SOCIETY OF ARCHITECTURAL HISTORIANS
SAH ARCHIPEDIA
ROTUNDA

TITLE: ARCHITECTURE AND THE ENVIRONMENT
SUBJECTS/TOPICS: ARCHITECTURE, GEOGRAPHY, HISTORY, SOCIAL STUDIES
GRADE LEVEL: 6-8 (2-3 CLASS PERIODS)
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LESSON OVERVIEW

In this lesson we will explore how environmental factors influence design and building performance, what makes a piece of historic architecture "green," and how some contemporary architects are dedicated to creating sustainable structures that beneficially impact the natural environment and the experiences of their users.

BACKGROUND

Read the following sections on the SAH Archipedia webpage: History and FAQ. Students will be using the database for research, so it is important to familiarize them with the resource and why it is valuable as an online tool.

In order to understand certain elements of architecture and its connection to the environment, students must become familiar with new vocabulary. An abbreviated vocabulary lesson is included at the end of this document.

Review the list of green architecture in SAH Archipedia. This will be a useful guide for some of the activities, especially if students are having trouble finding examples of certain environmental systems or project strategies. If students find additional projects, especially as SAH Archipedia continues to undergo regular updates, it would be a beneficial class endeavor to update or customize the list.

Many of the exercises within this Unit are designed as a scaffolded curriculum, so it may be beneficial to consult content from the grades 3-5 lesson to see if the activities could be modified and implemented for older students.

GUIDING QUESTIONS

What are different types of passive and active systems that bolster sustainable practices in the built environment?

Why is the concept of conservation critical to both architecture (the built environment) and the natural environment?

LEARNING OBJECTIVES

Study and visualize regional components that influence architectural design and production, such as the climate, local resources, and environmental challenges.

In order to be "green," buildings do not have to use the latest, most expensive technology: there are simple practices that can be implemented into almost any existing building to improve efficiency.

In many senses, the "greenest" building is the one already built so the field of adaptive reuse is extremely important to the future of architecture.

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PREPARATION

There are many definitions of sustainable design and in these lessons, we will focus on the components of sustainable design that directly relate to the built environment: architecture. As you will learn, the design and implementation of "green architecture" is much more than adding a few solar panels, wind turbines, and green walls to a project. Therefore, it is helpful to look at pre-modern and vernacular architecture to see how passive and low-tech solutions were used to harness and mediate the impact of the sun and natural forces such as wind and rain. In many senses, historic architecture forms the basis for green design: buildings were constructed with local materials and labor because advanced technologies and transportation systems were not available.

You will be conducting visual and textual research using SAH Archipedia. Read the following sections to familiarize yourself with the project as a whole and how to navigate the database: History and FAQ.

Center for Advanced Energy Studies, GSBS Architects
Idaho Falls, Idaho
Photo credit: Kevin Van Den Wymelenberg

CONTENT STANDARDS

Grade 6:

Key Ideas and Details
- CCSS.ELA-Literacy.RI.6.1

Integration of Knowledge and Ideas:
- CCSS.ELA-Literacy.RI.6.7
- CCSS.ELA-Literacy.RH.6-8.7
- CCSS.ELA-Literacy.RST.6-8.7

Text Types and Purposes
- CCSS.ELA-Literacy.W.6.2

Research to Build and Present Knowledge
- CCSS.ELA-Literacy.W.6.7
- CCSS.ELA-Literacy.W.6.9

Grade 7:

Key Ideas and Details
- CCSS.ELA-Literacy.RI.7.1

Integration of Knowledge and Ideas:
- CCSS.ELA-Literacy.RI.7.9
- CCSS.ELA-Literacy.RH.6-8.7
- CCSS.ELA-Literacy.RST.6-8.7

Text Types and Purposes
- CCSS.ELA-Literacy.W.7.2

Research to Build and Present Knowledge
- CCSS.ELA-Literacy.W.7.7
- CCSS.ELA-Literacy.W.7.9

Grade 8:

Key Ideas and Details
- CCSS.ELA-Literacy.RI.8.1

Integration of Knowledge and Ideas:
- CCSS.ELA-Literacy.RI.8.7
- CCSS.ELA-Literacy.RH.6-8.7
- CCSS.ELA-Literacy.RST.6-8.7

Text Types and Purposes
- CCSS.ELA-Literacy.W.8.2

Research to Build and Present Knowledge
- CCSS.ELA-Literacy.W.8.7
- CCSS.ELA-Literacy.W.8.9

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ACTIVITIES

Activity #1: Building and Energy Assessment, Part I

- Overall, it is estimated that buildings consume 40% of the world's energy. Although that is a huge number, we have to be careful that we do not automatically associate architecture, or industry, with bad environmental practices. Energy usage is shaped more by the choices made by people using buildings rather than the buildings themselves. This is compounded by the fact that, in America, we spend about 90% of our time indoors. Therefore, the environmental quality of our buildings, their immediate surroundings, and how we manage energy use in the built environment are extremely important. The proper siting of a building (e.g. location) can dramatically improve an occupant's quality of life. Responsible energy management around and within a building can also enhance the structure's lifecycle, reduce the environmental footprint of occupants, and, consequentially, save both owners and occupants money (approximately 5-30%).

- This activity asks you to explore relationships between your built and natural environment, quality of living, and energy management practices at various scales, using elements from one of the foremost green building assessment systems: LEED (Leadership in Energy and Environmental Design). You will examine your place of residence to assess its sustainable qualities in relation to three topics: Location & Transportation, Sustainable Sites, and Energy.

- Use the Building and Energy worksheet to complete this activity. Share your work with your classmates.

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Activity #2: Site Condition and Life Cycle

- Locate and research a "green" or sustainable project on the SAH Archipedia. Your teacher will give you some additional guidance for selecting a project.
    - Read the SAH entry.
    - Find additional photographs and, ideally, architectural drawings of the project online. A good place to start looking would be the architect's website.
- Visual observation and annotation
    - Locate the project on Google Earth and study the context from the aerial imagery.
    - Can you identify elements on the building that respond to the site, as well as its weather and climate? Think about elements such as the roof shape or pitch (the slope). Is there a porch, or other types of overhangs, that provides shade to certain sides or apertures of the building?
- Create a digital presentation to teach your classmates about the project
    - Include an aerial satellite image, a topographic map of the area from the USGS, any architectural drawings you can collect, and photographs of the project.
    - On the aerial image, mark the cardinal directions and explain the orientation of the building.
    - Identify the Climate Zone using tools from the US Office of Energy Efficiency & Renewable Energy
    - Use NOAA's National Climatic Data Center and the Weather Channel to explain the climatic conditions of the area. What are the temperatures, wind direction, and rainfall in the area? Create representative charts that show average, annual data.
    - Finally, create some original imagery. Using photographs of the project and original sketches, draw a series of systems diagrams illustrating different seasons and times of day:
        - What is the path of the sun around the building? How does daylight enter the building? What are the building's shading elements?
        - How does wind move around and through the building?
        - How does cool air enter the building, and hot air exit the building as it rises?
        - Trace the paths of rainwater on and around the building.
        - What is the role of vegetation around the building?
- As a class, create a shared Google Map with all of the selected projects, geolocated, and embed information about the projects' site and features designed to respond to the environment.

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Assessments:

Activity #1: Building and Energy Assessment

- Parts I and II of this assignment can be adapted to study your school, a particular business, or an assigned building from SAH Archipedia.

Activity #2: Site Conditions

- You may want to assign constraints for the research project. For example, you may want to limit the students to:
    - A certain geographical region
    - A certain range of dates
    - A building typology (i.e., house, office, civic building, religious structure, etc.)

- For examples of building system diagrams, see the following architecture firms:
    - Bjark Ingales Group: BIG
    - Foster + Partners

- This could easily be a longer-term research and reflection project, consisting of work time both in and out of the classroom. Students wishing to explore the building deeper could try making a SketchUp model.

Lesson Extensions and Resources:

- See the Architecture and the Environment Bibliography

- Era of the Anthropocene from the Smithsonian Magazine

- In terms of visualizing information, Information is Beautiful is an incredible site with a wealth of topics. To explore the process, watch Making Data into Art. The following are of interest for architecture and environment:
    - When Sea Levels Attack
    - How Do We Get to Zero Greenhouse Gas Emissions?
    - Methane

- If you would like to see some inspiring TED Talks about architecture and forwarding-thinking design:
    - William McDonough speaking on his concept of 'cradle to cradle' design
    - "Norman Foster: Building the Green Agenda"

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- One of the best ways to improve the energy performance of new buildings is to understand how we use energy within existing buildings. Check out this great series of infographics on energy use in New York City.

- Additional online architecture and sustainable design resources:
    - Arch Daily
    - Architectural Record
    - Architect
    - Architizer
    - Bustler
    - Detail
    - e-architect
    - Harvard Green Building Resource
    - Journal of Architecture
    - Journal of Architectural Education
    - Journal of Green Building
    - Places
    - Treehugger

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General Architectural Reference (with an American focus)

The Buildings of the United States series from the Society of Architectural Historians and the University of Virginia Press.

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ARCHITECTURE AND THE ENVIRONMENT: BUILDING AND ENERGY WORKSHEET

Part 1. Location and Transportation

Question	Yes/No
Does your residence have access to public transportation (e.g. bus, ride share)?	
Is your residence located within walking/public transportation access to: …a grocery store?	
…. to community resources (e.g. convenience store, farmer's market, pharmacy)?	
…. to services (e.g. gym, bank, laundry)?	
…. to civic/community resources (e.g. library, park, post office, worship, police/fire)?	
Is your residence in what the USGBC calls a "high priority area" [and for what]? [e.g. historic district, brownfield redevelopment (formerly polluted site)]	
Is your residence built on environmentally sensitive land (e.g. prime farmland, flood plain, threatened natural habitat, < 50 feet from wetlands, or < 100 feet from a body of water)?	
Does your residence have access to a bike share or bike parking?	

Reflection Questions – Part 1

1. In what ways does your residence's *location* affect your environmental footprint, and your relationship to the neighborhood and greater area?

2. Identify at least two things you could do right now to increase your use of public or green (e.g. a bike) transportation systems.

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Part 2. Sustainable Sites

Question	Yes/No
Does your residence have aesthetically pleasing views to the exterior?	
Does your residence have dedicated outdoor space (e.g.: adjacent outdoor areas for use)?	
If yes, does your outdoor space have pedestrian-oriented paving or space for social activities?	
If yes, is there a garden with a diversity of vegetation?	
If yes, are there signs of a healthy natural habitat?	
Does your residence have on-site rainwater management (e.g.: bioswale, rain garden, rain barrel)?	
Does your residence's site have natural shade (e.g. trees or vines)?	
Does your residence's site have built shade devices (e.g. trellis, porch, awnings)?	

Reflection Questions – Part 2

1. To what extent does your residence's site (immediate surroundings) contribute to your sense of community, and your relationship to the natural environment?

2. Identify at least two things you could do right now to enhance your residence's site.

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Part 3a. Energy Assessment

In evaluating your residence, inspect only locations that: (1) are SAFE and (2) you have PERMISSION to enter. Complete this exercise with caution; if you are unsure about safety or whether you should be in a given location to answer any of the below questions, please write "N/A" in the answer box.

Check for air leaks: hold a feather or lightweight piece of string in front of the areas noted below; if the feather or string moves [even slightly] there is airflow. Answer whether there is air flow at:

Item	Yes/No
Electrical outlets	
Switch plates (light switch covers)	
Window frames	
Baseboards (where walls meet floors)	
Weather stripping around doors	
Fireplace dampers - are they closed when not in use?	
Wall – or window – mounted air conditioners	

Lightbulbs: Number of incandescent (old-fashioned) light bulbs? _____
Number of compact fluorescent lights or LED's? _____ (much more efficient)

Item	Enter a number
Number of electronics/appliances plugged in when not in use	
Number of electronics/appliances unplugged when not in use or attached to a power strips to eliminate phantom power	

Building apertures: daylight, shade, and insulation	Enter a number
Number of windows in your residence	
• North facing (diffused light; can cause significant winter heat loss if not properly insulated)	
• East facing (morning light)	
• South facing (strongest/longest light; can cause significant heat gains in the summer)	
• West facing (afternoon light)	
Number of doors	
Number of windows with exterior shading devices (e.g. awnings, overhangs, operable shutters).	
Number of windows with interior shading devices (e.g. blinds, curtains, interior shutters).	

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Part 3b. Appliance Assessment

Go to: https://energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use. Once there, scroll through the list and identify at least five appliances that you use frequently. Then find their wattage information here: http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/major-appliances/miscellaneous-equipment-energy-consumption/default-energy-consumption-of-mels.

Complete the following table:

Appliance	Energy use (annual)	Estimated cost (annual)
1.		
2.		
3.		
4.		
5.		

Reflection Questions – Part 3

1. Which energy efficiency issues did you discover in your residence that surprised or concerned you? Why?

2. How does your residential energy use relate to both your budget and your environmental footprint?

3. Identify at least two things you could do right now to improve your residential energy efficiency:

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Architecture and the Environment Vocabulary

There are several important vocabulary words we need to understand in order to proceed with our lessons on sustainable design. Read the definitions below.

- **active environmental system:** any element or system of elements that function with moving parts and require regular user input. For example, a solar photovoltaic panel (PV) is an active solar device. The opposite of a passive system, but they often work together effectively.
- **adaptive reuse:** the conversion of a building, structure or area into a use other than that for which it was originally designed; this can often a 'green' practice since it saves existing structures and their associated embodied energy instead of completely demolishing a site
- **adobe:** thick earthen walls, effective thermal mass
- **apertures**: openings in a building, such as doors, windows, and skylights
- **brownfield:** a property that has or may have hazardous pollutants or contaminants; these need to be remediated (restore the soil, water, etc. to prevent further environmental damage) before redevelopment happens
- **building envelope:** the elements of a building that enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces. The major elements of the building envelop are the walls, windows and doors, the roof, and the floor or foundation.
- **cladding:** the exterior, protective and decorative layer of the building; this is separate from the structure
- **conditioned spaces:** the portions of a building that are mechanically heated or cooled; examples are rooms that have air conditioning
- **daylighting:** the use of the sun, instead of candles or electrical lighting, to illuminate interior spaces
- **ecology:** the interrelationships of living things to one another and to their environment, and the study of these interrelationships
- **embodied energy:** the amount of energy associated with extracting, processing, manufacturing, transporting and assembling building materials; a completed building has embodied energy
- **energy:** the potential to do work; power
- **energy flow:** the movement of potential/power from one part of a system to another
- **energy auditing:** the examination of the energy systems in a house as used by the current residents
- **energy ratings:** comparing existing houses to standard prototype residences
- **entropy:** the tendency for energy/matter to erode or become less organized over time in a system.
- **existing conditions:** the state of a site previous to the action of the designer. This includes all elements in the landscape and their arrangement. An existing conditions map, often call a base or index map, identifies and communicates these elements and often notes any particular challenges or opportunities. For design process purposes, it is essential that an architect fully study the existing conditions to understand key elements such as the environmental factors that may impact the site and the available, local material resources
- **feedback:** outputs of information, materials, or energy from a system. Positive feedback means that things are working well in the system; negative feedback means that one or more things need to be optimized in the system. Continually monitoring and management of feedback is important for getting the most beneficial and efficient results for a system.
- **glazing:** the use of glass in a building; to reduce solar gain and maintain indoor temperature balances, glass systems can be doubled, insulated and/or tinted
- **greywater:** water from bathroom sinks, showers, and any other non-kitchen and toilet fixtures. In terms of sustainable design practices, harvesting and reusing greywater can be a particularly valuable resource on a site.
- **infiltration:** accidental leakage of outside air into the building; major source of convective heat transfer through the building envelope

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- **insulation:** a material that helps maintain temperature consistencies (heating or cooling) for parts of a building
- **lifecycle analysis (or assessment):** tracking the environmental consequences and energy needs of material systems from resource extraction, through manufacturing and construction, to service-life performance, providing a powerful tool for measuring resource and energy efficiency
- **Life Cycle Cost Analysis (LCCA):** a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system
- **microclimate:** a small-scale climate usually resulting from a variation in solar gain (exposure vs. shade), wind patterns (still vs. calm), water flows (still vs. moving), and/or human-derived heat sources.
- **passive environmental system:** any element or system of elements which function without moving parts or regular user input. For example, a south facing wall of glass is a passive solar device since it naturally adds heat to a space. The opposite of an active system, but they often work together effectively.
- **recycled material:** a remade or repurposed item that can be used for building construction
- **renewable:** usually referring to sources of energy or materials that are produced in relatively short timeframes; an element that can be harvested and then replaced, however the amount of time needed for renewal can be variable.
- **solar energy:** photovoltaic (PV) panels collect energy from the sun that can be harvested and distributed for use in building systems. For the maximum annual solar gain, the panels should be tiled to be perpendicular to the sun at its zenith. For optimal tilt, it is important to know the latitute to know the position of the sun; elements that can reduce the effectiveness of PVs are humidity, cloud cover, pollution, and shadows.
- **solar heating:** evacuated tube solar hot water heaters are vacuum glass cylinders filled with water, glycol, and a copper tube that collect heat from the sun and convert it into steam to generate hot water for bathing, kitchen use, or radiant floor system. They work with a closed flow loop and are very efficient since 92% of the thermal energy collected can be used within the system.
- **specific heat:** the heat holding capacity of a material or surface; water and stone can hold heat well, so they have a high specific heat.
- **stack effect:** the buoyancy of warm air
- **thermal mass:** heavy materials with the highest specific heat (ability to hold heat) such as stone, water, or earth that store incoming solar heat (during sunny hours) and then re-radiate the heat when there is little or no solar gain. It is important to get the most sun exposure, so in the northern hemisphere elements using thermal mass are usually found on the southern side of a structure. In the built environment, structures with thermal mass are particularly effective where temperature fluctuations are high, such as the desert.
- **ventilation:** the way air moves through the building; this can be with passive systems (i.e., open windows, cool air entering at a low level then hot air rising and escaping through high windows) or active systems (air conditioning or heating)
- **Venturi:** this is the effect when air or water increases speed through tunnel because of constriction. A Venturi can happen unintentionally in a building or natural condition, but it can also be a designed element in the built environment that effectively generates passive cooling.
- **Volatile Organic Compounds (VOC):** Off gasses from such products as carpet adhesive and paint usually that often cause allergic reactions or can aggravate asthma. Most green buildings employ low-VOC (or no VOC) products.
- **walkability**: a measure of how friendly an area is to walking
- **waste:** a misplaced resource; this is typically an unintentional and unwanted output of a system. Systems that are the most efficient, naturally, or the best designed are able to match inputs with their waste to create a closed loop, or at least one with minimal waste.
- **windbreak:** a natural, biological or built feature that deflects or slows the flow of air.

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Green Architecture on SAH Archipedia

The following "green" projects can be found on SAH Archipedia; this is just a sampling and there are many more to explore. For the more contemporary projects, it would be useful for the students to explore affiliated websites for the architects, engineers, and builders in order to learn more about the sustainable systems and building's overall intensions (ex. William McDonough + Partners project)

- Alta Vista Elementary School Addition (1957)
- Aqua Tower (2007-2010)
- Atlantic Station (1995-2006)
- Atwood-Higgins House (1730; 1919-1962)
- Austin Resource Center for the Homeless (2004)
- Baer House (1971-1972)
- Bateson Building (1977-1981)
- Benewah Medical Center (2012)
- Berry College (1850-present)
- Bogue Supply Building (1904; 2001)
- Borden Building (1907-1908; 2007-2009)
- Bowersock North Shore Power Plant (2011-2013)
- California Academy of Sciences (2000-2008)
- Cass Technical High School (2005)
- Cedar Street Bridge Public Market (1893-c.1926; 1983-2005)
- Center for Advanced Energy Studies (2005-2008)
- Cherokee Mountainside Theatre (1949-1950)
- Cordova House (1848)
- Cosanti (1956-1974)
- Dam no. 4, Hydroelectric Plan (1909)
- Detroit School for the Fine and Performing Arts (2005)
- Ford River Rouge Center (1917-1938; 2004)
- Frey House II (1963-1964; 1972)
- Eagle Sanctuary (1995-1999)
- Eli and Edythe Broad Art Museum (2010-2012)
- Equitable Building (1944-1948)
- Georgetown University (1792-present)
- Googleplex (2004; 2013)
- Greater World Earthship Community (1994-present)
- Greensburg City Hall (2008)
- Harley-Davidson Museum (2008)
- Herman Miller Greenhouse (1995)
- Intermountain Gas Company HQ (1965)
- International Quilt Study Center and Museum (2004-2008; 2012-2015)
- Islandwood (2002)
- Kauffman Farm (18th and 19th c.)
- Laboratory House (1950s; 2003)
- Lady Bird Johnson Wildflower Center (1995)
- Lone Mountain Ranch House (2010-2012)
- Massachusetts Museum of Contemporary Arts (1872; 1999)
- Mattress Factory Building (1907-1912; 2002-2003)
- McLauthlin Building (1856-1864; 1979)
- Monticello (1768-1826; 1934-1941; 1979-1994; 1993-2002)
- Mystic River Restoration (1893; 2009)
- National Museum of American History (1955-1964)
- Nature Conservancy HQ (2010)
- Paccar Environmental Technology Building (2014-2016)
- Park East District (2008)
- Rapid Central Station (2004-2005)
- Richard E. Dill House (1936)
- Rosie Joe House (2004)
- Simmons Hall (2002)
- Sky City Cultural Center and Haak'u Museum (2000-2006)
- Solar Building (1955-1956)
- Sunset Magazine Demonstration Desert Garden (1963, 1971)
- Target Field (2007-2010)
- University of Arizona Poetry Center (2007)
- Wayne Clough Undergraduate Learning Commons (2002-2011)
- Wells Fargo Center (1972-1976)
- Wetland Discovery Point (2009)
- Whitney Water Purification Facility and Park (1997-2005)

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