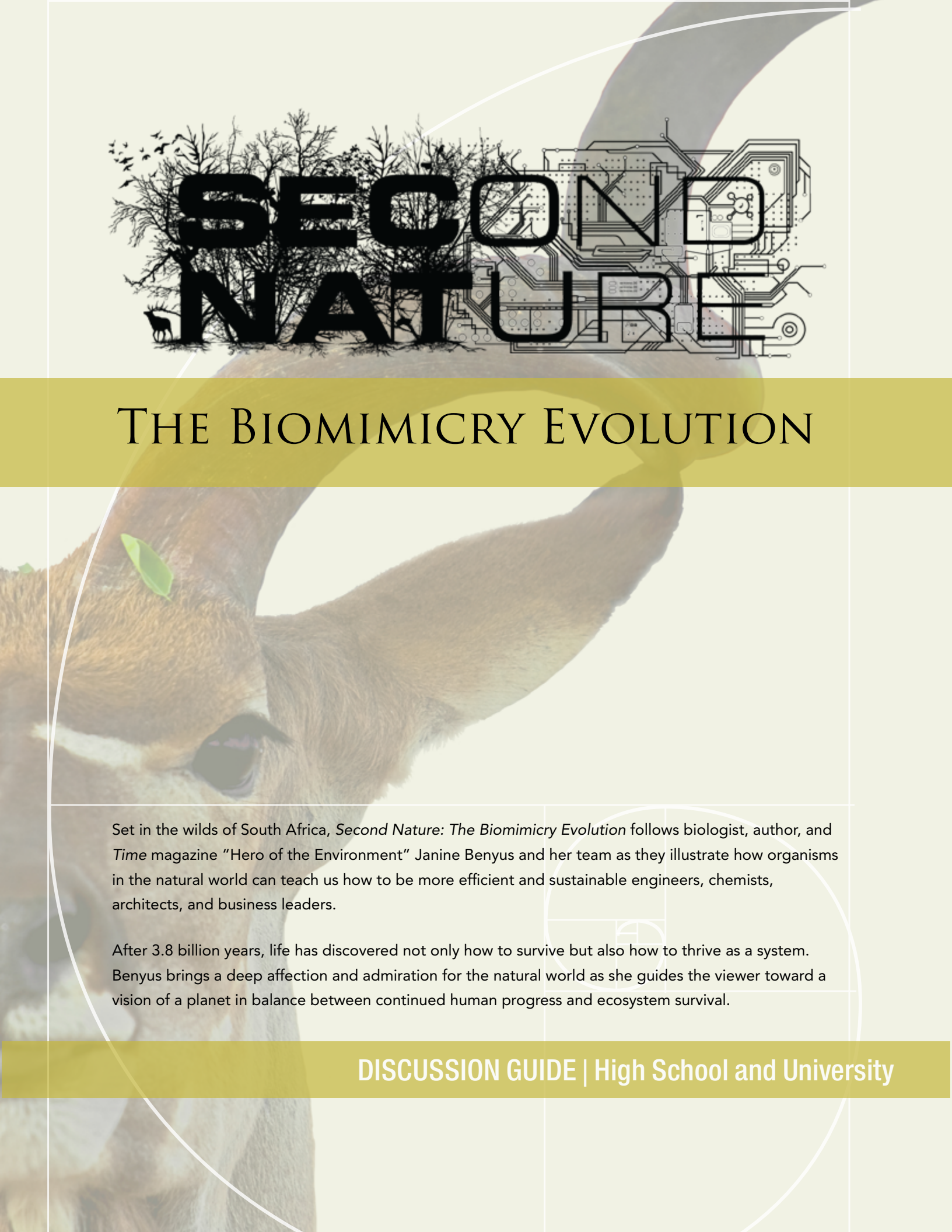

SECOND NATURE

The Biomimicry Evolution

Set in the wilds of South Africa, *Second Nature: The Biomimicry Evolution* follows biologist, author, and *Time* magazine "Hero of the Environment" Janine Benyus and her team as they illustrate how organisms in the natural world can teach us how to be more efficient and sustainable engineers, chemists, architects, and business leaders.

After 3.8 billion years, life has discovered not only how to survive but also how to thrive as a system. Benyus brings a deep affection and admiration for the natural world as she guides the viewer toward a vision of a planet in balance between continued human progress and ecosystem survival.

DISCUSSION GUIDE | High School and University

BIOMIMICRY 3.8

Second Nature: The Biomimicry Evolution
is a project of the Biomimicry 3.8 Institute

Introducing Biomimicry:

A Discussion and Activity Guide to Accompany *Second Nature: The Biomimicry Evolution*

Use the following guide after students have watched *Second Nature: The Biomimicry Evolution*. The discussion questions are organized by topic area so that you may pick and choose among them, and in what order you wish to discuss them. Additional information intended for the teacher or facilitator is provided in bracketed italics following each question.

Topic: Innovation

- In the video, Leonardo da Vinci is mentioned as an early biomimic. Indeed, looking to the natural world for innovation ideas is not new, yet relatively few inventors—or potential inventors—actually do it. Why do you think this is the case?
  [One of the reasons people who create our world (engineers, chemists, architects, etc.) may not think of looking for ideas in the natural world is because they assume the innovations there are not applicable to human challenges.]

- In the video, Janine Benyus says of the organisms around us that they are the "consummate engineers, chemists, and physicists of our planet. The aviators of our planet. The sailors of our planet. They've done everything that we want to do." In saying this, Janine is not just complimenting other species. Why does she say this?
  [Janine is saying that other species have faced, and both creatively and sustainably solved, many of the same challenges facing humans. In other words, the design solutions found in the rest of the natural world are applicable to the technological challenges facing humans. This is one of the most surprising ideas of biomimicry.]

- Janine talks about several ways in which biomimicry relates to automotive design, such as tires that grip as well as a tree frog's toe pads and windshields that remain as clean as a lotus leaf. Tire traction and clean windshields are two functions a car must perform. Can you think of others? Make a list, either individually or as a group. Then, for each function you identify, think about models in the natural world that perform that function, too. Write these biological models in a matching column next to your first list. In a third column, write down what innovation these biological models might inspire in how humans typically meet these automotive functions.

Function	Biological Model	Innovation
Gripping	*Tree frog toe pads*	*Tires that grip the road*
Staying clean	*Lotus leaf*	*Self-cleaning windshields*

- A theory about why zebras have their stripes has to do with managing temperature. Can you remember what the theory is? Can you draw what happens to air currents above a zebra's coat according to the theory? Can you devise an experiment to test whether or not this theory may be true?

- Recent evidence suggests that horseflies avoid the black and white striped pattern of zebra skin. Some scientists believe that zebra coloration may be an adaptation to deter these insects. Does this evidence disprove the thermoregulation theory? Why or why not?
  [The evidence does not disprove the thermoregulation theory, in part because adaptations in nature can be multifunctional (and often are), having several simultaneous advantages in a single design solution. An egg, for instance, is simultaneously strong, light, hydrodynamic, evenly distributes heat, and rolls in a tight circle back into the nest.]

- If the thermoregulation theory leads to innovation in architecture (e.g., coloration of building skins to reduce heat load), but turns out not to be the reason zebras evolved stripes, what does this say about the relationship between innovation and biology?
  [Biological understanding is based on evidence, and evidence changes with research. That's the nature of science. Perfect biological understanding is thus an ideal. We don't need perfect biological understanding to create real biomimetic innovation; biology can inspire innovation throughout our developing understanding of the natural world.]

- The video talks about architectural innovations inspired by nature, such as energy-efficient building ventilation systems based on the design of termite mounds. If you were going to build a house where you live, what biological models would you explore for innovative ideas about how you could design your building? How did you choose these models and why?

- What could we learn from a giraffe's tongue?

Topic: Sustainability

- The concept of sustainability is a very important one, if for no other reason than we often hear the term a lot. It's not clear, however, that we all understand the term or mean the same thing when we use it. Do you think it is possible for humans to create a sustainable way of life? Why or why not?

- Biomimicry contains an implicit assertion that humans *can* create a sustainable way of life. What is the reason for this belief?
  [The reason is that millions of other organisms around us have succeeded in creating a sustainable way of life. The rest of nature is thus "existence proof" for the possibility of developing sustainable and innovative technologies ourselves.]

- In the video, Janine says that organisms work together and create something beyond sustainability. What does she mean by this?
  [Janine points out that organisms don't just persist, they also improve the habitats in which they live.]

  We often paraphrase this idea as, "Life creates conditions conducive to life." What are some examples that illustrate this concept in the ecosystem in which you live? What are some examples of this at the scale of the entire planet? What are some examples of how you could "create conditions conducive to life" in your own life or work?

- Janine points out that chemistry done by other organisms is safe for living tissues (i.e., non-toxic). What exceptions to this general rule can you think of? What is different about toxic chemicals created by people versus toxins created by other organisms?
  [One key difference between the toxic chemicals created by people and the toxins created by other organisms is that toxic chemicals created by people are often unintentional by-products of manufacturing processes or of how our products interact with the environment. Toxins created by other organisms, in contrast, usually have an adaptive function (e.g., a spider's venom). Another key difference is that human-made toxic chemicals often persist in the environment, whereas toxins created by other organisms serve their purpose and then break down into non-toxic constituents. In other words, toxins not created by humans are generally limited in space and time, whereas toxic chemicals created by people often spread out in space and across time, lingering in the environment.]

- What technology currently exists to create self-cleaning surfaces? How is this technology different from the way a lotus leaf manages self cleaning?
  [The chemicals used in water- or oil-repellant surfaces (perfluorinated compounds) are known to be hazardous to people and the environment. Humans create self-cleaning surfaces using chemistry, while the lotus plant creates self-cleaning surfaces (leaves) using physical structures, relying on the physics of how physical materials interact.]

- In the video, Janine says, "Nature adds structure to materials. Every time we want a different function, we add a different material. Nature uses one material, adds a different structure to it, to get the various functions." What is significant about this contrasting approach to design?
  [Think about ideas such as material and energy efficiency, ease of decomposition, etc.]

- In the video, Janine says, "The interesting thing about CO_2 is, we think about it as the poison of our era. Life thinks about it as a building block. Everything green that you see on this planet uses CO_2 to build itself. It's a structural building material. Everything in the sea that is hard uses CO_2 in its recipe to make its shell." Do you think there is a lesson for how humans manufacture materials in these observations?

- What do kingfishers have to do with making trains quieter and more energy efficient? Can you come up with other examples of products or designs in which shape is important to how they function?
  [The shape of the kingfisher's beak helps it dive into water without causing a large compression wave to form under the surface, thus allowing it to catch fish before they can react. The shape allows the bird to go from one medium of material (air) into a denser medium (water) smoothly. This is the same challenge the bullet train faced, going from outside a tunnel to inside a tunnel (where air density increased). The shape of the kingfisher's beak when applied to the front end of a train allowed air in the tunnel to flow smoothly over and around the train, preventing a build-up of air-pressure.]

- In what way is spider silk stronger than steel? What is different between how a spider makes silk and how we create steel?
  [Spider silk is considered many times stronger than steel, ounce-for-ounce. In other words, a silk thread is much stronger than a thread of steel of the same diameter. While spider silk is made at ambient temperatures from digested insects, steel is mined from the ground and heated to high temperatures to formulate.]

- What might prairies have to teach us about agricultural practices?
  [Prairies are a polyculture, and a variety of different plants play similar roles or fill similar niches. There is redundancy built into the system. Polycultures are more resistant to drought, flood, disease, and insects. They also are made up of perennials, rather than annuals, and because of their resiliency they do not require irrigation, chemical fertilizers, or annual seeding.]

Topic: Relationship to Nature

- Claire Janisch, director of Biomimicry South Africa, says, "What's exciting about biomimicry is that it approaches nature with a sense that people need to be humble and need to seek a way of learning from nature and in that learning appreciate her services." At other times, the phrase "nature's apprentice" is used. Why is being humble important in order to practice biomimicry? How can this be "exciting"?

- The video begins with Janine Benyus saying, "Conservation begins with affection." Does biomimicry result in greater affection for the rest of the natural world? Why or why not?

- "Seeing nature as a teacher is very different than seeing nature as a warehouse of goods." Why is it so different? How do you treat a warehouse of goods? How do you treat a teacher?

- Janine says, "The wellsprings of good ideas are these habitats." What does she mean by this? What is happening to the world's natural habitats, and what does this mean for the future of biomimicry? How might seeing these places as a "source of good ideas" change this?

Topic: Miscellaneous

- In the video, biomimicry is described as a discipline. What skills do you think a person should have in order to successfully practice biomimicry? Make a list on the board together.
  [The list could include discipline-based skills such as biology, chemistry, physics, math, engineering, design, art, architecture, business, etc., or other skills such as observation, imagination, a tendency to tinker, etc.]

- Janine talks about "borrowing the recipe" from other organisms. What does she mean? How does this compare to farming or genetic engineering?

- Janine refers in the video to the "people who make our world." Who is Janine talking about? What is a "designer?" What are some occupations related to "making our world?" Choose an object in the room. Who was involved in making it? Think back as far as you can in its design and production through its eventual arrival in your classroom. How might these things be made differently if they were made with biomimicry in mind?

- Consider the setting of the film (an African grassland). How did the setting make you feel? Did it enhance or take away from your understanding of biomimicry? How would changing the setting of the movie influence your understanding of biomimicry? For example, what if the film were made in your local area? Write a script for a short video about what people could learn from organisms found in your region.

- Biomimicry is an intriguing but often unfamiliar concept to people. How would you tell _____ what biomimicry is? Write things like "Your mom," "A twelve-year old," "Your sports coach," etc. on individual slips of paper, and use yarn to string each piece of paper into a necklace. Create two concentric circles of equal numbers of students in the middle of the room, and give one necklace to each person in the inside circle. Tell the outside circle of student that they have three minutes to explain to the person (the mom, sports coach, etc.) they are facing what biomimicry is. Then, rotate one-person to the right (or left) and start again. After completing a full rotation, have the people in the inside circle hand their necklaces to the people in the outside circle, and repeat the activity so everyone gets a turn.

"The conscious emulation of life's genius is a survival strategy for the human race, a path to a sustainable future. 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