Architecture Beyond the Industrial Revolution

Grade Level or Special Area: Visual Arts, Eighth Grade
Written by: Sarah C. Sykes, Kinard Junior High School, Fort Collins, CO
Length of Unit: Three lessons (approximately four days; one day = 90 minutes)

I. ABSTRACT

In eighth grade, students study architecture. This unit provides a great deal of information about well-known international architects and architecture that heavily influenced the United States. The three lessons provide small exercises and one large project to help the students understand that a building isn't just a building.

II. OVERVIEW

A. Concept Objectives
   1. Students will understand how to relate the visual arts to various historical and cultural traditions. (Colorado Model Content Standard 4)
   2. Students will understand how to apply elements of art, principles of design, and sensory and expressive features of visual arts. (Colorado Model Content Standard 2)
   3. Students will understand visual arts materials, tools, techniques, and processes. (Colorado Model Content Standard 3)

B. Content from the *Core Knowledge Sequence*
   1. Eighth Grade Visual Arts: Architecture Since the Industrial Revolution (p. 193)
      a. Demonstrations of metal structures: Crystal Palace, Eiffel Tower
      b. First skyscrapers: "Form follows function"
         i. Louis Sullivan: Wainwright Building
         ii. Famous skyscrapers: Chrysler Building, Empire State Building
      c. Frank Lloyd Wright: Fallingwater, Guggenheim Museum
      d. The International Style
         i. Walter Gropius, Bauhaus Shop Block
         ii. Le Corbusier: Villa Savoye, Unite d'Habitation, Notre Dame du Haut
         iii. Ludwig Mies van der Rohe and Philip Johnson: Seagram Building

C. Skill Objectives
   1. Students will develop ideas for works of art by conducting research and making preliminary sketches or models.
   2. Students will maintain a sketchbook journal of ideas and writings to use as a resource and planning tool.
   3. Students will use brainstorming as a mean to generate ideas for works of art.
   4. Students will develop stronger team working skills.
   5. Students will evaluate architecture and write a statement which explains how the architect's feelings were portrayed visually.
   6. Students will use a variety of different mediums to create work.

III. BACKGROUND KNOWLEDGE

A. For Teachers
   1. *Modern Architecture Since 1900*, by William J.R. Curtis
   2. *A Visual Dictionary of Architecture*, by Frank Ching
   3. *The Architecture of Frank Lloyd Wright*, by Neil Levine

B. For Students
1. Grade Two: Visual Arts: Architecture (page 53)
2. Grade Four: Visual Arts (page 97)
a. Islamic Art and Architecture
i. Note characteristic features of Islamic architecture, such as domes and minarets, in Dome of the Rock (Mosque of Omar), Jerusalem, Alhambra Palace, Spain, Taj Mahal, India
3. Grade Five: Visual Arts (page 119)
a. Art of the Renaissance
i. Become familiar with Renaissance architecture, including
a) The Florence Cathedral, dome designed by Filippo Brunelleschi
b) St. Peter's in Rome

IV. RESOURCES

Internet Sites (many of these sites have wonderful articles, facts, and pictures on the architecture. You may use these sites as a reference and in your lessons for more examples.)

A. Official Site of the Eiffel Tower: http://www.tour-eiffel.fr/teiffel/uk/ (Lesson One)
B. Archpedia: http://www.archpedia.com/Architecture.html (Lesson One-Three)
C. The Great Buildings Collection: http://www.greatbuildings.com/ (Lessons One-Three)
D. Architectural Education Resource Center: http://committees.architects.org/kids/index.html (Lesson One-Three)
E. Wikipedia International Style: http://en.wikipedia.org/wiki/International_style_(architecture) (Lessons One-Three)
F. The Audubon Society: http://www.audubon.org/ (Lesson Three)
G. PBS Fallingwater 1934-1937: http://www.pbs.org/flw/buildings/fallingwater/fallingwater.html (Lesson Three)

Video

H. Frank Lloyd Wright: A Film by Ken Burns and Lynn Novick (can be ordered through **Crystal Art Resources**, 1-800-255-8629) (Lesson Three)

Poster

I. Eiffel Tower as well as other famous monuments (can be ordered through **Crystal Art Resources**, 1-800-255-8629) (Lesson One)

V. LESSONS

Lesson One: The Eiffel Tower (90 minutes)

A. *Daily Objectives*
1. Concept Objective
a. Students will understand how to relate the visual arts to various historical and cultural traditions.
2. Lesson Content
a. Demonstration of metal structure: Eiffel Tower (page 193)
3. Skill Objectives
a. Students will evaluate architecture and write a statement which explains how the architect's feelings were portrayed visually.
b. Students will maintain a sketchbook journal of ideas and writings to use as a resource and planning tool

B. *Materials (for a class size of 30)*
1. Appendix A: Industrial Revolution Background Information (one for teacher reference)
2. Appendix B: The Eiffel Tower Background Information (one for each student)

3. Appendix C: Eiffel Tower Photograph (one for each student)
4. Appendix D: Creative Writing Assessment (one for teacher reference)
5. Eiffel Tower Poster displayed
6. Sketchbook/notebook paper
7. Pencil (30)

C. *Key Vocabulary*

1. An *architect* is a licensed professional who organizes space. Architects design houses, office buildings, skyscrapers, landscapes, and even entire cities.
2. *Modern architecture* is a historic and stylistic term for the advanced design efforts of the 1920s and 1930s. It is a French term that implies a fashion oriented emphasis, lacking any serious theoretical basis.

D. *Procedures/Activities*

1. Set the stage for this lesson: Ask all the students in your class to write down three European monuments that they have seen, heard about, or recall in their sketchbook.
2. Ask your class for a show of hands on who had written down the Eiffel Tower as one of their three monuments. (Majority will probably equal Eiffel Tower.)
3. You may continue to ask about other monuments the students recalled, but then proceed to discuss the Eiffel Tower.
4. Reveal the poster on an easel.
5. Discuss the Industrial Revolution. (Use Appendix A: Industrial Revolution Background Information to guide you.)
    a. What was the Industrial Revolution?
    b. What were some positive and negative aspects to the Industrial Revolution?
    c. How did it have an affect on Architecture?
7. Lead into the discussion about the Eiffel Tower by passing out Appendix B: The Eiffel Tower Background Information.
8. Use Appendix B to aid in your discussion of the Eiffel Tower.
9. Key discussion points:
    a. How did the Industrial Revolution spur the building of the Eiffel Tower?
    b. What makes the Eiffel Tower so famous today?
    c. What is special about the design of the Eiffel Tower?
    d. Why do students think the designer designed the building?
    e. Do students think the Eiffel Tower will stand for another 100 years?
10. Once you have gone over Appendix B and discussed the key points as a class, students will be asked to do some creative writing in their sketchbook.
11. The Eiffel Tower is the topic of the 10-minute creative writing session.
12. Creative writing can be a poem, a story, a point in time, a dialogue, a song, a description, etc.
13. Time students for 10 minutes.
14. Once students are finished, have them pass their writing to a partner.
15. The partner is to read the creative writing.
16. The partner should then pick out three-five sentences in the writing that stand out as strong writing. These sentences can be anywhere throughout the writing.
17. Once the sentences have been underlined, the partner should pass the papers back to the owner.
18. All students should now put these sentences in a paragraph form.
19. Students can title their work.
20. For finishing touches, these writings can be typed by the students and displayed around the poster of the Eiffel Tower.

E. *Assessment/Evaluation*
   1. Use Appendix D: Creative Writing Assessment.

Lesson Two: Skyscrapers and International Style (90 minutes)

A. *Daily Objectives*
   1. Concept Objectives
      a. Students understand how to relate the arts to various historical and cultural traditions.
      b. Students understand visual arts materials, tools, techniques, and processes.
   2. Lesson Content
      a. First skyscrapers: "Form follows function" (page 193)
         i. Louis Sullivan: Wainwright Building
         ii. Famous skyscrapers: Chrysler Building, Empire State Building
      b. The International Style: (page 193)
         i. Walter Gropius
         ii. Le Corbusier, Villa Savoye, Unite d'Habitation, Notre Dame du Haut
         iii. Ludwig Mies van der Rohe and Philip Johnson: Seagram Building
   3. Skill Objectives
      a. Students will develop ideas for works of art by conducting research and making preliminary sketches or models.
      b. Students will use brainstorming as a means to generate ideas for a work of art.
      c. Students will develop stronger team working skills.

B. *Materials (for a class size of 30)*
   1. Appendix E: How Skyscrapers Work (one for each student)
   2. Appendix F: Skyscraper Photographs (one for each student)
   3. Appendix G: The Wainwright Building (one for each student)
   4. Appendix H: Skyscrapers and International Style Assessment (one for teacher reference)
   5. Appendix J: The International Style Background Information (one for each student)
   6. Masking tape (20-30 rolls)
   7. Scissors (30)
   8. Paper (an assortment of scraps, small or large)-the more the better!
   9. Clean empty tables
   10. Sketchbooks (students should have these)

C. *Key Vocabulary*
   1. *Bauhaus* was a German school of design in the 1920s and 1930s that became the leading intellectual and creative center in the development of modernism. Emphasis was placed on factory-produced designs that were simple, functional, and industrial.
   2. *International Style* is the term used to describe architectural design, that is simple, functional, and unornamented following the theoretical teachings of Bauhaus, and Modernism in the 1920s and 1930s.

D. *Procedures/Activities*
   1. Before Class Preparation:
      a. Make copies of all Appendices.
      b. Read over Appendices to get your background information.

c. Set up group stations of paper, tape and scissors.
d. Read any of the suggested websites for more resources.

2. Begin class by asking students what they know about skyscrapers.
3. Some example questions:
   a. What is the tallest building you have been in?
   b. How do they build skyscrapers?
   c. Why do they build skyscrapers?
4. Pass out Appendix E: How Skyscrapers Work,
5. This reading will set the stage for a fun group assignment.
6. Students should silently read Appendix E: How Skyscrapers Work.
7. Students should also look at the pictures in Appendix F: Skyscraper Photographs.
8. Discuss the International Style with students.
9. Buildings in the United States were influenced and, many times, designed by international designers.
10. Showing students pictures from Appendix J: International Style Background Information will help to give them a better understanding of the modern designs.
11. Remind students that we are looking at many different types of architecture in this unit.
12. Students should be taking brief notes on key terms describing how to build a skyscraper.
13. Once students have read the information, assign them to groups of four-five students.
14. The groups should go to the set up workstations.
15. Based on what the students have read and their notes, tell the students that they have 25 minutes to build the tallest skyscraper that they can with the materials provided.
16. This activity should be group work with little or no teacher direction.
17. Skyscraper Standards:
    a. Paper, scissors, tape
    b. Can stand up
    c. Creative use of supplies
    d. Aesthetically pleasing
    e. Shows an understanding of skyscrapers
    f. Shows an understanding of international design
    g. Students have a rough draft on paper
18. The group with the tallest skyscraper that meets all those standards wins a prize (homework pass, popcorn, piece of candy, etc.).
19. Teamwork Questions once judging has occurred:
    a. Was it difficult to build the paper skyscraper with a group?
    b. Would the task have been harder or easier individually?
    c. How would a team be beneficial in building a skyscraper?
20. Once you have completed the assignment, you may move on to Lesson Three.

E. *Assessment/Evaluation*

1. Use Appendix H: Skyscrapers and International Style Assessment

Lesson Three: Frank Lloyd Wright: Your Surroundings (90 minutes)

A. *Daily Objectives*

1. Concept Objectives
   a. Students understand how to apply visual arts to various and historical cultural traditions.

b. Students understand visual arts materials, tools, techniques, and processes.

2. Lesson Content
   a. Frank Lloyd Wright: Fallingwater, Guggenheim Museum (page 193)
3. Skill Objectives
   a. Students will develop ideas for works of art by conducting research and making preliminary sketches or models.
   b. Students will use brainstorming as a mean to generate ideas for a work of art.
   c. Students will use a variety of different mediums to create work.

B. *Materials (for a class size of 30)*
1. Appendix I: Frank Lloyd Wright (one for each student)
2. Appendix K: Birdhouse Project: Unit Assessment (one for teacher reference)
3. Foam core board (18" x 20" or larger sheets that can be cut down)
4. Acrylic paint (assortment of colors)
5. Brushes (class pack)
6. Utility knives (10)
7. Exacto knives (10)
8. Cutting boards (five)
9. Scissors (30)
10. Hot glue gun (five)
11. Glue sticks (pack of 100)
12. Glue (30 bottles)
13. Design materials (fabric, sticks, sequins) (students should bring in needed details for their birdhouse)
14. Video, Frank Lloyd Wright: A Film by Ken Burnes and Lynne Novick

C. *Key Vocabulary*
1. *Audubon's* mission is to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefits of humanity and the Earth's biological diversity.
2. *Design development* is when the architect prepares more detailed drawings and finalizes the design plans, showing correct sizes and shapes for rooms. Also included is an outline of the construction specifications, listing the major materials to be used.

D. *Procedures/Activities*
1. Before Class Preparation:
   a. Make copies of Appendices.
2. Begin class by passing out Appendix I: Frank Lloyd Wright.
3. Show the video.
4. Discuss Frank Lloyd Wright's Style:
   a. How did he consider his surroundings in Fallingwater?
   b. Can you determine what style he was influenced by from previous lessons?
   c. How did Fallingwater influence today's architecture?
   d. What is unique about Fallingwate***r***?
   e. Would Fallingwater be difficult to build?
5. Once you have discussed the video and appendix, prepare the students for their project.
6. Students will be building birdhouses.
7. Birdhouse steps include:

a. Research the bird that is going to live in the house (habitat, food, characteristics).
b. Students should research at this site:
The Audubon Society, http://www.audubon.org/
c. Once the bird is found, students need to print off that page and think about the characteristics that need to go into this bird's house.
d. Plan the house on graphing paper.
e. Gather the materials.
f. Build the house.
g. Add design elements to the house (painting, accessories, and details).

8. The above step may take two days. (One day for planning and gathering, another day for building and finishing details.)
9. It is important that students do the research on the bird.
10. Once they find a bird, they can then create their design.
11. The design should be functional yet aesthetically pleasing with the surroundings.
12. Students can think about Frank Lloyd Wright's houses, or other architecture that they were exposed to in the previous lessons.
13. Students should use the graphing paper to plan all four sides the bottom and the roof of the house.
14. This drawn out plan will help the student as well as the teacher.
15. Once the teacher has approved the plan, the student may begin to build.
16. Each student should start with foam board and make the necessary cuts for their birdhouses.
17. Students should use rulers and/or tape measures for this.
18. Exacto knives and utility knives should be used with care at a designated station.
    a. Designate one student to keep order at the station.
    b. Two to three students at the station at a time.
    c. Keep exact count of exacto knives/utility knives that are being used.
    d. Student partners may be helpful.
19. Once students have their basic shapes cut, they can begin building their birdhouses.
20. Depending on the materials used, most students should glue their shapes together.
21. They can use hot glue or Elmer's glue for this.
22. Once the birdhouse is together, it is time for the fun part.
23. Students may use the acrylic paint you have out for them, or anything they have brought from home.
24. Students should think about the simple architectural details they have looked at over the past few lessons.
25. Many different details can be added, yet students should keep their bird in mind.
26. Once the details are finished, students should make sure their name is on their work.
27. Create a display area to hang or set these birdhouses.
28. Student should now clean up.

E. *Assessment/Evaluation*
1. Use Appendix K: Birdhouse Project: Unit Assessment.

VI. CULMINATING ACTIVITY

A. Allowing the students to take the birdhouses outside and hang them in trees to display them may help to bring closure to this lesson. As a class, you could also have a critique outside. Some critique topics might include:

1. How do these architectural birdhouses fit in their environment?
2. Would birds enjoy living in them?
3. What are some birdhouses with unique designs?
4. Are some birdhouses more practical than others?
5. What birdhouses best fit the bird in which they were being built for?

VII. HANDOUTS/WORKSHEETS

A. Appendix A: Industrial Revolution Background Information
B. Appendix B: The Eiffel Tower Background Information
C. Appendix C: Eiffel Tower Photograph
D. Appendix D: Creative Writing Assessment
E. Appendix E: How Skyscrapers Work
F. Appendix F: Skyscraper Photographs
G. Appendix G: The Wainwright Building
H. Appendix H: Skyscrapers and International Assessment
I. Appendix I: Frank Lloyd Wright
J. Appendix J: The International Style Background Information
K. Appendix K: Birdhouse Project: Unit Assessment

VIII. BIBLIOGRAPHY

A. Ching, Frank. *A Visual Dictionary of Architecture*. New York: Van Nostrand Reinhold, 1995.
B. Curtis, William J. R. *Modern Architecture Since 1900*. 3rd ed. London: Phaidon Press, 1996.
C. Levine, Neil. *The Architecture of Frank Lloyd Wright*. Princeton, N.J.: Princeton University Press, 1996.

Appendix A

Industrial Revolution Background Information

In the last part of the 18th century, a new revolution gripped the world that we were not ready for. This revolution was not a political one, but it would lead to many implications later in its existence. Neither was this a social or cultural revolution. This revolution was an economic one.

The Industrial Revolution, as it know called by historians, changed how the world produced its goods. It also changed our societies from a mainly agricultural society to one in which industry and manufacturing was in control.

The Industrial Revolution first got its start in Great Britian, during the 18th century, which at the time was the most powerful empire on the planet. It was inevitable that the country with the most wealth would lead in this revolution. After its adoption in England, other countries such as Germany, the United States and France joined in this revolution. During this time, there were also many, new technological advancements, socioeconomic and cultural problems that arised.

On the technology front, the biggest advancements were in steam power. New fuels such as coal and petroleum were incorporated into new steam engines. This revolutionized many industries including textiles and manufacturing. In addition, a new communication medium was invented called the telegraph. This made communicating across the ocean much faster.

However, along with this great leap in technology, there was an overall downfall in the socioeconomic and cultural situation of the people. Growth of cities was, one of the major consequences of the Industrial Revolution. Many people were driven to the cities to look for work, in turn the ended living in the cities that could not support them. With the new industrial age, a new quantitative and materialistic view of the world took place. This caused the need for people to consume as much as they could. This still happens today.

In addition, during this time much international strife was occurring at this time. The American Revolution was occurring in the beginning part of the Industrial Revolution. The French Revolution was in the process at the turn of the 19th century. This was a great time, but resulted in newly found democratic rights that spread through Europe and North America.
The Industrial Revolution was not a good revolution for the planet. From the time of its start, the factories and industry has increased the amount of carbon dioxide in the atmosphere by two-folds. Also in our drive for consumerism, our planets natural resources are being depleted at an alarming rate. Pollution by nuclear waste, pesticides and other chemicals are also the result of the Industrial Revolution.

(information adapted from: The Industrial Revolution: http://www.msu.edu/user/brownlow/indrev.htm)

The Eiffel Tower Background Information

Date of Birth:

The Eiffel Tower was built in 1889 for the Universal Exposition celebrating the centenary of the French Revolution.

Contractor: Gustave Eiffel and Cie.
Engineers: Maurice Koechlin and Emile Nouguier
Architect: Stephen Sauvestre
Studies began: 1884
Construction: 1887 - 1889 (two years, two months and five days)

Workmen:

50 engineers, designers produced **5,300 "blueprints"**
100 ironworkers produced the **18,038 individual parts** to be assembled
121 men working the construction site

Weight:

The Eiffel Tower is relatively lightweight, creating a force of only 4.5kg/cm2 on the foundation.
If the Tower was placed in an air cylinder, its weight would not be more than that of the air cylinder.

Metal framework weight: 7,300 tons
Total weight: 10,000 tons

Movement:

The force of the wind causes the top of the Tower to sway 6 to 7 cm.
Heat also causes the Tower top to move, with a curve of movement measuring 18 cm.

At the Base:

The pillars are oriented in the manner of the four cardinal points, contained within a square with 125-meter sides.

Height:

1889 (height with flag): 312.27m
1991 (height with antenna): 317.96m
1994 (height with antenna): 318.70m
2000 (height with antenna): 324.00m

Until the construction of the Chrysler Building in 1930 by William Van Allen, architect, the Eiffel Tower was the tallest building in the world.

Paint:

The Tower is repainted **every five years**, necessitating 50 tons of paint.

Renovation:

1980 - 1985: Ambitious program of restoration
The structure was strengthened, while 1,343 tons of unnecessary materials were removed.
Added new elevators going from the second floor to the top, and new panoramic restaurants.
Added new illuminations (352 1,000-watt projectors lighting the Tower from the structure interior.

Number of Visitors:

In 2004, the Tower welcomed 6,230,050 visitors.

(information adapted from: The Official Site of the Eiffel Tower, http://www.tour-eiffel.fr/teiffel/uk/)

Appendix C

Eiffel Tower Photograph

(picture adapted from: Wikitravel guide, http://www.wikitravel.net/index.php/en/upload/3/32/Paris-eiffel-tower.jpg)

Appendix D

Creative Writing Assessment

Step One

This writing should be spontaneous and creative. It can be real or make-believe. Students are to write about the image of the Eiffel Tower and what they see, or how they feel when they view this image.

Sample Writing:

As I lay there in the lush green grass, I looked up into the night sky. A full moon had chosen to create these wonderful dancing shadows. There was just a hint of a breeze, telling me it was almost time to go back to my hotel. I wondered how many people had daydreamed under this spectacular monument. How many people had kissed at the top? Who was the oldest to visit? Who was the youngest? Where did people go from here? Nearby I could hear music from a café. The melodies floated, carried by the breeze. I stole one more cherished look at the Eiffel Tower before walking away.

Step Two

A partner should select three to five strong sentences from the writing. They should underline them.

Step Three

Once three to five sentences have been underlined, the author should arrange them in the order that they choose.

Sample Writing:

Nearby I could hear music from a café. A full moon had chosen to create these wonderful dancing shadows. The melodies floated, carried by the breeze.

Step Four

Students create final draft.

Nearby I could hear music from a café.

A full moon had chosen to create these wonderful dancing shadows.

The melodies floated, carried by the breeze.

Written By: Sarah Camille Sykes

Step Five

The final writing should be displayed around the poster. These writings should reflect thoughts, feelings and emotions from viewers of the Eiffel Tower.

Appendix E, page 1

How Skyscrapers Work

by Tom Harris

Throughout the history of architecture, there has been a continual quest for height. Thousands of workers toiled on the pyramids of ancient Egypt, the cathedrals of Europe and countless other towers, all striving to create something awe-inspiring. People build skyscrapers primarily because they are convenient -- you can create a lot of real estate out of a relatively small ground area. But ego and grandeur do sometimes play a significant role in the scope of the construction, just as it did in earlier civilizations.

Up until relatively recently, we could only go so high. After a certain point, it just wasn't feasible to keep building up. In the late 1800s, new technology redefined these limits. Suddenly, it was possible to live and work in colossal towers, hundreds of feet above the ground.

In this article, we'll look at the innovations that made these incredible structures possible. We'll examine the main architectural issues involved in keeping skyscrapers up, as well as the design issues involved in making them practical. Finally, we'll peer into the future of skyscrapers to find out how high we might go.

Fighting Gravity

The main obstacle in building upward is the downward pull of gravity. Imagine carrying a friend on your shoulders. If the person is fairly light, you can support them pretty well by yourself. But if you were to put another person on your friend's shoulders (build your tower higher), the weight would probably be too much for you to carry alone. To make a tower that is "multiple-people high," you need more people on the bottom to support the weight of everybody above. This is how "cheerleader pyramids" work, and it's also how real pyramids and other stone buildings work. There has to be more material at the bottom to support the combined weight of all the material above. Every time you add a new vertical layer, the total force on every point below that layer increases. If you kept increasing the base of a pyramid, you could build it up indefinitely. This becomes infeasible very quickly, of course, since the bottom base takes up too much available land. In normal buildings made of bricks and mortar, you have to keep thickening the lower walls as you build new upper floors. After you reach a certain height, this is highly impractical. If there is almost no room on the lower floors, what is the point in making a tall building?

Using this technology, people didn't construct many buildings more than 10 stories -- it just wasn't feasible. But in the late 1800s, a number of advancements and circumstances converged, and engineers were able to break the upper limit -- and then some. The social circumstances that led to skyscrapers were the growing metropolitan American centers, most notably Chicago. Businesses all wanted their offices near the center of town, but there wasn't enough space. In these cities, architects needed a way to expand the metropolis upward, rather than outward.

The main technological advancement that made skyscrapers possible was the development of mass iron and steel production. New manufacturing processes made it possible to produce long beams of solid iron. Essentially, this gave architects a whole new set of building blocks to work with. Narrow, relatively lightweight metal beams could support much more weight than the solid brick walls in older buildings, while taking up a fraction of the space. With the advent of the Bessemer process, the first efficient method for mass steel production, architects moved away from iron. Steel, which is even lighter and stronger than iron, made it possible to build even taller buildings.

Giant Girder Grids

The central support structure of a skyscraper is its steel skeleton. Metal beams are riveted end to end to form vertical columns. At each floor level, these vertical columns are connected to horizontal girder beams. Many buildings also have diagonal beams running between the girders, for extra structural support. In this giant

three-dimensional grid -- called the super structure -- all the weight in the building gets transferred directly to the vertical columns. This concentrates the downward force caused by gravity into the relatively small areas where the columns rest at the building's base. This concentrated force is then spread out in the substructure under the building.

In a typical skyscraper substructure, each vertical column sits on a spread footing. The column rests directly on a cast-iron plate, which sits on top of a grillage. The grillage is basically a stack of horizontal steel beams, lined side-by-side in two or more layers (see diagram, below). The grillage rests on a thick concrete pad poured directly onto the hard clay under the ground. Once the steel is in place, the entire structure is covered with concrete.

This structure expands out lower in the ground, the same way a pyramid expands out as you go down. This distributes the concentrated weight from the columns over a wide surface. Ultimately, the entire weight of the building rests directly on the hard clay material under the earth. In very heavy buildings, the base of the spread footings rest on massive concrete piers that extend all the way down to the earth's bedrock layer.

One major advantage of the steel skeleton structure is that the outer walls -- called the curtain wall -- need only to support their own weight. This lets architects open the building up as much as they want, in stark contrast to the thick walls in traditional building construction. In many skyscrapers, especially ones built in the 1950s and '60s, the curtain walls are made almost entirely of glass, giving the occupants a spectacular view of their city.

Making it Functional

In the last section, we saw that new iron and steel manufacturing processes opened up the possibility of towering buildings. But this is only half the picture. Before high-rise skyscrapers could become a reality, engineers had to make them practical. Once you get more than five or six floors, stairs become a fairly inconvenient technology. Skyscrapers would never have worked without the coincident emergence of elevator technology. Ever since the first passenger elevator was installed in New York's Haughwout Department Store in 1857, elevator shafts have been a major part of skyscraper design. In most skyscrapers, the elevator shafts make up the building's central core.

Figuring out the elevator structure is a balancing act of sorts. As you add more floors to a building, you increase the building's occupancy. When you have more people, you obviously need more elevators or the lobby will fill up with people waiting in line. But elevator shafts take up a lot of room, so you lose floor space for every elevator you add. To make more room for people, you have to add more floors. Deciding on the right number of floors and elevators is one of the most important parts of designing a building.

Building safety is also a major consideration in design. Skyscrapers wouldn't have worked so well without the advent of new fire-resistant building materials in the 1800s. These days, skyscrapers are also outfitted with sophisticated sprinkler equipment that puts out most fires before they spread very far. This is extremely important when you have hundreds of people living and working thousands of feet above a safe exit.

Architects also pay careful attention to the comfort of the building's occupants. The Empire State Building, for example, was designed so its occupants would always be within 30 feet (ft) of a window. The Commerzbank building in Frankfurt, Germany has tranquil indoor garden areas built opposite the building's office areas, in a climbing spiral structure. A building is only successful when the architects have focused not only on structural stability, but also usability and occupant satisfaction.

Wind Resistance

In addition to the vertical force of gravity, skyscrapers also have to deal with the horizontal force of wind. Most skyscrapers can easily move several feet in either direction, like a swaying tree, without damaging their structural integrity. The main problem with this horizontal movement is how it affects the people inside. If the building moves a substantial horizontal distance, the occupants will definitely feel it.

The most basic method for controlling horizontal sway is to simply tighten up the structure. At the point where the horizontal girders attach to the vertical column, the construction crew bolts and welds them on the top and bottom, as well as the side. This makes the entire steel super structure move more as one unit, like a pole, as opposed to a flexible skeleton.

For taller skyscrapers, tighter connections don't really do the trick. To keep these buildings from swaying heavily, engineers have to construct especially strong cores through the center of the building. In the Empire State Building, the Chrysler Building and other skyscrapers from that era, the area around the central elevator shafts is fortified by a sturdy steel truss, braced with diagonal beams. Most recent buildings have one or more concrete cores built into the center of the building.

Making buildings more rigid also braces them against earthquake damage. Basically, the entire building moves with the horizontal vibrations of the earth, so the steel skeleton isn't twisted and strained. While this helps protect the structure of the skyscraper, it can be pretty rough on the occupants, and it can also cause a lot of damage to loose furniture and equipment. Several companies are developing new technology that will counteract the horizontal movement to dampen the force of vibration. To learn more about these systems, check out How Smart Structures Will Work.
Some buildings already use advanced wind-compensating dampers. The Citicorp Center in New York, for example, uses a tuned mass damper. In this complex system, oil hydraulic systems push a 400-ton concrete weight back and forth on one of the top floors, shifting the weight of the entire building from side to side. A sophisticated computer system carefully monitors how the wind is shifting the building and moves the weight accordingly. Some similar systems shift the building's weight based on the movement of giant pendulums.

Vertical Variations

As we have seen in the previous sections, skyscrapers come in all shapes and sizes. The steel skeleton concept makes for an extremely flexible structure. The columns and girders are something like giant pieces in an erector set. The only real limit is the imagination of the architects and engineers who put the pieces together. The earliest skyscrapers, built in the late 1800s, were very basic boxes with simple stone and glass curtain walls. To the architects who built these skyscrapers, the extreme height was impressive enough. In the period around 1900, the aesthetic began to change. Buildings got taller, and architects added more extravagant gothic elements, hiding the boxy steel structure underneath.
The art deco movement of the 1920s, '30s and '40s extended this approach, creating buildings that stood as true works of art. Some of the most famous skyscrapers, including the Empire State Building and the Chrysler Building (above), came out of this era. Things shifted again in the 1950s, when international style began to take hold. Like the earliest skyscrapers, these buildings had little or no ornamentation. They were made mostly with glass, steel and concrete.

Since the 1960s, many architects have taken the skyscraper to new and unexpected places. One of the most interesting variations has been the combination of several vertical skeleton sections -- or tubes -- into one building. The Sears Tower in Chicago, the most famous example of this approach, consists of nine aligned tubes that reach to different heights. This gives the building an interesting staggered appearance.

Onward and Upward

The "world's tallest" title passes regularly from skyscraper to skyscraper. This is one of the most competitive contests in construction. Architects and engineers heartily embrace the challenges of building higher, and corporations and cities are always attracted to the glory of towering over the competition. The current champion is the Petronas Towers in Malaysia (see sidebar in previous section).

By all accounts, the skyscraper race is far from over. There are more than 50 proposed buildings that would break the current record. Some of the more conservative structures are already in construction. But the more ambitious buildings in the group are only theoretical at this time. Are they possible? According to some engineering experts, the real limitation is money, not technology. Super tall buildings would require extremely

sturdy materials and deep, fortified bases. Construction crews would need elaborate cranes and pumping systems to get materials and concrete up to the top levels. All told, putting one of these buildings up could easily cost tens of billions of dollars.

Additionally, there would be logistical problems with the elevators. To make the upper floors in a 200-story building easily accessible, you would need a large bank of elevators, which would take up a wide area in the center of the building. One easy solution to this problem is to arrange the elevators so they only go part way up the building. Passengers who want to go the top would take an elevator halfway, get off and then take another elevator the rest of the way.

Experts are divided about how high we can really go in the near future. Some say we could build a mile-high (5,280 ft, or 1,609 m) building with existing technology, while others say we would need to develop lighter, stronger materials, faster elevators and advanced sway dampers before these buildings were feasible. Speaking only hypothetically, most engineers won't impose an upper limit. Future technology advances could conceivably lead to sky-high cities, many experts say, housing a million people or more.

Whether we will actually get there is another question. We might be compelled to build farther upward in the future, simply to conserve land. When you build upward, you can concentrate much more development into one area, instead of spreading out into untapped natural areas. Skyscraper cities would also be very convenient: More businesses can be clustered together in a city, reducing commuting time.

But the main force behind the skyscraper race might turn out to be basic vanity. Where monumental height once honored gods and kings, it now glorifies corporations and cities. These structures come from a very fundamental desire -- everybody wants to have the biggest building on the block. This drive has been a major factor in desire -- everybody wants to have the biggest building on the block. This drive has been a major factor in skyscraper development over the past 120 years, and it is a good bet it will continue to push buildings up in the centuries to come.

(information adapted from: How Skyscrapers Work, By Tom Harris, http://science.howstuffworks.com/skyscraper.htm/printable)

Appendix F
Skyscraper Photographs

The Empire State Building in New York City. The view from the building's 86th-floor observatory is one of New York City's top tourist attractions. The Empire State Building's 73 elevators can move 600 to 1,400 feet (183 to 427 meters) per minute. At the maximum speed, you can travel from the lobby to the 80th floor in 45 seconds.

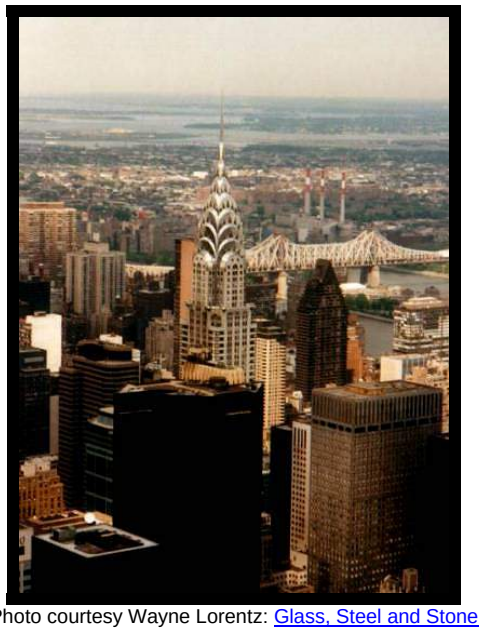

Photo courtesy Wayne Lorentz: Glass, Steel and Stone

The distinctive chrome-nickel-steel crown of the 1,046-foot (319-meter) Chrysler Building is a classic example of art deco architecture.

(information adapted from: How Skyscrapers Work, By Tom Harris, http://science.howstuffworks.com/skyscraper.htm/printable)

Appendix G

The Wainwright Building

Louis Henry (Henri) Sullivan (September 3, 1856 - April 14, 1924) was an American architect, called the "father of modernism," considered by many as the creator of the Prairie School of architecture, was an influential architect and critic of the Chicago School, and a mentor to Frank Lloyd Wright. The Wainwright Building is a 10-story red-brick landmark office building in downtown St. Louis, Missouri built in 1891, designed by Louis Sullivan, and is a candidate for the first skyscraper in the world. Sullivan adopted the steel frame and developed his own system of intricate terra cotta ornament to emphasize the verticality of the building. After a period of neglect, the building now houses Missouri state offices and is well maintained. It is named for local financier Ellis Wainwright.

(information and picture adapted from: http://en.wikipedia.org/wiki/Wainwright_Building)

Appendix H

Skyscrapers and International Assessment

Student: _____

Points
1-Does not meet expectations
2-Average grasp of directions, showed some skill
3-Very good idea of the class, followed all directions
4-Above average art skill, exceptional skill with media
5-Above and beyond expectations for this lesson, creativity and skill

1. Student cooperated well with his/her group.

   1 2 3 4 5

2. The skyscraper showed influences of an architectural style.

   1 2 3 4 5

3. The skyscraper was built with strong craftsmanship in mind.

   1 2 3 4 5

4. The materials were used appropriately.

   1 2 3 4 5

5. The student followed all directions.

   1 2 3 4 5

6. The arrangement was finished on time.

   1 2 3 4 5

Total Points:_____

Additional Comments:

Appendix I
Frank Lloyd Wright

St. Louis Dispatch, 1937
"A House That Straddles A Waterfall"

Spring Green, Wisconsin: Frank Lloyd Wright the venerable dean of modernism in American architecture, has recently designed a dozen structures which are now being planned or built in eight states. A country house straddling a waterfall. A spacious and stately office that breathes through nostrils and fixtures, street doors or windows—the word is usually understood. A fabricated house to cost a little over $5000 and be as expansive and luxurious as the architect thinks any house has a right to be. These will seem the most startling innovations.

Not to their architect, though. They culminate and express principles, ideals, experiments and a common-sense artistic logic that Frank Lloyd Wright has been living with for most of his 68 years. Long ago, he built a Pasadena house inside the rim of a ravine. As far back as 1903 he built the first air-conditioned, possibly the first fireproof, office building—the Larkin Building in Buffalo, New York. Over the active span of his fiercely creative years, he has designed many houses containing some of the principles that must go into any lowcost factory built house. Bold originator that he is, all Frank Lloyd Wright's building is the product of what he considers a leisurely and relentlessly logical inner growth of ideas.

Test this against the waterfall house, which is being built for Edgar Kaufmann, a wealthy merchant of Pittsburgh. It is still under construction in Bear Run, a luxuriantly wooded ravine in southern Pennsylvania's Alleghenys. Though it is probably true that no house very like this has ever been built anywhere, this one didn't spring full-blown from the architect's imagination. When finished (probably in June) it will seem to have grown by a natural process of geology out of the boulders of Bear Run.

(information adapted from: PBS, Fallingwater: http://www.pbs.org/flw/buildings/fallingwater/fallingwater.html)

Appendix J, page 1

The International Style

International style, also known as the Modern movement, is a primarily American offshoot of Bauhaus architecture that was exported to various parts of the world. International style was a major architectural trend in the 1920s and 1930s and is considered the most minimal form of modernism.

International style was influenced by German and Dutch movements of Bauhaus, de Stijl and the Deutscher Werkbund. In 1927, one of the first and most defining manifestations of the international style was the Weissenhof Estate in Stuttgart as a component of the exhibition "Die Wohnung," organized by the Deutscher Werkbund. Major participants were:
Mies van der Rohe
Walter Gropius
Le Corbusier
Mart Stam
Hans Scharoun

Many of its ideas and ideals were formalized by the Congres Internationaux d'Architecture Moderne. Some of its most important architects (including Ludwig Mies van der Rohe) fled the upcoming Nazi regime in Germany in the 1930s and moved to the United States, which caused the International Style to spread worldwide.

The term *international style* came from the title of a book by Henry-Russell Hitchcock and Philip Johnson, written in 1932. In that same year, the International Exhibition of Modern Architecture at the Museum of Modern Art in New York City spread the ideals of the style, making it one of the dominant architectural movements of the mid-20th Century.

Architects who worked in the international style wanted to break with architectural tradition and design simple, unornamented buildings. The most commonly used materials are glass for the facade, steel for exterior support, and concrete for the floors and interior supports; floor plans were functional and logical. The style became most evident in the design of skyscrapers. Perhaps its most famous/notorious manifestations include the United Nations headquarters and the Seagram Building in New York.

Detractors of the international style claim that its stark, uncompromisingly rectangular geometry is dehumanizing. Le Corbusier once described buildings as "machines for living," but people are not machines and do not want to live in machines. Even Philip Johnson admitted he was "bored with the box." Since the early 1980s, many architects have deliberately sought to move away from strictly geometrical designs.

Walter Adolph Gropius (May 18, 1883 – July 5, 1969) was a German architect and founder of Bauhaus. Gropius was an architect, like his father before him, and designed buildings, which used modern materials like concrete on a steel-frame construction and glass brick and are often compared to abstract paintings. In 1919 he founded the Bauhaus, a school of design where students were taught to use modern and innovative materials and mass-produced fittings, often originally intended for industrial settings, to create original furniture and buildings.

Gropius fled Germany in 1934 due to the rising power of the Nazi Party and lived and worked in Britain, at the Isokon project, and then, from 1937 to the United States, where his own house, the Gropius House in Lincoln, Massachusetts, was influential in bringing International Modernism to the US. Gropius did not like the term: "I made it a point to absorb into my own conception those features of the New England architectural tradition that I found still alive and adequate." [1]. Gropius and his Bauhaus protégé

Marcel Breuer both came to Cambridge, Massachusetts to teach at the Harvard Graduate School of Design, before their professional split in 1941. In 1944, he became a naturalized citizen of the United States.

In 1945, Gropius founded The Architects' Collaborative (TAC) based in Cambridge with a group of younger architects. The original partners included Norman C. Fletcher, Jean B. Fletcher, John C. Harkness, Sarah P. Harkness, Robert S. MacMillan, Louis A. MacMillen and Benjamin C. Thompson. TAC would become one of the most well known and respected architectural firms in the world.

Gropius died in 1969 in Boston, Massachusetts at age 86. He was known to have a snappy sense of style and was often seen wearing a bowtie.

Ludwig Mies van der Rohe (born *Maria Ludwig Michael Mies*) (March 27, 1886 - August 17, 1969) was an architect and designer. Born in Aachen, Germany, he worked in the family stone-carving business before he moved to Berlin and joined the office of Bruno Paul. He entered the studio of Peter Behrens in 1908 and remained until 1912.

A physically imposing, deliberative, and reticent man, Mies renamed himself as part of his transformation from a stonecutter's son to a member of Berlin's cultural elite. In the 1910s and 1920s, under Behrens' influence, Mies developed and pursued the single design approach that would occupy him for the rest of his long career. It was based on advanced structural techniques and Prussian Classicism. He also developed sympathy for the aesthetic credos of both Russian Constructivism and the Dutch De Stijl group. He borrowed from the post and lintel construction of Karl Friedrich Schinkel for his designs in steel and glass.

In the 1930s, Mies served briefly as Director of the Bauhaus, at the request of his friend and competitor Walter Gropius, and presided over its closing due to political pressure. He built very little in that decade (his major built commission was Philip Johnson's New York apartment) because of the economic downtown, and he was *persona non grata*. He fled reluctantly in the late 1930s as he saw the Nazis growing in power. When he arrived in the United States in 1937, he was already well known.

Mies settled in Chicago, Illinois where he was appointed as head of the architecture school at Chicago's Armour Institute of Technology (later renamed Illinois Institute of Technology - IIT). One of his conditions for taking this position was that he would be able to redesign the campus. Some of his most famous buildings still stand there, including Crown Hall, the home of IIT's School of Architecture.

In 1944, he became a naturalized citizen. From 1946 to 1950, Mies van der Rohe built the Farnsworth House for Dr. Edith Farnsworth, a doctor in Chicago. It was the first home Mies built in the United States. The house is rectangular with eight steel columns set in two parallel rows. Suspended between columns are two concrete slabs (one the floor, the other the roof) and a simple, glass-enclosed living space and porch. All the exterior walls are glass, and the interior is entirely open except for a wood paneled area containing two bathrooms, a kitchen and service facilities. Besides the glass, the building is bright white. (The Farnsworth House is sometimes confused with Philip Johnson's Glass House.)

In 1958, Mies van der Rohe built what has been regarded as the ultimate expression of the International Style of architecture, the Seagram Building in New York. Mies was chosen by the daughter of the client, Phyllis Bronfman Lambert, who has become an architectural figure in her own right. The Seagram Building is a large glass work, but controversially, the architect chose to set the structure back, include a massive plaza and fountain, and create an open space in Park Avenue. Mies had to argue with the

Bronfman's bankers about exploiting all of the plat. More controversially, Mies included external I-beams that were not structurally necessary but that 'expressed' the structure, touching off a conversation about whether Mies had or had not committed the crime of ornamentation. Philip Johnson had a role in designing the plaza and the Four Seasons restaurant. The Seagram's Building is said to also be the first major 'fast-track' construction process, when design and construction are done concurrently.

Famous for his dictums 'Less is More' and 'God is in the details', Mies attempted to create contemplative, neutral spaces through an architecture based on material honesty and structural integrity. Over the last twenty years of his life, Mies achieved his vision of a monumental 'skin and bone' architecture. His later works provide a fitting denouement to a life dedicated to the idea of a universal, simplified architecture.

Le Corbusier (October 6, 1887–August 27, 1965) was a Swiss architect famous for what is now called the International Style, along with Ludwig Mies van der Rohe, Walter Gropius, and Theo van Doesburg. He was also an urban planner, painter, sculptor, writer and furniture designer.

Le Corbusier was at his most influential in the sphere of urban planning, and was a founding member of the Congres Internationaux d'Architecture Moderne (CIAM). One of the first to realize how the automobile would change human agglomerations, Le Corbusier described the city of the future as consisting of large apartment buildings isolated in a park-like setting on pilotis. Le Corbusier's theories were adopted by the builders of public housing in the United States. For the design of the buildings themselves, Le Corbusier said, "by law, all buildings should be white" and criticized any effort at ornamentation. The large spartan structures, in cities, but not of cities, have been widely criticized for being boring and unfriendly to pedestrians. The city plan of Brasília was based on his ideas.
Le Corbusier was heavily influenced by the problems he saw in the industrial city of the turn of the century. He thought that industrial housing techniques led to crowding, dirtiness, and a lack of a moral landscape. He was a leader of the modernist movement to create better living conditions and a better society through housing concepts.

Since his death, Le Corbusier's contribution has been hotly contested. At the level of building, his later works expressed a complex understanding of modernity's impact, yet his urban designs have drawn scorn from critics.
Techno-historian and architecture critic Lewis Mumford wrote,
"*the extravagant heights of Le Corbusier's skyscrapers had no reason for existence apart from the fact that they had become technological possibilities; the open spaces in his central areas had no reason for existence either, since on the scale he imagined there was no motive during the business day for pedestrian circulation in the office quarter. By mating utilitarian and financial image of the skyscraper city to the romantic image of the organic environment, Le Corbusier had, in fact, produced a sterile hybrid*" (Yesterday's City of Tomorrow).

Le Corbusier's views on urban planning have also been largely discredited for encouraging the design of public plazas that are viewed by many as being sterile and divisive of urban space. The public housing projects influenced by his ideas are seen by most as having had the effect of isolating poor communities in monolithic high-rises and breaking the social ties integral to a community's development. One of his most influential critics has been Jane Jacobs, who delivered a scathing critique of Le Corbusier's urban design theories in her seminal work *The Death and Life of Great American Cities*. The city of Brasilia, currently the capital of Brazil, is a planned city based exclusively on the principles of Le Corbusier. Unfortunately, Brasilia is considered by most urban planners to be a colossal failure.

Bauhaus in Dessau, By Walter Gropius

The Villa Savoye at Poissy

Interior and Roof Terrace of Villa Savoye *Furniture by Le Corbusier*

The Villa Savoye was designed as a weekend country house and is situated just outside of the small village of Poissy in a meadow, which was originally surrounded by trees. The polychromatic interior contrasts with the primarily white exterior. Vertical circulation is facilitated by ramps as well as stairs. The house fell into ruin during World War Two, but has since been restored and is open for viewing.

New York City, New York, USA
1958
Joseph Seagram and Sons (Phyllis Lambert)

Appendix K

Birdhouse Project: Unit Assessment

Student: _____

Points
1-Does not meet expectations
2-Average grasp of directions, showed some skill
3-Very good idea of the class, followed all directions
4-Above average art skill, exceptional skill with media
5-Above and beyond expectations for this lesson, creativity and skill

1. The students design for the house reflects the characteristics of the bird in mind.

   1 2 3 4 5

2. The birdhouse showed influences of an architectural style.

   1 2 3 4 5

3. The birdhouse was built with strong craftsmanship in mind.

   1 2 3 4 5

4. The materials were used appropriately.

   1 2 3 4 5

5. The student followed all directions.

   1 2 3 4 5

6. The arrangement was finished on time.

   1 2 3 4 5

Total Points:_____

Additional Comments: