweight ceramics inspired by natural hierarchical cellular structures;
- durable solar cells inspired by insect eyes;
- scalable passive cooling film inspired by Longhorn beetles;
- computational design process inspired by evolution;
- elastic concrete material inspired by sea urchin shells;

- vivid structural colour inspired by bird wings; and
- efficient thin film solar cells inspired by black butterfly wings

Firestien (2020) stated that forced connections is his "go-to method to help increase combinent thinking" (p. 81). He describes combinent thinking, "Combine ideas across areas of knowledge. Connect ideas that seem to be unrelated to the problem you are working on to generate novel ideas" (p. 27). Combining ideas from unrelated areas brings about novel ideas that have been transformed into unexpected results. Forced connections help the group in a brainstorming session to create ideas for innovative products or services. According to Firestien (2020), forced connections create breakthrough solutions, gets ideas flowing, and images encourage new ways of thinking. Combining nature and fashion; nature and architecture; or nature with other disciplines creates products or services that are unique and novel. Bailey et al. (2019) discussed the combination using science and technology that promotes new ways of thinking, creative thinking, and inspirational thinking. The forced connections tool creates an exciting and unique approach to brainstorming and problem solving.

Walsh (2016) listed tools that are "mind expanders" and "pictures that drive creativity" (p. 127-129). He said, "Association tools work on the principle of encouraging us to take our mind on the path that seemingly has nothing to do with the issue on the table" (p. 127).
He speaks about the power of images that expand our thinking in ways that we might not have considered before. Walsh (2016) made an interesting point about common or well-documented association tools that compare items from nature. He commented, "Similarities and differences: Comparing an item from nature, say, with the issue (compare a natural process/system with a designed process/ system or a natural "thing" with a designed "thing")" (p. 127). Other scholars

or practitioners discussed connecting unrelated items to develop novel solutions (Firestien, 2020; Miller et al., 2011).

Innovation

Walsh et al. (2022) identified innovation to be an important factor in the growth and and development of organizations and society. However, innovation was also identified as complex and "difficult to examine, understand, and lead with appropriate strategy" (p. 71). Kahn (2018) explored innovation in the organization and emphasized three elements to understand innovation including outcome, process, and mindset. *Innovation as an outcome* says, "What do you want to happen?" (p. 454). *Innovation as a process* requires that you consider, "How can I make this happen?" (p. 457). *Innovation as a mindset* asks, "What should be instilled and ingrained to prepare for the what and the how?" (p. 458). Kahn (2018) argued that understanding about innovation makes it attainable.

Innovation as an outcome refers to products or services that are created, developed, and distributed. There are two types of *innovation as a process* in an organization. First, there is the process throughout the entire organization. Second, is the "new product development process" (Kahn, 2018, p. 453). Innovation as a mindset "addresses the internalization of innovation by individual members of the organization where innovation is instilled and ingrained along with the creation of a supportive organizational culture that allows innovation to flourish" (Kahn, 2018, p. 453). Walsh et al. (2022) agreed that there are outputs, processes, and mindsets. They said, "Therefore, to improve the success rate of innovation and get the most out of related strategies, we need to do more to understand the mindsets of innovation and in particular how these are applied in practice" (p. 71). They concluded that these elements would improve the success rate of innovation.

Friedman (2016) defined three drivers of innovation that determine whether innovation is present in the organization: (1) innovation leaders who "inspire, communicate, authorize, fund, and enable stakeholders to build the future" (p. 215); (2) key stakeholders who "build the future" (p. 216); and (3) innovation support is "a team that coordinates innovation activities and ensures that tools, training, and connection to expert resources are in place as needed" (p. 216).

Chirazi et al. (2019) described types of innovation:

> • to improve existing products, for example, noise reduction and vibration of aviation wings inspired by owls;
>
> • to develop new products, as seen for example with the development of artificial attachment devices based on the dry adhesion of the gecko; and
>
> • or to transpose a scientific discovery to an application, as seen with the self-cleaning properties of the lotus plant, which also led to a true paradigm shift (p. 4).

Walsh et al. (2022, p. 73) created a framework called *Driving Mindsets of Innovation*. They described the mindsets that define and drive the innovation process as phases of curiosity, creativity and clarity with action oriented sub-phases. The three driving mindsets of innovation include: (1) curiosity with the action oriented sub-phases discovering and understanding; (2) creativity with the action oriented sub-phases creating and testing; and (3) clarity with the action oriented sub-phases resourcing and implementing.

Dyer et al. (2009) identified five skills of disruptive innovators and are associated with a mindset:

- Associating: drawing connections between questions, problems, or ideas from unrelated fields;
- Questioning: posing queries that challenge common wisdom;

- Observing: scrutinizing the behavior of customers, suppliers, and competitors to identify new ways of doing things;
- Networking: meeting people with different ideas and perspectives:
- Experimenting: constructing interactive experiences and provoking unorthodox responses to see what insights emerge (p. 2).

They mentioned that networking and experimenting are the most important skills. The elements in the environment, drivers, types of innovation, and skills enable innovation to grow and flourish (Dyer et al., 2009).

Resources: Websites and Key Scholars

The following websites or key scholars will be an asset to this project because they are valuable resources to gain knowledge about biomimicry:

1. The Biomimicry Institute

The Biomimicry Institute (2023). Humanity's Biggest Challenges. Nature's Proven Solutions. https://biomimicry.org/

The Biomimicry Institute is an excellent resource and support for nature-inspired innovators. Janine Benyus is a co-founder of The Biomimicry Institute, biologist, and author. This website provides design challenges, workshops, courses, pilot projects, and reports on nature-inspired design.

The Biomimicry Institute — Nature-Inspired Innovation

Janine Benyus – Biomimicry Institute

Staff, Board, and AC – Biomimicry Institute

Launchpad – Biomimicry Institute

Biomimicry Design Toolbox

https://toolbox.biomimicry.org/

2. asknature.org

The Biomimicry Institute (2021). Asknature. https://asknature.org/

Asknature is owned by The Biomimicry Institute and a portal allowing easy access to nature-inspired innovators to search for biological strategies and innovations.

Search — AskNature

Innovations — AskNature

The Language of Biomimicry — Resource — AskNature

3. Biomimicry 3.8

Biomimicry 3.8 (2016). Biomimicry 3.8. https://biomimicry.net/

This website is the world's leading bio-inspired consultancy offering innovation, education, and inspiration.

4. Color in Nature Exhibit: University of Alberta

University of Alberta (2020). Living colours: A story of structural colour in nature and science.

Living Colours: A Story of Structural Colour in Nature and Science — news.library.ualberta.ca

In this exhibit, we learn about the phenomena of structural colour and use microscopes to experience how it works in nature. This exhibit highlights how structural colour connects the latest research in science, art and design (University of Alberta, 2020).

5. The University of Akron: Biomimicry Research and Innovation Center

The University of Akron (2023). Biomimicry research and innovation center.

https://www.uakron.edu/bric/

Biomimicry Research and Innovation Center: Home : The University of Akron, Ohio (uakron.edu)

This is a valuable research and innovation center that provides educational opportunities and services related to biomimicry.

6. Learn Biomimicry

Learn Biomimicry (n. d.) The best biomimicry courses and certificates of 2022. https://www.learnbiomimicry.com/blog/Best-Biomimicry-Courses-2022#:~:text=Top%205%20of%20the%20Most%20Popular%20Biomimicry%20Courses,PhD%20Program%20-%20The%20University%20of%20Akron%20

Learn Biomimicry provides a list of courses and certificates on biomimicry and nature-inspired design.

The Best Biomimicry Courses and Certificates of 2022 (learnbiomimicry.com)

7. Neri Oxman - Architect, Designer, Inventor, and Professor of media arts and science at the MIT Media Lab. Neri is known for art and architecture combining design, biology, computing, and materials engineering. Her work focuses on 3-D printing.

Neri Oxman | Neri Oxman (mit.edu)

SECTION THREE: PROCESS PLAN

Plan to Achieve My Goals and Outcomes

The project goals include: (1) providing an understanding about using biomimicry and nature to solve problems; (2) using forced connections and unrelated items to inspire designs and solutions; (3) gaining insights and understandings about innovation in outcomes, mindset, process, imagination, and skills; (4) developing a biomimicry lens by asking the questions: What would nature do? How can this improve that I am doing? How can organizations benefit and learn by using aspects of nature to solve problems? There are two journals that are the outcomes of this project. Ideas and conceptual bio-inspired designs will be documented in a *Biomimicry and Forced Connections Design Journal*. The *Reflection Learning Journal* will contain prior learning from events, readings, process work, and reflections. The goals demonstrate the outcomes and knowledge that I will gain from the research and writing.

Biomimicry and Forced Connections Design Journal

A *Biomimicry and forced Connections Design Journal* will include an inspiration mood board, bio-inspired designs, and problem-solving using nature. This journal will achieve the project goals with journal entries of images, sketches, and notes using biomimicry to create bio-inspired designs using a technique called forced connections. Images from nature serve as sources of inspiration for the conceptual designs. Entries will be made using nature to solve several problems. I will also develop a biomimicry approach as a designer by asking the question: How would nature solve this problem?

Reflection Learning Journal

The *Reflection Learning Journal* includes entries of the design process, knowledge gained from readings, events, and learning from bio-inspired designs and solutions. Searching

for inspiration from nature may enhance imagination, creativity, and innovation. Therefore, I will gain insights and understandings about innovation in the outcomes, mindset, process, imagination, and skills. Outcomes are the products created for this project include the journals and conceptual designs.

Rimanoczy (2020) claimed that an internal-individual sustainability mindset includes "values, sense of purpose, preferences, assumptions, and beliefs" (p. 10). The sustainability mindset was defined to be a way of thinking. The external-individual sustainability mindset involves behaviors, habits, initiatives, and leadership (Rimanoczy, 2020). Kahn (2018) said that the innovation can be seen in two areas of an organization: (1) the design process and (2) process throughout the organization. This journal will explore innovation in the design process. Walsh et al. (2022) identified skills associated with a driving mindset of innovation to be curiosity, discovery, understanding, creativity, creating, testing, clarity, resourcing, and implementing (p. 73).

Project Timeline

The project timeline illustrates the major tasks, estimated hours of work, completion dates, and planning. See Table 1 for the project timeline.

Table 1

Master's Project Timeline

Major Tasks	Estimated Hours	Completion Date	Verify Completion
Bring draft of concept paper to class Week 2	2 hours	February 8, 2023	
Submit Concept paper Week 3	72 hours	February 13, 2023	
Begin format for final submission	Ongoing work		
Share the project direction Week 4	2 hours	February 22, 2023	

Major Tasks	Estimated Hours	Completion Date	Verify Completion
Corrections to sections 1-3 Weeks 5 & 6	4-6 hours	February 1 & 8, 2023	
Journal about learning from writing the Master's Project	10 Hours -document weekly	ongoing	
Share progress Week 7	2 hours	March 15, 2023	
Submit Sections 1-3 Week 8	1 hour	March 21, 2023	
Journal bio-inspired designs	10 Hours -document weekly	Week 8 and 9	
Work on journal and section 4	10 hours	Week 8	
Document 2 problem solving examples using biomimicry	10-15 Hours -document weekly	Week 8 & 9	
Work on journal and sections 5-6 Week 9	10 hours	April 5, 2023	
Share sections 4-6 Week 10	2 hours	April 12, 2023	
Submit Section 4-6 Week 11	1 hour	April 23, 2023	
Correction to Sections 4-6	2 hours	April 27, 2023	
Share work Week 12	2 hours	April 26, 2023	
Read the Master's Project Edit and check references	2 hours	April 29, 2023	
Compile journal reflections and illustrations	4-6 hours	April 29, 2023	
Submit Final Master's Project Week 13	1 hour	May 1, 2023	
Submit Final Paper to Digital Collections Buffalo State University	1 hour	May 8, 2023	
Master's Project Presentation	Preparation 24-48 hours	Presentation date: May 17, 2023	

Evaluation Plan

I plan on disseminating beyond the master's project, therefore, I will get feedback from my colleagues as to the potential of turning the journals into conference proposals, journal articles, and a book. The plan is to submit proposals to creativity, education, or biomimicry conferences and journals. Examples are listed below:

Creativity Conferences

- Creativity Expert Exchange (CEE) Buffalo State University
- SOU Creativity Conference: Southern Oregon University

Education Conferences

- Canadian Society for the Study of Education (CSSE)
- Society for Teaching and Learning in Higher Education (STLHE)
- American Educational Research Association (AERA)

Biomimicry Conferences

- Biomimicry Education Summit and Global Conference at UMass Boston

Journals

Submissions to academic journals are peer-reviewed by editors and faculty members who are experts in the field.

- The Journal of Creative Behavior (JCB)
- Thinking Skills and Creativity
- Journal of Creativity (JoC)
- Education Journal
- Canadian Journal of Education
- Biomimetics

Informal Feedback

Informal feedback may provide ways to improve the project, new contacts for dissemination, or provide new directions that I had not considered before. The informal feedback list includes:

- Hosting an event on Eventbrite.

- Contacting associations or schools to present the project.
- Having a casual conversation with interested parties about the topic.
- Conducting a self-evaluation.
- Examining my reflection and learning journal for insights.

Verifying the Goals and Outcomes

Questions that I might reflect on include:

- Did I achieve all project goals?
- What insights about biomimicry, forced connections, and innovation have I found?
- How is my topic original, unique, and creative?
- How was I successful in conceptualizing and learning about the project?
- How might I use this information in the future?

SECTION FOUR: OUTCOMES

The two project outcomes include a *Biomimicry and Forced Connections Design Journal* and a *Reflection Learning Journal*. The *Biomimicry and Forced Connections Design Journal* contains process work such as an inspiration mood board, biology-to-design process, biology-to-design illustrations, challenge-to-biology process, challenge-to-biology applications, and challenge-to-biology images. The *Reflection Learning Journal* includes past experiences that contributed to my knowledge, elements of the project goals: skills, mindset, imagination, forced connections, innovation; and insights from reflecting while working on this project. This project included two processes: the biology-to-design process and the challenge-to-biology process.

Biomimicry and Forced Connections Design Journal

The *Biomimicry and Forced Connections Design Journal* contains the process work and conceptual designs. An inspiration mood board, biology-to-design process, biology-to-design examples, challenge-to-biology process and application, and challenge-to-biology images are included in this section. The inspiration mood board with images of nature helps the designer to remain focused on the goals of the project. The biology-to-design process uses nature as the source of inspiration. Biology-to-design examples were created from unrelated objects in different disciplines. The challenge-to-biology begins by asking: How does nature…?

Inspiration Mood Board

Designers create inspiration mood boards that serve as visual guides and communication tools. The images help designers to remain focused and to envision goals. The board may have a theme that is a source of inspiration or focus. Sample materials used in the discipline may be included on the board. For the biomimicry board, the designer could add elements of nature such

as bark or leaves. See Figure 1 for the inspiration mood board of this project using royalty-free images from unsplash.

Figure 1

Biomimicry Inspiration Mood Board

Note. Inspiration Mood Board. Own work. Images from Unsplash royalty free images.

Processes

Biology-to-Design

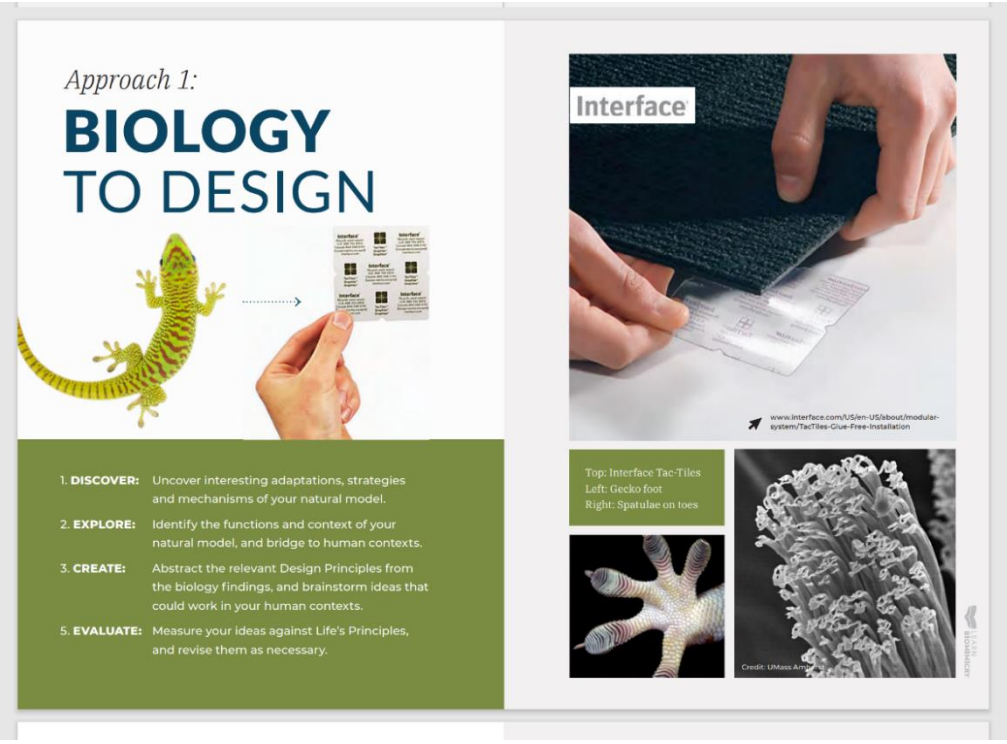
Biomimicry Institute (2023) described biology-to-design in two steps. Biological inspiration is the first step when innovators become aware of "interesting mechanism or

phenomena in the natural world". There is no specific challenge associated with this process. The institute recommends that innovators make time "observing and interacting with the natural world." In developing biomimicry habits of mind, innovators become more aware and familiar of how the natural environment and living things work (Biomimicry Institute, 2023). Helms et al. (2009) pointed out, "Biologically inspired design is inherently interdisciplinary. By definition, it is based on cross-domain analogies requiring expertise across two disparate domains (engineering and biology)" (p. 606). Using the biology-to-design process with elements from different disciplines creates sustainable innovation through the process and product.

The biology-to-design approach includes four steps: discover, explore, create, and evaluate. See Figure 2 for an explanation of the challenge-to-biology approach from www.learnbiomimicry.com.

Figure 2

Biology-to-Design Approach



Note. Used with permission from www.learnbiomimicry.com

Table 2 identifies the steps in the *Biology-to-Design* process with descriptive details of biomimicry. In the first step, biological inspiration, designers are observing and noticing interesting aspects of nature that serve as inspiration. In the second step, designers are identifying a use for the inspirational object in nature. Then the bio-inspired designs are created with illustrations and notes.

Table 2

Biology-to-Design Process

Steps	Explanation
Biological inspiration	Noticing interesting objects or animals in nature. Inspiration may come from a variety of sources such as a process, form, or a system. The elements of design can be used as sources of inspiration: line, color, texture, shape, or space.
Identifying an application	Selecting an application Creating bio-inspired designs

Note. Steps in Table 2 are from Biomimicry Institute (2023)

Biology-to-Design Illustration

The design process involved two steps: (1) selecting a nature-inspired image from a photography website called unsplash (https://unsplash.com/). and (2) identifying an application by creating bio-inspired designs. The images on unsplash are royalty free and can be used for commercial or non-commercial purposes. The following example has been created using this design process below:

Figure 3

Bio-inspired Design 1

Design 1: Source of Inspiration

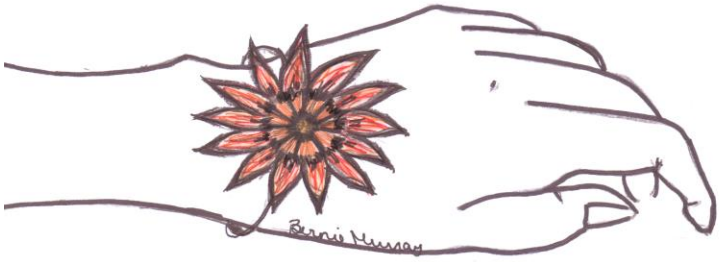
Photo by Aziz Acharki on Unsplash

Note: Images from Unsplash royalty free images

Figure 4

Flower-inspired Bracelet

Emulating Form: Shape and Color



Note. Flower-inspired Bracelet Illustration. Own work.

Challenge-to-Biology

The challenge-to-biology begins with a question. How does nature….? The biomimicry thinking design process for the challenge-to-biology approach has four phases: (1) scoping phase; (2) discovering phase; (3) creating phase; and (4) evaluating phase (Rowland, 2017). In

the scoping phase the design challenge is contextualised, and a design brief is created for the challenge. Rowland (2017) stated that the design brief includes the following:

> (a) the description of the chosen design challenge, (b) the description of the context in which the challenge arises as a problem and in which its potential solution must perform, (c) a design statement listing the specific function that a potential solution must fulfil, (d) a vision statement for the desired outcome and impact in the described context and (e) life's principles most relevant to the specific type of design challenge (p. 104-105).

The discovery phase "biologising the function-based design statement into a biology-based research question" (Rowland, 2017, p. 106). How does nature…? The design brief in the discovery phase contains the same elements as in the scoping phase. Additional information in the discovery phase outlined by Rowland (2017) includes:

> (a) biologised research question/s, (b) a set of function cards and (c) the final list of design criteria, including the basic function defined during the scoping phase, abstracted design principles that emerged during the discovering phase and the already-defined life's principles most relevant to the design challenge in question (p. 106).

The creating phase begins with a design charrette and can be described as a collaborative design or problem-solving meeting. Participants are from different disciplines in order to provide a collaborate session with diverse ideas. Rowland (2017) stated, "Once the group is fully informed, the fun begins with collaborative transdisciplinary brainstorming and design activities, such as decomposition matrices, kinaesthetic modelling and storyboarding that lead to initial design concepts" (p. 109). In the evaluation phase, the prototype is assessed using life's principles including sustainability-related assessments (Rowland, 2017). The evaluation format asks the following questions: What would nature do in the situation? What would nature not do

in the situation? How sustainable is the solution? Is there anything else to investigate? According to Rowland (2017) the life's principles are discussed and confirmed how well the solution has included the principles. The tools used in the evaluation phase are the design brief and life's principles. See Table 3 for the challenge-to-biology process using steps and descriptive details.

Table 3

Challenge-to-Biology Process

Steps	Explanation
Scoping	The design challenge is contextualized. A design brief includes a description of the design challenge; context, design statement, vision statement, and use of relevant life's principles.
Discovery	Develop a biology-based research question: How does nature…? Create function cards, final list of design criteria, and abstracted design principles.
Creating	A design charrette with a group of diverse participants to brainstorm ideas and solutions. Design activities are assigned to complete.
Evaluating	Begin with a series of questions on what nature does and how sustainable is the solution. Life's principles are discussed and confirmed.

Note. Biomimicry biology-to-design process from Biomimicry 3.8 (2015)

Challenge to Biology Design Process: Design Spiral

Benyus (2009) presented three ways to use nature: (1) nature as model: study nature's models then imitate or take inspiration from "designs and processes to solve human problems" (p. 7); (2) nature as measure: learn from nature what has worked, appropriate, and lasts; and (3) nature as mentor: value nature and "what we can *learn* from it" (p. 7). Biomimicry.org (2017) described the biomimicry design process using a biomimicry design spiral. The spiral lists the essential elements of the design process that uses nature for creating solutions. the steps indicate a specific sequence; however, the designer may return to a previous step if new information is learned. Biomimicry.org (2017) described the *Challenge to Biology Design Process* as:

Define

Clearly articulate the impact you want your design to have in the world (i.e. the challenge you want to solve) and the criteria and constraints that will determine success.

Biologize

Analyze the essential functions and context your design solution must address. Reframe them in biological terms, so that you can "ask nature" for advice.

Discover

Look for natural models (organisms and ecosystems) that need to address the same functions and context as your design solution. Identify the strategies used that support their survival and success.

Abstract

Carefully study the essential features or mechanisms that make the biological strategies successful. Restate them in non-biological terms, as "design strategies."

Emulate

Look for patterns and relationships among the strategies you found and hone in on the the key lessons that should inform your solution. Develop design concepts based on these elements.

Evaluate

Assess the design concept(s) for how well they meet the criteria and constraints of the design challenge and fit into Earth's systems. Consider technical and business model feasibility. Refine and revisit previous steps as needed to produce a viable solution. (p. 2)

Biomimicry 3.8 (2015) discussed the design lens with the four areas including scoping, discover, creating, and evaluating. They stated:

> Biomimicry thinking provides context to where, how, what, and why biomimicry fits into the process of any discipline or any scale of design. While akin to a methodology, Biomimicry thinking is a framework that is intended to help people practice biomimicry while designing anything. There are four areas in which a biomimicry lens provides the greatest value to the design process (independent of the discipline in which it is integrated): scoping, discovering, creating, and evaluating. Following the specific steps within each phase helps ensure the successful integration of life's strategies into human designs (p. 9).

Biomimicry 3.8 (2015) defined the four stages as follows: (1) Scoping: Define contexts, identify function, and integrate life's principles; (2) Discover: Discover natural models and abstract biological strategies; (3) Creating: Brainstorm bio-inspired ideas and Emulate design principles; and (4) Evaluating: Measure using life's principles. See Figures 5-11 for an explanation of the challenge-to-biology approach from www.learnbiomimicry.com:

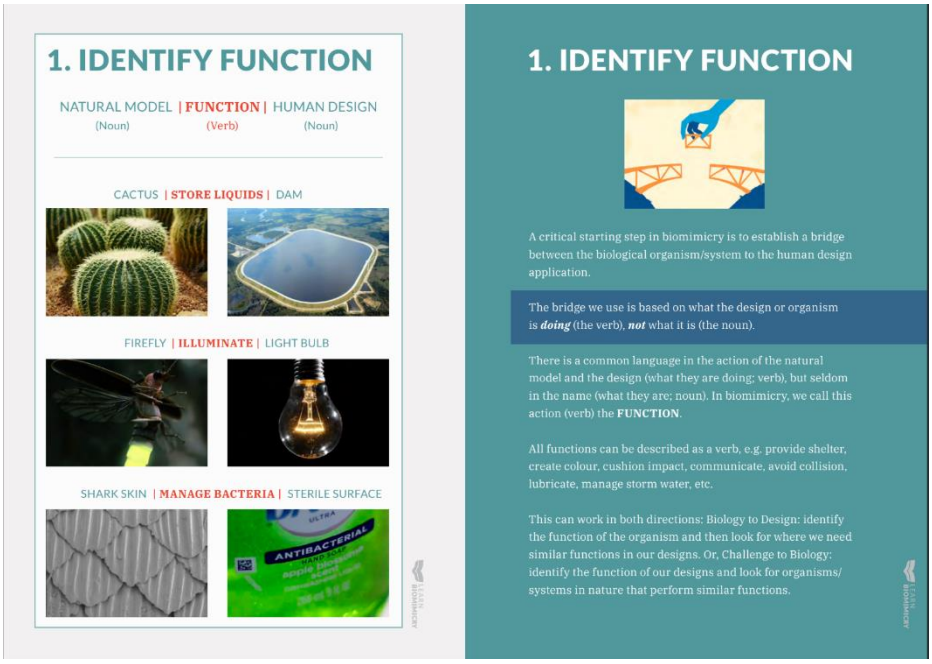
Figure 5

Approach 2: Challenge to Biology

Note. Used with permission from www.learnbiomimicry.com

Figure 6

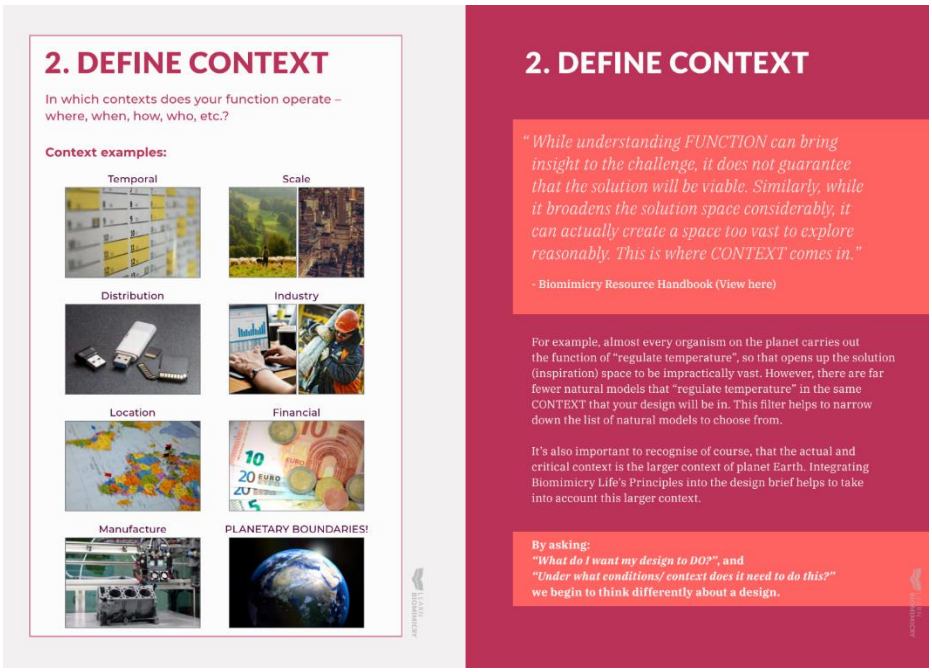
Identify Function



Note. Used with permission from www.learnbiomimicry.com

Figure 7

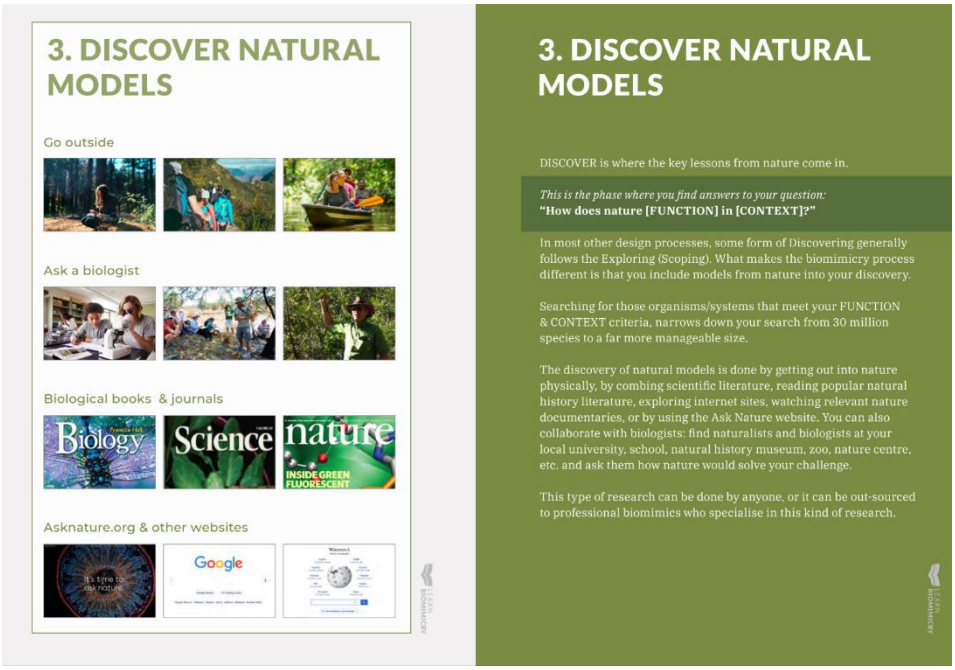
Define Context



Note. Used with permission from www.learnbiomimicry.com

Figure 8

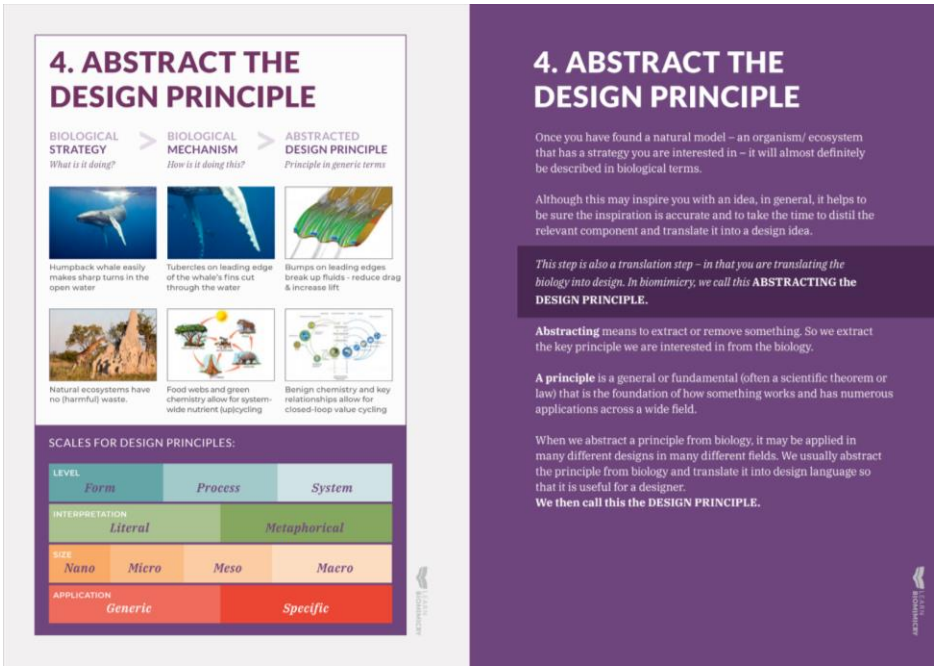
Discover Natural Models



Note. Used with permission from www.learnbiomimicry.com

Figure 9

Abstract the Design Principle



Note. Used with permission from www.learnbiomimicry.com

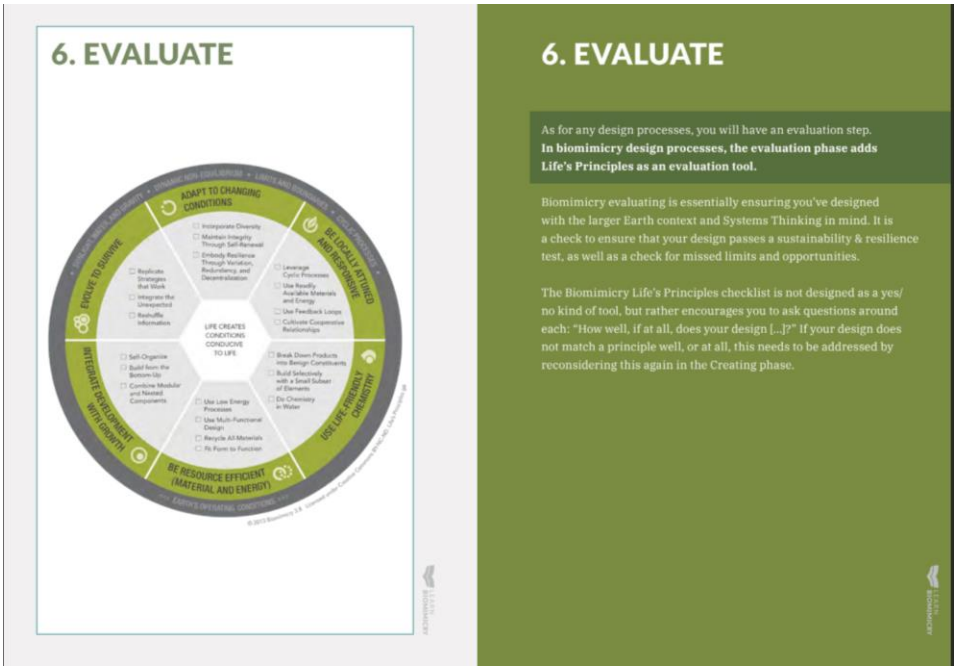
Figure 10

Create Designs

Note. Used with permission from www.learnbiomimicry.com

Figure 11

Evaluate



Note. Used with permission from www.learnbiomimicry.com

Reflection Learning Journal

The *Reflection Learning Journal* includes prior experiences that contribute to my knowledge, elements of the project goals: skills, mindset, imagination, forced connections, innovation, and insights or reflections while I was working on this project. There were important prior experiences that contributed to my interest, understanding, and support for this project. A biomimicry workshop hosted by the *Creativity and Change Leadership Department* at *Buffalo State University* was a beneficial introduction to biomimicry. The CRS 625 *Creativity and Change Leadership* class reading circles and the CRS 625 Big Question Conference were valuable class activities that provided an opportunity to learn about biomimicry and share those learnings with faculty members, peers, and alumni. Writing course papers provide an opportunity to become familiar with the topic and understand the connection between biomimicry, forced

connections, and innovation. I reflect in-action and on-action throughout the creation of the journal.

The *Reflection Learning Journal* contains resources, websites, readings, and reflections. Questions that I will answer: Why are the resources important to me? What did I learn about biomimicry, forced connections, or innovation? What are interesting elements about the topic? What are skills that I developed in the process of the project? There may be similarities or complexities with the definition of creativity and innovation. I will consider learning though a process, new language, and on different elements throughout the project. Learning about biomimicry may provide new language and distinct processes: biology-to-design and challenge-to-biology. I will reflect and consider things that I may have overlooked or missed on forced connections and the link to innovation or testing for innovation. I will incorporate an Osborn (1953) quote on the importance of combinations. I will discuss the project goals, insights, and findings. Did any themes emerge? I will reflect on the information, processes, and learning. In reviewing the journals, I will consider what I learned about forced connections and innovation. See Appendix B for *Reflections on my Project Goals from the Learning Journal.*

SECTION FIVE: KEY LEARNINGS

Overview of Project

The purpose of this project was to explore biomimicry and integrating forms of nature to generate unique ideas and possible solutions to problems. The two outcomes of this project were a *Reflection Learning Journal* and a *Biomimicry and Forced Connections Design Journal*. The *Reflection Learning Journal* contains prior experiences that contributed to my knowledge, elements of the project goals: skills, mindset, imagination, forced connections, innovation, and insights or reflections while I worked on this project. The *Biomimicry and Forced Connections Design Journal* contains the process work and conceptual designs. An inspiration mood board, biology-to-design process, biology-to-design examples, challenge-to-biology process, and challenge-to-biology images that are included in this journal. The process work and reflections highlighted the importance of forced connections that inspire groups during brainstorming sessions.

Section Five presents the findings that emerged from the documentation and reflections in the journals. This section includes content learning, process learning, project findings, and project evaluation.

Key Learnings

Content learning relates to the topic and literature review to include journal articles, books, videos, podcast, biomimicry guide, and biomimicry websites. The project contained five phases of process learning including: developing a question that served as a focus for the inquiry, designing the outcomes that allowed opportunities for learning and reflection, applying the knowledge on biomimicry processes that resulted in conceptual design and problem solving, solving a human problem using nature, and synthesizing the journal reflections into project

findings. The project findings address the question: What can I learn about imagination, forced connections, process, mindset, and innovation by copying aspects of nature or being inspired by nature? The project evaluation considers successful elements of this project and any recommendations for change to improve the project.

Content Learning

The literature and resources included books, journal articles, videos, podcast, and biomimicry websites relating to three main areas: biomimicry, forced connections, and innovation. The first learning goal was gaining an understanding of the three content areas and demonstrate this knowledge in the project. The second goal was making a connection between three content areas (biomimicry, forced connections, and innovation) into a question for the project. The third goal was applying the principles and methods of biomimicry to concepts and designs. I have connected with nature by gaining knowledge and an understanding of sustainable practices. I learned about the processes and how they are applied in several disciplines. In my journals, I provided examples of the biology-to-design and challenge-to-biology approaches.

Researching the topic, combining the content areas into one question and vision, reflecting on content and learning, and applying the knowledge into two applications that were ways of representing knowledge learning. Skills that I acquired throughout this project include: (1) biomimicry skills and looking to nature for inspiration and solving problems; (2) enhancing the sustainability application in conceptual designs; (3) deepening my understanding of forced connections and the power of combining ideas; and (4) examining innovation through outcomes, mindset, and process. Content learning from multiple sources contributed to my understanding and clarity of the topic, sparked my curiosity to embark on this emerging area of research, and served as inspiration to force connections leading to innovation.

The content learning table used the categories listed in the revised Bloom's Taxonomy (Krathwohl, 2002): remember, understand, apply, analyze, evaluate, and create. Each category and the actions used in this project are listed below in Table 4.

Table 4

Content Learning for the Project

Categories	Description of Actions in the Project
Remember	Memorizing methods and concepts of biomimicry
	Recalling concepts of biomimicry, forced connections, and innovation for the *Big Question Conference*
	Defining facts and concepts in the project
Understand	Explaining ideas and concepts at the *Big Question Conference*
	Describing, discussing, and explaining the question and concepts in the concept and project papers
Apply	Using the information in new situations such as biology-to-design examples and challenge-to-biology
Analyze	Drawing connections between biomimicry, forced connections, and innovation
Evaluate	Selecting and citing relevant literature for the project
Create	Producing original designs and ideas that utilize the two biomimicry processes

Note. Used Revised Bloom's Taxonomy Categories (Krathwohl, 2002).

Process Learning

This project consisted of five phases of process learning such as: developing a question that served as a focus for the inquiry, designing the outcomes that allowed opportunities for learning and reflection, applying the knowledge on biomimicry processes that resulted in conceptual design and problem solving, solving a human problem using nature, and synthesizing the journal reflections into project findings. Each phase contributed to my learning and the success of this project. Process learning from readings and journals resulted in moments of discovery, insights, and reflection. I was focused on the content and the creation of biology-to-design conceptual ideas including problem solving using the challenge-to-biology approach. The journals represent knowledge gained and my interpretation of the content.

My mindset during the process was to learn by reading and engaging in the activities. I was inspired by nature and considered how I might use this information in creative ways. As I made journal entries, I thought about how I could learn more about this interesting area of research. Experiential learning activities gave me opportunities to make connections between biomimicry, forced connections, and innovation. I willingly let the experience unfold in the writing and journals. Effective process learning was a result of my motivation to succeed and dedication to complete the task. A valuable takeaway from this experience was to work through times of ambiguity and to consider this a part of creativity. I trusted the process and knew I had to continue to clarify my ideas to get a breakthrough.

Project Findings

Four key components of this project were biomimicry, brainstorming, forced connections, and innovation to answer the question: What can I learn about imagination, forced

connections, process, mindset, and innovation by copying aspects of nature or being inspired by nature?

Insights from the Literature

Several insights emerged from the readings:

- In a podcast with Janine Benyus, she described biomimicry as a design discipline. (Tippett, 2023, 8:44)
- “Forced Connections is the essence of creativity; the practice of combining ideas that don’t appear to be related in a new way. This method helps you get ideas flowing when you're stuck” (Firestien, 2020, p. 81).
- Osborn (1953) commented about the importance of combinations, synthesis, and questioning. He pointed out that most ideas emerge from combinations.
- Imagination skills may include the “ability to see and care about surprise”, “ability to rethink mental models”, or “willingness and ability to collide ideas with the world”, “ability to broker across groups to cultivate collective imagination”, “ability to turn ideas into institutional scripts”, or “the capacity for serial imagination” (Reeves & Fuller, 2021, p. 147-148).
- Innovation has three components: outcomes, processes, and mindset. (Kahn, 2018)
- I connected with and understood the biology-to-design process because I have a design background.
- I need to think like a designer when I use the biology-to-design process.
- I need to think like a zoologist or botanist when I use the challenge-to-biology process.

Insights from My Journals

The *Reflection Learning Journal* and *Biomimicry and Forced Connections Design Journal* entries, biology-to-design examples, and problem solving using the challenge-to-biology process demonstrate my learning and insights throughout this project.

Imagination and Forced Connections

Key insights regarding imagination and forced connections in brainstorming sessions include: (1) The visual images serve as a source of inspiration combined to make an outcome or solve a problem; (2) Forcing a connection between unrelated images with the research questions results in innovation; (3) Unusual combinations expose novel designs that have not been seen before in the marketplace; (4) Combinations of unrelated items provide opportunities to expand new ways of thinking with different perspectives; (5) Building on the ideas of other people creates the environment where innovation will flourish, and (6) Connecting or combining unrelated objects and ideas is called combinent thinking. As Piirto (2004) points out, "Visual imagination is not the only kind of imagination that creators use… composers imagine works in their "mind's ear," and mechanics imagine problems in their physical, spatial array" (p. 61).

Applying and encouraging skills at the beginning of the creative process brings innovation to a higher level. Using imagination skills for personal or professional reasons increases the chances that people will expand their creative potential.

Innovation: Outcomes, Mindset, Process, and Skills

Key insights regarding innovation include: (1) Innovation occurs in outcomes, mindset, process, and skills; (2) There are two process innovations in an organization. The first innovation is a process throughout the organization. The second innovation is in the design process; (3) By understanding innovation, it becomes attainable (Kahn, 2018). (4) Walsh et al. (2022) identified

innovation to be an important factor in the growth and development of organizations and society; and (5) The mindset of the innovator is someone who has the following: opportunity seeker and seeking challenges to solve a problem, not worried about opinions or acceptance, not worried about failing, visionary, and the person is always evolving and changing.

Figure 12

Bio-inspired Design 2

Design 2: Source of Inspiration

Photo by Javardh on Unsplash

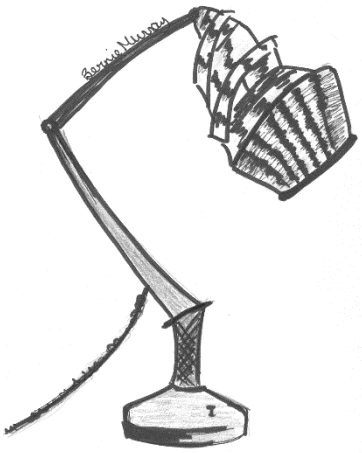
Note: Images from Unsplash royalty free images

Figure 13

Shell-inspired Lamp

Emulating Form

Shape and Texture



Note. Shell-inspired Lamp Illustration. Own work.

Challenge-to-Biology

The challenge-to-biology approach is applied by identifying an organism, traits, biological strategy, human design application, creating solutions, and evaluation. The information to develop Table 5 was taken from The Biomimicry Institute (2021) at https://asknature.org/.

Table 5: Application of Challenge-to-Biology

Biomimicry Term	Information using nature from https://asknature.org/
Organism	Ants
Trait(s)	Self-organizers
Function	Ants are social insects that self-organize and carry out complex group tasks through simple individual interactions.
Biological Strategy	Searching for food: Using different paths, the two ants "release a trail of pheromones (chemicals) that the other ants in the colony can detect. The ant that takes the shorter route doubles back to the nest more quickly."
Human Design Application	Possible use: Self-organization and create activities that are not controlled or supervised for organizations. Human design or application is developed: Illustrations/prototypes/notes/strategy
Make suggestions for the biological model and the design application.	Solutions are created. Evaluations are conducted following life's principles.

Note. Information on categories and nature from: The Biomimicry Institute (2021) at https://asknature.org/

Project Evaluation

Components of the project that were successful included the selection of literature and resources used for this project. The three areas including biomimicry, forced connections, and innovation served as key literature to answer the project question. Two key scholars who focus their work on biomimicry were included as expert resources in the field. Another successful component was the use of journals as the project outcomes. The journals were informative, reflective, and insightful throughout the project. The contents are a collection of valuable information on biomimicry, forced connection, and innovation. The *Biomimicry and Forced Connection Design Journal* documents biology-to-design examples and the application for challenge-to-biology. The application of the two processes provided me with the knowledge and understanding of this emerging area of research. Aspects of the project that could be changed to enhance learning or the project outcomes include: (1) developing a professional project brief that outlines all steps in the challenge-to-biology process; (2) creating additional examples of biology-to-design and challenge-to-biology; and (3) applying biomimicry design solutions into an organizational structure.

SECTION SIX: CONCLUSION

This project explored biomimicry and integrating forms of nature to generate unique ideas and possible solutions to problems. The combination of unrelated items was best defined as a forced connection and an essential component enabling innovation to occur. Ultimately, this leads to financial success and organizational innovation. Souto (2022) states that sustainable development is key to a firms' competitiveness, survival, growth, and profitability. Section Six contains reflections about creativity and change leadership, future goals and directions, implications for future research, and the conclusion.

Reflections about Creativity and Change Leadership

As a result of completing this project, I acquired new knowledge in four areas to include biomimicry, imagination, forced connections, and innovation. From a previous workshop, I was aware of the concept of biomimicry. However, I was not aware of the two processes: The first process, biology-to-design is searching for inspiration in nature to incorporate into designs in any discipline. There are three levels of mimicry that can be used: (1) form emulates shape, structure, and physics; (2) process emulates nature's processes including biochemistry and biophysics; and (3) system emulates nature's systems, at all scales, especially ecosystems. The second process, challenge-to-biology begins with a question. How does nature….? The biomimicry thinking design process for the challenge-to-biology approach has four phases: (1) scoping phase; (2) discovering phase; (3) creating phase; and (4) evaluating phase (Biomimicry 3.8, 2015; Rowland, 2017).

Nurturing the imagination and developing creativity skills are essential for personal or professional advancement. From working on this project, I had a deeper understanding of the importance of skill development for imagination and creativity beginning with conceptual ideas

and skills that nurture the imagination. The creativity skills enhance the creative output. Finally, novel ideas lead to innovation. There is a connection between imagination, creativity, innovation. Reeves and Fuller (2021) discuss the importance of surprise, “rethinking mental modes”, “colliding ideas with the world”, “cultivating collective imagination” using storytelling, understanding why an imaginative experiment was successful, “designing for reflection”, and “encouraging flexibility in roles” (p. 147-148). They stress the importance of imagination with activities to help us achieve success.

In CRS 559: *Principles in Creative Problem-Solving*, Dr. Firestien and Dr. Yates introduced *Creative Problem-Solving* (CPS) including divergent and convergent tools. Forced connections was a tool used in the group brainstorming sessions. Images that were unrelated to the problem were combined resulting with wild and novel ideas. Osborn (1953) emphasized the importance of combinations, synthesis, and questioning. He indicated that most ideas emerge from combinations. Ultimately, forcing a connection with an object with one from another discipline creates unusual and novel ideas or designs. While working on this project, I became aware of the link between forced connections, imagination, and innovation. Since innovation is deemed profitable in business, learning how to use forced connections in brainstorming sessions is essential.

Finally, I developed a better understanding of the driving mindsets of innovation to involve curiosity, creativity, and clarity (Walsh et al., 2022). They described each phase with two action-oriented sub-processes. The first phase, curiosity, has the sub-processes discovering and understanding. The second phase, creativity, has the sub-processes, creating and testing. The third phase, clarity, has the sub-processes, resourcing and implementing. Dyer et al. (2009)

identified five skills that are associated with *Innovation as a Mindset*. The skills support innovation and encourage new ways of thinking include associating, questioning, observing, experimenting, and networking.

Future Goals and Directions

Fritz (1984) said that our vision is what we want it to be. I am looking at his suggestion to consider my future vision for my personal and professional life. I am starting with the "blank slate" that he was talking about. It seems easier this way to dream about my future using this approach. Fritz (1984) also discussed life as a creation. I am creating my new path in life using the knowledge I have obtained from the *Creativity and Change Leadership* program. I have future goals, dreams, and directions that require planning for several short-term and long-term goals. What I see myself doing next is…

Events and Activities Beyond the Scope of this Project

Beyond the scope of this project, there are several goals that I intend to pursue:
The first goal for consideration in the academic environment includes courses for development including the course syllabus, weekly lectures, assignments, and assessment. This could be a course series or individual courses. I envision three different courses: (1) biomimicry; (2) brainstorming focusing on forced connections; and (3) innovation. The second goal is to use the knowledge gained as a focus for academic presentations and publications. The CPS/creativity skills that I am using for this project include the ideate stage of the CPS model, divergent thinking, combinent thinking, brainstorming, and forced connections.

The third goal is writing a book that uses the biology-to-design focus. The journals for this project provide a starting point that can be further developed. The journals illustrate designs and ideas using the biomimicry lens and a journal that reflects on learning about biomimicry,

imagination, forced connections, and innovation for this project. A fourth goal is to develop a resource and educational guide on bio-inspired design that could be published. A fifth goal is to write a reflection paper about learning this valuable area of research that would be submitted to a journal.

Further evaluation of the project may be informal feedback that provides ways to improve the project, new resources, or provides new directions for further work. Presenting the work to colleagues may provide new insights and considerations for future directions. In planning for the evaluation session, I would create a list of key evaluation points, questions, and measurable outcomes. The questions could focus on process outcomes and project outcomes. I could conduct a self-evaluation using the same criteria as previously mentioned for my colleagues. Feedback could be solicitated from a panel of design experts or biomimicry experts. These specialized panels may provide valuable feedback regarding design, development, and the marketplace.

Suggested evaluation of this project may include the following: (1) evaluation of the project with biomimicry's life principles; (2) project resources and sustainable materials; and (3) production methods. The product materials and processes of development contribute to sustainable products. Another method of obtaining feedback may include a focus group that provides feedback and potential success in the marketplace.

Implications for Future Research

Future research could focus on determining how biomimicry solves various challenges and how effective the long-term results are for organizations. Researchers could also interview designers who have adopted biomimicry practices to understand how they have benefited and the challenges that they faced from the time of adoption to the present time. It would also be

interesting to focus the research on imagination and forced connections. The study may examine how forced connections in brainstorming impacted innovation of the product, process, and person. Future research may concentrate on biomimicry, innovation, and incorporating aspects of nature into an organization. Researchers could also create a study examining the mindset of students who have completed biomimicry, problem solving, or innovation programs. A longitudinal study could look at their perceptions after graduation and at various points in time. Future research may focus on strategies that motivate designers, engineers, and other stakeholders to adopt this emerging field of study.

Conclusion

The purpose of this project was to explore biomimicry and integrating forms of nature to generate unique ideas and possible solutions to problems. I had an opportunity to explore biomimicry, imagination, forced connections, and innovation. The project outcomes included a *Reflection Learning Journal* and a *Biomimicry and Forced Connections Journal*. I gained knowledge from literature, videos, podcast, journal entries, and reflections. This project provided an excellent learning opportunity to explore nature and innovation. Blok and Gremmen (2016) described the use of biomimicry as a new way of thinking and ecological innovation.

Janine Benyus (Biomimicry Institute, 2020) also discussed biomimicry as innovation inspired by nature and a new way of inventing. As the co-founder of the *Biomimicry Institute*, she stated:

> “Biomimicry is innovation inspired by nature and it's a new way of inventing by looking to the natural world for our inspiration how and asking before we design anything um what would nature do here when we're doing biomimicry is we're looking for nature's designs you know its structures and its forms because they're so elegant they're so energy

> efficient we're looking at its processes its recipes than the chemistry's that are so life friendly and then we're also looking at its strategies on an ecosystem level right how do all these organisms interact in a way that enhances this place and by looking to the natural world for our models and as our mentor (1:56).

From this project comes an understanding of combining elements of nature with designs or problems, combining unrelated items together in brainstorming, and elements of innovation in organizations.

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Appendix A

Permission from Learn Biomimicry

BUFFALO STATE
The State University of New York

Bernadine Murray <murraybm01@mail.buffalostate.edu>

Asking permission to include images from "A Field Guide to Biomimicry" in my master's project

Learn Biomimicry <accounts@learnbiomimicry.com> Fri, Apr 21, 2023 at 6:21 AM
To: Bernadine Murray <murraybm01@mail.buffalostate.edu>

Hi Bernie

We hereby grant you permission to use the images in your project and reflective journal. Please ensure a reference is visible to www.learnbiomimicry.com for any illustrations, imagery or content used.

If you are interested to sign up to our Foundational Short Course Set (which is an indpeth dive into the world of biomimicry), and purpose built for those who know what biomimicry is but are looking to apply or practice it, you can register for 50% off (students and educators only).

Thanks for reaching out to us, wishing you a lovely Friday and restful weekend

Wild regards
Alistair

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Appendix B

Reflections on my Project Goals from the Learning Journal

The project goals include: (1) applying knowledge and inspiration from nature to create bio-inspired designs (biology-to-design) and to solve a problem (challenge-to-biology); (2) using forced connections as a tool to inspire the designs and solutions; (3) gaining insights and understandings about innovation in outcomes, mindset, process, and skills; and (4) developing a biomimicry lens by asking the questions: What would nature do?

Project Goal 1

(1) Applying knowledge and inspiration from nature to create bio-inspired designs (biology-to-design) and to solve a problem (challenge-to-biology).

This goal was accomplished learning about the processes using nature and applying the knowledge.

Project Goal 2

(2) Using forced connections as a tool to inspire the designs and solutions.

Using nature to create jewelry, buildings, or to solve problems is a forced connection. The mindset, process, skills, and outcomes are innovative.

Project Goal 3

(3) Gaining insights and understandings about innovation in outcomes, mindset, process, and skills.

I see innovation throughout the entire organization now. Insights, reflection, and knowledge were the tools that helped me along the way.

Project Goal 4

(4) Developing a biomimicry lens by asking the question: What would nature do?

Using a Biomimicry Lens

Using a biomimicry lens means that I will: (1) use creative problem-solving skills that will reframe the challenge; (2) apply nature to develop solutions or strategies; (3) discover new ways to look at the problem using nature; (4) design and develop solutions that are documented in a journal; and (5) learn to search for inspiration in nature.

Asking the question: What would nature do? This question made me curious to explore in order to find out the answer. The question brought about more questions such as: Should I research plants or animals? How does biology and nature influence imagination, creativity, and innovation?

What did it teach me about imagination and innovation?

- Unusual combinations reveal novel designs that have not been seen before in the marketplace.
- The conceptual ideas begin the process in brainstorming.
- Nature can be applied to any discipline.
- As a designer, I am curious and intrigued with the process and the combined results.
- The product is innovative because it evolves from two different components.
- The product, process, or mindset are innovative because the competition does not have all the elements together.

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- I hereby grant permission to the Department of Creativity and Change Leadership, Center for Applied Imagination at Buffalo State University permission to place a digital copy of this master's Project (Biomimicry and Forced Connections to Inspire Innovation) as an online resource.

Bernadine Murray

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Name

April 30, 2023

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Date