Design by Nature

A one-hour Green STEM program for students in grades 4-12.

To the Teacher:

Thank you for making the *Design by Nature* Green STEM Program a part of your curriculum. During this exciting educational program, students will be introduced to biomimicry as a means for people to use nature's inspiration to design solutions to human challenges. They will visit activity stations, meet a live animal, and experiment with models depicting various strategies desert animals and plants use to save water and keep cool. They will use what they learn to create a preliminary design for a desert-wise home that uses very little water and keeps cool without a big energy input.

The following information contains pre- and post-program background and activity ideas along with a vocabulary list and suggested resources. These activities and the program content are aligned with Arizona Academic Standards in Science and support Next Generation Science Standards (http://www.nextgenscience.org/next-generation-science-standards) as detailed below. The following materials were gathered to help you extend this class topic with both introductory and follow-up lessons. The pre-visit information will introduce students to some of the basic concepts presented in *Design by Nature* and help prepare them for the program. The on-grounds activity sheet extends the program ideas with real-world examples students can discover around the Museum. The post-visit activity allows them to engineer and share their design ideas generated in the program. We hope you'll find this information useful and easy to incorporate into your science curriculum. For more information about the Desert Museum and the Sonoran Desert, visit our website at **www.desertmuseum.org.**

Sincerely,

ASDM Department of Conservation Education and Science

DESIGN BY NATURE

Biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time tested patterns and strategies. Through experimentation with models, a live animal encounter, and exploration of how animal and plant adaptations have inspired human innovation, students will undertake a design challenge for the arid southwest.

Program Objectives:

Through the examination and manipulation of materials and models at activity stations and interaction with a live animal, students will:

- Compare adaptations in nature that inspired design by humans.
- Observe and describe desert plant and animal adaptations for survival in a dry, hot land.
- Incorporate desert plant and animal adaptations into a design for a dwelling that saves water and uses very little energy to keep cool.

Arizona Academic Standards Correlation:

Science Standards:

GRADE 4:

Strand 1: Inquiry Process

Concept 1: Observations, Questions, and Hypotheses: Observe, ask questions, and make predictions.

PO 3. Formulate predictions in the realm of science based on observed cause and effect relationships.

Concept 2: Scientific Testing (Investigating and Modeling): Participate in planning and conducting investigations, and recording data.

PO 3. Conduct controlled investigations (e.g., related to erosion, plant life cycles, weather, magnetism) in life, physical, and Earth and space sciences.

PO 4. Measure using appropriate tools (e.g., ruler, scale, balance) and units of measure (i.e., metric, U.S. customary).

Concept 3: Analysis and Conclusions: Organize and analyze data; compare to predictions.

PO 1. Analyze data obtained in a scientific investigation to identify trends.

PO 2. Formulate conclusions based upon identified trends in data.

Strand 3: Science in Personal and Social Perspectives

Concept 2: Science and Technology in Society: Understand the impact of technology.

PO 3. Design and construct a technological solution to a common problem or need using common materials.

Strand 4: Life Science

Concept 3: Organisms and Environments: Understand the relationships among various organisms and their environment.

PO 4. Describe ways in which resources can be conserved (e.g., by reducing, reusing, recycling, finding substitutes).

Concept 4: Diversity, Adaptation, and Behavior: Identify plant and animal adaptations.

PO 2. Give examples of adaptations that allow plants and animals to survive.

- camouflage – horned lizards, coyotes
- mimicry – Monarch and Viceroy butterflies
- physical – cactus spines
- mutualism – species of acacia that harbor ants, which repel other harmful insects.

GRADE 5:

Strand 1: Inquiry Process

Concept 3: Analysis and Conclusions: Analyze and interpret data to explain correlations and results; formulate new questions.

PO 1. Analyze data obtained in a scientific investigation to identify trends and form conclusions.

Strand 3: Science in Personal and Social Perspectives

Concept 1: Changes in Environments: Describe the interactions between human populations, natural hazards, and the environment.

PO 2. Propose a solution, resource, or product that addresses a specific human, animal, or habitat need.

GRADE 6:

Strand 1: Inquiry Process

Concept 3: Analysis and Conclusions: Analyze and interpret data to explain correlations and results; formulate new questions.

PO 1. Analyze data obtained in a scientific investigation to identify trends.

Strand 3: Science in Personal and Social Perspectives

Concept 2: Science and Technology in Society: Develop viable solutions to a need or problem.

PO 3. Design and construct a solution to an identified need or problem using simple classroom materials.

GRADE 7:

Strand 1: Inquiry Process

Concept 3: Analysis and Conclusions: Analyze and interpret data to explain correlations and results; formulate new questions.

PO 5. Formulate a conclusion based on data analysis.

GRADE 8:

Strand 1: Inquiry Process

Concept 1: Observations, Questions, and Hypotheses: Formulate predictions, questions, or hypotheses based on observations. Locate appropriate resources.

PO 3. Generate a hypothesis that can be tested.

Concept 2: Scientific Testing (Investigating and Modeling): Design and conduct controlled investigations.

PO 3. Conduct a controlled investigation to support or reject a hypothesis.

Strand 3: Science in Personal and Social Perspectives

Concept 2: Science and Technology in Society: Develop viable solutions to a need or problem.

PO 3. Design and construct a solution to an identified need or problem using simple classroom materials.

Strand 4: Life Science

Concept 4: Diversity, Adaptation, and Behavior: Identify structural and behavioral adaptations.

PO 1. Explain how an organism's behavior allows it to survive in an environment.

HIGH SCHOOL:

Strand 1: Inquiry Process
Concept 1: Observations, Questions, and Hypotheses: Formulate predictions, questions, or hypotheses based on observations. Evaluate appropriate resources.

PO 2. Develop questions from observations that transition into testable hypotheses.

PO 4. Predict the outcome of an investigation based on prior evidence, probability, and/or modeling (not guessing or inferring).

Strand 3: Science in Personal and Social Perspectives
Concept 1: Changes in Environments: Describe the interactions between human populations, natural hazards, and the environment.

PO 5. Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity.

Concept 2: Science and Technology in Society: Develop viable solutions to a need or problem.

PO 3. Support a position on a science or technology issue.

Next Generation Science Standards:

4-LS1 From Molecules to Organisms: Structures and Processes
Science and Engineering Practices:
Developing and Using Models
Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)

Disciplinary Core Ideas:
LS1.A: Structure and Function
Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics
Science and Engineering Practices:
HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

Constructing Explanations and Designing Solutions
Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)

Disciplinary Core Ideas:

LS4.D: Biodiversity and Humans

ETS1.B: Developing Possible Solutions

Engineering Design: 3-5-ETS1

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

MS-ETS1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Science and Engineering Practices:

Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1).

Design a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade-off considerations. (HS-ETS1-2)

Disciplinary Core Ideas:

ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)

Crosscutting Concepts:

Influence of Science, Engineering, and Technology on Society and the Natural World

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)

Recommended Teacher Resources:

Benyus, Janine M. *Biomimicry: Innovation Inspired by Nature*. New York, NY: William Morrow and Company, Inc., 1997.

Desert Botanical Garden, Solutions Inspired by Nature, a Biomimicry Curriculum Teacher's Guide for 5 – 8th Grade: Contains pre- and post-visit activities related to a biomimicry program taught at the gardens. https://www.dbg.org/sites/dbg.dd/files/solutions_teacher_guide_fy15.pdf

Teach Engineering, Biomimicry Curriculum for K-12 Teachers: Provides extensive examples of biomimicry used in engineering design as well as activity ideas to teach biomimicry and the engineering design process.
https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_bio/cub_bio_lesson05_activity1.xml

The Biomimicry Institute empowers people to create nature-inspired solutions for a healthy planet. Their website features several examples of biomimicry and an AskNature section that features over 1,800 natural phenomena and hundreds of bio-inspired applications to get students thinking about new design ideas. http://biomimicry.org/

Vocabulary:

Adaptation: A physical or behavioral feature of a plant or animal that helps it survive in its environment. For example, a hawk's talons help it catch and kill its food.

Biomimicry: An approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies.

Design: To form or conceive in the mind; contrive; plan.

Engineer: A person who applies scientific and mathematical principles to creative and practical ends such as the design, manufacture and operation of efficient and economical structures, machines, processes and systems.

Imitate: To copy or follow as a model or example.

Inspire: To be the cause or source of; to influence or bring about.

Mimic: To mimic or copy.

Model: (noun) A standard or example for imitation or comparison. (verb) To simulate, make or construct something to help visualize or learn about something else (as the living human body, a process or an ecosystem) that cannot be directly observed or experimented upon.

Sustainable: Capable of being maintained at a steady level without exhausting natural resources or causing severe environmental damage.

ACTIVITY OVERVIEW:

We recommend that teachers introduce the concepts that will be covered in more depth in the Design by Nature program with two videos and discussion as shown in the pre-program activity. While at the Museum, the Biomimicry Scavenger Hunt complements the program and provides students with opportunities to see real-world examples of nature's inspiration throughout the Museum grounds. After the program, students can apply engineering practices and expand their design ideas back in the classroom to create models from their initial concept drawings created in the program.

PRE-PROGRAM ACTIVITY

What is Biomimicry?
Students view two videos to introduce the topic of biomimicry and how plant adaptations to desert life might be applied to sustainable design ideas.

ON GROUNDS ACTIVITY

Biomimicry Scavenger Hunt Student Copy
Biomimicry Scavenger Hunt Answer Key

POST-PROGRAM ACTIVITY

Bringing Design Ideas to Life
Students take design ideas inspired by their Design by Nature program and engineer models of a sustainable desert home.