CENTER FOR ARCHITECTURE

SKYSCRAPERS: STRUCTURE AND STRENGTH Student Day Resource Packet

Pre & Post Visit Activities ▪ Vocabulary & Resource Lists ▪ Curriculum Connections

CENTER FOR ARCHITECTURE

Before Your Visit :

Prepare your students for their visit with these introductory pre-visit activities.

1	Introduce the *Structure and Strength: Skyscrapers Vocabulary List* on Page 3 to your students so they can be active participants during our discussion at the Center for Architecture.
2	Ensure that students understand the factors that made skyscrapers possible. Students can do some brief research about the history of skyscrapers to respond to the questions on the *Skyscraper Research Sheet* on Page 4.
3	Help your students think about the idea of structure by comparing the structure of our bodies to the structure of buildings. Students can use the *Building and Body Structure* activity on Page 5 to organize their thoughts.

During Your Visit :

During this program, students will be asked to consider the historical and contemporary challenges of building tall. The design educator will facilitate a discussion to introduce different structural strategies that can be used to overcome these challenges. Students will be challenged to question material choices, patterns, and geometry from some of the tallest buildings around the world. These observations will lead to several experiments to test the forces of tension and compression as well as strategies of triangulation and cross bracing. As a class, we will consider the internal forces of a skyscraper (building weight, dead loads, and live loads) and the external forces (wind loads, seismic loads, etc.)

After this interactive presentation, students will be asked to apply this knowledge by building a structural frame that is both tall and strong using toothpicks and marshmallows.

After Your Visit :

Continue the learning by facilitating these suggested extension activities.

1	**Scale Modeling:** Students can use the *Bank of China Tower Model Template* on Page 6 to construct a scale model of this skyscraper. If available, this template should be copied onto cardstock. Students will recognize this building from the slideshow and discussion about triangulation. Using this template as an example, challenge your students to design their own paper model of a skyscraper of their choice.
2	**Slenderness Ratio:** Encourage your students to explore the relationship of ratio, proportion and scale by completing the *Slender Skyscrapers* activity on page 7. Students will be challenged to measure four different skyscrapers in NYC. Using these dimensions, students can complete the S*lenderness Ratios* activity on page 8. The second half of this worksheet asks students to work backwards to make sense of limited data. You can find the *Slenderness Ratios Answer Sheet* on page 9.

After Your Visit (continued)

3

Writing Activity: Use the writing prompts below to help your students consider skyscraper design through a new lens.

Find and research a building that once stood as "the tallest building in the world." Why was it important for the building to have this status? How did the architects, designers, and engineers of this building use the technology of the time to achieve this goal?

Pick your favorite skyscraper and try to imagine the steps that were needed to construct it. Write and create an illustrated guide that shows this construction process.

Student Model from the Structure and Strength: Skyscrapers Workshop

CENTER FOR ARCHITECTURE

Skyscrapers: Structure and Strength Vocabulary List

Beam	A horizontal piece of structure that spans across a space and is supported on both ends.
Building Core	A reinforced, vertical shaft in a building that acts like our spine or the trunk of a tree, providing solid support for the rest of the building. It is often located in the center and contains the staircases, elevators, cables, pipes, etc.
Building Skin	The exterior of a building that creates a permanent layer between the inside and outside.
Column	A vertical piece of structure that carries the weight of a beam, floor, truss or other structure above it.
Compression	A pushing or pressing force.
Dead Load	A force on a building that is relatively constant. This is typically the weight of the building's floors, walls, pipes, etc.
Foundation	The part of the building structure that safely connects it to solid ground. This is usually below ground level.
Horizontal	Describing something that goes from side to side, as opposed to up and down.
Live Load	A force on a building that can change or move. This force may be caused by the movement of people and furniture or by natural elements such as wind, rain, snow, earthquakes, etc.
Structure	The parts of a building that hold up weight and provide support.
Slenderness Ratio	The relationship of a building's height compared to its smallest width.
Tension	A pulling or stretching force.
Truss	A structure that is usually built from straight pieces of metal or wood to form a series of triangles.
Vertical	Describing something that goes up and down, as opposed to side to side.

Additional Resources

The Skyscraper Museum located in Lower Manhattan

Burj Khalifa Video by Real Engineering on YouTube

Tuned Mass Dampers in Skyscrapers Video and Article by Grady Hillhouse

Council on Tall Buildings and Urban Habitat (www.ctbuh.org)

The Skyscraper Center (www.skyscrapercenter.com)

SkyscraperModels.us by John B. Townsend (www.skyscrapermodels.us)

CENTER FOR ARCHITECTURE

Skyscraper Research Sheet

Research and answer the following questions to learn about the history of skyscrapers.

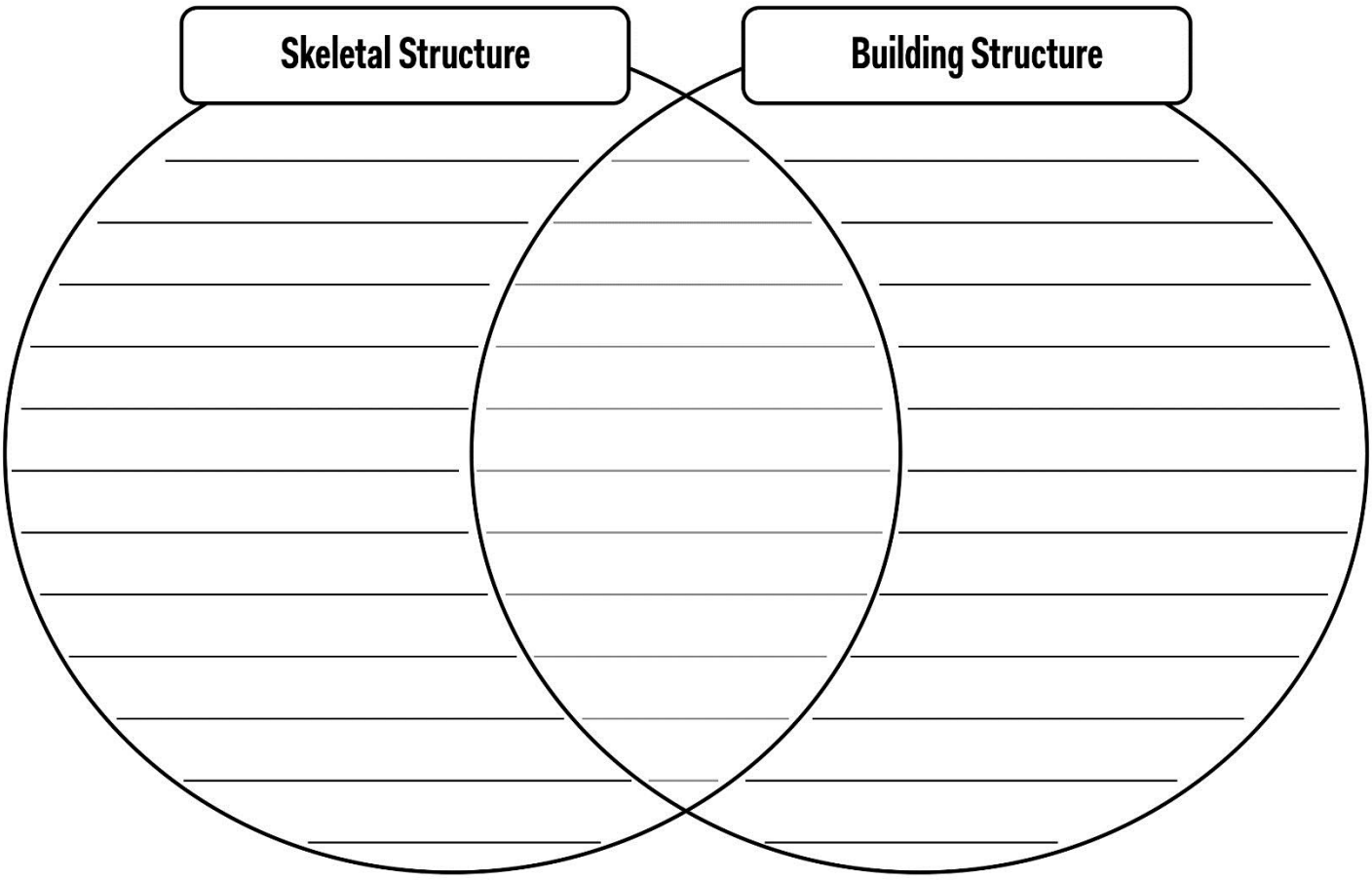
1 Why is there a need for skyscrapers in New York City?

2 What type of technology was necessary to build skyscrapers?

3 Who was Elisha Otis and how did he contribute to the advancement of skyscrapers?

Building and Body Structure

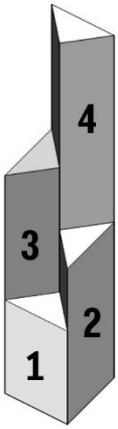
Use the diagram below to think about the structure of our bodies and the structure of buildings. How are they similar and how are they different?

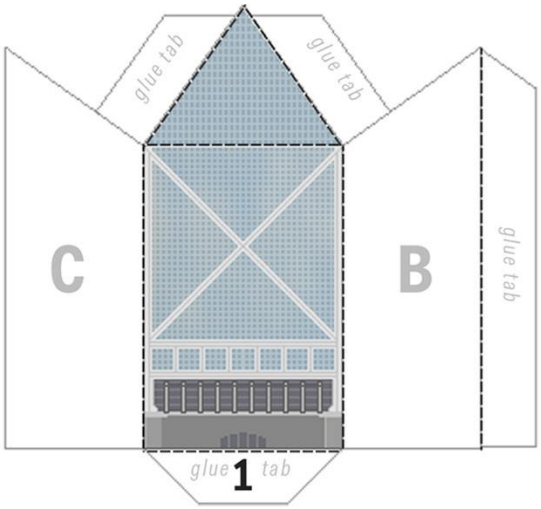


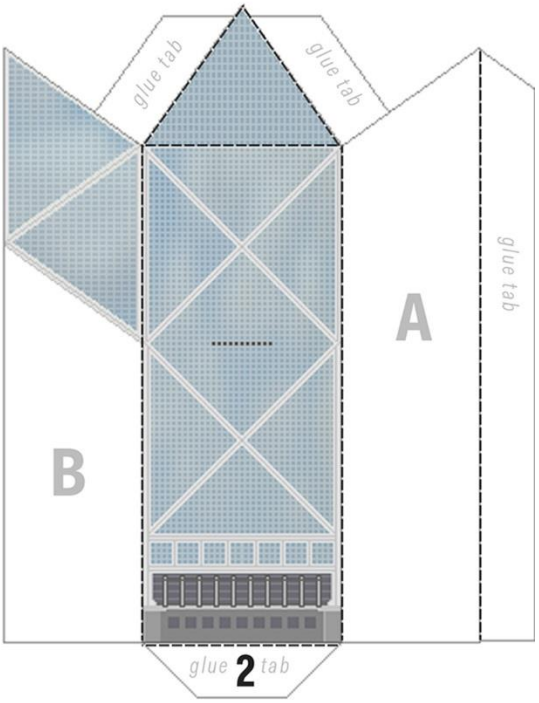
In what other ways might a building be similar to the human body?

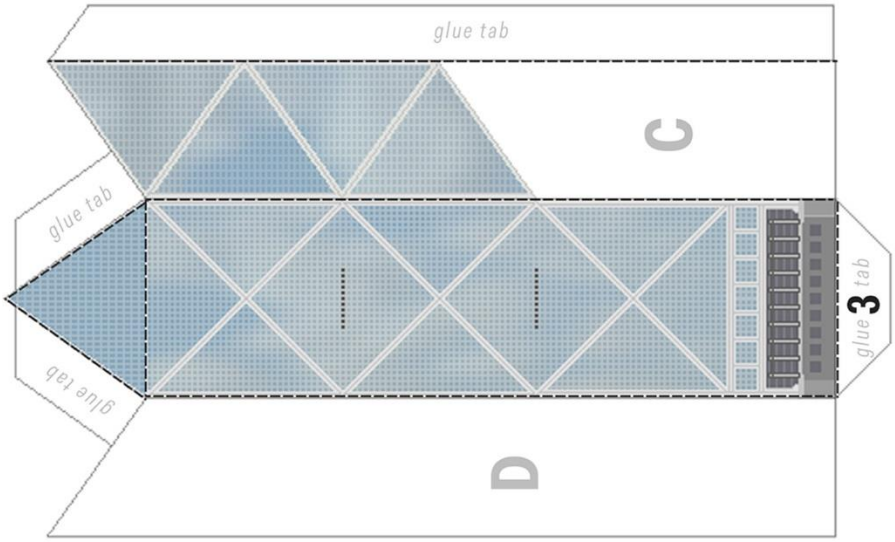
Bank of China Tower Model Template

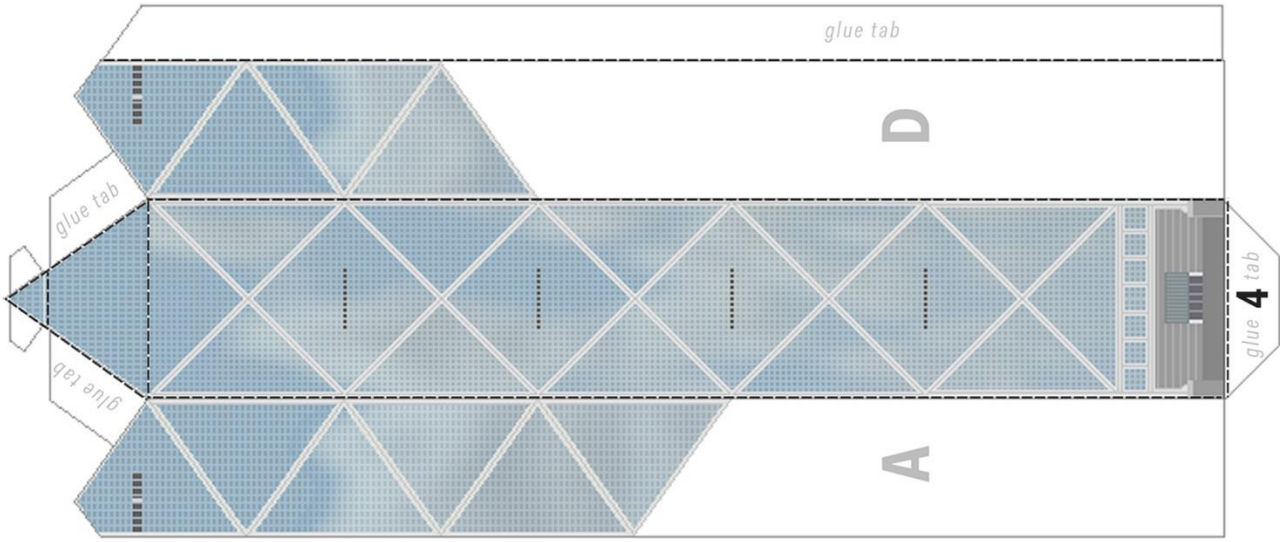
1) Cut out each of the 4 templates below. 2) Fold along the dotted lines to glue and assemble four triangular prisms. 3) Glue each prism together as shown in the numbered diagram below by matching the lettered sides.







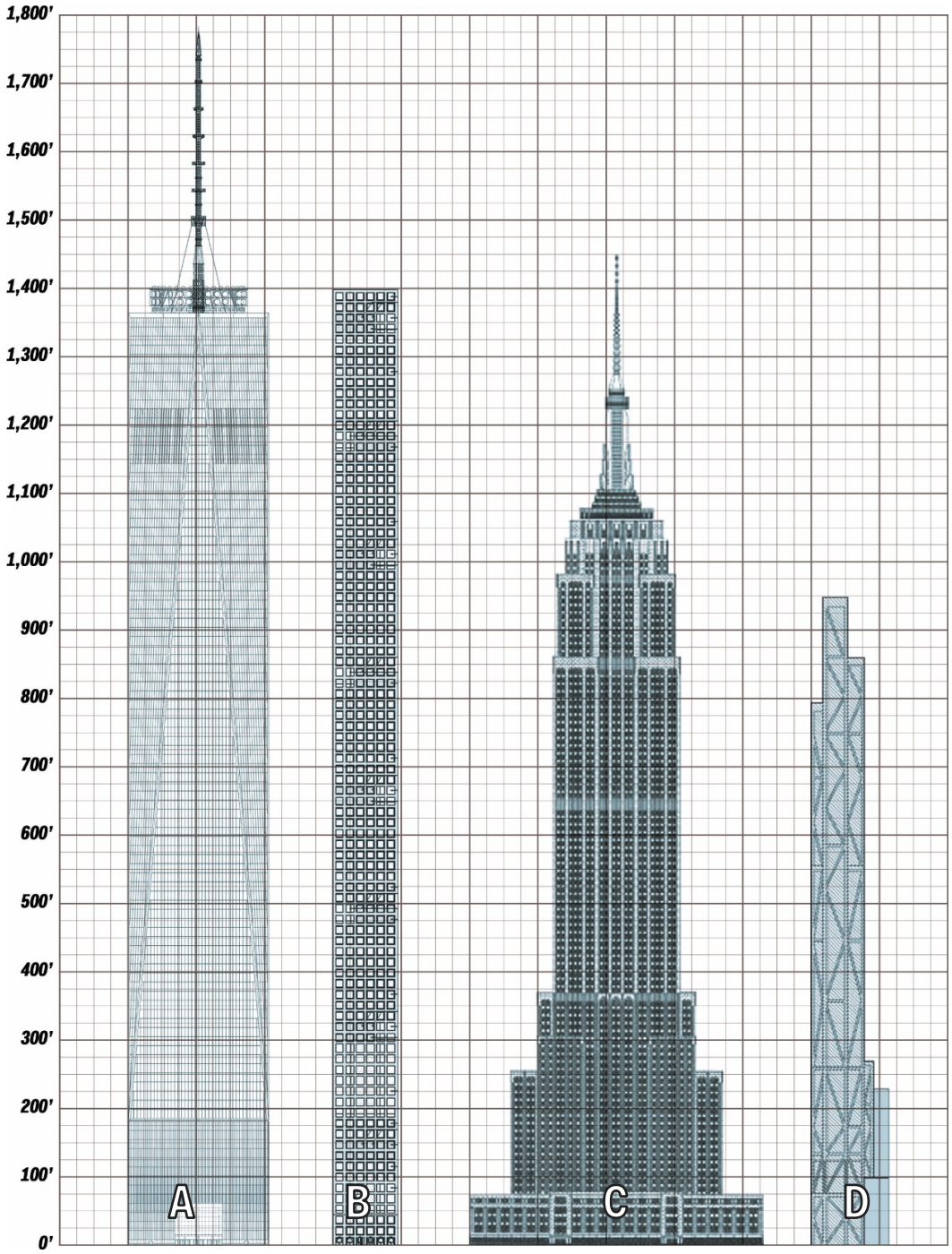




This template was adapted from one available on skyscrapermodels.us

Slender Skyscrapers

Advances in technology have allowed skyscrapers to become more slender than ever before! Architects and engineers use the **slenderness ratio** of a building to help inform their designs. A ratio is the relationship between two measurements, showing the number of times one value contains or is contained by the other. In this case, the slenderness ratio of a skyscraper compares the building's width to the building's height. The scaled drawing below shows four skyscrapers in New York City. Use the grid to measure the width and height of each building, including the spire. The distance between each bold line of the grid represents 100'. Round your answers to the nearest 50' line. Record your information in the chart on the *Slenderness Ratio* page.



Slenderness Ratios

Use the table below to record your measurements from the *Slender Skyscrapers* activity. Simplify the ratios by dividing both measurements by the building's width. For example, a slenderness ratio of 200' : 750' can be expressed as 1 : 3.75.

Building	Width in Feet	Height in Feet	Slenderness Ratio	
			Ratio in Feet	Simplified Ratio
(A) One World Trade Center	200 '	1,800 '	200 ' : 1,800 '	1 : 9
(B) 432 Park Avenue			:	1 :
(C) The Empire State Building			:	1 :
(D) 53 West 53rd Street			:	1 :

Working Backwards

Use the table below to fill in the missing information for each skyscraper. Round your answers to the nearest foot.

Building	Width in Feet	Height in Feet	Slenderness Ratio	
			Ratio in Feet	Simplified Ratio
111 West 57th Street		**1,428'**	**: 1,428'**	**1 : 24**
262 5th Avenue		**1,010'**	**:**	**1 : 20**
125 Greenwich Street	**97'**		**:**	**1 : 14**
The Chrysler Building		**1,046'**	**:**	**1 : 5**
One Vanderbilt Place	**210'**		**: 1,400'**	**1 :**

CENTER FOR ARCHITECTURE

Slenderness Ratios (Answer Sheet)

Use the table below to record your measurements. Simplify the ratios by dividing both measurements by the building's width. For example, a slenderness ratio of 200 ' : 750 ' can be expressed as 1 : 3.75.

Building	Width in Feet	Height in Feet	Slenderness Ratio	
			Ratio in Feet	Simplified Ratio
(A) One World Trade Center	200 '	1,800 '	200 ' : 1,800 '	1 : 9
(B) 432 Park Avenue	**100 '**	**1,400 '**	100 ' : 1,400 '	1 : 14
(C) The Empire State Building	**450 '**	**1,450 '**	450 ' : 1,450 '	1 : 3.2
(D) 53 West 53rd Street	**100 '**	**950 '**	100 ' : 950 '	1 : 9.5

Working Backwards

Use the table below to fill in the missing information for each skyscraper. Round your answers to the nearest foot.

Building	Width in Feet	Height in Feet	Slenderness Ratio	
			Ratio in Feet	Simplified Ratio
111 West 57th Street	**60 '**	**1,428'**	**60 ' : 1,428'**	**1 : 24**
262 5th Avenue	**51 '**	**1,010'**	**51 ' : 1,010 '**	**1 : 20**
125 Greenwich Street	**97'**	**1,358 '**	**97 ' : 1,358 '**	**1 : 14**
The Chrysler Building	**209 '**	**1,046'**	**209 ' : 1,046 '**	**1 : 5**
One Vanderbilt Place	**210'**	**1,400 '**	**210 ' : 1,400'**	**1 : 6.7**

CENTER FOR ARCHITECTURE

Student Day Curriculum Connections

New York State Learning Standards for the Arts: Learning Standards for the Arts at Three Levels		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
1	Creating, Performing and Participating in the Arts	■	■	■	■	■	■	■
2	Knowing and using Arts Materials and Resources	■	■	■	■	■	■	■
3	Responding to and Analyzing Works of Art	■	■	■	■			■
4	Understanding the Cultural Dimensions and Contributions of the Arts	■	■	■	■			■

NYC Blueprint For Teaching and Learning in Visual Arts: Five Strands of Art Learning		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
I.	Art Making	■	■	■	■	■	■	■
II.	Literacy in Visual Arts	■	■	■	■	■	■	■
III.	Making Connections	■	■	■	■	■	■	■
IV.	Community and Cultural Resources	■	■	■	■	■	■	■
V.	Careers and Lifelong Learning	■	■	■	■	■	■	■

CENTER FOR ARCHITECTURE

Common Core State Standards for Mathematics: Standards for Mathematical Practice		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
1	Make sense of problems and persevere in solving them.	■	■	■		■	■	■
2	Reason abstractly and quantitatively.					■	■	
3	Construct viable arguments and critique the reasoning of others.			■	■	■		
4	Model with mathematics.	■	■		■	■	■	■
5	Use appropriate tools strategically.	■				■	■	
6	Attend to precision.	■				■	■	

NYC K-5 Science Scope & Sequence + NYC 6-12 Science Scope & Sequence		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
K Unit 2	**Exploring Properties** How do we observe and describe objects and the physical properties of objects?				■			
Grade 1 Unit 2	**Properties of Matter** How do we describe the properties of matter?				■			
Grade 2 Unit 2	**Forces & Motion** What causes objects to move?	■						■
Grade 3 Unit 2	**Energy** How does the use of various forms of energy affect our world?			■				
Grade 3 Unit 3	**Simple Machines** How do simple machines help us in our daily lives?	■						■
Grade 6 Unit 4	**Interdependence** What factors affect the interdependence of living and nonliving things?			■				
Grade 7 Unit 2	**Energy & Matter** What materials are best to conserve and efficiently use energy?			■				
Grade 8 Unit 4	**Humans and the Environment: Needs and Tradeoffs** How can energy resources affect the future planning for the continuity of life on Earth?			■				

CENTER FOR ARCHITECTURE

New York State P-12 Science Learning Standards		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
DIMENSION 1: SCIENTIFIC AND ENGINEERING PRACTICES								
1	Asking questions (for science) and defining problems (for engineering)	■	■	■	■	■	■	■
2	Developing and using models	■	■	■	■	■	■	■
3	Planning and carrying out investigations	■	■	■	■	■	■	■
4	Analyzing and interpreting data	PV		PV		PV		
5	Using mathematics and computational thinking	PV		PV		■	■	
6	Constructing explanations (for science) and designing solutions (for engineering)	■	■	■		■	■	■
7	Engaging in argument from evidence	■		■				■
8	Obtaining, evaluating, and communicating information	■		■		■		
DIMENSION 2: CROSSCUTTING CONCEPTS								
1	Patterns	■	■	■	■			■
2	Cause and effect: Mechanism and explanation	■		■				■
3	Scale, proportion, and quantity	■	■	■	■	■	■	■
4	Systems and system models	■	■	■		■		■
5	Energy and matter: Flows, cycles, and conservation			■				
6	Structure and function	■	■	■	■	■	■	■
7	Stability and change	■	■	■				■

CENTER FOR ARCHITECTURE

New York State P-12 Science Learning Standards (continued)		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
DIMENSION 3: DISCIPINARY CORE IDEAS								
Physical Sciences								
PS1.A	Structure and Properties of Matter				■			
PS2.A	Forces and Motion	■						■
PS2.C	Stability and Instability in Physical Systems	■	■					■
PS3.A	Definitions of Energy			■				
PS3.B	Conservation of Energy and Energy Transfer			■				
PS3.D	Energy in Chemical Processes and Everyday Life			■				
Life Sciences								
LS2.A	Interdependent Relationships in Ecosystems			■				
LS2.C	Ecosystem Dynamics, Functioning, and Resilience			■				
LS2.D	Social Interactions and Group Behavior					■		
Earth & Space Sciences								
ESS1.B	Earth and the Solar System			■				
ESS2.A	Earth Materials and Systems			■				
ESS2.D	Weather and Climate			■				
ESS3.A	Natural Resources			■				
ESS3.B	Natural Hazards							■
ESS3.C	Human Impacts on Earth Systems			■				
ESS3.D	Global Climate Change			■				

CENTER FOR ARCHITECTURE

New York State P-12 Science Learning Standards (continued)		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
DIMENSION 3: DISCIPINARY CORE IDEAS (continued)								
Engineering, Technology, and Applications of Science								
ETS1.A	Defining and Delimiting and Engineering Problem	■	■	■				■
ETS1.B	Developing Possible Solutions	■	■	■	■	■	■	■
ETS1.C	Optimizing the Design Solution		■	■	■	■	■	■
ETS2.A	Interdependence of Science, Engineering, and Technology	■	■	■	■	■	■	■
ETS2.B	Influence of Engineering, Technology, and Science on Society and the Natural World	■	■	■	■	■	■	■

Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR READING *								
1	Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textural evidence when writing or speaking to support conclusions drawn from the text.	■		■	■		■	■
2	Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.			■	■			
7	Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.	■	■	■	■	■	■	■
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR WRITING								
1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.				PV	PV		

At the Center for Architecture, we consider visual representations (i.e., photos, drawings, models, etc.) to be texts with their own set of vocabulary. Through this lens, we practice "reading a building" to consider its design and purpose.

PV *These standards are met by completing the suggested extension activities found in the Student Day Resource Packet.*

CENTER FOR ARCHITECTURE

Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects (continued)		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR WRITING (continued)								
2	**Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.**			PV	PV	PV		
7	**Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.**	PV	PV	PV	PV	PV		PV
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR SPEAKING AND LISTENING								
1	**Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.**	■	■	■	■	■	■	■
2	**Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.**	■	■	■	■	■	■	■
4	**Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.**					■		
5	**Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.**					■		
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR LANGUAGE								
4	**Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.**	■	■	■	■	■		■
6	**Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.**	■	■	■	■	■	■	■

CENTER FOR ARCHITECTURE

New York State K-8 Social Studies Framework: Social Studies Practices	Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
A Gathering, Using, and Interpreting Evidence	■		■	■			■
B Chronological Reasoning and Causation	■						■
C Comparison and Contextualization				■			
D Geographic Reasoning	■		■	■	■		■
F Civic Participation					■		

NYC K-8 Social Studies Scope & Sequence + NYC 9-12 Social Studies Scope & Sequence	Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
K Unit 3 **Geography, People and the Environment** What makes a community?				■			
Grade 1 Unit 3 **The Community** What is a community?				■			
Grade 2 Unit 2 **New York City Over Time** How and why do communities change over time?	■						■
Grade 2 Unit 3 **Urban, Suburban and Rural Communities** How are communities the same and different?	■			■			■
Grade 8 Unit 2 **A Changing Society and the Progressive Era** How do people, policies and technological advances shape a nation?							■
Grade 10 Unit 6 **Globalization and the Changing Environment** Is globalization a force for progress and prosperity?			■				

CENTER FOR ARCHITECTURE

536 LaGuardia Place New York, NY 100012 ▪ www.centerforarchitecture.org ▪ 212-358-6132

This educational resource was made possible by generous funding from Deutsche Bank Americas Foundation.