The Biomimetic Sampler: A Constraint-Based Ideation Exercise for Introductory Biodesign Education

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Ethical Standards

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Abstract

This demo presents the Biomimetic Sampler: a constraint-based ideation exercise that introduces participants to foundational concepts of biodesign through two linked activities, observation and translation, conducted under time pressure. The exercise requires no prior background in design, life sciences, biomimicry, or fabrication, and has been deployed across six sessions at three institutions with audiences ranging from engineering undergraduates to experienced design educators to members of the public.

Participants begin by observing a biological specimen, a fossil, shell, seed pod, or other preserved organism, and producing written descriptions on cards that speculate on the organism's behavior, relationships, and strategies based on form affordances rather than naming its parts or naming its appearance. These cards are then redistributed: each participant receives a stranger's descriptions and constructs a wearable object through interpretation of those descriptions alone, without seeing the original specimen. The visual link between biological source and material output is deliberately severed forcing information through abstracted language.

This constraint does specific pedagogical work. By removing visual access to the source, the exercise forecloses surface mimicry of natural form and requires engagement with functional and ultimately relational biological logic. The speculative work of the description phase, inferring behavior and strategy from static form alone, introduces participants to modes of biological reasoning that precede and enable deeper biodesign thinking.

The wearable as a target object class compounds this: a wearable must negotiate the human body, its scale, its movement, and its social context, requiring that the biological translation arrive at a proposal for how a human might enact and inhabit the relational logic of another organism.

Time pressure and exhaustive iteration are integral to the methodology in its most effective forms. Participants produce multiple prototypes in rapid succession, a structure that exhausts the most literal responses and which generates surprise and adaptation.

The exercise was first developed for DESIGN 289: REDRESS Biomaterials and the Future of Fashion at Stanford University, which was awarded the Outstanding Instructor Award at the 2025 Biodesign Challenge. In nomination letters submitted by

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students, the exercise, which is the first of the class, was the most consistently cited element of the course. Ultimately, students who arrived to REDRESS with no prior experience in design, life sciences, or biodesign have gone on to secure competitive funding to continue the research first begun in the course. The kickoff exercise, The Biomimetic Sampler, has since been deployed at four additional non-curricular contexts, confirming that it functions independently of the course structure and scales across audience types and institutional settings.

Keywords:

Biodesign Education, Constraint-Based Design, Experiential Learning, Biomimetic Design, Design Pedagogy

Impact Statement

Developing practitioners who can simultaneously engage with biology and design as source and method for the creation of new knowledge is foundational to the future of biodesign. The Biomimetic Sampler is a replicable, freely adoptable exercise that builds this capacity from the ground up, requires no prior knowledge in design, biology, or craft, and has been validated across six deployments at three institutions.



Figure 1. The Biomimetic Sampler as presented at the Yale Center for Engineering Innovation and Design (CEID) April of 2026. (a) specimens from the Peabody Museum arranged for selection, (b) individual handouts to supplement projected and spoken guidance, (c) participants wearing and demonstrating their prototype wearables at the end of the exercise.

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Introduction

Students new to biologically-engaged design, from both science and design prior backgrounds, often first explore the interface of the fields visually, copying or representing surface forms, textures, and colors rather than functional principles or relational strategies. This pattern, characterized in the biology-derived design literature as biomorphism, is a distinct mode of engagement from the analysis of biological mechanisms that defines biomimicry,[1] or the fuller integration of living systems that defines biodesign.[2,3] Transitioning between these modes typically requires sustained exposure and direct pedagogical intervention.[4]

In parallel, exercises built on multiple outputs in compressed timeframes at the edge of one's ability are an established practice in design pedagogy, grounded in research on the relationship between constraint and creative output because limiting the available solution space is understood to focus attention and exhaust the most obvious responses before more generative directions emerge.[5,6] The Biomimetic Sampler applies this principle to the specific problem of biologically-engaged design. It introduces a structural gap between biological observation and material making, passing the translation through language rather than vision, from organism to human, and uses time pressure and iteration to prevent the outcome from settling at its most literal or obvious concept.

The exercise draws on a pedagogical lineage established at the RISD Nature Lab, where Tom Weis and Jennifer Bissonnette developed approaches to design education through direct engagement with the biological collections there, using preserved and living specimens as active prompts.[7] The Biomimetic Sampler extends this foundation by introducing alienation, speculation, and abstraction gaps,[8] by centering organism experience and relationships[9,10], and by targeting the wearable as the output object class, which requires that the biological logic arrive at the human body and engage with its movement, scale, and social meaning. The use of static and fossilized specimens enhances the alienation and abstraction: because behavior cannot be directly observed, it must be inferred and speculated upon, a mode of engagement with non-human organisms that connects to a broader tradition of inquiry into the perceptual and relational worlds of other species.[11,12]

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Figure 2. The Biomimetic Sampler as presented at Stanford. (a) specimens from the Doerr School of Sustainability specimen collection arranged for selection, (b) Prototypes of wearables taking shape during the d.school Teaching Summit in September 2025; Audience of 30 composed of d.school teaching community members and leaders., (c) one REDRESS student's multiple outputs from a single written abstraction in the fall of 2025.

Significance and Evidence

The exercise makes two claims simultaneously: that it provides an accessible entry point into foundational biodesign concepts for participants with no prior background, and that the mindset of creative, determined discomfort it trains is generative enough to seed sustained research and innovation.

The first claim is supported by the deployment record. Across six sessions at three institutions, with audiences ranging from Stanford undergraduates with no design or life sciences background to engineering students at Yale to craft and biomimicry specialists at RISD, the exercise produced wearable concepts grounded in biological logic in every case. Table 1 documents the variation in audience, structure, and time constraints across deployments. The consistency of output quality across this range of contexts and variations in exercise parameters confirms that the methodology does not depend on prior knowledge to function.

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Table 1. Deployment record across five instances of the Biomimetic Sampler.

Instance	Audience	Prior knowledge	Group structure	Time / prototypes	Instance
Stanford DESIGN 289 (REDRESS) (a) Winter and (b) Fall 2025[13]	14 students, wide-ranging departments and rank	Each with distinct depth but without interdisciplinarity	Individual	Two days; multiple rounds (extended variation)	Stanford DESIGN 289 (REDRESS)
d.school Teaching Summit	30 instructors, designers, instructional designers	Limited in Life Sciences; none in Biodesign; strong design	Individual or pairs (optional)	40 min; 2 prototypes required	d.school Teaching Summit
Stanford Interplay Salon, Cantor Arts Museum[14]	40 participants: students, faculty, public	Wide-ranging; no Biodesign orientation	Pairs	12 min; 2 prototypes per pair	Stanford Interplay Salon, Cantor Arts Museum
RISD Nature Lab[15]	12 participants, high craft and biomimicry orientation	Strong in biology-inspired design	Individual	90 min; 1 prototype required	RISD Nature Lab
Yale University, CEID[16]	~20 predominantly engineering undergraduates	None in Biomimicry or Biodesign	Individual	60 min; 2 prototypes required	Yale University, CEID

The second claim is supported by outcomes from DESIGN 289 at Stanford, where the exercise serves as the opening assignment of the course. In the nomination letters submitted by students that led to the course being awarded the 2025 Biodesign Challenge Outstanding Instructor Award,[17] students consistently identified the exercise as a impactful moment in their engagement and learning. One student described completing the first assignment as follows:

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> Our first assignment was a challenge to create 10 prototypes of wearable objects inspired by descriptions that other classmates had written about various fossils and natural artifacts. Char armed us with a simple sewing kit, basic fabric, and oodles of encouragement, and the class stepped up to the plate and made 100+ weird and wacky wearables in just the first week of class. It was the coolest experience I had for a first-class assignment at Stanford. (Student A, BDC nomination letter, 2025)

Another student described the specific phenomenological experience of the translation gap:

> I received the phrase 'polka dot dancers lost in step.' How was I supposed to create something that represented that? Days later, I found myself sewing a pair of socks with polka dot figures frozen mid-dance. Exercises like this pushed us to be more imaginative, resourceful, and collaborative. (Student B, BDC nomination letter, 2025)

A third student named the no-prior-knowledge dimension directly: the course "was able to start off with a group of students who had little experience with biomaterials and end up with the same group of students who are pursuing projects and grants on the future of sustainable fashion within the span of 10 weeks" (Student C, BDC nomination letter, 2025).

Student teams from the course have gone on to secure competitive funding to continue the research first begun in the course.[18,19] These outcomes are certainly not attributed solely or wholly to this exercise or the course design, but they have notably been produced by students who entered the course with no prior background in the field. The exercise was sufficiently effectiveness as an onboarding methodology not just into established knowledge of the field but into producing new knowledge within it.

The pedagogical ambition underlying the exercise is not mastery of a defined body of knowledge within Biodesign but the development of patterns of thinking and working that are prerequisite to generating new knowledge in the field. This distinction, between education that transmits known content and education that cultivates the capacity for genuine inquiry, is well established in the philosophy of design education and in broader debates about the relationship between making and knowing.[20,21,22] The nomination letters and the downstream project outcomes together provide evidence that the exercise produces the latter.

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Figure 3. Phases of (a) observation and writing, (b) making wearables, (c) demonstrating and wearing, and (d) debriefing at the Biomimetic Sampler Workshop held at the RISD Nature Lab in April 2026

Conclusion

The Biomimetic Sampler teaches an approach to biological systems as subjects with their own relational logics, speculating beyond what is immediately perceivable, and to commit to a material proposition under conditions of genuine uncertainty. These are skills that emerge from making, and specifically from making under pressures that prevent the maker from defaulting to what they already know.

The exercise is offered here as a replicable contribution to the field of biodesign education. Its materials are inexpensive and sourced from the waste of fashion textile R&D teams. Its protocol is simple enough to run without specialized training. It has functioned across institutional contexts, with audiences whose prior knowledge ranged from none to substantial, and it has produced consistent results in each. Conference attendees are invited to experience it directly at the demo booth, and to take the protocol back to their own courses, labs, and organizations. The handout is available on request.

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Technical Requirements

At the Biodesign Conference, the demo consists of pre-populated specimens and prototype pairs from past sessions, making the translation gap visible and explorable as a process. Visitors can engage more interactively by selecting a description card drawn from real past sessions and constructing a wearable object from donated textile waste, with the option of a time constraint. No facilitation or prior knowledge is required to participate.

The demo booth is self-contained. The presenter supplies all materials. Conference organizers need only provide:

- A table: specimen and prototype display and making materials
- Chairs or stools for the participant makers
- Approximately 100 square feet of floor space
- One standard electrical outlet (optional)

No special hardware, software, or advance preparation is required. Biological specimens will be sourced locally in the conference region. Fabrication materials will be sourced from donated textile waste from regional designers where possible.

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Author Contributions

Charlotte McCurdy: Conceptualization, Methodology, Data Curation, Visualization, Writing, Review, Editing, and Submission.

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