The Bee Cause Pollinator Insect

High School Life Science and Visual Art

Scientific Illustration Unit Plan

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Youth Services Librarian

Calhoun County Library

900 F. R. Huff Drive,

Saint Matthews, SC 29135

Dear Teachers,

In my current life I am the youth services librarian at the Calhoun County Library. Because the county is small, I have been fortunate to work closely with teachers and children from all of the county's schools on our pollinator education initiative, which features a garden across the street from the library and an observation learning hive in our children's library. In my former life, I worked as a middle and high school art teacher. I taught public school for 8 years and I taught privately for 3 years. I am still certified K-12 in South Carolina and intend to keep my certification. In almost all the years that I taught, I made nearly non-existent budgets stretch to impossible lengths and always made time to create lesson plans that not only addressed national and state art standards but also incorporated cross-curricular elements.

This four lesson unit on scientific illustration will hopefully provide everything you need so that you can spend very little of your budget, make your administrators happy by using standards that show STEAM and cross-curricular planning, and enjoy more time actually teaching your students.

The picture below is of Alexis Easterlin. She was an eleventh grader in Ms. Tiffany Spencer's art class last year. Her finished images as well as two others were used to make beautiful note cards that were sold to support The Bee Cause and direct funds back into the art classroom. Please contact Tami Enright (http://www.thebeecause.org/)if you would like information about this as a possible means of meeting your school's pay-it-forward commitment and sharing observation hives with more children.

This unit is freely given to you under a Creative Commons copyright license. Further, for readers of this unit plan who may not be in education, please know that academic teaching standards are not revised yearly. The S. C. State Department of Education revises standards about every 3 to 5 years for some academic areas and even longer for others. Also, please know that what might sound like a great idea on the surface, may not fit into every classroom. Art teachers must have already have mastered the techniques that they are expected to teach. Some are really great at drawing or painting, yet not have great colored pencil skills. Others may be great with colored pencils, but not be so great with watercolor and ink. Please talk to teachers before assuming that they can fit this unit into their curriculum.

Finally, I want to thank the teachers, students, library staff, and community partners that have worked with me on our initiative. Without their enthusiasm and support, we would not have had the very successful first year that we did.

If you have any questions or feedback, please reach me at jjeffcoat@calhouncountylibrary.org.

Sincerely,
Jeri

Table of Contents

Grades/Level: High School (9–12)
Subjects: Visual Arts, Science (Biology)
Time Required: 6 Days (Six 50 Minute Class Periods)

Introduction and Purpose

Pollination is an exceedingly important part of what insects do. Pollinator insects are threatened by modern environmental changes and insecticides. Increasing public awareness about pollinator insects may be crucial to humanity's continued existence. Art is a great tool that can be used to educate and inform the public. This unit on scientific illustration is designed to accomplish this.

Each lesson in the unit focuses on specific South Carolina Educational Standards for high school biology and/or high school art. The standards are listed in each lesson. Lesson one is about the history of scientific illustration and modern practices. It is important that art students realize that scientific illustration is still a viable career choice. Lesson Two is concerned with insects, pollination, and the biological characteristics of pollinator insects and how to make realistically drawn anatomically correct scientific drawings. Lesson Three teaches students how to render scientific drawings in color and provides students with an opportunity to create a scientific illustration. Lesson Four is the closure for the unit and provides for formal assessment, self assessment, informal assessment and a formal critique activity.

WHAT IS SCIENCE ILLUSTRATION?

The below information comes as a direct quote from The Guild of Natural Science Illustrators website at https://gnsi.org/

As art reflects culture, scientific illustration reflects the findings of science and technology. Scientific illustration takes the viewer to the often unobservable — from molecules and viruses to the universe, from depiction of the internal anatomy of arthropods and plants to geologic cross sections and reconstruction of extinct life forms, ranging from realistic to abstract portrayal. Shapes, anatomy, details, and concepts that cannot be conveyed with words form the essence of this art. Finished work appears in print, exhibits…, the [internet]…, video, and wall art.

Science illustrators are artists in the service of science. They use scientifically informed observation, combined with technical and aesthetic skills to accurately portray a subject. Accuracy and communication are essential. The skilled scientific illustrator can clarify multiple focal depths and overlapping layers, emphasize important details, and reconstruct broken specimens on paper — results unattainable through photography. Structure and detail may be depicted with cutaway drawings, transparencies, and exploded diagrams. Many steps may be required to achieve accuracy.

Very early scientific discourses, such as "*herbals*," included illustrations. (An herbal is "a collection of descriptions of plants put together for medicinal purposes" [Singer, p. 95]). They were sometimes more stylized and imaginary than accurate depictions of specimens. But other early descriptions of animals and plants had no accompanying visuals. Imagine a description of a yellow butterfly in words only! What shade of yellow? What is the wing shape? What does the color pattern look like? These deficiencies in communication made obvious the need for illustration. Thus, artists accompanied early exploring expeditions to record discoveries visually.

Scientific illustrations are critical for differentiating species; for example, mosquitoes that carry disease, aquatic animals of economic importance, plant seeds that are considered weeds, or plants of agricultural and medical importance. For the military, decks of cards have been illustrated to depict edible and poisonous plants and animals, used by personnel lost in tropical environments. Medical illustrations elucidate how new surgeries are performed or the anatomy of domestic animals as well as humans.

Usually, the person who becomes a scientific illustrator finds the field an ideal fusion of interests in art and science. Often the artist sees an important feature missed by the scientist. Goethe has been quoted as observing that you really do not see a plant until you draw it. Although most scientific illustrators have a penchant for precision and a great tolerance for and appreciation of detailed work, demand exists for more expressive work that conveys science concepts and ideas. Either approach can lead to a beautiful drawing or painting that is as true as possible to its subject and that will supplement a body of scientific information or independently convey a message.

Hodges, E. R. S., & Guild of Natural Science Illustrators (U.S.). (2003). *The Guild Handbook of Scientific Illustration*. New Jersey: Wiley. (Pages xi-xii)

Singer, C. (1923.) Herbals. *The Edinburgh Review* 237: 95–112. From the Guild of Natural Science Illustrators https://gnsi.org/

THE IMPORTANCE OF POLLINATORS

By Joe Lamp'l from PBS

The below information comes as a direct quote from the *PBS - Growing a Greener World* website at http://www.growingagreenerworld.com/the-importance-of-pollinators/

Imagine living in a world without flowers or fruit or even coffee or chocolate for that matter. Thanks to the wonderful work of pollinators like bees, much of the food we eat and flowers and plants we enjoy are possible.

And it's not just bees that are doing all the work. Butterflies, birds, beetles, bats, wasps and even flies are important in the pollination process. But despite the importance of pollinators, they are taken for granted all too often. Worldwide, there is an alarming decline in pollinator populations. Excessive use of pesticides and an ever-expanding conversion of landscapes to human use are the biggest culprits.

It is estimated that more than 1,300 types of plants are grown around the world for food, beverages, medicines, condiments, spices and even fabric. Of these, about 75% are pollinated by animals. More than one of every three bites of food we eat or beverages we drink are directly because of pollinators. Indirectly, pollinators ultimately play a role in the majority of what we eat and consume.

Pollinators are vital to creating and maintaining the habitats and ecosystems that many animals rely on for food and shelter. Worldwide, over half the diet of fats and oils comes from crops pollinated by animals. They facilitate the reproduction in 90% of the world's flowering plants.

You can make a positive difference in your home environment. Provide a diverse assortment of flowering plants and encourage native species in your landscape. Use pesticides only when necessary and then only late in the day or evening. Look for alternative ways to deal with pest and disease issues before reaching for a quick fix. These often come at a price. Learn about and practice IPM (Integrated Pest Management). The actions you take in and around your garden can either help reduce or promote the population of pollinators in your landscape. Hopefully it's the latter.

Lamp'l, J. (N.D.) The importance of pollinators. *PBS - Growing a Greener World*. Retrieved 22 July 16 from http://www.growingagreenerworld.com/the-importance-of-pollinators/

Lesson 1

Introduction to Scientific Illustration

Lesson Overview:
The teacher introduces the unit about scientific illustration and explains that it is a cross-curricular unit that includes visual art and biology. Students will analyze specific examples of scientific illustrations and decorative art to better understand the distinctions between the two styles. Also, students will practice drawing from observation by creating contour, gesture and value sketches of natural objects. (Note for non-art lesson plan readers: in art "value" does not mean the worth of an object, it means the lightness and darkness of colors. To do a value sketch or study means to do a monochromatic drawing with shadows using a pencil or charcoal.)

Time: One 50 Minute Class Period

Learning Objectives:

- Students will discuss the importance of visual communication in science.
- Students will be able to differentiate between scientific illustration and other types of art.
- Students will enhance their observation and drawing skills.

Standards:

South Carolina Academic Standards and Performance Indicators for Science
South Carolina Department of Education, 2014

BIOLOGY 1, SCIENCE AND ENGINEERING PRACTICES

Standard H.B.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

H.B.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:
H.B.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts.
H.B.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

South Carolina Academic Standards for the Visual and Performing Arts
South Carolina Department of Education, 2010

VISUAL ARTS HIGH SCHOOL LEVELS 1, 2, 3, & 4

Creating Works of Visual Art

Standard 1: The student will demonstrate competence in the use of ideas, materials, techniques, and processes in the creation of works of visual art.

Indicators:

VAH1-1.1, VAH2-1.1, VAH3-1.1, VAH4-1.1 Recognize and analyze the similarities and differences between materials, techniques, and processes in works of visual art.

VAH1-1.2, VAH2-1.2, VAH3-1.2, VAH4-1.2 Describe ways that different materials, techniques, and processes evoke different responses in one who is creating or viewing artworks.

VAH1-1.3, VAH2-1.3, VAH3-1.3, VAH4-1.3 Communicate ideas through the effective use of a variety of materials, techniques, and processes in works of visual art.

VAH1-1.4, VAH2-1.4, VAH3-1.4, VAH4-1.4 Apply materials, techniques, and processes with skill, confidence, and sensitivity sufficient to make his or her intentions observable in the artwork that he or she creates.

VAH1-1.5, VAH2-1.5, VAH3-1.5, VAH4-1.5 Use a variety of art materials, tools, and equipment in a skillful, safe, and responsible manner.

VAH3-1.6 Demonstrate proficiency in a specific visual arts genre (for example, painting, photography, sculpture, ceramics).

Using Structures and Functions

Standard 2: The student will use composition and the elements and principles of design to communicate ideas.

Indicators:

VAH1-2.1, VAH2-2.1, VAH3-2.1, VAH4-2.1 Recognize, describe, and analyze the elements and principles of design and other compositional structures and strategies used in the visual arts to communicate ideas.

VAH1-2.2, VAH2-2.2, VAH3-2.2, VAH4-2.2 Create works of visual art that use the elements and principles of design and other compositional strategies.

VAH1-2.3, VAH2-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies.

VAH3-2.3, VAH4-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies to communicate ideas.

Exploring Content

Standard 3: The student will examine the content of works of visual art and use elements from them in creating his or her own works.

Indicators:

VAH1-3.1, VAH2-3.1, VAH3-3.1, VAH4-3.1 Explore the sources of the subject matter and the ideas in a variety of works of visual art.

VAH1-3.2, VAH2-3.2, VAH3-3.2, VAH4-3.2 Analyze and describe the relationships among subject matter, symbols, and themes in communicating intended meaning in his or her own artworks and in those of others.

VAH1-3.3, VAH2-3.3, VAH3-3.3, VAH4-3.3 Select and effectively use subject matter, symbols, and ideas to communicate meaning through his or her artworks.

History and Culture

Standard 4: The student will understand the visual arts in relation to history and world cultures and the technologies, tools, and materials used by artists.

Indicators:

VAH1-4.1, VAH2-4.1, VAH4-4.1 Describe ways that the subject matter, symbols, ideas, and technologies in various artworks are related to history and culture.

VAH1-4.2, VAH2-4.2, VAH4-4.2 Identify specific artworks as belonging to a particular culture or historical period and explain the characteristics that led him or her to make that identification.

VAH1-4.3, VAH2-4.3, VAH4-4.3 Describe and discuss the function and meaning of specific artworks from various world cultures and historical periods.

Interpreting Works of Visual Art

Standard 5: The student will analyze and assess the characteristics and qualities of his or her own works of visual art and those of others.

Indicators:

VAH1-5.1, VAH2-5.1, VAH3-5.1, VAH4-5.1 Analyze the intention of the artist in a specific artwork and justify his or her interpretation.

VAH1-5.2, VAH2-5.2, VAH3-5.2, VAH4-5.2 Make complex, descriptive, interpretative, and evaluative judgments about his or her own artworks and those of others.

VAH1-5.3, VAH2-5.3, VAH3-5.3, VAH4-5.3 Formulate criteria for interpreting and evaluating his or her artworks and those of others.

VAH1-5.4, VAH2-5.4, VAH3-5.4, VAH4-5.4 Maintain a personal portfolio of his or her artworks.

Making Connections

Standard 6: The student will make connections between the visual arts and other arts disciplines, other content areas, and the world.

Indicators:

VAH1-6.1, VAH2-6.1, VAH3-6.1, VAH4-6.1 Analyze the similarities and differences between the visual arts and other arts disciplines.

VAH1-6.2, VAH2-6.2, VAH3-6.2, VAH4-6.2 Compare and contrast concepts, issues, and themes in the visual arts and other subjects in the school curriculum.

VAH1-6.3, VAH2-6.3, VAH3-6.3, VAH4-6.3 Identify specific visual arts careers and describe the knowledge and skills that one needs for these careers.

Materials: pencils, erasers, paper, pine cones, sea shells, and other natural objects

Lesson Sequence:

1) Ask, "What is scientific illustration?" Then explain that scientific illustrations, as opposed to decorative art, are more detailed, more realistic, and aid in the learning about the organism depicted. Show students examples of decorative illustration and scientific illustration. Next, engage students in a whole class discussion of the examples where students should be asked to provide specific examples of the differences.

The following are two examples of decorative illustrations from *The Travelling Beehive* by Elena García, Manuel Ángel Rosado, and Juan Hernaz. Retrieved from https://www.behance.net/gallery/9857081/The-travelling-beehive-(illustrated-book)

Below are examples of scientific illustrations. The first is the detail of the interior anatomy of a bee by Paul Pfurtscheller in his book *Zoological Plates.* The second is *Study of Insects, Butterflies and Flowers* by Jan van Kessel the Elder.

2) Ask students "Who creates scientific illustrations?" Then, direct students to page through their science textbook, field guides, and other science books to find examples of scientific illustrations. Have the students look at the image credits in the books and also search the Internet for images of "scientific illustration."

Show students images by Paul Pfurtscheller, Gina Mikel, Jan van Kessel the Elder, and other scientific illustrators. Explain that sometimes the scientists themselves do their own illustrations, and sometimes they hire artists who are trained in the sciences. Scientific illustration requires a combination of good observation skills, good drawing skills, and knowledge of the subject. Emphasize the fact that scientific illustration can be a viable career choice.

3) Give students the opportunity to practice sketching for a scientific illustration. Emphasize that the objects that will be used in this lesson are not the subjects for the final project for this unit. Have each student choose a pine cone, sea shell, or other natural object that has been collected for this lesson. Demonstrate very briefly "gesture," "contour," and "value" drawing. Talk students through the following steps to scientific drawing:
    a. Look at your object! Spend at least five minutes, pencils down, just looking at the object you wish to draw. Look at it up close, at arm's length, and from all possible angles. Look for patterns and overall shapes as well as details.
    b. Warm up! Use your pencil to make scribbles and marks on your page, with emphasis on using larger drawing motions instead of small writing motions.
    c. Contour drawing! This exercise helps with hand-eye coordination. Find an angle on your object that you like. Study its outline. Now, pretend your eye is an ant that crawls very slowly over the outline of the object. As your eye moves, use your pencil to draw what your eye is seeing. The catch is that you should not look at your paper as you are drawing. If you get lost, start another. Five or six contour drawings are a good warm-up.
    d. Gesture drawing! This exercise helps students find overall shapes and draw quickly. This will be important when sketching in the field, especially live animals. Draw the object as quickly as possible, preferably in ten seconds or less. Do this several times.
    e. Draw! Spend ten minutes or so drawing the natural object as accurately as possible. Keep in mind the three (or more) characteristics of scientific illustration that the class identified (more detailed, more realistic, and aids in the learning about the organism depicted). Midway through, ask students if they have noticed any patterns in the natural object that might make drawing easier.
    f. Draw some more! Professional illustrators often do ten or twenty sketches of a subject before settling in to work on a final drawing. While this is not necessary in most classroom situations, students will find they draw better if they draw more often.

The above steps were created by Rachel MaKarrall and Diane Podgornik for the University of Minnesota Duluth and can be accessed from *Drawing Science* at http://www.d.umn.edu/gk12/FellowTeacherTeams/2007-08teams/Rachel-Diane/MaKarrall-Podgornik.html

Wrap-Up and Informal Assessment:

Look at students work and give feedback as to how well they were able to achieve success. Ask students to show each other their drawings, and to keep an eye open in newspapers, magazines, and books for examples of scientific illustration.

Lesson 2

Pollinator Insect Anatomy and Scientific Illustration

Lesson Overview:
Students will study naturalist and scientific renderings of insects. They will then research pollinator insects and identify the unique characteristics which enable these insects to be pollinators. Students will look closely at insects and create sketches that are anatomically correct using drawing techniques that help with scale and proportion. Also, students will incorporate a variety of lines and shapes and use value to depict their subjects' three-dimensionality.

Time: Two 50-Minute Class Periods

Learning Objectives:

- Students will use observation, research, and prior knowledge to describe characteristics shared by all insects.
- Students will use knowledge about insect anatomy to differentiate among various species of insects represented in historically significant and modern scientific drawing.
- Students will understand that insects are invertebrates with exoskeletons.
- Students will create drawings of insects using a variety of shapes, lines, and textures.
- Students will apply techniques that aid in achieving correct scale and proportion. (Pencil and thumb method).
- Students will use value to create the illusion of three-dimensionality in drawings.

Standards:

South Carolina Academic Standards and Performance Indicators for Science
South Carolina Department of Education, 2014

BIOLOGY 1, SCIENCE AND ENGINEERING PRACTICES

Standard H.B.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

H.B.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:
H.B.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge scientific arguments or claims.
H.B.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
H.B.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.
H.B.1A.4 Analyze and interpret data from informational texts and data collected from

investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions.

H.B.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.

H.B.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.

H.B.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts.

H.B.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

ECOSYSTEM DYNAMICS

Standard H.B.6: The student will demonstrate an understanding that ecosystems are complex, interactive systems that include both biological communities and physical components of the environment.

H.B.6A. Conceptual Understanding: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. Limiting factors include the availability of biotic and abiotic resources and challenges such as predation, competition, and disease.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6A.1 Analyze and interpret data that depict changes in the abiotic and biotic components of an ecosystem over time or space (such as percent change, average change, correlation and proportionality) and propose hypotheses about possible relationships between the changes in the abiotic components and the biotic components of the environment.

H.B.6C. Conceptual Understanding: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively stable over long periods of time. Fluctuations in conditions can challenge the functioning of ecosystems in terms of resource and habitat availability.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6C.1 Construct scientific arguments to support claims that the changes in the biotic and abiotic components of various ecosystems over time affect the ability of an ecosystem to maintain homeostasis.

H.B.6D. Conceptual Understanding: Sustaining biodiversity maintains ecosystem functioning and productivity which are essential to supporting and enhancing life on Earth. Humans depend on the living world for the resources and other benefits provided by biodiversity. Human activity can impact biodiversity.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6D.1 Design solutions to reduce the impact of human activity on the biodiversity of an ecosystem.

South Carolina Academic Standards for the Visual and Performing Arts
South Carolina Department of Education, 2010

VISUAL ARTS HIGH SCHOOL LEVELS 1, 2, 3, & 4

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VAH1-1.2, VAH2-1.2, VAH3-1.2, VAH4-1.2 Describe ways that different materials, techniques, and processes evoke different responses in one who is creating or viewing artworks.

VAH1-1.3, VAH2-1.3, VAH3-1.3, VAH4-1.3 Communicate ideas through the effective use of a variety of materials, techniques, and processes in works of visual art.

VAH1-1.4, VAH2-1.4, VAH3-1.4, VAH4-1.4 Apply materials, techniques, and processes with skill, confidence, and sensitivity sufficient to make his or her intentions observable in the artwork that he or she creates.

VAH1-1.5, VAH2-1.5, VAH3-1.5, VAH4-1.5 Use a variety of art materials, tools, and equipment in a skillful, safe, and responsible manner.

VAH3-1.6 Demonstrate proficiency in a specific visual arts genre (for example, painting, photography, sculpture, ceramics).

VAH4-1.6 Demonstrate proficiency in creating a body of work in a specific visual arts genre, such as painting, drawing, printmaking, photography, sculpture, ceramics, graphic design, or fiber arts.

Using Structures and Functions

Standard 2: The student will use composition and the elements and principles of design to communicate ideas.

Indicators:

VAH1-2.1, VAH2-2.1, VAH3-2.1, VAH4-2.1 Recognize, describe, and analyze the elements and principles of design and other compositional structures and strategies used in the visual arts to communicate ideas.

VAH1-2.2, VAH2-2.2, VAH3-2.2, VAH4-2.2 Create works of visual art that use the elements and principles of design and other compositional strategies.

VAH1-2.3, VAH2-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies.

VAH3-2.3, VAH4-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies to communicate ideas.

Exploring Content

Standard 3: The student will examine the content of works of visual art and use elements from them in creating his or her own works.

Indicators:

VAH1-3.1, VAH2-3.1, VAH3-3.1, VAH4-3.1 Explore the sources of the subject matter and the ideas in a variety of works of visual art.

VAH1-3.2, VAH2-3.2, VAH3-3.2, VAH4-3.2 Analyze and describe the relationships among subject matter, symbols, and themes in communicating intended meaning in his or her own artworks and in those of others.

VAH1-3.3, VAH2-3.3, VAH3-3.3, VAH4-3.3 Select and effectively use subject matter, symbols, and ideas to communicate meaning through his or her artworks.

History and Culture

Standard 4: The student will understand the visual arts in relation to history and world cultures and the technologies, tools, and materials used by artists.

Indicators:

VAH1-4.1, VAH2-4.1, VAH4-4.1 Describe ways that the subject matter, symbols, ideas, and technologies in various artworks are related to history and culture.

VAH1-4.2, VAH2-4.2, VAH4-4.2 Identify specific artworks as belonging to a particular culture or historical period and explain the characteristics that led him or her to make that identification.

VAH1-4.3, VAH2-4.3, VAH4-4.3 Describe and discuss the function and meaning of specific artworks from various world cultures and historical periods.

VAH1-4.4, VAH2-4.4, VAH4-4.4 Demonstrate visual literacy by deconstructing images in a variety of contexts.

VAH1-4.5, VAH2-4.5, VAH4-4.5 Apply a knowledge of art history, various cultures, and technologies in the creation of original works of visual art.

Interpreting Works of Visual Art

Standard 5: The student will analyze and assess the characteristics and qualities of his or her own works of visual art and those of others.

Indicators:

VAH1-5.1, VAH2-5.1, VAH3-5.1, VAH4-5.1 Analyze the intention of the artist in a specific artwork and justify his or her interpretation.

VAH1-5.2, VAH2-5.2, VAH3-5.2, VAH4-5.2 Make complex, descriptive, interpretative, and evaluative judgments about his or her own artworks and those of others.

VAH1-5.3, VAH2-5.3, VAH3-5.3, VAH4-5.3 Formulate criteria for interpreting and evaluating his or her artworks and those of others.

VAH1-5.4, VAH2-5.4, VAH3-5.4, VAH4-5.4 Maintain a personal portfolio of his or her artworks.

Making Connections

Standard 6: The student will make connections between the visual arts and other arts disciplines, other content areas, and the world.

Indicators:

VAH1-6.1, VAH2-6.1, VAH3-6.1, VAH4-6.1 Analyze the similarities and differences between the visual arts and other arts disciplines.

VAH1-6.2, VAH2-6.2, VAH3-6.2, VAH4-6.2 Compare and contrast concepts, issues, and themes in the visual arts and other subjects in the school curriculum.

VAH1-6.3, VAH2-6.3, VAH3-6.3, VAH4-6.3 Identify specific visual arts careers and describe the knowledge and skills that one needs for these careers.

Materials:

- Handouts for each student entitled “Insect Anatomy,” “Anatomy of the Bee,” “Pollinators and Pollinator Syndromes,” and “Symmetry of a Bee.”
- Digital and print photographic images of pollinator insects. (Students should be allowed to use their phones and other devices to look at and research pollinator insects.)
- Digital and print copies of contemporary and antique scientific illustrations of pollinator insects.
- Drawing pencils, kneaded erasers, 9” x 12” sketch paper.

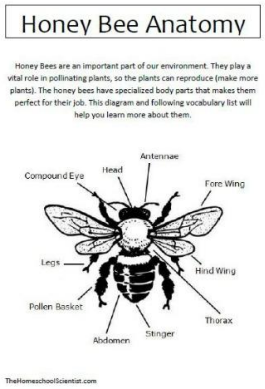
Lesson Sequence:

1) Provide students with the handout "Symmetry of a Bee."

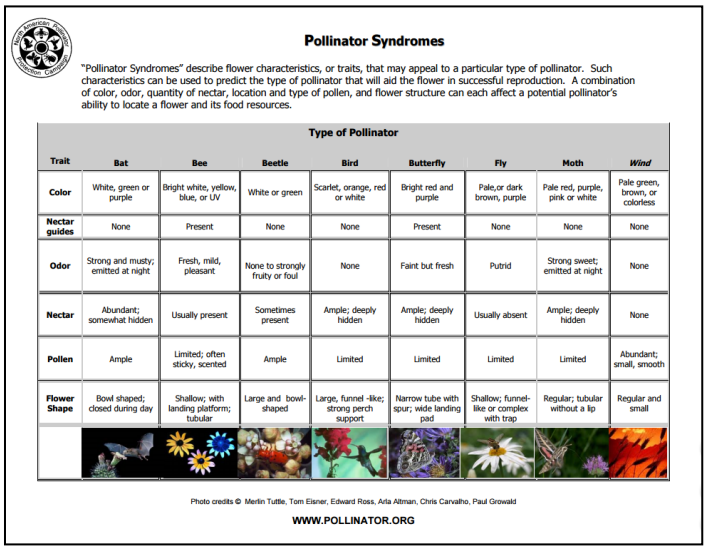
2) As a beginning activity ask students to quickly complete the other side of the image on the handout "Symmetry of a Bee."

3) Provide students with handout "Insect Anatomy" and discuss anatomy of insects. Discuss the fact that insects are invertebrates with exoskeletons and point out the head, thorax, abdomen, legs, antennae, and mandibles (when relevant). They should be able to identify the three characteristics that are universal to all insects (exoskeletons, 3 main body parts - head, thorax, abdomen, and 6 jointed legs).

4) Have student complete the "Anatomy of the Bee" handout.
http://thehomeschoolscientist.com/wp-content/uploads/2014/01/honey-bee-anatomy.pdf



5) Go over the handout entitled "Pollinator Syndromes" describing which insects pollinate what plants.
http://pollinator.org/Resources/Pollinator_Syndromes.pdf



Pollinator Syndromes

"Pollinator Syndromes" describe flower characteristics, or traits, that may appeal to a particular type of pollinator. Such characteristics can be used to predict the type of pollinator that will aid the flower in successful reproduction. A combination of color, odor, quantity of nectar, location and type of pollen, and flower structure can each affect a potential pollinator's ability to locate a flower and its food resources.

	Type of Pollinator							
Trait	**Bat**	**Bee**	**Beetle**	**Bird**	**Butterfly**	**Fly**	**Moth**	***Wind***
Color	White, green or purple	Bright white, yellow, blue, or UV	White or green	Scarlet, orange, red or white	Bright red and purple	Pale,or dark brown, purple	Pale red, purple, pink or white	Pale green, brown, or colorless
Nectar guides	None	Present	None	None	Present	None	None	None
Odor	Strong and musty; emitted at night	Fresh, mild, pleasant	None to strongly fruity or foul	None	Faint but fresh	Putrid	Strong sweet; emitted at night	None
Nectar	Abundant; somewhat hidden	Usually present	Sometimes present	Ample; deeply hidden	Ample; deeply hidden	Usually absent	Ample; deeply hidden	None
Pollen	Ample	Limited; often sticky, scented	Ample	Limited	Limited	Limited	Limited	Abundant; small, smooth
Flower Shape	Bowl shaped; closed during day	Shallow; with landing platform; tubular	Large and bowl-shaped	Large, funnel -like; strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel-like or complex with trap	Regular; tubular without a lip	Regular and small

Photo credits © Merlin Tuttle, Tom Eisner, Edward Ross, Arla Altman, Chris Carvalho, Paul Growald

WWW.POLLINATOR.ORG

6) Look at various images of insects and scientific drawings, discuss sketching images of insects. Demonstrate the pencil and thumb technique and the grid method which are both used to create realistic drawings that are scaled correctly and have anatomically correct proportions. Direct students' attention to the details of scientific drawings. Ask them to consider what the artist did to make the insects look three-dimensional. Point out examples of shadows and shading and show the students how the use of value gives scientific insect drawings a three-dimensional appearance.

   This is a web address to a video tutorial on how to use the thumb and pencil method which can be printed if students need more help:
   http://www.drawinghowtodraw.com/stepbystepdrawinglessons/2010/01/how-to-find-measurements-proportions-and-angles-to-draw-with-pencil-thumb-method/

   This is a web address to a video tutorial on how to use the grid method which can be printed if students need more help:
   http://www.drawinghowtodraw.com/drawing-lessons/improve-drawing/drawing-with-grids.html

7) Give students access to the Internet or science texts and ask them to choose a pollinator insect that they wish to sketch and then develop into an actual scientific illustration. The teacher may wish to allow students with digital images to print a copy of their insects. Regardless, students should record the common, scientific name and where the insect lives, and what the insect pollinates.

8) Hand out art supplies.

9) Allow students to begin anatomically correct value studies of their chosen insect using a variety of shapes, lines, and textures.

Wrap-Up and Informal Assessment:

Display students' "Symmetry of a Bee" worksheets and value studies. Help students decide which study should be used to develop into the final colored scientific illustration.

Lesson 3
Scientific Illustration in Color

Lesson Overview:
Students closely observe insects and create scientific illustrations that depict three-dimensionality, are anatomically correct, and are realistically rendered in true-to-life color.

Time: Two or Three 50-Minute Class Periods
Learning Objectives:

- Students will apply knowledge about drawing techniques that aid in achieving correct scale and proportion. (Pencil and thumb method)
  http://www.drawinghowtodraw.com/drawing-lessons/improve-drawing/measure-measuring-proportions.html
- Students will apply knowledge about drawing techniques that aid in achieving the illusion of three-dimensionality in drawings.
- Students will apply knowledge of colored pencil, water color, colored ink, or pastel techniques to achieve a realistically colored scientific illustration.
- Students will create an original scientific illustration that is a synthesis of Lessons 1, 2, and 3.

Standards:

South Carolina Academic Standards and Performance Indicators for Science
South Carolina Department of Education, 2014

BIOLOGY 1, SCIENCE AND ENGINEERING PRACTICES

Standard H.B.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

H.B.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:
H.B.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge scientific arguments or claims.
H.B.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
H.B.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.
H.B.1A.4 Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses,

explanations, claims, or designs, or (3) evaluate the strength of conclusions.
H.B.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate
metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.
H.B.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or
describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

South Carolina Academic Standards for the Visual and Performing Arts
South Carolina Department of Education, 2010
VISUAL ARTS HIGH SCHOOL LEVELS 1, 2, 3, & 4

Creating Works of Visual Art

Standard 1: The student will demonstrate competence in the use of ideas, materials, techniques, and processes in the creation of works of visual art.

Indicators:

VAH1-1.4, VAH2-1.4, VAH3-1.4, VAH4-1.4 Apply materials, techniques, and processes with skill, confidence, and sensitivity sufficient to make his or her intentions observable in the artwork that he or she creates.
VAH1-1.5, VAH2-1.5, VAH3-1.5, VAH4-1.5 Use a variety of art materials, tools, and equipment in a skillful, safe, and responsible manner.
VAH3-1.6 Demonstrate proficiency in a specific visual arts genre (for example, painting, photography, sculpture, ceramics).
VAH4-1.6 Demonstrate proficiency in creating a body of work in a specific visual arts genre, such as painting, drawing, printmaking, photography, sculpture, ceramics, graphic design, or fiber arts.

Using Structures and Functions

Standard 2: The student will use composition and the elements and principles of design to communicate ideas.

Indicators:

VAH1-2.2, VAH2-2.2, VAH3-2.2, VAH4-2.2 Create works of visual art that use the elements and principles of design and other compositional strategies.

Exploring Content

Standard 3: The student will examine the content of works of visual art and use elements from them in creating his or her own works.

Indicators:

VAH1-3.3, VAH2-3.3, VAH3-3.3, VAH4-3.3 Select and effectively use subject matter, symbols, and ideas to communicate meaning through his or her artworks.

History and Culture

Standard 4: The student will understand the visual arts in relation to history and world cultures and the technologies, tools, and materials used by artists.

Indicators:

VAH1-4.5, VAH2-4.5, VAH4-4.5 Apply a knowledge of art history, various cultures, and technologies in the creation of original works of visual art.

Interpreting Works of Visual Art

Standard 5: The student will analyze and assess the characteristics and qualities of his or her own works of visual art and those of others.

Indicators:

VAH1-5.4, VAH2-5.4, VAH3-5.4, VAH4-5.4 Maintain a personal portfolio of his or her artworks.

Making Connections

Standard 6: The student will make connections between the visual arts and other arts disciplines, other content areas, and the world.

Indicators:

VAH1-6.3, VAH2-6.3, VAH3-6.3, VAH4-6.3 Identify specific visual arts careers and describe the knowledge and skills that one needs for these careers.

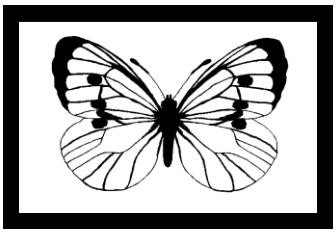
Materials

Students' chosen insect images.
Digital and print photographic images of pollinator insects.
Drawing pencils, kneaded erasers, 9" x 12" smooth Bristol board in tan, ivory, and white. Colored pencils, pastels, or pen and ink with water color. Fixative for pastels. (Choose the media you think your students will be most successful with, or that they need to have more practice with.)
A copy of the "Self-Assessment Rubric" for each student.
A copy of the "Scientific Illustration Label" for each student.

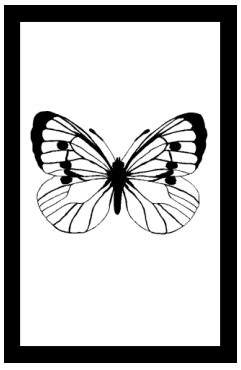
Lesson Procedures:

1) Give students a copy of the rubric. Go over the requirements of the assignment. Explain that their drawing should leave sufficient room around the edges so that the work can be matted and framed. Also, stress that the orientation of the paper should maximize the illustration of the insect. An example of this is seen when drawing a butterfly in landscape instead of portrait layout.

Good.



Not so good.



2) Demonstrate the medium students are to use in order to add color. This assignment should not be the students' first experience with the media. Allow students to practice with the media before it is applied to the drawing. The following YouTube videos are a quick and engaging way to teach or refresh memory of processes.
    - Colored Pencil - https://www.youtube.com/watch?v=hHJiRCQAVFE
    - Pastels - https://www.youtube.com/watch?v=wixgn_lSiC4
    - Watercolor and Ink - https://www.youtube.com/watch?v=4WPABn0pQVY

3) Hand out all art materials and assist as needed. When most of the class nears completion, point out that they must submit the "Self-Assessment Rubric" along with the separate form "Scientific Illustration" label that lists the artist's neatly printed name, date, scientific and common name of their specimen, the region where specimen lives, and the plants that specimen pollinates. Also, remind students to sign their artwork and to pay attention to where their signature is placed so that if the work is matted and framed, the mat will not cover their signature.

Lesson 4

Formal Critique of Pollinator Insect Scientific Drawings

Overview:
Students will look at and critically discuss their work and the work of their classmates. (Note for non-art lesson plan readers: "Critically discuss" does not mean criticize, it means to formally analyze a work of art based on the Elements of Art and the Principals of design whereby one describes, examines, interprets, and judges a work of art.)

Time: One 50-Minute Class Period

Objectives:
The students will be able to formally discuss and assess their work and the works of others.

Standards:

South Carolina Academic Standards for the Visual and Performing Arts
South Carolina Department of Education, 2010

VISUAL ARTS HIGH SCHOOL LEVELS 1, 2, 3, & 4

Creating Works of Visual Art

Standard 1: The student will demonstrate competence in the use of ideas, materials, techniques, and processes in the creation of works of visual art.

Indicators:

VAH1-1.1, VAH2-1.1, VAH3-1.1, VAH4-1.1 Recognize and analyze the similarities and differences between materials, techniques, and processes in works of visual art.

VAH1-1.2, VAH2-1.2, VAH3-1.2, VAH4-1.2 Describe ways that different materials, techniques, and processes evoke different responses in one who is creating or viewing artworks.

Using Structures and Functions

Standard 2: The student will use composition and the elements and principles of design to communicate ideas.

Indicators:

VAH1-2.1, VAH2-2.1, VAH3-2.1, VAH4-2.1 Recognize, describe, and analyze the elements and principles of design and other compositional structures and strategies used in the visual arts to communicate ideas.

VAH1-2.3, VAH2-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies.

VAH3-2.3, VAH4-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies to communicate ideas.

Exploring Content

Standard 3: The student will examine the content of works of visual art and use elements from them in creating his or her own works.

Indicators:

VAH1-3.1, VAH2-3.1, VAH3-3.1, VAH4-3.1 Explore the sources of the subject matter and the ideas in a variety of works of visual art.

VAH1-3.2, VAH2-3.2, VAH3-3.2, VAH4-3.2 Analyze and describe the relationships among subject matter, symbols, and themes in communicating intended meaning in his or her own artworks and in those of others.

History and Culture

Standard 4: The student will understand the visual arts in relation to history and world cultures and the technologies, tools, and materials used by artists.

Indicators:

VAH1-4.1, VAH2-4.1, VAH4-4.1 Describe ways that the subject matter, symbols, ideas, and technologies in various artworks are related to history and culture.

VAH1-4.2, VAH2-4.2, VAH4-4.2 Identify specific artworks as belonging to a particular culture or historical period and explain the characteristics that led him or her to make that identification.

VAH1-4.3, VAH2-4.3, VAH4-4.3 Describe and discuss the function and meaning of specific artworks from various world cultures and historical periods.

Interpreting Works of Visual Art

Standard 5: The student will analyze and assess the characteristics and qualities of his or her own works of visual art and those of others.

Indicators:

VAH1-5.1, VAH2-5.1, VAH3-5.1, VAH4-5.1 Analyze the intention of the artist in a specific artwork and justify his or her interpretation.

VAH1-5.2, VAH2-5.2, VAH3-5.2, VAH4-5.2 Make complex, descriptive, interpretative, and evaluative judgments about his or her own artworks and those of others.

VAH1-5.3, VAH2-5.3, VAH3-5.3, VAH4-5.3 Formulate criteria for interpreting and evaluating his or her artworks and those of others.

VAH1-5.4, VAH2-5.4, VAH3-5.4, VAH4-5.4 Maintain a personal portfolio of his or her artworks.

Making Connections

Standard 6: The student will make connections between the visual arts and other arts disciplines, other content areas, and the world.

Indicators:

VAH1-6.1, VAH2-6.1, VAH3-6.1, VAH4-6.1 Analyze the similarities and differences between the visual arts and other arts disciplines.

VAH1-6.2, VAH2-6.2, VAH3-6.2, VAH4-6.2 Compare and contrast concepts, issues, and themes in the visual arts and other subjects in the school curriculum.

VAH1-6.3, VAH2-6.3, VAH3-6.3, VAH4-6.3 Identify specific visual arts careers and describe the knowledge and skills that one needs for these careers.

Materials:

Self-Assessment Rubrics, the "Scientific Illustration" labels, binder clips or paper clips.

Lesson Sequence:

1) Have students paperclip their labels to the back of their work and hang the projects around the classroom.

2) Conduct a formal critique.
   This is a source on how to conduct a formal critique:
   https://www.uwgb.edu/malloyk/art_criticism_and_formal_analysi.htm

Wrap-Up and Assessments:
Have the students fill out their self-assessment rubric and turn it in. Then have students fill out their Scientific Illustration art label and paper clip it to the back of their art. Hang the art for a formal critique. Use the "Teacher's Rubric" along with critique participation and the "Self-Assessment Rubric" to obtain a final grade for the unit and provide feedback in the comments section of the rubric.

Notes on Lesson Plan Resources

Images, Artists, and History:

Botanical Art History**:** http://mnborealart.com/Trees/Botanical_Art_History.html

Botanical Art & Artists: http://www.botanicalartandartists.com/history.html

Digitized copy of Insectorum Sive Minimorum Animalium Theatrum by Thomas Moffett, 1553- 1604 with many examples of scientific illustrations: http://www.biodiversitylibrary.org/item/123182#page/1/mode/1up

Digitized copy of *The Transformations (or Metamorphoses) of Insects* (1882) by P. Martin Duncan: https://archive.org/details/transformationso00dunc

Digitized copy of *Zoological Plates Drawn and Issued by Prof. Dr. Paul Pfurtscheller in Vienna*: https://babel.hathitrust.org/cgi/pt?id=coo.31924018440747;view=1up;seq=7

Illustrations from Anatomy of the Honey Bee by R.E. Snodgrass: http://articles.extension.org/pages/26467/illustrations-from-anatomy-of-the-honey-bee-by-re-snodgrass

Images from *The Travelling Beehive* by Elena García, Manuel Ángel Rosado and Juan Hernaz illustrator. Publisher: Atlantic Botanical Garden, CIBIO and Spanish Enthomology Society, 2012: https://www.behance.net/gallery/9857081/The-travelling-beehive-(illustrated-book)

Jan van Kessel the Elder (1626 - 1679): https://www.pubhist.com/person/294/jan-van-kessel-the-elder/works

Modern Scientific Illustrator Gina Mikel: http://www.scientificillustrator.com/insects.html

Techniques:

Colored Pencil YouTube video tutorial: https://www.youtube.com/watch?v=hHJiRCQAVFE

Grid method video tutorial for drawing correct scale and proportion: http://www.drawinghowtodraw.com/drawing-lessons/improve-drawing/drawing-with-grids.html

Pastels YouTube video tutorial: https://www.youtube.com/watch?v=wixgn_lSiC4

Thumb and pencil method for drawing correct scale and proportion: http://www.drawinghowtodraw.com/stepbystepdrawinglessons/2010/01/how-to-find-measurements-proportions-and-angles-to-draw-with-pencil-thumb-method/

Watercolor and Ink YouTube video tutorial: https://www.youtube.com/watch?v=4WPABn0pQVY

Science:

Chocolate and Pollinators by the North American Pollinator Protection Campaign. A fun and educational extension lesson: http://pollinator.org/Resources/Chocolate%20and%20Pollinators.pdf

List of Pollinated Foods: http://pollinator.org/list_of_pollinated_food.htm

Middle school resource but great for high school teachers: http://sciencespot.net/Pages/adinsless.html

Pollinators information: http://www.fs.fed.us/wildflowers/pollinators/index.shtml

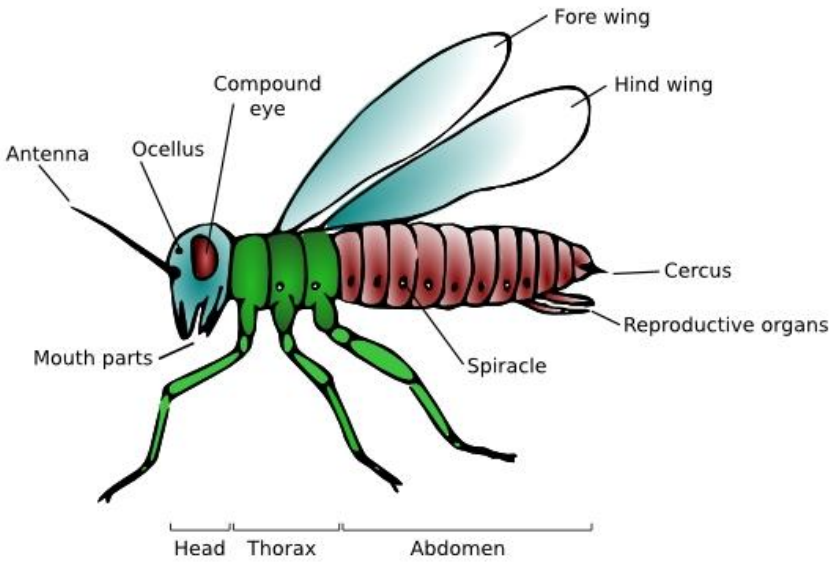
Insects

By The Amateur Entomologists' Society

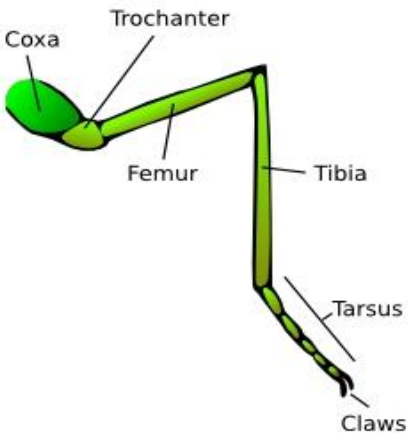
The following information comes directly from The Amateur Entomologists' Society's web page at https://www.amentsoc.org/insects/what-bug-is-this/insects.html

Insects are the most numerous life forms on the planet (in terms of number of species). Approximately seven out of every eight living species are insects. Insects show a number of characteristics, the three by which they are most easily recognized are:-

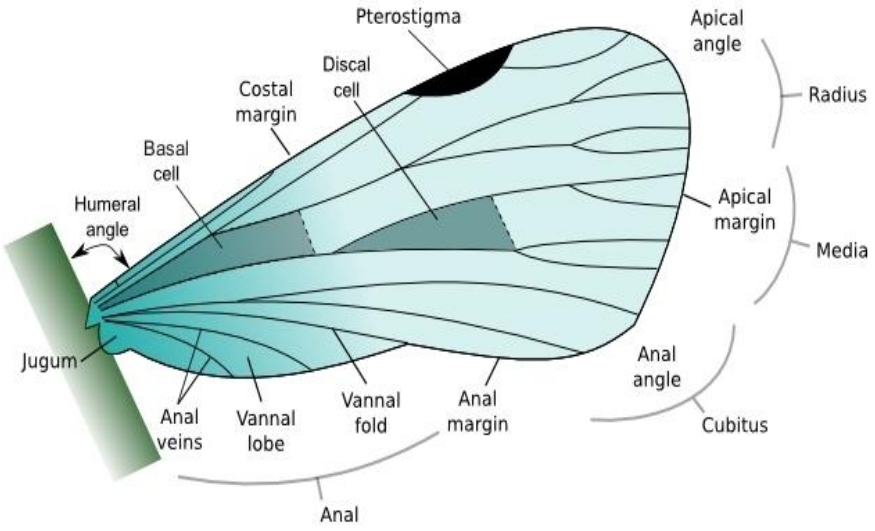
The body is divided into three distinct regions - **head**, **thorax**, and **abdomen**. Each region is further divided into segments. Typically, there are six in the head, three in the thorax and eleven in the abdomen. In the more advanced insects segments may become fused together, particularly in the abdomen. The structure of a generalized insect is illustrated below, but insects are a very diverse group and have evolved many different forms:



There are three pairs of walking legs on the thorax, one pair to each segment. The legs show a very characteristic structure, but this is often modified to fulfill a variety of tasks, e.g. swimming or holding of prey. The *generalized* structure of an insect leg:



The adults of most insects show two pairs of wings, one pair on each of segments two and three. The wings are supported by a series of veins, the pattern of veins being important in classification. The naming of the veins and regions on an insect wing:



Respiration

Insects 'breathe' through a system of branching tubes, the trachea. Oxygen and carbon dioxide move along these by a process called diffusion. The trachea opens on the surface of the body at special pores, the spiracles. The insect may control the size of these pores. It is this method of 'breathing' which stops insects from getting very large. The insect body cannot get bigger than a diameter of about three centimeters. Above this size diffusion of oxygen into the body tissues becomes too inefficient for the insect to live.

Vision

The head bears a pair of compound eyes. These consist of a number of individual 'eyes', each of which produces a separate image. Hence the overall picture that the insect sees is made up of a series of dots. This is rather like a television picture, but with much poorer sharpness. This type of eye is very good at judging distance and movement. Hence insects which are active predators, such as dragonflies, have very well developed eyes.

Antennae

The antennae (or 'feelers') are mainly organs of smell and taste. They do have other functions in certain insects, e.g. they may be used to detect air currents. Hence the word 'feeler' does not describe their function and should not be used. They are made up of individual 'segments' that are attached to one another by flexible membranes. There are muscles inside the antennae that allow them to move. Antennae come in a variety of forms, and may be different in male and female, e.g. in chironomid midges. The antennae of male chironomid midges are 'bushy' because smell is very important in finding a female to mate with.

Pollinator Syndromes

"Pollinator Syndromes" describe flower characteristics, or traits, that may appeal to a particular type of pollinator. Such characteristics can be used to predict the type of pollinator that will aid the flower in successful reproduction. A combination of color, odor, quantity of nectar, location and type of pollen, and flower structure can each affect a potential pollinator's ability to locate a flower and its food resources.

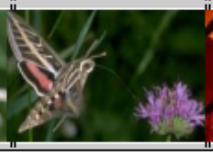
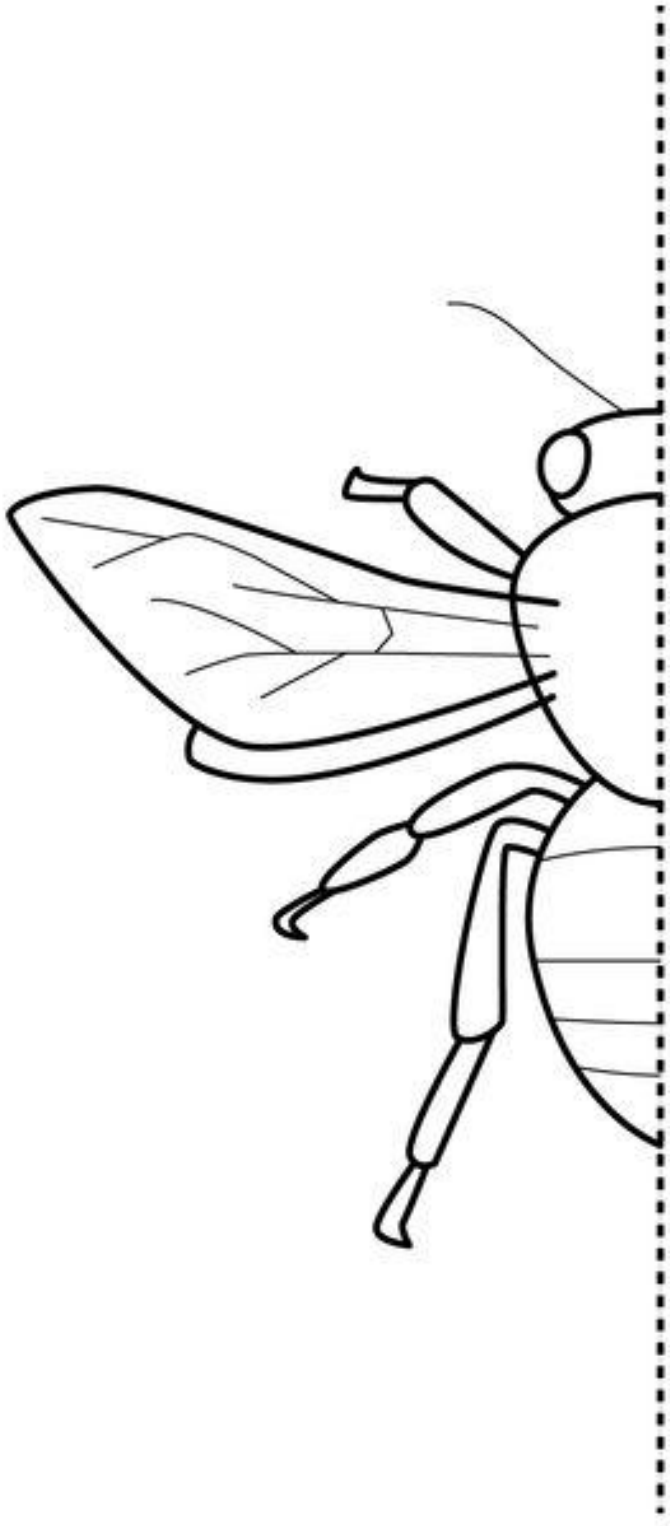
	Type of Pollinator							
Trait	**Bat**	**Bee**	**Beetle**	**Bird**	**Butterfly**	**Fly**	**Moth**	***Wind***
Color	White, green or purple	Bright white, yellow, blue, or UV	White or green	Scarlet, orange, red or white	Bright red and purple	Pale,or dark brown, purple	Pale red, purple, pink or white	Pale green, brown, or colorless
Nectar guides	None	Present	None	None	Present	None	None	None
Odor	Strong and musty; emitted at night	Fresh, mild, pleasant	None to strongly fruity or foul	None	Faint but fresh	Putrid	Strong sweet; emitted at night	None
Nectar	Abundant; somewhat hidden	Usually present	Sometimes present	Ample; deeply hidden	Ample; deeply hidden	Usually absent	Ample; deeply hidden	None
Pollen	Ample	Limited; often sticky, scented	Ample	Limited	Limited	Limited	Limited	Abundant; small, smooth
Flower Shape	Bowl shaped; closed during day	Shallow; with landing platform; tubular	Large and bowl-shaped	Large, funnel -like; strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel-like or complex with trap	Regular; tubular without a lip	Regular and small
								

Photo credits © Merlin Tuttle, Tom Eisner, Edward Ross, Arla Altman, Chris Carvalho, Paul Growald

Symmetry of a Bee

Name: _____

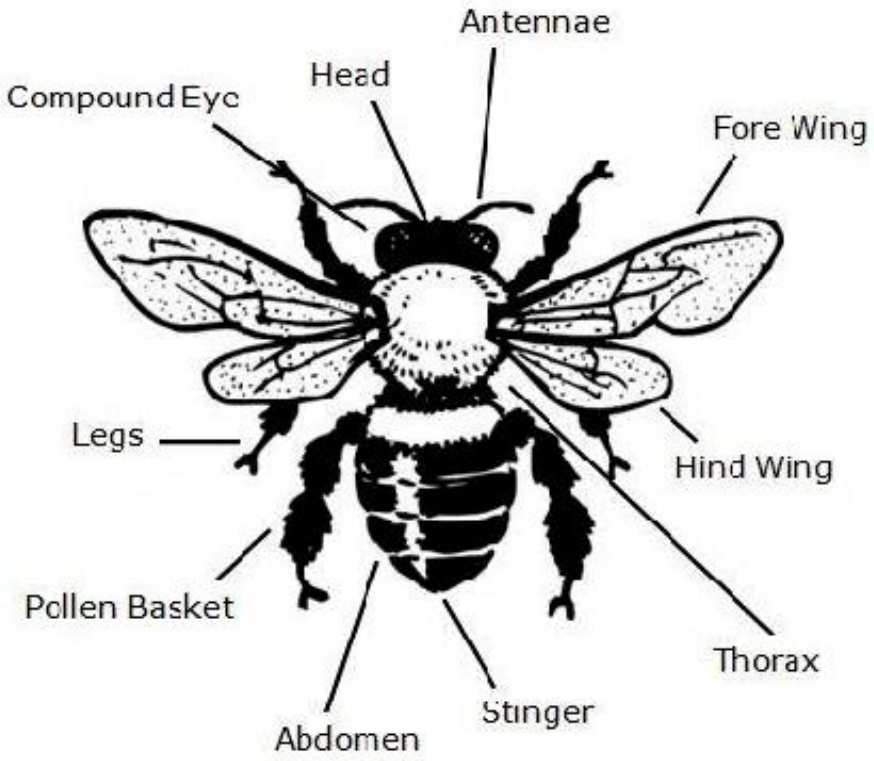
Date: _____



From: https://www.artforkidshub.com/10-free-coloring-pages-bug-symmetry/

Honey Bee Anatomy

Honey Bees are an important part of our environment. They play a vital role in pollinating plants, so the plants can reproduce (make more plants). The honey bees have specialized body parts that makes them perfect for their job. This diagram and following vocabulary list will help you learn more about them.



TheHomeschoolScientist.com

From: http://thehomeschoolscientist.com/wp-content/uploads/2014/01/honey-bee-anatomy.pdf

Honey Bee Vocabulary

Abdomen - contains the digestive system organs and the heart. In a laying queen bee, the ovaries take up much of the abdomen

Antennae - "feelers" on the top of the honey bee head covered with sensor cells for smell and touch

Compound Eye – multifaceted eye that allows the honey bee to see in all directions at once

Fore Wing and Hind Wing – Honey bees have 2 pairs of wings that hook together during flight to form a single surface, but separate when not in flight.

Head – contains the brain, compound and simple eyes, antennae and mouthparts

Legs – Honey bees have 6 jointed legs that can both grab or stick to surfaces.

Pollen Basket – area on the rear legs of the honey bee where pollen is collected

Proboscis (not shown) – long tongue used to drink nectar from flowers

Stinger – Honey bees are usually not aggressive and only use the stinger for defense.

Thorax – legs and wings are connected here, mostly contains muscles used for flight

From: http://thehomeschoolscientist.com/wp-content/uploads/2014/01/honey-bee-anatomy.pdf

Name: _____

Date: _____

Label Your Own Honey Bee

From: http://thehomeschoolscientist.com/wp-content/uploads/2014/01/honey-bee-anatomy.pdf

South Carolina Academic Standards and Performance Indicators for Science 2014
South Carolina Department of Education
Columbia, South Carolina

http://ed.sc.gov/scdoe/assets/file/agency/ccr/StandardsLearning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf

BIOLOGY 1

SCIENCE AND ENGINEERING PRACTICES

Standard H.B.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

H.B.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:

H.B.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge scientific arguments or claims.

H.B.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.

H.B.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.

H.B.1A.4 Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions.

H.B.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.

H.B.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence
and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.

H.B.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts.

H.B.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

ECOSYSTEM DYNAMICS

Standard H.B.6: The student will demonstrate an understanding that ecosystems are complex, interactive systems that include both biological communities and physical components of the environment.

H.B.6A. Conceptual Understanding: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. Limiting factors include the availability of biotic and abiotic resources and challenges such as predation, competition, and disease.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6A.1 Analyze and interpret data that depict changes in the abiotic and biotic components of an ecosystem over time or space (such as percent change, average change, correlation and proportionality) and propose hypotheses about possible relationships between the changes in the abiotic components and the biotic components of the environment.

H.B.6A.2 Use mathematical and computational thinking to support claims that limiting factors affect the number of individuals that an ecosystem can support.

H.B.6B. Conceptual Understanding: Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged between the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6B.1 Develop and use models of the carbon cycle, which include the interactions between photosynthesis, cellular respiration and other processes that release carbon dioxide, to evaluate the effects of increasing atmospheric carbon dioxide on natural and agricultural ecosystems.

H.B.6B.2 Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases (such as carbon dioxide and methane) on the carbon cycle and global climate.

H.B.6C. Conceptual Understanding: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively stable over long periods of time. Fluctuations in conditions can challenge the functioning of ecosystems in terms of resource and habitat availability.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6C.1 Construct scientific arguments to support claims that the changes in the biotic and abiotic components of various ecosystems over time affect the ability of an ecosystem to maintain homeostasis.

H.B.6D. Conceptual Understanding: Sustaining biodiversity maintains ecosystem functioning and productivity which are essential to supporting and enhancing life on Earth. Humans depend on the living world for the resources and other benefits provided by biodiversity. Human activity can impact biodiversity.

Performance Indicators: Students who demonstrate this understanding can:

H.B.6D.1 Design solutions to reduce the impact of human activity on the biodiversity of an ecosystem.

South Carolina Academic Standards For The Visual And Performing Arts
South Carolina Department of Education 2010

http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/AcademicStandardsforVisualArts.pdf

HIGH SCHOOL LEVELS 1, 2, 3, & 4

Creating Works of Visual Art

Standard 1: The student will demonstrate competence in the use of ideas, materials, techniques, and processes in the creation of works of visual art.

Indicators:

VAH1-1.1, VAH2-1.1, VAH3-1.1, VAH4-1.1 Recognize and analyze the similarities and differences between materials, techniques, and processes in works of visual art.

VAH1-1.2, VAH2-1.2, VAH3-1.2, VAH4-1.2 Describe ways that different materials, techniques, and processes evoke different responses in one who is creating or viewing artworks.

VAH1-1.3, VAH2-1.3, VAH3-1.3, VAH4-1.3 Communicate ideas through the effective use of a variety of materials, techniques, and processes in works of visual art.

VAH1-1.4, VAH2-1.4, VAH3-1.4, VAH4-1.4 Apply materials, techniques, and processes with skill, confidence, and sensitivity sufficient to make his or her intentions observable in the artwork that he or she creates.

VAH1-1.5, VAH2-1.5, VAH3-1.5, VAH4-1.5 Use a variety of art materials, tools, and equipment in a skillful, safe, and responsible manner.

VAH3-1.6 Demonstrate proficiency in a specific visual arts genre (for example, painting, photography, sculpture, ceramics).

VAH4-1.6 Demonstrate proficiency in creating a body of work in a specific visual arts genre, such as painting, drawing, printmaking, photography, sculpture, ceramics, graphic design, or fiber arts.

Using Structures and Functions

Standard 2: The student will use composition and the elements and principles of design to communicate ideas.

Indicators:

VAH1-2.1, VAH2-2.1, VAH3-2.1, VAH4-2.1 Recognize, describe, and analyze the elements and principles of design and other compositional structures and strategies used in the visual arts to communicate ideas.

VAH1-2.2, VAH2-2.2, VAH3-2.2, VAH4-2.2 Create works of visual art that use the elements and principles of design and other compositional strategies.

VAH1-2.3, VAH2-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies.

VAH3-2.3, VAH4-2.3 Evaluate the effectiveness of artworks by analyzing the use of the elements and principles of design and other compositional structures and strategies to communicate ideas.

Exploring Content

Standard 3: The student will examine the content of works of visual art and use elements from them in creating his or her own works.

Indicators:

VAH1-3.1, VAH2-3.1, VAH3-3.1, VAH4-3.1 Explore the sources of the subject matter and the ideas in a variety of works of visual art.

VAH1-3.2, VAH2-3.2, VAH3-3.2, VAH4-3.2 Analyze and describe the relationships among subject matter, symbols, and themes in communicating intended meaning in his or her own artworks and in those of others.

VAH1-3.3, VAH2-3.3, VAH3-3.3, VAH4-3.3 Select and effectively use subject matter, symbols, and ideas to communicate meaning through his or her artworks.

History and Culture

Standard 4: The student will understand the visual arts in relation to history and world cultures and the technologies, tools, and materials used by artists.

Indicators:

VAH1-4.1, VAH2-4.1, VAH4-4.1 Describe ways that the subject matter, symbols, ideas, and Technologies in various artworks are related to history and culture.

VAH1-4.2, VAH2-4.2, VAH4-4.2 Identify specific artworks as belonging to a particular culture or historical period and explain the characteristics that led him or her to make that identification.

VAH1-4.3, VAH2-4.3, VAH4-4.3 Describe and discuss the function and meaning of specific artworks from various world cultures and historical periods.

VAH1-4.4, VAH2-4.4, VAH4-4.4 Demonstrate visual literacy by deconstructing images in a variety of contexts.

VAH1-4.5, VAH2-4.5, VAH4-4.5 Apply a knowledge of art history, various cultures, and technologies in the creation of original works of visual art.

Interpreting Works of Visual Art

Standard 5: The student will analyze and assess the characteristics and qualities of his or her own works of visual art and those of others.

Indicators:

VAH1-5.1, VAH2-5.1, VAH3-5.1, VAH4-5.1 Analyze the intention of the artist in a specific artwork and justify his or her interpretation.

VAH1-5.2, VAH2-5.2, VAH3-5.2, VAH4-5.2 Make complex, descriptive, interpretative, and evaluative judgments about his or her own artworks and those of others.

VAH1-5.3, VAH2-5.3, VAH3-5.3, VAH4-5.3 Formulate criteria for interpreting and evaluating his or her artworks and those of others.

VAH1-5.4, VAH2-5.4, VAH3-5.4, VAH4-5.4 Maintain a personal portfolio of his or her artworks.

Making Connections

Standard 6: The student will make connections between the visual arts and other arts disciplines, other content areas, and the world.

Indicators:

VAH1-6.1, VAH2-6.1, VAH3-6.1, VAH4-6.1 Analyze the similarities and differences between the visual arts and other arts disciplines.

VAH1-6.2, VAH2-6.2, VAH3-6.2, VAH4-6.2 Compare and contrast concepts, issues, and themes in the visual arts and other subjects in the school curriculum.

VAH1-6.3, VAH2-6.3, VAH3-6.3, VAH4-6.3 Identify specific visual arts careers and describe the knowledge and skills that one needs for these careers.

Scientific Illustration Label
(Please Print)

Artist's Name:

____

Date:

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Scientific Name of Insect:

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Common Name of Insect:

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Regional Habitat of Insect:

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Pollination Syndrome of Insect:

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Scientific Illustration Label
(Please Print)

Artist's Name:

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Date:

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Scientific Name of Insect:

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Regional Habitat of Insect:

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Pollination Syndrome of Insect:

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Pollinator Insect Scientific Illustration Self-Assessment Rubric

Student's Name: _____ Date: _____

Directions: Circle the portions for each category that match your illustration. Consider your work and assign an appropriate numeric grade for each project category. When you are finished, add up your total score.

Project Categories	20 -25	15-19	9-14	0-9	Score
Accurate Color Details	Colors in the illustration match the colors of the specimen	Colors in the illustration closely match the colors of the specimen	Colors in the illustration mostly don't match the colors of the specimen	Colors in the illustration are missing or don't match the true colors of the specimen	
Accurate Anatomy Details	All anatomy closely represents the body plan of the specimen	Some of the anatomy drawn does not represent the body plan of the specimen	A majority of the anatomy drawn does not represent the body plan of the specimen	The anatomy drawn does not represent the body plan of the specimen	
Accurate Proportion Details	All proportions of the body plan are an accurate representation of the specimen	Some proportions of the body plan are an accurate representation of the specimen	Many proportions of the body plan are not an accurate representation of the specimen	Majority of proportions of the body plan are not an accurate representation of the specimen	
Completely filled out *Scientific Illustration Label* with accurate information ☐Artist's Name ☐Date ☐Scientific Name of Insect ☐Common Name of Insect ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	All of the following present: ☐Artist's Name ☐Date ☐Scientific Name of Insect ☐Common Name of Insect May be missing <u>one</u> of the below criteria: ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	All of the following present: ☐Artist's Name ☐Scientific Name of Insect <u>or</u> Common Name of Insect May be missing <u>one</u> of the below criteria: ☐Date ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	All of the following present: ☐Artist's Name ☐Scientific Name of Insect <u>or</u> Common Name of Insect May be missing the below criteria: ☐Date ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	Artist's name and Scientific <u>or</u> Common Name of Insect is missing May be missing the below criteria: ☐Date ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	

Total:

Comments:

Teacher's Pollinator Insect Scientific Illustration Rubric

Student's Name: _____ Date: _____

Project Categories	20 -25	15-19	9-14	0-9	Score
Accurate Color Details	Colors in the illustration match the colors of the specimen	Colors in the illustration closely match the colors of the specimen	Colors in the illustration mostly don't match the colors of the specimen	Colors in the illustration are missing or don't match the true colors of the specimen	
Accurate Anatomy Details	All anatomy closely represents the body plan of the specimen	Some of the anatomy drawn does not represent the body plan of the specimen	A majority of the anatomy drawn does not represent the body plan of the specimen	The anatomy drawn does not represent the body plan of the specimen	
Accurate Proportion Details	All proportions of the body plan are an accurate representation of the specimen	Some proportions of the body plan are an accurate representation of the specimen	Many proportions of the body plan are not an accurate representation of the specimen	Majority of proportions of the body plan are not an accurate representation of the specimen	
Completely filled out *Scientific Illustration Label* with accurate information ☐Artist's Name ☐Date ☐Scientific Name of Insect ☐Common Name of Insect ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	All of the following present: ☐Artist's Name ☐Date ☐Scientific Name of Insect ☐Common Name of Insect May be missing <u>one</u> of the below criteria: ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	All of the following present: ☐Artist's Name ☐Scientific Name of Insect <u>or</u> Common Name of Insect May be missing <u>one</u> of the below criteria: ☐Date ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	All of the following present: ☐Artist's Name ☐Scientific Name of Insect <u>or</u> Common Name of Insect May be missing the below criteria: ☐Date ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	Artist's name and Scientific <u>or</u> Common Name of Insect is missing May be missing the below criteria: ☐Date ☐Regional Habitat of Insect ☐Pollination Syndrome of Insect	

Total:

Comments: