Learning from Nature: A Course in Biomimicry

An open-source curriculum by Sustainability Leaders Network designed to strengthen and inform the biomimicry movement among educators and learners locally and around the world.

> *The more our world functions like the natural world, the more likely we are to endure on this home that is ours, but not ours alone.* - Janine Benyus, leading biomimicry scholar

What is biomimicry?
Biomimicry is a growing discipline that studies nature's systems and then imitates these designs and processes to sustainably solve current challenges. Studying a leaf to invent a better solar cell is an example of biomimicry. Studying the intertwined complexities of a watershed to understand systems thinking is another. While biomimicry may be an emerging discipline in western culture, it is preceded by the practice of biomimicry embedded in many indigenous cultures.

Why teach biomimicry?
Using biomimicry, you can help expose your students to new ways of knowing and loving the natural world of their home. An overarching goal is to contribute to a shift in mindset – from seeing nature as something to exploit for short-term human benefit – to seeing nature as an invaluable teacher and model. This shift can help us understand how to regenerate natural resources, organize our societies, and live lightly on the Earth.

About this curriculum
This course offers an introduction to biomimicry and how to learn from nature. With an emphasis on getting outside and exploring the land around you, the biomimicry curriculum that we have designed, tested, and refined focuses on observing, appreciating and learning from nature and natural systems in your locality. Cognizant of the ways in which consumption and population growth have degraded our environment, we focus on positive solutions learned from nature and ways to take meaningful action.

> *I know all of the statistics of destruction, but I have chosen to come to this out of love, because I love this place. And I want to stay here. I want to stay home.* - Janine Benyus

Course goals
Through this course, teachers and learners alike will:

1. Become knowledgeable and enthusiastic about biomimicry.
2. Get outside and strengthen relationships with the local environment.
3. Learn to better recognize, observe, and think creatively about processes and systems in nature.
4. Shift to see nature not as something to exploit, but as a teacher and model.
5. Collaborate with nature to devise and apply practical solutions to current challenges.

Course reading

- *Biomimicry: Innovation Inspired by Nature* by Janine Benyus
- *Dancing with Systems* by Donella Meadows

- Additional short articles, resources, and websites as assigned

Course outline
Depending on your students, outdoor conditions, and your time availability, select from among the following class sessions. Each session is intended to be approximately two hours long and activity times are estimates.

All curriculum materials are provided on our website, http://www.sustainabilityleadersnetwork.org/2013/03/biomimicry-curriculum/, and include:

- Learning from Nature: A Course in Biomimicry, Teacher's Curriculum
- Day 1 Slides on Biomimicry
- Day 2 Biomimicry Taxonomy
- Day 2 Course Outline for Students
- Day 3 Slides on Systems Thinking
- Day 9 Living Machine Handout

Using our curriculum and providing feedback
Our curriculum is flexible in terms of content and order, encouraging adaptation to local surroundings and realities, and getting students outside as much as possible. With minor adjustments, it can be made appropriate for a learner of nearly any age, including teenagers, university students, and adults. Our pilot course was taught to 9th and 10th grade students at The Sharon Academy in Vermont. This curriculum may only be used for not-for-profit, educational purposes.

When using the course, please credit the Sustainability Leaders Network and let us know of your successes and challenges and how many students you have worked with, either through a comment at the bottom of this page: http://www.sustainabilityleadersnetwork.org/2013/03/biomimicry-curriculum/ or by writing to us: info [at] sustainabilityleadersnetwork [dot] org. We are very open to feedback on the curriculum and, like nature, are always seeking to evolve.

General Preparations
Each class outline lists specific preparations for that particular day. Here are some things you might want to consider doing before the course starts:

- Secure a *Biomimicry* book by Janine Benyus for each student
- If you have not done so before, read the book to familiarize yourself further with the topic
- If you have no or very little familiarity with biomimicry, consider taking one of Biomimicry 3.8's online courses: http://biomimicry.net/educating/online-courses/
    - Introduction to Biomimicry Foundational Course
    - Introduction to Biomimicry for Youth Educators
- Start planning one or two field trips; see examples, below

Course Assumptions

- Students have an "outside" place to explore. This could range from school grounds, nearby woods, a streambed, a park, or a green space in an urban setting
- An indoor classroom setting, equipped with a computer, beamer/projector, and Internet access
    - Alternatively, slides could be printed out and shared for the first and third class

Field Trip Examples
Field trips are highly localized experiences that can help reinforce the goals of this course. Classes 7 and 9 are examples of field trips we took in Vermont, linking them back to overarching biomimicry themes.

- We learned about processes, systems, and technologies on a farm that relate directly back to nature (visit to Luna Bleu Farm: A Focus on Food).
- We also visited a high tech "living machine" designed to clean waste water with plants and use geothermal energy to heat a building (visit to Sharon, Vermont Route 89 highway rest stop's Living Machine: A Focus on Waste and Energy).

We encourage you to organize one or two field trips that relate to specific chapters in the *Biomimicry* book and integrate these at appropriate places in the course. Additional examples could include:

- Visit a LEED certified building on your campus or in your city to talk with architects or owners about how nature may have inspired the design
- Meet with representatives of the urban planning commission in your city to learn about if/how they take nature into account in their planning
- Tour a drinking water reservoir and/or waste water treatment facility to get a full understanding of your local, domestic water system
- Visit a building or structure that was designed with the inspiration of nature; for example, if you happen to be in Barcelona, Spain, visit anything designed by Gaudi, like the Sagrada Familia

Rain Plan
Depending on where you live, it will likely rain on a day when you had planned to go outside with students. Here are two options to consider:

a) Wear rain jackets and go outside anyway. There is a lot to be learned from your local environment when it is responding to rain.

b) Watch segments of the film *Animals are Beautiful People.* The film provides an excellent view into a rich, diverse ecosystem. Encourage students to take notes in their journals during the film segment, followed by a group discussion. Questions to consider include:

- Observe carefully the ecosystems, animals, insects and birds with a biomimic's eye. Note how each moves, what building designs they make, what special adaptations they have.
- Which adaptation designs seem useful to you? How can they be applied to solve current societal challenges? Take notes on skills and adaptations that you think could be used to design something.
- What animal, insect, bird, ecosystem, etc. speaks to you personally? Which can you learn from to develop your own skills?

Acknowledgements and Credits

A great deal of thanks is due to Janine Benyus, Dayna Baumeister, and the staff at Biomimicry 3.8 who have built a rich foundation from which courses like ours can grow. We are grateful to administrators and students at The Sharon Academy who supported and participated in our pilot teaching of this semester-long course. Their feedback was valuable in refining the curriculum that we share here.

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Edie Farwell and Dominic Stucker designed the original curriculum, Edie taught the course at The Sharon Academy in autumn 2012, and Dominic Stucker and Alex Bauermeister further developed the course for publication.

1
Cluster: Introduction to Biomimicry and Systems
Class: Introduction to One Another and Biomimicry

Preparation

- Review "Day 1 Slides on Biomimicry" adapted from Biomimicry Institute: http://www.sustainabilityleadersnetwork.org/2013/03/biomimicry-curriculum/
- Print out presentation script, below
- Prepare computer and beamer
- Prepare Hurricane Irene video or comparable video from your own region:
    - You are more than welcome to pick a different video from your region that illustrates how nature responds in effective ways to disasters or other challenges. Be sure that the video can be used to answer the question: "What can we learn from nature about [a particular local challenge]?" Examples might include mangroves protecting against flooding, wetlands purifying water supply, regeneration of an ecosystem after naturally occurring forest fires, etc.

Goals

- Get to know one another
- Understand logistics of course
- Gain exposure to the concept of biomimicry

Outline

00:00 Name Game

- Please tell us your name
- And, if you could be a type of plant, animal, or ecosystem, which one would you be, and why?

00:10 Brief Course Overview

- This class will give an introduction to biomimicry and how to learn from nature. There will be an emphasis on getting outside and exploring the land around us from a biomimicry perspective.
- Biomimicry is a growing discipline that studies nature's systems and then imitates these designs and processes to sustainably solve current challenges. Studying a leaf to invent a better solar cell is an example of biomimicry.
- While biomimicry may be an emerging discipline in western culture, it is preceded by the practice of biomimicry embedded in many indigenous cultures.
- In addition to several short articles, we will read the book *Biomimicry* by Janine Benyus.
- Discuss grading system, if any

00:15 Course Logistics

- Share with students how they can get a copy of *Biomimicry*.
- Be sure to bring outside clothes and shoes (including rain gear) for each class
- Bring a journal and pen/pencil to each class
- We will also be taking one or two field trips

0:20 Hurricane Irene video: What Went Right?

- This video (11 minutes) demonstrates the valuable flood protection services provided by wetlands in a river basin.
    - "The Connecticut River Watershed Council and The Conservation Law Foundation have joined together to step back to look at why Otter Creek in

Rutland, [Vermont] leapt up as Irene struck, increasing in flow by nearly 20 times in the space of a little more than a day, while downstream in Middlebury, [Vermont] the river rose much more gradually, and more safely. The film is narrated by Gov. Howard Dean."
http://www.youtube.com/watch?feature=player_embedded&v=ucb-Y8iipng

Video Discussion

- What kind of impacts did the Hurricane Irene flooding have along Otter Creek in Vermont?
- Why did the river rise dramatically in Rutland, while rising only gradually downstream in Middlebury?
- Based on this video, what can we learn from nature about flood management?

00:50 Break

01:00 Give presentation adapted from Biomimicry Institute: "Day 1 Slides on Biomimicry," encouraging students to engage actively throughout.

Suggested Slide Script
Slide 1
Today we're going to be talking about biomimicry.

Slide 2
We are going to start with the kind of houses that animals, birds, insects, etc live in.

We live in an environment that we humans built around ourselves. Much like these other species here that also build homes for themselves. [Briefly explain each picture: shell as a home, termite mound, woodpecker's home in tree, ant colony].

Slide 3
Our home is complicated and full of different things like homes, factories, offices, roadways, telephones, schools, etc. These are the things which comprise our built environment. We generally don't think too much about this. We take our environment for granted. But the world is a lot more interesting when you look around and realize that all of this [gesture around classroom] is *created*, by us, for us.

Slide 4
Today we're going to talk about where the things in our world come from. A pencil, for example, can you tell me where it comes from? [From a manufacturing plant, transported to stores, made of natural resources like wood from trees and graphic which is mined]. Okay, so that's where the physical object comes from, but what about the *idea* for a pencil? Where does *that* come from?

Slide 5
Where do the ideas come from that people use to fashion all of the objects in our built environment? Like all of these things here. Where did the idea for how to make a bicycle come from? Or a house? Do you have any ideas?

Well, people come up with these ideas. Architects design buildings, right? Engineers design bridges, etc. We can call these people designers. They design what's in our world, how it looks, and how it works.

Slide 6
Designers get their ideas from lots of places. From own minds, from talking with other people, from doing research on the computer, or from reading books, or doing experiments, and so forth.

Slide 7
We also get our ideas of what to design from nature.

Slide 8
What if we learned to make tape, for example, from geckos? Geckos are lizards that can crawl up any surface, even smooth glass…

Slide 9
… because of the unique structure of their toe pads.

Slide 10
Or what if we learned to clean things like leaves do? Have you ever noticed how things in nature are often so clean? You don't see anyone out there dusting off the trees! How do they do it? In the case of this leaf, the lotus plant…

Slide 11
…the surface of the leaf has tiny, tiny bumps on it that you can't even see with the naked eye. The bumps cause water to ball up, and the balls of water slide along the leaf pulling off dirt particles as they go.

Slide 12
Or what if we learned how to pump water like a tree? Trees move water straight up for over a hundred feet, and they use no pumps. How do they do it? We could save a lot of energy if we could learn to do that!

Slide 13
It turns out Nature is FULL of good ideas for how to do things. After all, when you think about it, the other species on this planet have had to learn to do many of the same things that we humans have to do – find energy, move things from one place to another, store things, communicate with one another, make materials and fibers, etc. And nature has been doing all of these things for a LONG time. So it's really good at doing all of these things. For example spider silk [point out lower right photo] is 5 times stronger than steel given its size. Humans still can't build anything that strong!

Getting ideas from nature about how to make things is called "biomimicry."

Slide 14
Biomimicry has two parts, "bio," which means "life"… so biology is "the study of life"… and "mimicry", or mimic, which means to copy or an even better word is "emulate"…

As we will see in the main book for this course, *Biomimicry*, by Janine Benyus, the majority of indigenous cultures long ago embraced the concept of biomimicry. On page 3 of the Introduction chapter, Janine writes: "Virtually all native cultures that have survived without fouling their nests have acknowledged that nature knows best, and have had the humility to ask the bears and wolves and ravens and redwoods for guidance."

Slide 15
Using biomimicry, people have learned from beetles how to collect water even in dry places like deserts, like this Namibian beetle does.

Slide 16
They've learned from the lotus leaf how to make self-cleaning paint, so that buildings don't have to be cleaned anymore because the rain does it for free.

Slide 17
They've learned from termites and termite mounds how to keep buildings cool in the summer without using expensive air conditioning systems…

Slide 18
And they've learned from sharks how to create boats that glide through the water more smoothly, using less energy… and to make swim suits used in the Olympics that have less friction.

Slide 19
So, what does this mean to you?

Slide 20
The sky's the limit, for example imagine: shoe soles that grip like a mountain goat; t-shirts that wick sweat like a horned lizard; fasteners that stick like burrs; and vitamins based on the diet of forest apes.

Slide 21
Clothing colored without dyes like a butterfly, peacock, or sea slug

Slide 22
Sandwich bags that biodegrade like tethers of blue mussel and zip closed like a feather

Slide 23
Computer screens that create color the same way as butterfly wings; computers as fast as neurons; and systems interconnected like trees in a old-growth forest

Slide 24
And we can do all of this using manufacturing methods that are much more environmentally-friendly than the way we generally build our world today. Because not only can we get good ideas from nature of *what* to make, we can also learn how to make these things sustainably, renewably, and with recycled materials, the way nature does it.

Slide 25
So what possibilities can you imagine? What creatures will inspire you to think of things to create, or new ways to create them?

Slide 26
Can you look to nature for inspiration?

Slide 27
Here are some ways to start:

- Get outside, take a hike!

- Sit quietly outside and observe
- Read books about the natural world
- Ask questions in science class
- Research your favorite creature and all its cool functions

Through this class, you'll have opportunities to do many of the above, and I encourage you to pursue these activities on your own, too.

Slide 28
Never stop asking *why* and *how* about both the natural and built world around you. Remember, it's your future that's being created. You can be a part of it. Biomimicry is one tool that you can use to help make that future better!

1:40 Journaling
In your journal, please write about the following and be prepared to share with the class:
- Name a plant, animal, or ecosystem that impresses you with a certain quality or ability.
- Why does this plant, animal, or ecosystem impress you?
- If you have time, draw your selected plant, animal or ecosystem.

1:50 Discussion
- Share your plant, animal, or ecosystem with the class.

2:00 Closing: Homework
- Distribute a copy of *Biomimicry* by Janine Benyus to each student
- Browse the biomimicry case studies at Ask Nature: www.asknature.org/aof/browse

2
Cluster: Introduction to Biomimicry and Systems
Class: What is Biomimicry?

Preparation

- Print a copy for each student of the following:
  - "Day 2 Biomimicry Taxonomy" and "Day 2 Course Outline for Students" at: http://www.sustainabilityleadersnetwork.org/2013/03/biomimicry-curriculum/
  - *Dancing with Systems* article at http://www.sustainer.org/pubs/Dancing.html
- Place 8 sticky notes on each student's desk/chair
- If you only have 1 computer in the classroom, pre-select 3-4 case studies from Ask Nature for discussion in class: www.asknature.org/aof/browse

Goals

- Explore the variety of functions that plants, animals and ecosystems perform
- Discuss the importance of applying biomimicry now
- Become familiar with course overview and goals

Outline

00:00 Biomimicry Taxonomy

- Using the distributed sticky notes, students write down a verb or phrase on each one, answering the question: "What are some of the things that plants, animals, and ecosystems do?"
- When finished, students stick the sticky notes to the board or a wall, arranging them into clusters of similar actions.
- Review all the clusters together to check for consistency and to see if anything is missing.
- Add any missing actions on new sticky notes.
- Now, distribute the "Day 2 Biomimicry Taxonomy" handout and give students a chance to look at the various groups, sub-groups, and functions listed.
- Ask students to compare their groupings to the Biomimicry Taxonomy.
  - What additional ideas does the Taxonomy offer?
  - Which ideas from students do not appear in the taxonomy?
  - Where is there similarity and overlap?

00:15 Ask Nature Case Studies

- Now, drawing on the Biomimicry Taxonomy, supplemented with the clusters generated by students, explore further biomimicry case studies using the Ask Nature database.
- Biomimicry case studies often consist of three parts:
  - Plant or animal's function that is being mimicked
  - Inspirational story from the plant or animal
  - The "sustainability win" that demonstrates the innovation is consistent with natural principles

- If only one computer is available, please use your 3-4 pre-selected case studies to lead a class-wide discussion that mimics the following.

- OR ask students to form groups of 2-3, based on how many computers are available.
  - Looking for the above case study parts, ask students to read about and take notes on two to three cases in the Ask Nature database.

- Notice that it is organized according to the Biomimicry Taxonomy: www.asknature.org/aof/browse

00:25 Ask Nature Discussion
Ask each group to share 1-2 examples with the class, indicating the function, inspiration, and "sustainability win" for each.

00:35 Break. Ask students to get ready to go outside.

00:45 Go outside! Bring journals and pens.
- Remind students of Janine Benyus' definition of biomimicry:
  - Biomimicry (from *bios*, meaning life, and *mimesis*, meaning to imitate) - the science and art of studying nature's best ideas and then imitating these designs and processes to solve human problems.
- Find additional examples of plants and animals on the school grounds and/or local environment from which to learn. For each example, ask students to answer:
  - What form or function might we mimic?
  - How does the plant, animal, or ecosystem inspire us?
  - In applying potential innovations inspired by the plant, animal, or ecosystem, what sustainability wins do we gain?
  - Some students may also like to draw the plant or animal being discussed.

1:30 Return to classroom OR gather outside to share examples of biomimicry case studies found by students.
- Based on the cases studies students have seen today and during the last class, carry the discussion on with these questions:
  - Why is it important to study biomimicry?x
  - Why is it important to practice biomimicry now?
  - What attracted you to taking this course on biomimicry?
- End with this quote:
  - "The more our world functions like the natural world, the more likely we are to endure on this home that is ours, but not ours alone." - Janine Benyus

1:45 Hand-out "Day 2 Course Outline for Students" to each student and review.

1:55 Homework
- As preparation for our next class on "What is a system?" please read *Dancing with Systems* article by Donella Meadows.
  - Hand out a copy of the article to each student.

3
Cluster: Introduction to Biomimicry and Systems
Class: What is a System?

Preparation

- Review "Day 3 Slides on Systems Thinking:" http://www.sustainabilityleadersnetwork.org/2013/03/biomimicry-curriculum/
- Print presentation script, below
- Prepare computer and beamer

Goals

- Explore the basics of systems thinking
- Get outside and observe natural systems

Outline

00:00 Present slideshow: "Day 3 Slides on Systems Thinking" and interspersed discussions

Slide 1: Introduction slide

Slide 2: Goals for today

- Explore the basics of systems thinking
- Get outside and observe natural systems

Slide 3: Dancing with Systems Discussion

- Donella Meadows article lists 14 principles or guidelines for engaging in complex systems
- Which ones resonated most with you? Why?
- Which ones do you do well? Examples?
- Which ones do you want to do better?

00:20 Slide 4: Systems thinking is the capacity to understand and change complex systems.

- Draw a linear line from A→ B on the board, then draw a curved line from B back to A.
    - Part of systems thinking recognizes that not only does A impact B, but B impacts A.
    - For example: if you and your neighbor are both throwing parties on Friday night, they might turn up their music, which might cause you to turn up your music, which might cause them to turn up their music… until the police arrive.
    - Another example that might escalate in the same way is gang violence, pitting one group against another in a relationship of revenge.
    - A balancing example might be when a neighborhood is seen to be very desirable for living (cost of housing is low, there is little traffic, it is not overcrowded), more people will move there, increasing the cost of housing, traffic, and making it more overcrowded, ultimately make is less desirable to live there.
    - Good news stories may inspire more good news stories because hearing one good news story might inspire people to take similar actions, content for more good news stories.q
- Ask students for additional examples of complex systems. These might include climate change, poverty, hate crimes, systems in their school and natural systems, etc.

Slide 5: A system is an interconnected set of elements that is coherently organized in a way that achieves something.

- A system must consist of three kinds of things:
    - elements, interconnections and function or purpose.
    - Some examples include a school soccer or basketball team, theater students and their performance, a whole university, a farm.

Interactive Game and Debrief Discussion

Play "Triangles" game, adapted from The Systems Thinking Playbook by Linda Booth Sweeney and Dennis Meadows (1995). This adaptation helps to demonstrate the interconnections in a system, how change in one part of the system influences other parts. Follow these steps:

1) Go outside or clear a space sufficient for all students to move about freely. This may mean moving chairs and desks to the walls of the room.
2) Ask students to stand in a circle in the middle of the room, ideally with an arm's distance or more between them.
3) Ask each person to pick two other reference people from among the group. They can keep this information to themselves.
4) Explain that the group is forming a simple system. The elements are the students, the interconnections have to do with the two reference people each person chose, and the purpose of the system is to come to rest.
5) Now, the goal for each student is, after you say "Go!" to move through the room until they are an equal distance from both of their reference people. This could mean that they are close to both or far away from both, but the distance to each should be equal.
6) With two volunteers, demonstrate what it looks like for you to be equal distance from them both. Ask one of them to move and then respond accordingly, moving yourself so that you remain equidistant from both.
7) Step out of the circle, ask students to remember their two reference people and the goal of being equidistance from them, and say "Go!"
8) What typically ensues is much initial movement, slowing to stasis.
9) You might choose to repeat this exercise a couple of times so that students can 'feel' interdependence in a system. Once everyone has come to stasis, you can also move an individual across the room, asking everyone else to respond accordingly.
10) Lead a short debrief discussion, asking questions like:
    a. How did that feel for you?
    b. What did you notice happened to our group/system over time?
    c. What happened when I moved just one person/element of the system?
    d. What might this exercise have to do with biomimicry?

00:50 Slide 6: Components of a System

- The elements, the material "stuff" – often the most visible, tangible part - people, trees, water, buildings, highways, cars, etc.
- The interconnections, the flows of information that connects the "stuff" – laws, rules, beliefs, decision making processes, cause and effect relationships, etc.
    - The price of gasoline, the advertising that promotes this year's new model of automobile, the word of mouth about the performance of the new model, the interest rate, the traffic congestion, the level of concern about climate change, the impact on trees of air pollution
- Systems are usually embedded in larger systems and contain sub-systems within themselves

Slide 7: Blind men and elephant. Systems thinking helps us see the larger picture.

Slide 8: Benefits of Systems Thinking

- Promotes exploration of assumptions
- Helps strategizing about leverage, places to intervene to 'steer' or 'dance with' the systems we participate in
- Helps show the similarities between seemingly different systems, so that learning about one can inform responses in another
- Can be taken to the level of computer simulation when complexity increases beyond what our minds can 'simulate'

Slide 9: Trying to Grasp and Describe Principles of our Experience

- Systems thinking is one subculture's effort to uncover underlying principles of the way nature works and to understand, respect and operate by them.
- Every culture and period has had to grapple with the realities of complex systems. The resulting tales, stories, practices, art works, songs, etc. are all examples of systems thinking.

01:00 Break, get ready to go outside

01:10 Go outside and identify and observe three systems in nature that have elements, interconnection, and function.

- Record in your journal the components of the three systems
- Why did you choose them?

01:40 Return inside OR pick a place outside for discussion

- Ask students to share some of the systems they observed, plus their components
- What are the interconnections in these systems?
- How would changing one part affect the rest?

01:55 Homework: Respond to these questions in your journals:

- What systems are you a part of?
- What systems can you change?
- What would a biomimicry-inspired approach to systems change look like?
- What might be some of the core principles or guidelines of this biomimicry approach?

4
Cluster: Introduction to Biomimicry and Systems
Class: A Biomimicry Approach to Change

Preparation

- Bring in art supplies for students to decorate their journals
- Prepare Janine Benyus TED Talk, "Biomimicry in Action, "for viewing: http://www.youtube.com/watch?v=k_GFq12w5WU&feature=relmfu
- Ensure that each student has access to Janine Benyus' book, *Biomimicry*
- Bring in a beach ball for Moon Ball systems game

Goals

- Practice identifying parts of systems
- Explore biomimicry principles for changing systems
- Apply a biomimicry approach to personal challenges and improvement of skills

Outline

00:00 Discuss Homework and Last Class

From students' journals**:**

- What systems are you a part of?
- What systems can you change?
- What would a biomimicry-inspired approach to systems change look like?
- What might be some of the core principles or guidelines of this biomimicry approach?
- Any other reflections from last class?

00:15 Practice with Systems

- Ask students to think of three systems from a local river or stream.
    - What are the elements of each system?
    - How are the elements interconnected?
    - What is the overall purpose or function of the system?

00:25 Video and Designing Journals

- Watch this TED Talk on "Biomimicry in Action" by Janine Benyus. The video is 20:15 long.
    - http://www.youtube.com/watch?v=k_GFq12w5WU&feature=relmfu
- While watching, decorate journals with pictures and/or drawings of animals, plants, insects, ecosystems, etc. that inspire or interest you.
- Also write down any additional principles of a biomimicry-inspired approach to design and change that Janine mentions.

00:50 Biomimicry and Personal Change

Now what would it look like to apply biomimicry to your personal challenges and interests?

- Discuss students' challenges or personal skills that nature can help solve or improve.
- Write each challenge or skill on the board, surrounded by related lessons from nature.
- A couple of examples include:
    - Someone who is the goalie on the soccer team wants to emulate a grizzly bear to improve her or his performance.
    - Someone who loves tree climbing and asks herself or himself the question "What parts of nature can I observe to be an even better tree climber?"

01:10 Go Outside to Play Moon Ball!

- Play this systems thinking and team learning game adapted from *The Systems Thinking Playbook* by Linda Booth Sweeney and Dennis Meadows. The purpose is to have fun while problem-solving together, and to reflect on learning as a team.
- This game works best with 10-15 people, but can be conducted with 8-30 people. If your group is large, consider dividing them into smaller groups.
- Holding the beach ball you brought, gather everyone into a circle and explain the rules:
    - Your goal as a group is to hit the ball as many times as possible in a two-minute span, while keeping it in the air. Show them how to hit the ball: move your arm in an upward arc and hit the ball with the palm of your hand, like a volleyball.
    - You will have a total of three attempts, with a 2-minute planning period before each attempt.
    - When it is your turn, you may only hit the ball once and you can only use your hands.
    - You cannot hit the ball again until everyone else has hit the ball one time.
    - Your score drops to zero if the ball hits the ground or if someone hits the ball again before everyone else has hit it.

- If students have no questions, start timing their first 2-minute planning session, followed by their first 2-minute attempt. Count their score out load for them or together.
- Allow for two more rounds of planning and implementation.
- Debrief the exercise:
    - Ask students to tell the story of what happened from the first to the last attempt.
    - Discuss two important variables: team learning and team performance. Did increased (or decreased) team learning reflect in their scores?
    - What were the challenges of this activity? What strengths did your group have?
    - What are the lessons you can learn from this activity about group learning processes?

01:30 Observation

Nature has been learning and adapting for 3.8 billion years.

- Ask students to find, observe and journal about:
    - An insect, a plant, a tree, and/or a bird
- How do these animals and plants interact with and change their surroundings?
- What general principles for biomimicry-inspired change can you observe in their behaviors?

01:55 Closure and Homework

- Reflect further and continue writing in your journal about your insect, plant, tree, and/or bird.
- Read Chapter 1 in *Biomimicry*, Echoing Nature

5
Cluster: Innovation Inspired By Nature
Class: Seeing Patterns and Systems in Nature: A Focus on Shelters

Preparation

- Read Chapter 1 in *Biomimicry*
- Buy or check out the book *Design Like you Give a Damn* by Architecture for Humanity: http://designlikeyougiveadamn.architectureforhumanity.org/

Goals

- Practice identifying parts of systems
- Explore biomimicry through natural shelters
- Gain experience in looking to nature for solutions

Outline

00:00 Goals for Today

- Practice identifying parts of systems
- Explore biomimicry through natural shelters
- Look to nature for solutions

00:05 Discuss Homework Reading: Chapter 1 from *Biomimicry*

Ask students:

- What did you learn from the reading?
- What new insights came up for you?
- What questions do you have about the reading?
- What are some examples of systems that were discussed in Chapter 1?

00:25 Practice with Systems

Ask students (in small groups or pairs) to write down the three components of systems they read about in Chapter 1:

- Elements
- Interconnections
- Purpose or function

Ask them to share examples of systems, indicating these three components, with the whole class.

00:40 Shelter Designs

Browse and discuss shelter designs in the *Design Like You Give a Damn* book.

- Looking at the shelters like a system, what are their elements, interconnections, and purpose?
- Brainstorm shelters and houses you may find outside of your building.

01:00 Break and get ready to go outside with journals

01:10 Go Outside in Search of Shelters, imitate nature when building a shelter

- Find and observe houses, nests, and other shelters
- Examine the structure and materials
- Take notes and draw shelters
- Alone or in pairs, start to build a shelter based on how an animal, bird or insect designs its shelter

- Students should know that they will be coming back to their shelter in the next class and should choose where and what they build accordingly.

01:45 Discussion Outside

- How much of your schooling to date has you looking to nature?
- What do you think about the idea of looking to nature for (design) solutions?

01:55 Closure and Homework

- Homework: read pages 129-139, “Along Came a Spider,” in *Biomimicry* Chapter 4: How Will We Make Things

6
Cluster: Innovation Inspired By Nature
Class: Completing Shelters

Preparation

- Preview selected videos and slideshows:
  - Garden Spider: http://www.arkive.org/garden-spider/araneus-diadematus/video-00.html
  - Living Bridges in India: http://www.snotr.com/video/7331/The_Living_Bridge
  - Buy or check out a copy of the film *Animals are Beautiful People* or stream it here: http://www.youtube.com/movie/animals-are-beautiful-people

Goals

- Collaborate with nature to devise and apply practical solutions to current challenges
- Complete shelters

Outline

00:00 Goals for Today

Review the goals of the course, emphasizing the final one as a focus for the day

1. Become knowledgeable and enthusiastic about biomimicry.
2. Get outside and strengthen relationships with the local environment.
3. Learn to better recognize, observe, and think creatively about processes and systems in nature.
4. Shift to see nature not as something to exploit, but as a teacher and model.
5. Collaborate with nature to devise and apply practical solutions to current challenges.

00:00 Discuss Homework

Discuss pages 129-139, "Along Came a Spider," in *Biomimicry* Chapter 4: How Will We Make Things?

00:10 Expand on Spiders

Watch 2-minute video from ARKive on the Garden Spider: http://www.arkive.org/garden-spider/araneus-diadematus/video-00.html

Watch 5-minute video on living bridges in India, an application of biomimicry, integrated with nature: http://www.snotr.com/video/7331/The_Living_Bridge

Give students an opportunity to ask questions and respond to the videos.

- What challenges do spiders address by building webs?
- What challenges do the living bridges address?
- How might these and other innovations from nature inform how we build homes, office buildings, towns, cities, and transportation infrastructure?

00:20 Applying Biomimicry and Systems Thinking to Current Challenges

Brainstorm current challenges or issues with students in your school, organization, town, state, or country. Challenges could also be personal, relating to students, or groups of students.

- Record these on the left side of the board

Now ask students how they can look to innovation and principles in nature for solving these challenges.

- Record these on the right side of the board for related challenges

00:50 Animals are Beautiful People
Watch 15 minutes of the film *Animals are Beautiful People*, an excellent view into a rich, diverse ecosystem.

In their journals, ask students to jot down responses to these topics while watching:

- **Observe** carefully the ecosystems, animals, insects and birds with a biomimic's eye. Note how each animal moves, how they design their shelters and what materials they use, and what special adaptations they have.
- Which are **useful designs** that we should know about? Can any be applied to solve current human challenges?
- Take notes on **skills and adaptations** that you could use or adapt.
- What animal, insect, bird, ecosystem, etc **speaks to you personally**? Which can you learn from to develop your own skills?

Does the homework reading and/or the videos give you any additional ideas for your shelter? Preview that students will have the opportunity to restore (in case they got damaged) and finish their shelters after the break.

01:10 Break and get ready to go outside to

01:20 Go Outside
Ask students to finish building their shelters based on how an animal, bird or insect might design their own shelter. In addition to staying warm and dry, can shelters perform other functions?

01:40 Tour Shelters
Take a walking tour of shelters, inviting students to point out parts of their shelter that take inspiration from the natural world, and what functions they serve.

01:55 Closure and Homework

- Ask students to read the rest of Chapter 2 from *Biomimicry*, How Will We Feed Ourselves?
- Preview field trip to farm and ask students to write down 3 systems and biomimicry-related questions to ask while there.

Optional if there is time in class or as homework: Rainforest Habitat
View up to 24 photo examples of inspiration from a Rainforest Habitat:

- http://www.asknature.org/strategy/highlight/Rainforest+habitat

7
Cluster: Field Trip Examples
Class: Field Trip to Luna Bleu Farm: A Focus on Food*

* Please see note on ideas for Field Trips at the beginning of this curriculum.

Preparation
- Organize field trip logistics in advance.
- Be sure to describe to farm hosts the overall aim of the course and how the farm tour fits in.

Description of Luna Bleu Farm, from their website: http://lunableufarm.org/

> *Luna Bleu is a diversified organic farm in central Vermont. We, Tim Sanford and Suzanne Long, have been farming on this land in South Royalton since 1993. Before that we farmed in South Strafford, VT and Lebanon, NH. Each year we are joined by a crew of hardworking apprentices and local employees and often our son and daughter, Lucas and Shona. Together we produce a wide variety of organic vegetables. We also raise cows, pigs and poultry organically. In the spring, many gardeners purchase healthy, organic plants from us. Summer is of course the peak harvest time and we bring an abundant farm harvest to farmers' markets and our CSA [Community Supported Agriculture] members. In the fall, we harvest and store a wide variety of root crops, onions, cabbages and garlic for our winter CSA and winter markets. We also begin planting again in our greenhouses for an exciting array of greens in the cold winter months. Always something going on at the farm!*

Goals
- See real-life applications of biomimicry and systems thinking in a farm setting.

Outline
On the Way to the Farm
Discuss Chapter 2 from *Biomimicry*, How Will We Feed Ourselves?
- Discuss possible applications in a farm setting like Luna Bleu

Goals for Today
- See real-life applications of biomimicry and systems thinking in a farm setting.

Farm Tour
Get 1-hour tour of the farm, including discussion of:
- aspects of the farm system, how it works, how organic vegetable farming and livestock interact
- the farm's seasonal rhythms, how the various parts relate over time
- how the land is used, taken care of, and planted for maximum vegetable production each year
- how Community Supported Agriculture (CSA) works

Student Questions
Students each ask one or more of the 3 questions they prepared for farmer that pertain to:
- how they use biomimicry for specific aspects of the farm operations
- farm systems
- environmental and financial sustainability

Journal

- Record observations and insights in journal throughout the tour.
- Record reflections on farming, food, biomimicry and systems at the end of the tour.

Homework

- Read Chapter 5 from *Biomimicry*, How Will We Heal Ourselves?

8
Cluster: Innovation Inspired By Nature
Class: A Focus on Healing Ourselves

Preparation

- Preview Ask Nature case studies, below
- Print out "Day 9 Living Machine Handout" for each student, available here: http://www.sustainabilityleadersnetwork.org/2013/03/biomimicry-curriculum/

Goals

- Explore how nature can help us cleanse and heal ourselves and our environment

Outline

00:00 Goals for today

- Explore how nature can help us cleanse and heal ourselves and our environment

Discuss homework

Ask students to discuss *Biomimicry* Chapter 5, How Will We Heal Ourselves.

- What were the main insights you had?
- Tell us in depth about your favorite part of the chapter.
- Based on our recent field trip, what are some of the links between farms, food, and healing?

00:15 Ask Nature: Pair or Small Group Work

a) If enough laptops and Internet access are available, divide students into 6 pairs or small groups. Ask each pair to learn about one of the following examples of healing in nature, prepare a short summary (timing will depend on class size), and present it to the class. Ask each pair/group to focus on how each example relates to healing.
b) OR If you have one computer, view these examples together, looking at each in terms of how animals and plants heal.

Self-medicating with plants: chimpanzees
http://www.asknature.org/strategy/f84d46736c03e235f6dfd1edd6b7e739

Eating leaves to control reproduction: chimpanzees
http://www.asknature.org/strategy/55dfb8f31c6cdfdeca3f5f142f105ecc

Sex of offspring controlled: mantled howler monkey
http://www.asknature.org/strategy/7a68cda4a65dfb9ec010303c532d5306

Self-medicating to prevent malaria: house sparrows
http://www.asknature.org/strategy/3f107336d5277e38989270036f296d51

Self-healing foams from plants
http://www.asknature.org/product/0cdb9af70b601cf77b5caf68cafa785c

Smart bandage
http://www.asknature.org/product/84b05783b105ac6f511cb22758a94d13#changeTab

00:45 Healing and Cleansing Organisms Related to Next Field Trip: Living Machine
As preparation for the next field trip to the Living Machine, review these examples of healing and cleansing organisms. (If you plan a somewhat different field trip, you may want to select a different set of examples from the Ask Nature case studies.)

Symbiosis enhances pollutant breakdown: plants and microbes
http://www.asknature.org/strategy/8ea24c1f1872710dbac52e986c6d24f6

Bill used to filter: roseate spoonbill
http://www.asknature.org/strategy/411b8ea9baba1fbf06c8c62dd9f62aa4

Non-toxic mosquito repellant
http://www.asknature.org/product/bac21d352d9da23796cee88d3a0d0a2b

01:00 Assign Homework
Ask students to:

- Read *Biomimicry* Chapter 3: How Will We Harness Energy?
- Read the "Day 9 Living Machine Handout"

Break and prepare to go outside

01:15 Go Outside
Based on the reading and discussion of *Biomimicry* Chapter 5, How Will We Heal Ourselves? and on the Ask Nature case studies:

- Observe plants, fungus, bark, leaves, etc.
- What looks like it may have been damaged? Degraded? Dried out? Water-logged?
- What looks like it might be healing?
- How would you go about seeing if they have healing properties?

While observing, record your observations and make drawings in your journal of plants.

- What properties do they have?
- What can you learn from them?
- Why and how might they be useful for healing?

01:50 Share Journal Drawings
Encourage students to informally share their plant drawings and observations with one another.

9
Cluster: Field Trip Examples
Class: Field Trip to the Living Machine Rest Area: A Focus on Cleansing and Energy *

* Please see note on ideas for Field Trips at the beginning of this curriculum.

Preparation
- Organize field trip logistics in advance.
- See a description of the rest area's green wastewater treatment system here: http://www.fhwa.dot.gov/publications/publicroads/00mayjun/vermont.cfm

Goals
- See real-life applications of biomimicry and systems thinking through technology.

Outline
On the Way to the Rest Area
Discuss homework reading: Chapter 3 from *Biomimicry* on How Will We Harness Energy?

1-hour Tour of the Living Machine
- Observe the Living Machine in detail and read all information boards
- Discuss use of plants, what student see, smell, don't smell
- Observe plants and ask what students are learning from them

Journal
Ask students to write about three things they learned during the field trip.

Discussion
Consider a Vermont marsh and its cleaning properties.
- What could the properties of a local marsh be used for?

Discuss how seeing the Living Machine in a rest area shows how such innovations are possible, and inspires creative thinking and courage to implement innovative solutions in other places.
- How might the Living Machine technology – or other healing and cleansing technologies – be applied elsewhere?

Homework
Read Chapter 6 in *Biomimicry*: How Will We Store What We Learn?

10
Cluster: Innovation Inspired by Nature
Class: A Focus on Storing Knowledge

Preparation

- Load Ask Nature case studies, below, on your computer's Internet browser
- Set up computer and beamer

Goals

- Explore how nature stores, organizes, and shares knowledge

Outline

00:00 Review

Ask students to tell you what biomimicry is and what they are learning.

Review goals of the course

1. Become knowledgeable and enthusiastic about biomimicry.
    a. Model: Biomimicry is a science that studies Nature's models and then emulates these forms, processes, systems, and strategies to solve human problems — sustainably.
    b. Mentor: Biomimicry is a particular way of viewing and valuing nature. It is a way of thinking that is based not on what we can extract from the natural world, but what we can learn from it. This is something that many indigenous cultures have valued and passed on from one generation to the next.
    c. Measure: Biomimicry uses an ecological standard to judge the sustainability of our innovations. After 3.8 billion years of evolution, nature has learned what works and what lasts.
2. Get outside and strengthen relationships with the local environment.
3. Learn to better recognize, observe, and think creatively about processes and systems in nature.
4. Shift to see nature not as something to exploit, but as a teacher and model.
5. Collaborate with nature to devise and apply practical solutions to current challenges.

00:15 Discuss Homework

Chapter 6 from *Biomimicry* book: How Will We Store What We Learn?

- What parts inspired you?
- What are one or two things you learned from the chapter?
- How is storing of information important in your life?

00:30 Extended Discussion: Ask Nature Case Studies

As a group, view and discuss the following Ask Nature web pages.

- How does each relate to storing knowledge?

Leaves convert photons to energy: spinach
http://www.asknature.org/strategy/fa8a4085cba2f9a0ff42cfc281b715d7

Cat Algorithms
http://www.asknature.org/product/f17a8c01ec9d55d8f4a9bff9d5de190d

Individuals share information: red harvester ant
http://www.asknature.org/strategy/900505c787a363fd59ee3bbdfd1fb9b5

Precursors to molecular wires build themselves
http://www.asknature.org/product/67f61c6b14229aca66fcb9d7ed0fb48f

00:50 Break and get ready to go outside

01:00 Go Outside
Look for parts of nature that can help computers perform better. In pairs or individually, ask students to practice observation, noticing details.

- Do you see any plants, insects, or ecosystems that store and organize information?
- Any that share information?
- How do these woods organize information?
- What information do these woods have that you can learn from?

Journal
While outside, ask students to record drawings, observations and findings in their journals.

01:35 Sharing and Discussion
Bring students back together to share some of their drawings and observations. Ask these overarching questions for further reflection:

- What does nature have to teach us about design and innovation?
- How can you apply these lessons to your own life?
- How can we apply these lessons to challenges that we face here at our school or in our community?

01:55 Assign Homework

- Read one section from *Biomimicry* Chapter 7: How Will We Conduct Business?
    - Rather than read the whole chapter, ask students to choose one section and read it thoroughly, preparing to share about insights during the next class
- Review the components of a system

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Cluster: Innovation Inspired by Nature
Class: A Focus on Conducting Business

Preparation

- Load Dayna Baumeister's video "Presenting at InnoTown" on your computer and set up projector: http://biomimicry.net/inspiring/videos/
- Load online Ask Nature case studies on your computer
- Set up computer and beamer

Goals

- Explore how nature can inspire product design and help us address challenges we face

Outline

00:00 Systems Review

Ask students to describe the three parts of a system (elements, interconnections/relationships, and function/purpose)

- Please give an example of a system you have seen in nature, describing its elements, relationships between the elements, and overall purpose.

As we discuss business today, bear in mind how a working person might take a biomimetic approach to leveraging systems for the "triple bottom line" of profit, people, and planet.

00:15 Discuss Homework

Invite students to share their insights from the section they read in *Biomimicry* Chapter 7: How Will We Conduct Business?

- Perhaps you've spent some time thinking about what kind of work you'd like to do (or already do).
- How might you apply concepts from biomimicry and systems thinking to the work you do or would like to do?

00:30 Examples of Mimicking Nature in Products

Starting at minute 22:40, watch 10-15 minutes of Co-Founder of the Biomimicry Institute, Dayna Baumeister, presenting at InnoTown Innovation Conference in 2011:
http://biomimicry.net/inspiring/videos/

- The examples are all products designed from nature's inspiration

00:45 Discussion on Challenges

- What is a current issue or challenge you might look to nature to solve?
- This can be personal challenge, an issue at school, something in the news, energy efficiency, conservation of water, etc.
- Where in nature would you look to solve it?

01:00 Break and get ready to go outside

01:10 Prep for Going Outside: Ask Nature Case Studies *

View up to 25 slides of Ask Nature case studies on strategies to stay warm here:
http://www.asknature.org/strategy/highlight/Stay+Warm

* If it is a hot time of year and plants and animals are trying to cool down, use these 24 case studies from Ask Nature on cooling down:

http://www.asknature.org/strategy/highlight/Cooling+Down

01:20 Go Outside **
Observe staying warm strategies in the environment around you:

- What strategies do animals and birds use to stay warm?
- How do plants and insects make it through the winter?
- What do ecosystems do to prepare for the winter?

** As above, adapt these observation questions from "staying warm" to "cooling down" if need be.

Journal
While outside, record observations in your journals as drawings and/or written notes.

- Also consider: What staying warm strategies could you use in the shelter that you built?

01:45 Share from Journal Observations

01:55 Assign Homework

- Read Chapter 8 in *Biomimicry* Where will we go from here? Towards a biomimetic future

12
Cluster: Being a Biomimic
Class: Creating with Nature and Being a Biomimic

Preparation

- Either draw on your own artistic skills for this session or consider inviting an artist to co-teach the class with you
- Check out Andy Goldsworthy book(s) from the library; if you do not have access to his books, browse some of his works here: http://www.goldsworthy.cc.gla.ac.uk/ and set up computer and beamer

Goals

- Consider what it means to be a biomimic
- Co-create a piece of art work with nature

Outline

00:00 Discuss Homework

Talk about *Biomimicry* Chapter 8: Where will we go from here? Toward a biomemetic future.

- The chapter starts with geese. Discuss their "v" leadership flying style.
- When did Janine become a biomimic?

00:15 Visiting Artist: Blythe Ostermann (or teach yourself)

- Share images of Andy Goldsworthy's works with students either in books or online: http://www.goldsworthy.cc.gla.ac.uk/
- Notice and discuss form, color, and texture in his pieces

00:30 Go Outside: Creating with Nature

- On your own or in pairs, find a place in the woods that inspires you
- Sit there and observe the patterns, systems, and other aspects of nature all around you
- Attuned to those patterns and processes, co-create an art piece with nature using found materials

01:20 Visit Earth Art Pieces

Call everyone together and visit each piece.

- Hear from the artist/biomimic about the inspiration for the piece, its materials, design, creative process, and possible meaning
- Consider taking pictures of each piece to then share with the whole class

01:40 Closing Discussion

- For you, what does it mean to be a biomimic?
- How might you continue to apply biomimicry to your own life and to challenges in your community and the world?