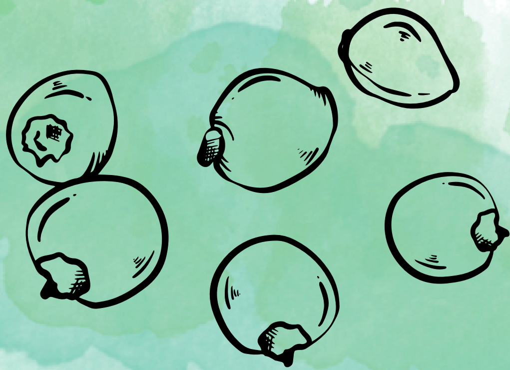
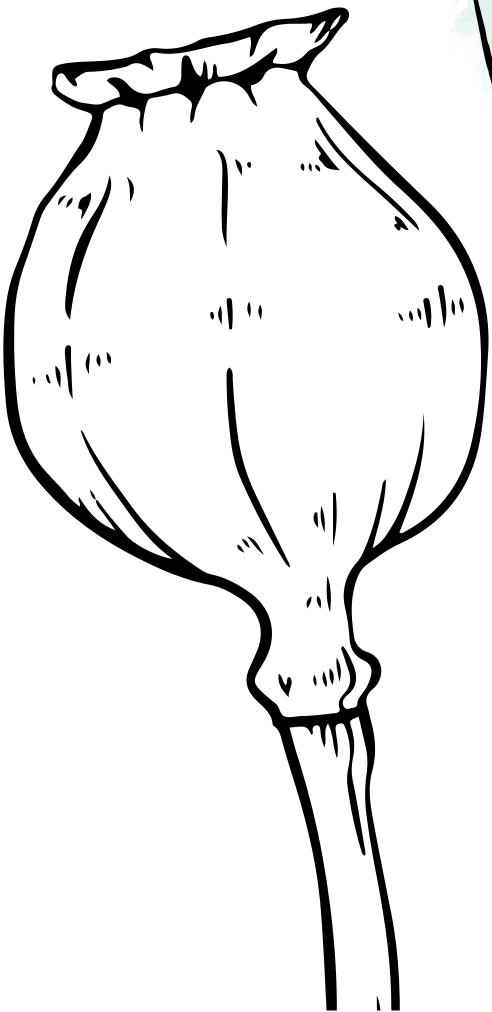
Nature Lab

Biomimicry





Nature's Principles

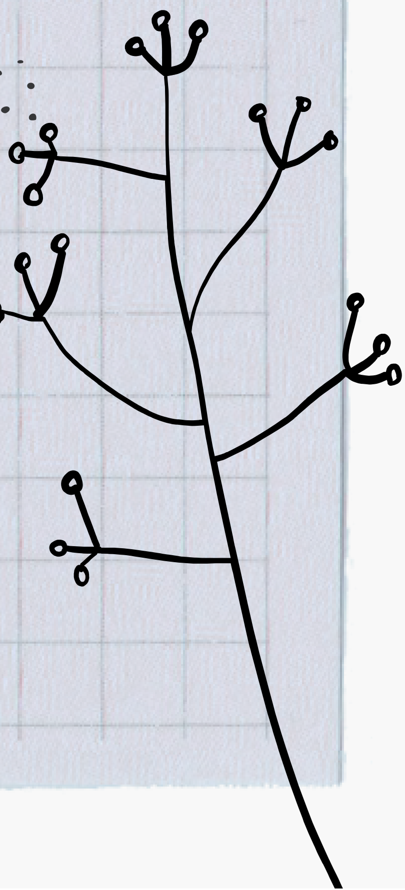
Biomimicry is the process of nature-inspired design. So we need to know nature's principles.

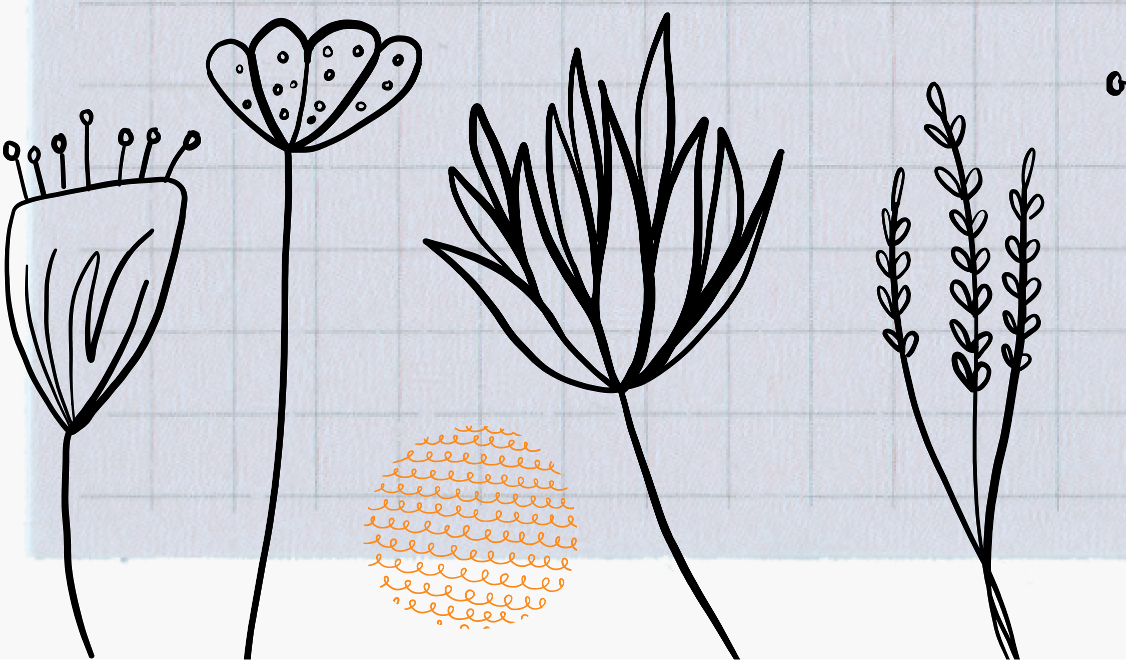
- **Nature runs on sunlight**
- **Nature uses only the energy it needs**
- **Nature fits form to function**
- **Nature recycles everything**
- **Nature rewards cooperation**
- **Nature banks on diversity**
- **Nature demands local expertise**
- **Nature seeks balance**
- **Nature taps the power of limits**

https://biolearn.eu/biomimicry-principles/

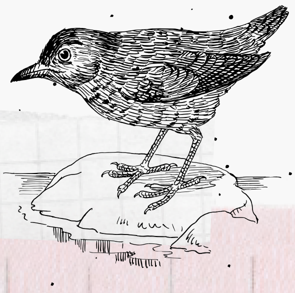
Deep ecology does not see the world as a collection of isolated objects but rather as a network of phenomena that are fundamentally interconnected and interdependent. It recognizes the intrinsic value of all living beings and views humans—in the celebrated words attributed to Chief Seattle—as just one particular strand in the web of life.

— Fritjof Capra, The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism





Nature on Campus



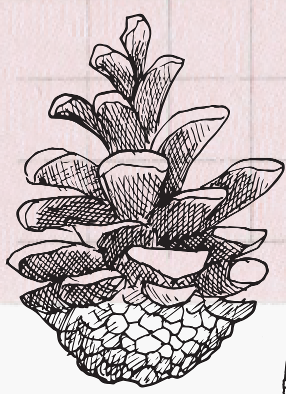
There are 11.000 plant species, 19.000 invertebrate species, 161 mammal species, 469 bird species, 141 reptile / amphibian species and 916 fish species of which more than 320 of them living in inland waters in Turkey and 1/3 of these species are endemic.

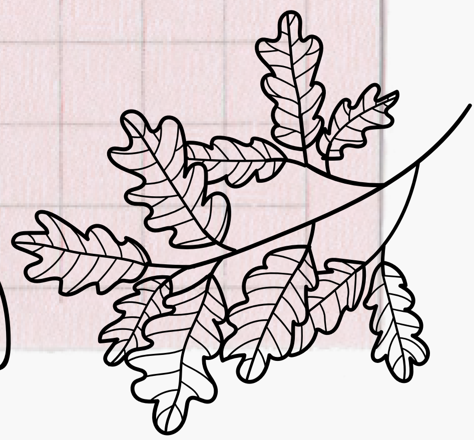
Being one of the oldest centers of civilization in the world, Anatolia is the home of many local varieties of agricultural products. A small-scale model of our country's ecosystem and biodiversity is also located on the METU campus, which has an area of 45 km2 in Ankara metropolis with a population of 5.3 million.

Besides the forest ecosystem, the steppe cover of the campus is an extremely valuable and rare example with many herbaceous plant species it contains, thanks to being away from human influence for decades. METU campus is one of the few Central Anatolian steppe ecosystems, which has been intervened as little as possible, are free of grazing pressure, was not used pesticides, and preserved its nature.

There are approximately 700 plant species in the natural steppe cover, which constitutes 1/3 of the total plant species (2100 plant species) within the borders of Ankara province. METU forest is mostly covered with black pines, and also scotch pines and Taurus cedars are among the most common tree species. Tree-like steppe vegetation such as hawthorn, wild pear, almond, and mahaleb are also located in the campus area. Planted during the afforestation activities carried out over the past decades, these species are very important for wildlife with their flowers and fruits.

Birds are the best-studied organisms among the METU fauna. The observations made on campus more than 210 bird species (about half of Turkey's avian fauna) have been detected. Although invertebrates are not well known, more than 100 butterfly species have been identified in METU in recent years.





Nature Observation

Sit and Stay

The most basic way to observe nature is to simply sit in a natural setting for 10-15 minutes without doing anything with a phenomenological approach; don't explain, don't comment, or even don't take photographs, just write your observation. The first 2-3 minutes pass relatively easily, as there's a lot of new stuff to look at. The next 5 minutes often get challenging; you may find your mind wandering and your body feeling fidgety. Stick with it. If you push past those distractions and remain in place for the rest of the time or even longer, it's amazing what is revealed to you in this deeper state of observation.

Some questions you can ask yourself during or after your experience might be:

- What operating conditions (or context) are
- organisms contending within this environment?
- What are some adaptations (behavioral or
- physiological strategies) you see as a response
- to the context?
- What relationships do you see?
- Do you notice any patterns?

Observation Tips

Track Changes Over Time Visit the same spot in as many different conditions and times of day and seasons as possible. Record your observations each time, noting differences and changes in both the site and your perception of it.

Blind Drawing Sit in front of an organism or natural object. Draw a quick sketch of the object (don't worry if you "can't" draw). Now draw the organism or artifact again, but this time look only at the object and not at your paper while you draw. Try to make your pen follow the path that your eyes take. Compare drawings; did you discover anything new the second time?

Make Believe Imagine being one of the organisms that you observe. Imagine how you perform each of the functions that your species needs to survive. What are you made of? What and who do you depend on to survive? Who depends on you to survive? What roles do you play in your ecosystem throughout your life? What is your special niche? What adaptations make you fit best in your niche?

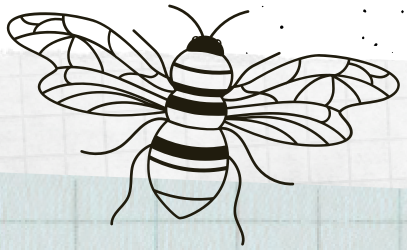
Sound Map With your journal or paper in front of you, mark an "X" at the center of the page to represent yourself. Then close your eyes and listen. Create a symbol on your page to represent each sound that you hear. Make a map of the sounds you hear all around you, in all directions and whether human caused or not. Are the sounds related or responsive to each other? This is also an interesting exercise to do at night, when some organisms become more active.

Translate What You See Create a technical drawing of one system in the environment you see around you, for example, draw the system of energy flows. Use arrows, symbols, and notes like those you would find in an engineering drawing.

Finding Function Explore your environment by looking for examples of nature performing functions that human designs also seek to perform. Some examples: Moving water, filtering (air, water, etc.), adhesion, cleaning, transforming waste, storing carbon, and communicating.

Zooming In Mark off a square foot (approximately 0.1 sq meters) of ground in any natural habitat, using string or sticks or a hoop. Look at it from a standing position for 5 minutes. Notice what you see. Then kneel down and observe it from that vantage point for 5 minutes. Notice the things that you missed while standing. Next, lie on your belly or lean closer to explore the area in detail. Look at it as if you were an astronaut on a strange planet. If you find something that captures your attention, such as an insect, worm, or plant, observe it as long as you want, then explore somewhere else in your square. Stay with your exploration for at least 10 minutes.

Biologize Tips



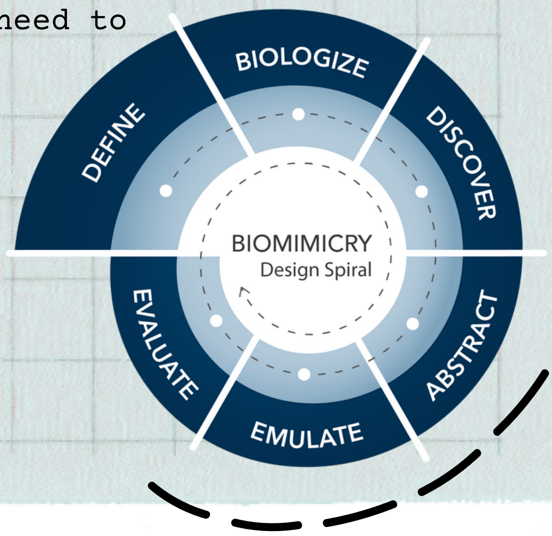
- **Ask "How does nature…?" questions.** This simplified question expresses the essence of what the design challenge is all about. *How does nature regulate the temperature in hot climates? How does nature manage excess water? How does nature create color?*

- **Think about analogous life functions and contexts in nature.** A function, by definition, is the purpose of something. In the context of biomimicry, function refers to the role played by an organism's adaptations or behaviors that enable it to survive. Importantly, function can also refer to something you need your design solution to do.For example, the wings of a bird and of an insect are analogous organs.

- **Consider multiple possibilities.** As you examine your design question, you might discover that there are multiple functions at play or multiple ways to define the function and context of your challenge biologically.

- **Flip the question.** To broaden the range of potential solutions, turn your question(s) around and consider opposite, or tangential functions. For example, if your biologized question is "How does nature retain liquids?", you could also ask "How does nature repel liquids?" because similar mechanisms could be at work in both scenarios.

- **Don't rush!** Defining and biologizing your design question is one of the more difficult parts of the biomimicry process. Don't rush this process. It is well worth spending the time you need to get your questions right.



Reverse Engineering

Reverse engineering is the process of discovering the technological principles of an object by taking it apart and carefully studying its different parts. Now choose a plant part, leaf, seed, or flower.

- Carefully take apart your object and sketch its different components.

- Describe the colors and textures of the object. Why was the object created with these materials?

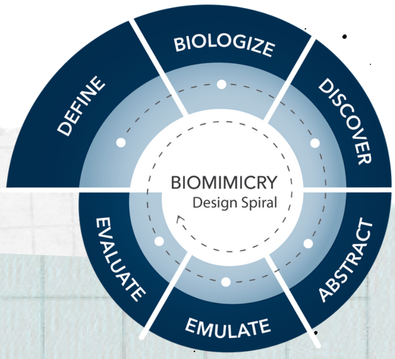
- Describe the overall shape and structure of the object. What challenges might the object be solving by having this shape and structure?

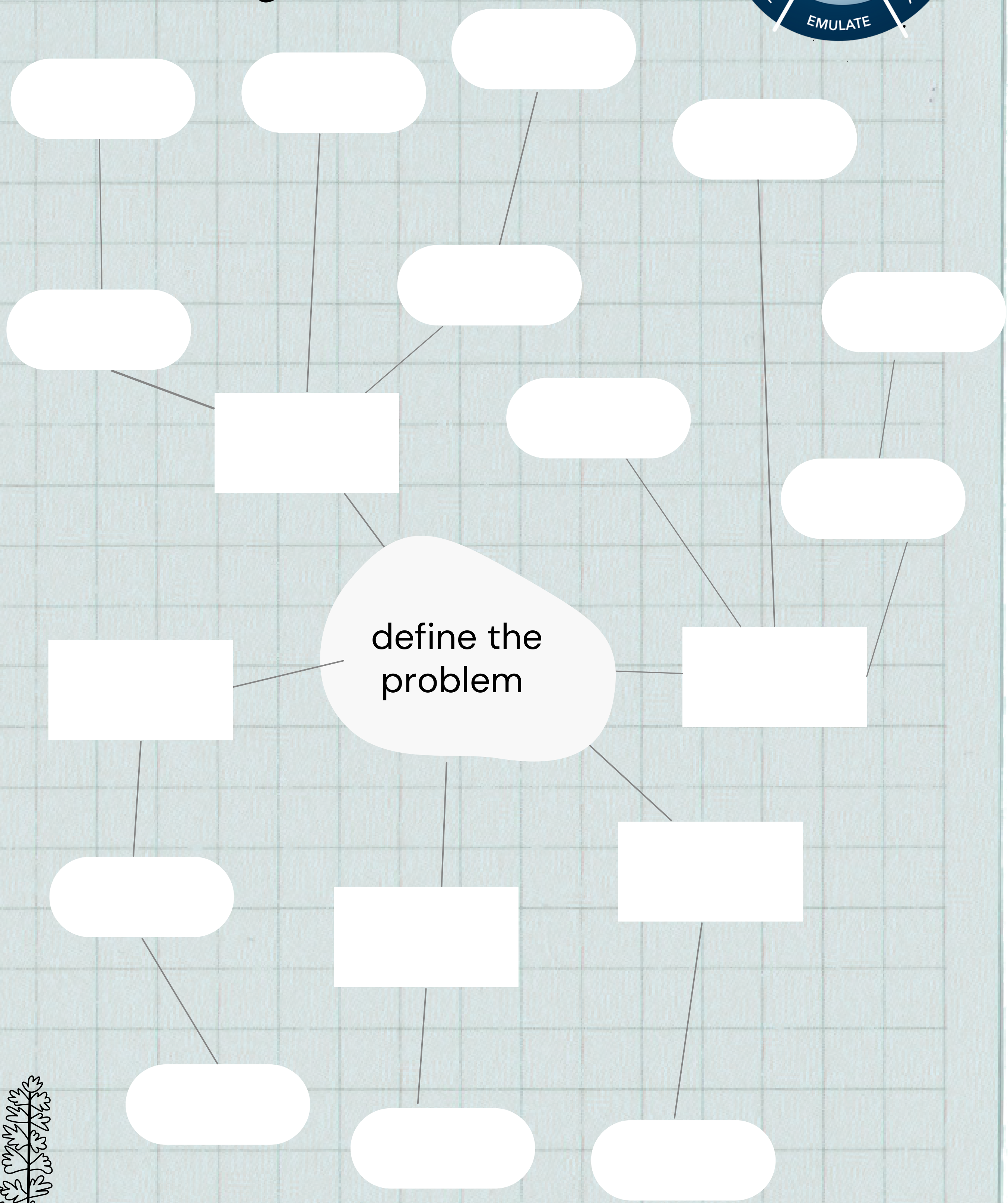
- How could you, as an engineer, mimic the material, color, shape, and structure of the flower to design something new? In the space below, sketch a new product or design.

- What scientific concepts that you have learned about before relate to your object?

https://www.teachengineering.org/content/cub_/activities/cub_lifescience/cub_lifescience_lesson03_activity2_worksheet_tedl.pdf

Map Your Idea





Pine cone strategy

Pine cones protect seeds throughout maturation. Pine cone scales are composed of two different layers of the same material with varying orientation that controls a varying response to moisture. One layer is composed of long tissues that expand longitudinally under conditions of high humidity. The second layer expands at a much slower rate. During fall when humidity levels drop, one orientation dries faster than the other, causing the individual scales of the pine cone to bend out, thus exposing the seeds for dispersal.

Function

Varying response of layered materials controls shape

Challenge Ideas

Manipulate orientation to yield varying responses in single materials.
Leverage ambient conditions to control the right time opening.
Use layers to affect material response to stimuli over time.

Decideous trees strategy

As days get shorter and colder and drier, deciduous trees prepare for dormancy. These trees begin to reclaim highly valuable, scarce elements like nitrogen (a key component of green chlorophyll) from their leaves, before shedding them for the winter. The chlorophyll is reabsorbed back into the branches for use in new spring leaves. The reds, oranges, and yellows revealed in the brightly colored autumn leaves are made of more readily available elements (e.g. carbon, hydrogen, oxygen), which can easily be taken from the soil in the spring.

Function

Selective release of valuable resources saves energy

Challenge Ideas

Design for easy retrieval of high-value resources.
Use strategic timing to lower resource costs.
Differentiate reclamation strategies based on value.

Spine strategy

Spines are derived from leaves (either the entire leaf or some part of the leaf that has vascular bundles inside, like the petiole or a stipule) and prickles are derived from epidermis tissue (so that they can be found anywhere on the plant and do not have vascular bundles inside. Thorns, spines, and prickles, and in general spinose structures (sometimes called spinose teeth or spinose apical processes), are hard, rigid extensions or modifications of leaves, roots, stems or buds with sharp, stiff ends, and generally serve the same function: physically deterring animals from eating the plant material.

Function

Physically deterring animals from eating the plant material

Challenge Ideas

Use the strategy for saving water.
Change its shape and material.
Find another defense system.