

University of Oregon - School of Architecture and Allied Arts - Department of Architecture  
ARCH 410/510 Winter 2017 CRN Wed 10:00am-11:50am in 405A LA, Friday in 283M LA

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Office hours M 10:45am-12:45pm in 477c or Skype (ncheng1)

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<http://blogs.uoregon.edu/bioform>

## BIOMIMICRY & PARAMETRIC DESIGN: Form for environmental performance

### SYLLABUS



*Biomimicry Design Cycle by the Biomimicry Institute*  
<http://www.biomimicryinstitute.org/about-us/biomimicry-a-tool-for-innovation.html>

**Purpose:** This course examines how biomimicry and parametric design can address environmental challenges.

Plants and animals thrive in their habitats because they have structures, mechanisms and systems that work efficiently in specific environmental conditions. This class will examine how natural organisms can be models for architectural design using Biomimicry 3.8 principles and morphogenetic parametric design. Starting from the beauty of nature as inspiration, students will study ways that architects and designers are examining nature's forms, mechanisms and systems to discover principles for approaching design problems. Design approaches will include processes of observation, description, analysis, metaphor and abstraction.

Biomimicry and systems thinking will provide a framework for looking at skins, growth and bones as paradigms for designing static structures and dynamic systems. Students will study how designers have used natural models to generate architectural systems and kinetic constructions. Examples will include landscapes, architecture and product design.

The course develops understanding of concepts through readings, lectures and discussions, then fosters applied skills through design-oriented homework assignments. To develop flexible formal ideas, students will articulate geometric relationships with Rhinoceros-Grasshopper (GH) parametric design software. Climate visualization, solar and lighting simulation will be done using the GH Ladybug-Honeybee plug-in.

Class sessions will include presentations, discussions and hands-on activities. Successful completion of this course will count towards the advanced technology requirement.

**Pre-requisites:** ARCH 4/571 & 4/572, 384 or permission of the instructor

Students do not need to bring a scientific knowledge, instead students are invited to investigate how organisms thrive in their environments, to grapple with understanding key biological, physical or chemical processes that underlie observed phenomena.

## Course Requirements

All students have a Windows computer with Rhino 5.0 software installed to class. Students should have some knowledge of some kind of 3D modeling, previous experience with Rhino and Grasshopper is helpful but not required.

**ASSIGNMENTS:** As long as students address the assignment intentions, aspects of the assignment may be customized - please check with the instructor if you have questions or suggestions. All work will be posted to the Course Blog for sharing. Rhino and GH files will need to be compressed to ZIP format, Image and PDF files need to be optimized so that they are easily downloadable.

**DIGITAL EXERCISES:** Non-graded in-class digital exercises will build on documented tutorials. Students will be challenged to build on and modify parametric design definitions. Exercises will not be graded but results will be turned into the course folder to document abilities. Collaboration and peer coaching is encouraged.



*Section through a christmas rose leaf showing round chloroplasts from Michael Hensel's (Synthetic) Life Architectures: Ramifications and Potentials of a Literal Biological Paradigm for Architectural Design, Architectural Design journal, v.76 no.2, p. 20*

## Assignment Overview

Students will carefully examine the relationship between processes and geometry in natural and designed contexts. Collaboration is encouraged. Given the small size of the class, the course content and assignments may be tailored to the students' interests. Check with the instructor if you have questions or suggestions.

**Inspiration Presentation:** presented during the term – Sign up for a date.

To better comprehend how biomimicry can be used, students will research the process of how the creators transferred ideas from organism to application. What was the challenge, how did designers find a model, how was the model adapted, what were the most helpful steps. As with the natural organism, students will diagram the underlying organization, and for kinetic systems, how external inputs trigger actuation.

- Illustrated narrative of the design process PPT

- include diagrams of the basic geometric organization, external forces / responses

Graduate students will have to write up the presentation into a 3 page paper.

### 1A: SKIN: Sketches & Parametric Patterns

Take a walk observe and sketch interesting natural patterns.

Using one natural pattern as inspiration, draw the basic element in Rhino or GH and then tessellate it using Grasshopper arrays (linear, polar) and grids (rectangular, triangular, hexagonal, etc.)

Create 3 variations similar to those observed in nature, and try to create 3 with emergent shapes from the interaction between parts.

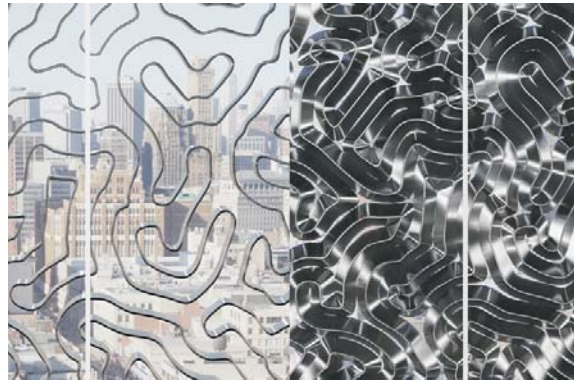
Then use Paneling Tools-2DMorph to wrap your shape around surfaces different surfaces. Fill the shape and bake it. Next, model a 3D module and use Paneling Tools-3DMorph to stretch it between two surfaces

### 1B: SKIN: Solar Adjustable Module

Model a panel with a variable aperture through using a sliding, stretching, folding or rotating element. Use Heliotrope to make a shape change according to the sun angle: scaling, aligning, rotating, etc. Create a catalog that shows how this Module could adapt to different sun angles for different orientations or times of day.

### 1C: SKIN: Solar Responsive Surface

Use Ladybug to visualize climate data and sun paths. Test variations of Solar-driven pattern using Ladybug to measure incident and transmitted solar radiation. Create a responsive wall, canopy or sculptural surface that demonstrates adaptation to different solar conditions or a static system with shading customized to typical summer solar radiation.



Homeostatic Wall: Yeagon-Decker

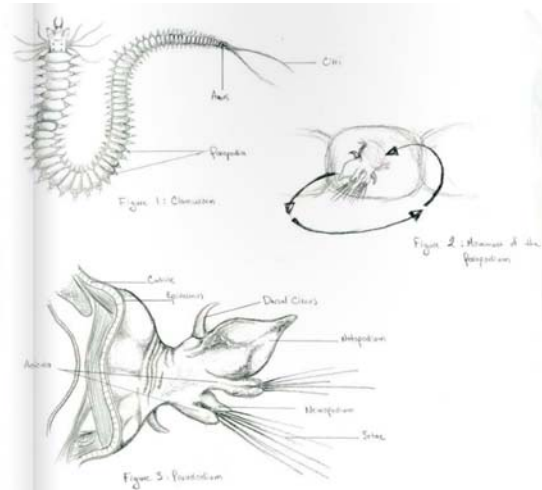
### 2: DYNAMIC SYSTEM

Model a transformation in Grasshopper that could be used to create an adaptable building component.

Students will start by examining a specific organism: drawing and modeling the forms at different stages of growth or movement. Modeling of components can initially be done in Rhino in order to develop skills in building complex form. To assist deeper understanding of the dynamic processes, students will diagram the underlying organizational framework. They will look at how stimuli are sensed and processed, using diagrams to explain how the organism changes over time in response to internal stimuli and external forces.

#### 2A. Sketch & Digitally Diagram

- Naturalistic drawings of 3 stages (cross-sections and plans at a consistent scale) + 2+ perspectives (*image from [http://issuu.com/egqermont/docs/bio\\_drawing\\_sample](http://issuu.com/egqermont/docs/bio_drawing_sample)*)
- Motion diagrams or collages with forces indicated.
- Digital 3D diagram of the organism's basic geometric organization



#### 2B: Parametric System

From the studying natural and the designed systems, students will choose an aspect of a dynamic process to model in Grasshopper. Create the forms, kinetic logic and mechanisms from the original and then show how they can be adapted for new situations by creating a catalog of forms.

### 3: DESIGN PROJECT (GROUPWORK)

The major term project (4 weeks) is to apply biomimetic and parametric design to a design problem. Students may choose to address an aspect or component of their design studio problem OR identify another crucial problem. The challenge is to translate the structure, process or system of a natural organism into an architectural form or environmental design element.

#### 3A RESEARCH : Case Study Analysis (visual summary)

Define the problem and analyze how an organism has conquered it.

1. Biomimetic inspiration: hand-sketches
2. Diagrams of physiological, behavioral or anatomical elements: How are the organism's physical systems, behaviors and structures adapted to climate? How do they enable specific functions?
3. Climatic Interface: How does the organism's structure, process or system mediate the external environment?

#### 3B DESIGN

Show how a designed building, structure, responsive surface or object addresses a specific challenge or deficiency.

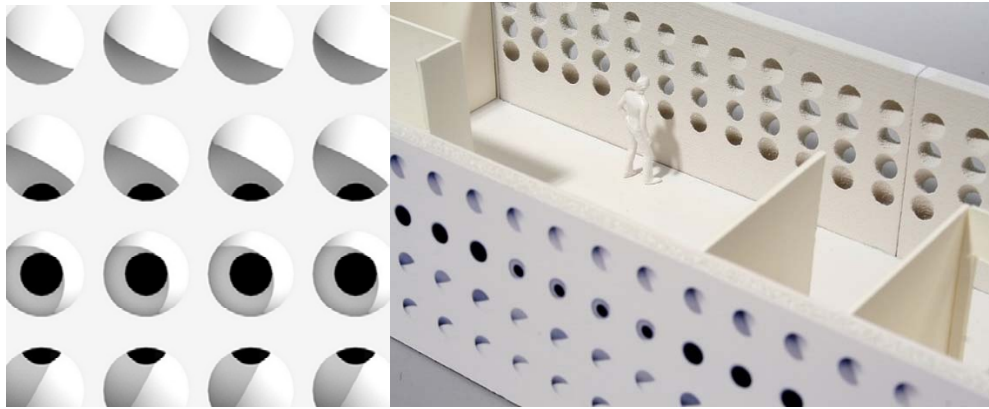
Students can develop their project through these stages:

- i. Statement & Conceptual sketches
- ii. Work-in Progress with Development Plan including team roles
- iii. Draft Presentation

Optional: Change over time, before and after

### 3C PRESENT

Final illustrated report that includes the 3A Research and a final version of 3B Design. Undergraduates ~750 words, Graduate students ~1200 words.



*Simon Cygielski's circlewall*

## Requirements and Evaluations.

Students are expected to take responsibility for their learning. They must come to all classes prepared and on-time. As timeliness is critical to academic advancement and professional practice, students are encouraged to turn in even partial work-in-progress on time, with additions accepted later. **Late initial submissions may be penalized up to 10% for every day late.** In-class time will include feedback on how to meet learning goals. Quantitative feedback will be given 3 times during the term. Successful completion means:

- Engagement with content, instructor and peers through discussion and evidence of reading comprehension. Communication is essential: asks questions and support others.
- Effort to grow beyond pre-existing knowledge and skills
- Completeness of assignments, with a high level of care and craft demonstrated (citations, layout, grammar and spelling)
- Technical virtuosity and aesthetic quality of digital design efforts

### EVALUATION COMPONENTS

Assignment 1: Skin	25%
Assignment 2: Dynamic System	20%
Assignment 3: Design Project	40%
Inspiration Report	5%
Class Participation: attendance, discussion, blog posts	10%
<hr/> TOTAL	<hr/> 100 points