SKYSCRAPERS UNIT PLAN

Compelling Question	**Why do we build tall structures?**
Standards and Practices	*C3 Historical Thinking Standards* – D2.His.1.9-12. Evaluate how historical events and developments were shaped by unique circumstances of time and place as well as broader historical contexts. *C3 Historical Thinking Standards* – D2.His.2.9-12. Analyze change and continuity in historical eras. *Common Core Content Standards* – CCSS.ELA-LITERACY.WHST.9-10.1.B Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns. *AP World History Thematic Learning Objectives* – ENV-4 Explain how environmental factors have shaped the development of diverse technologies, industrialization, transportation methods, and exchange and communication networks. *AP World History Thematic Learning Objectives* – CUL-3 Explain how cross-cultural interactions resulted in diffusion of culture, technologies, and scientific knowledge. *AP World History Thematic Learning Objectives* – ECON-3 Explain how different modes and locations of production and commerce have developed and changed over time.
Staging the Question	How and why has humanity built up?

Supporting Question 1	**Supporting Question 2**	**Supporting Question 3**	**Supporting Question 4**
What are the earliest examples of tall structures?	How have tall structures stayed the same throughout history and how have they changed?	What technologies have allowed humans to build taller structures?	Will we continue to build up?
Formative Performance Task	**Formative Performance Task**	**Formative Performance Task**	**Formative Performance Task**

Imagine you are the architect of one of the earliest tall buildings. Write a journal entry describing your reasons for building up.	Create an infographic comparing tall buildings from across time and space.	Add information about threshold technologies to your infographic from Supporting Question 2 (SQ2).	Analyze the motivations for building up and the technologies that enabled humanity to build higher, and conduct a class debate addressing SQ4.
Featured Sources	**Featured Sources**	**Featured Sources**	**Featured Sources**
1A. Herodotus. "An Account of Egypt." Gutenberg. January 25, 2013. Accessed July 08, 2018. http://www.gutenberg.org/files/2131/2131-h/2131-h.htm. 1B. "Etemenanki (the "Tower of Babel")." Livius. April 12, 2018. Accessed July 13, 2018. http://www.livius.org/articles/place/babylon/etemenanki/. 1C. Vasari, Giorgio. "Lives of the Most Eminent Painters Sculptors and Architects, Vol 2, Berna to Michelozzo Michelozzi." Project Gutenberg. June 11, 2008. Accessed July 13, 2018. http://www.gutenberg.org/files/25759/25759-h/25759-h.htm#Page_193. 1D. Edirisinghe, Tharindu Ishan. "Largest Brick Structure in the World Jetavanaramaya." Scribd. October 14, 2012. Accessed July 17, 2018.	2A. Bellis, Mary. "The First Skyscrapers (And How They Became Possible)." ThoughtCo. https://www.thoughtco.com/how-skyscrapers-became-possible-1991649 (accessed July 13, 2018). 2B. "Home Insurance Company Building." Encyclopædia Britannica. Accessed July 13, 2018. https://www.britannica.com/place/Home-Insurance-Company-Building. 2C. "The World's Tallest Skyscrapers." The World Trade Center: Statistics and History. Accessed July 13, 2018. http://skyscraper.org/TALLEST_TOWERS/tallest.htm. 2D. "Smith to Help Build Highest Skyscraper." *The New York Times*, August 30, 1929. 2E. Glaeser, Edward. "How Skyscrapers Can Save the City." *The Atlantic*. February 19, 2014. Accessed July 16, 2018. https://www.theatlantic.c	3A. "Philadelphia City Hall." American Society of Civil Engineers (ASCE). Accessed July 14, 2018. http://www.asce.org/project/philadelphia-city-hall/. 3B. "The Construction of the Empire State Building (1929-1930)." Click Americana. March 25, 2018. Accessed July 13, 2018. https://clickamericana.com/topics/places/announcement-of-the-empire-state-building-1929. 3C. Bessemer, Henry. "Sir Henry Bessemer, F.R.S.: An Autobiography; with a Concluding Chapter: Bessemer, Henry, Sir, 1813-1898: Free Download, Borrow, and Streaming." Internet Archive. January 01, 1970. Accessed July 14, 2018. https://archive.org/details/sirhenrybessemer00bessuoft. 3D. Bessemer, Henry. "A Brief Statistical Sketch of the Bessemer Steel Industry: Past and Present." *Engineering Review*, July 20, 1894.	4A. Barr, Jason M. "Asia Dreams in Skyscrapers." The New York Times. October 11, 2017. Accessed July 16, 2018. https://www.nytimes.com/2017/10/11/opinion/china-asia-skyscrapers.html. 4B. Glaeser, Edward. "How Skyscrapers Can Save the City." The Atlantic. February 19, 2014. Accessed July 16, 2018. https://www.theatlantic.com/magazine/archive/2011/03/how-skyscrapers-can-save-the-city/308387/. 4C. Nelson, Andrew. "New Renderings Appear for Supertall 5 World Trade Center." New York YIMBY. June 14, 2018. Accessed July 17, 2018. https://newyorkyimby.com/2018/06/new-renderings-appear-for-supertall-5-world-trade-center.html. 4D. Leduff, Charlie. "A Mohawk Trail To the Skyline; Indian Ironworkers Return, Lured by Building Boom." The New York Times. March 16, 2001. Accessed July 17, 2018. https://www.nytimes.com/2001/03/16/nyregion/a-

https://www.scribd.com/document/109963356/Largest-Brick-Structure-in-the-World-Jetavanaramaya.	om/magazine/archive/2011/03/how-skyscrapers-can-save-the-city/308387/. 2F. "A French Tower of Babel." *The New York Times*(New York), January 4, 1885.	3E. Bellis, Mary. "The History of the Elevator - Elisha Otis." The Inventors. 2006. Accessed July 15, 2018. http://theinventors.org/library/inventors/blelevator.htm. 3F. Paumgarten, Nick. "Up And Then Down." The New Yorker. August 01, 2017. Accessed July 16, 2018. https://www.newyorker.com/magazine/2008/04/21/up-and-then-down.	mohawk-trail-to-the-skyline-indian-ironworkers-return-lured-by-building-boom.html.
Summative Performance Task	**Argument**	Write a thesis essay that directly addresses Supporting Question 4 using specific claims and relevant evidence from historical sources to support your claims while acknowledging competing views.	
	Extension	Research the current state of technologies that might allow us to build even higher.	
Taking Informed Action	**UNDERSTAND:** Research the impact of tall structures on contemporary society. **ASSESS:** To what extent do the effects of tall buildings positively impact humanity? **ACTION:** Based on your assessment of their impact on humanity, create an online campaign to support or oppose more skyscrapers, and post (or repost) "articles" to help generate energy on your social network.		

TO THE TEACHER

All *REACH* Instructional Units are intended to be "classroom-ready." Each unit begins with a *Unit Plan* in the form of a *C3 Inquiry Design Model*. The *Unit Plan* includes learning objectives, content standards, formative and summative tasks, links to primary and secondary resources, and a warm-up activity.

Units are organized around a *Compelling Question* designed to inspire curiosity and promote discussion among students. To that end, we have also included a brief student introduction to the topic entitled, *Staging the Question*. Once students have been introduced to the topic, any number of *Formative Performance Tasks* may be completed using the included *Document Excerpts* (teachers may elect instead to utilize full-text documents linked within the *Featured Sources* section). *Document Excerpts* are print-ready in single-sheet format and keyed to the citations in the *Featured Sources* section of the *Unit Plan*. Teachers should select the *Formative Performance Tasks* and accompanying *Sources* that best suit their own instructional needs – content requirements, performance goals, student readiness, and time constraints. Upon the completion of each unit, students should be adequately prepared to complete the *Summative Performance Task* and *Taking Informed Action* sections of the *Unit Plan*.

To further assist the teacher, we have included a more thorough *Background Information* section. This document is intended to serve as professional reading prior to implementing the unit. Teachers may also wish to read the full-length primary and secondary sources from which the shorter excerpts were taken.

STAGING THE QUESTION

The symbol of growth in China and India of the early 21st century is the proliferation of skyscrapers. This was also the symbol of urbanization in the early 20th century U.S. How did this come about? As cities grow, people are packed into greater and greater densities (e.g., tenements) but there are limits to what even poor people can tolerate. So, the choices are to build out or build up. Building out requires the construction of advanced transportation systems—first trolleys, trains and rails, later cars and buses and roads and bridges and tunnels. Building up requires new techniques of construction of course, but also ways to deal with the energy needed to get up and down, and issues like heating, cooling, lighting and communication.

The industrial revolution began in the late 18th century in Britain. Industrialization combined great production and trade growth with a mindset of scientific research and engineering improvement. The British began to construct bridges out of iron, which because of its weight and relative strength was superior to stone and brick and wood. They also tried to build taller buildings, but could not get much past 10 stories with existing techniques. Then, in 1797, in Shrewsbury, Charles Bage constructed a flax mill with an iron frame. Although only five stories tall, this technique enabled a large structure with a roomy interior (compare the giant stone pyramids, with their tiny burial chambers). The problem with iron was that cast iron – high-carbon iron that could be melted – was brittle, while wrought iron – iron with no carbon – was soft. Steel had just the right amount of carbon to be hard and not brittle, but it could only be produced by taking the carbon out of cast iron or adding it to wrought iron – both were difficult, expensive, and energy-hungry processes. In 1855, Charles Bessemer invented a process for directly producing inexpensive steel from raw pig-iron, making it both inexpensive and plentiful.

Industrial innovation shifted to the U.S. in the mid-nineteenth century. In 1885, the engineer William Le Baron Jenney designed in Chicago a 10-story building that was mostly supported by a metal frame that combined wrought iron, cast iron, and Bessemer steel. Immediately following, in 1889, George A. Fuller also in Chicago built the 13-story Tacoma Building completely with Bessemer steel and with no load-bearing walls. (Note that Chicago had more room and incentive to innovate in building because the Great Fire had recently wiped out most of the downtown buildings.) Also in 1889, The Ames building was built in Boston. It is one of the tallest buildings in the world built by the old masonry (stone) technique. But Boston being a literary town, on November 1891 *The Boston Journal* first used the term skyscraper (originally the top sail of a sailing ship, and later used to mean anything tall) to describe tall buildings—and the name has stuck.

Although the steel technique was perfected in Chicago, New York was the growing engine of the US economy. In 1902, a Chicago company built the 22-story Flatiron Building, then one of the tallest in the world. Yet, by 1913 it wasn't close to the tallest in the City – the 57-story Woolworth building opened in that year as the tallest in the world (792 ft). Between 1912 and 1973, various New York skyscrapers were built – each surpassing the other in height: Chrysler Building (1930) 77 stories and 927 ft.; Empire State Building (1931) 102 stories and 1250 ft.; World Trade center (1972) 110 stories and 1368 ft. In 1974, the Sears Tower (now the Willis Tower) returned the crown to Chicago, topping out at 108 stories (1450 ft.).

Of course, Bessemer steel was not the only technology driving buildings upward. Among the several innovations enabling the construction of skyscrapers were the elevator, air conditioner, and fire sprinkler. Pulley-based lifting systems were in place since ancient times, but as with everything else, inventors worked to improve them. In 1852, Elisha Otis invented the safety elevator (demonstrated in 1854 and installed in 1857). In 1880, Siemens invented the electric elevator, made even more practical in 1882 when the Edison Pearl Street Station first supplied electric to New York City office buildings. In 1887, Alexander Miles, an African-American inventor from Minnesota patented the first automatic elevator door, which, along with the Grinnell sprinkler (1878), made vertical transport significantly safer. In 1902, Willis Haviland Carrier invented electric air conditioning, making the trip much more comfortable as well.

While steel frame construction made skyscrapers possible, the elevator and all its related technologies made very tall buildings practical and even desirable. As these various technologies were refined and improved throughout the 20th century, builders continued to reach higher. As of today, more than 100 buildings around the world stretch beyond 1000 in height, and over 100 more due to be completed in the next three years. The tallest so far, at 2717 feet, is the Burj Khalifa in Dubai, but the Jeddah Tower (Jeddah, Saudi Arabia) will be 3281 feet upon its completion in 2021 and Tokyo has hopes to begin work on a mile-high structure, known as Sky Mile Tower, intended to open in 2045.

PRINT DOCUMENTS

Document 1A

Down to the time when Rhampsinitos [*probably Ramses III*] was king, they told me there was in Egypt nothing but orderly rule, and Egypt prospered greatly; but after him Cheops [*Khufu – builder of the Great Pyramid at Giza*] became king over them and brought them to every kind of evil: for he shut up all the temples, and having first kept them from sacrifices there, he then bade all the Egyptians work for him. So, some were appointed to draw stones from the stone-quarries in the Arabian mountains to the Nile, and others he ordered to receive the stones after they had been carried over the river in boats, and to draw them to those which are called the Libyan mountains; and they worked by a hundred thousand men at a time, for each three months continually. Of this oppression there passed ten years while the causeway was made by which they drew the stones, which causeway they built, and it is a work not much less, as it appears to me, than the pyramid; for the length of it is five furlongs and the breadth ten fathoms and the height, where it is highest, eight fathoms, and it is made of stone smoothed and with figures carved upon it. For this they said, the ten years were spent, and for the underground he caused to be made as sepulchral chambers for himself in an island, having conducted thither a channel from the Nile. For the making of the pyramid itself there passed a period of twenty years; and the pyramid is square, each side measuring eight hundred feet, and the height of it is the same. It is built of stone smoothed and fitted together in the most perfect manner, not one of the stones being less than thirty feet in length. This pyramid was made after the manner of steps which some called "rows" and others "bases": and when they had first made it thus, they raised the remaining stones with machines made of short pieces of timber, raising them first from the ground to the first stage of the steps, and when the stone got up to this it was placed upon another machine standing on the first stage, and so from this it was drawn to the second upon another machine; for as many as were the courses of the steps, so many machines there were also, or perhaps they transferred one and the same machine, made so as easily to be carried, to each stage successively, in order that they might take up the stones; for let it be told in both ways, according as it is reported. However, that may be the highest parts of it were finished first, and afterwards they proceeded to finish that which came next to them, and lastly, they finished the parts of it near the ground and the lowest ranges. On the pyramid it is declared in Egyptian writing how much was spent on radishes and onions and leeks for the workmen, and if I rightly remember that which the interpreter said in reading to me this inscription, a sum of one thousand six hundred talents of silver was spent; and if this is so, how much besides is likely to have been expended upon the iron with which they worked, and upon bread and clothing for the workmen, seeing that they were building the works for the time which has been mentioned and were occupied for no small time besides, as I suppose, in the cutting and bringing of the stones and in working at the excavation under the ground? Cheops moreover came, they said, to such a pitch of wickedness, that being in want of money he caused his own daughter to sit in the stews, and ordered her to obtain from those who came a certain amount of money (how much it was they did not tell me): and she not only obtained the sum appointed by her father, but also she formed a design for herself privately to leave behind her a memorial, and she requested each man who came in to give her one stone upon her building: and of these stones, they told me, the pyramid was built which stands in front of the great pyramid in the middle of the three, each side being one hundred and fifty feet in length.

This Cheops, the Egyptians said, reigned fifty years; and after he was dead his brother Chephren [*Khafre – actually Khufu's son*] succeeded to the kingdom. This king followed the same manner of dealing as the other, both in all the rest and also in that he made a pyramid, not indeed attaining to the measurements of that which was built by the former (this I know, having myself also measured it), and moreover there are no underground chambers beneath nor does a channel come from the Nile flowing to this one as to the other, in which the water coming through a conduit built for it flows round an island within, where they say that Cheops himself is laid: but for a basement he built the first course of Ethiopian stone of diverse colors; and this pyramid he made forty feet lower than the other as regards size, building it close to the great pyramid. These stand both upon the same hill, which is about a hundred feet high….

SOURCE: Herodotus. "An Account of Egypt." Gutenberg. January 25, 2013. Accessed July 08, 2018. http://www.gutenberg.org/files/2131/2131-h/2131-h.htm.

Document 1B

The story of the Tower of Babel, found in the Biblical book of *Genesis*, is one of the most famous and beloved legends of mankind.

> The whole earth was of one language, and of one speech. And it came to pass, as they journeyed from the east, that they found a plain in the land of *Shinar* [country of two rivers], and they dwelt there. And they said one to another, "Come, let us make bricks and burn them thoroughly." And they had brick for stone, and slime had they for mortar. And they said, "Come, let us build us a city and a tower whose top may reach unto heaven; and let us make us a name, lest we be scattered abroad upon the face of the whole earth."
>
> And the Lord came down to see the city and the tower which the children of men built. And the Lord said, "Behold, the people are one and they have all one language, and this they begin to do; and now nothing will be withheld from them which they have imagined to do. Come, let Us go down, and there confound their language, that they may not understand one another's speech." So the Lord scattered them abroad from thence upon the face of all the earth; and they left off building the city.
>
> Therefore is the name of it called *Bâbel* (that is "Confusion") because the Lord did there confound the language of all the earth; and from thence did the Lord scatter them abroad upon the face of all the earth.

Let's start our discussion of the *Etemenanki* [a ziggurat presumed to be the Tower of Babel] with some remarks about this Biblical story. The Hebrew word *Bâbel*, Confusion, is often used for Babylon (Akkadian *Bab-ili*), but this is not sufficient to prove the identification of the tower with a monument in this big city. (Imagine a legend about the unity of mankind, which is situated by scholars in Union, Connecticut.) Fortunately, the story contains a second geographical clue: the tower was erected on "a plain in the land of Shinar". This country is known from other books of the Bible (*Isaiah* 11.11 and *Zechariah* 5.11) and is translated as "Babylonia" in the *Septuagint* [the earliest extant Greek translation of the Old Testament from the original Hebrew]. So there is nothing that keeps us from identifying the Biblical building with a monument in ancient Babylon. This must be the building known as *E-temen-an-ki*, the 'House of the foundation of heaven on earth', a giant mountain of bricks and tiles with, on top, a temple for the god Marduk [chief god of Babylonia]. He had a second temple in the neighborhood, the Esagila.

The ancient Babylonians called these brick mountains a *ziqqurratu* or ziggurat, which can be translated as "rising building" (Akkadian *zaqâru*, "to rise high"). This type of temple tower is the oriental equivalent of the Egyptian pyramid and just as old, although there are two differences: the ziggurat was not a tomb, and ziggurats were built well into the Seleucid age, whereas the building of pyramids came to an end after c.1640 BCE. Ziggurats played a role in the cults of many cities in ancient Mesopotamia. Archaeologists have discovered nineteen of these buildings in sixteen cities; the existence of another ten is known from literary sources.

The Etemenanki was among the largest of these, and the most important. (The largest was the shrine of Anu at Uruk, built in the third or second century BCE.) According to the Babylonian creation epic, *Enûma êliš*, the god Marduk defended the other gods against the diabolical monster Tiamat. After he had killed it, he brought order to the cosmos, built the Esagila, which was the center of the new world, and created mankind. The Etemenanki was next to the Esagila, and this means that the temple tower was erected at the center of the world, as the axis of the universe. Here, a straight line connected earth and heaven. This aspect of Babylonian cosmology is echoed in the Biblical story, where the builders say, "let us build a tower whose top may reach unto heaven".

The best description of the monumental tower can be found in a cuneiform tablet from Uruk, written in 229 BCE. It is a copy of an older text and is now in the Louvre in Paris. It states that the tower was made up of seven terraces and it gives the height of the seven stocks - 91 meters all in all. The ground floor measured 91 x 91 meters, and this is confirmed by archaeological excavations conducted by Robert Koldewey after 1913 (91,48 x 91,66 m). Large stairs were discovered at the south side of the building, where a triple gate connected the Etemenanki with the Esagila. A larger gate in the east connected the Etemenanki with the sacred procession road. Seen from the triple gate, the Etemenanki must have resembled a true "stairway to heaven", because the gates on the higher terraces seemed to be standing on top of each other.

Using the archaeological data and the tablet at the Louvre, several reconstructions have been proposed. However, there is one caveat: it is possible that the Louvre tablet describes not the real temple tower, but an idealized sanctuary - a blueprint for an Etemenanki that still has to be built.

On the highest terrace was a temple, dedicated to the Babylonian supreme god Marduk. The Louvre tablet again offers information. There were several cult rooms: Marduk shared his room with his wife Sarpanitu, a second room offered accommodation to the scribe-god Nabû and his wife Tashmetu, and there were rooms for the water god Ea, the god of light Nusku, the god of heaven Anu, and finally Enlil, Marduk's predecessor as chief of the Mesopotamian pantheon. A seventh room was called "house of the bed" and contained a bed and a throne. A second bed was on the inner court of the temple on the highest platform of the Etemenanki. Finally, there must have been stairs to the roof. It is possible that the famous Babylonian astronomers, the Chaldeans, did their observations at the topmost level of the building.

This is the point where another text becomes useful: the *Histories* by the Greek researcher Herodotus of Halicarnassus (fifth century BCE). Although he probably never visited Babylon, his description of the Etemenanki tells us something about the temple ritual. (Herodotus correctly calls the supreme god of Babylon *Bêl* ("lord"), because his real name was not pronounced.)

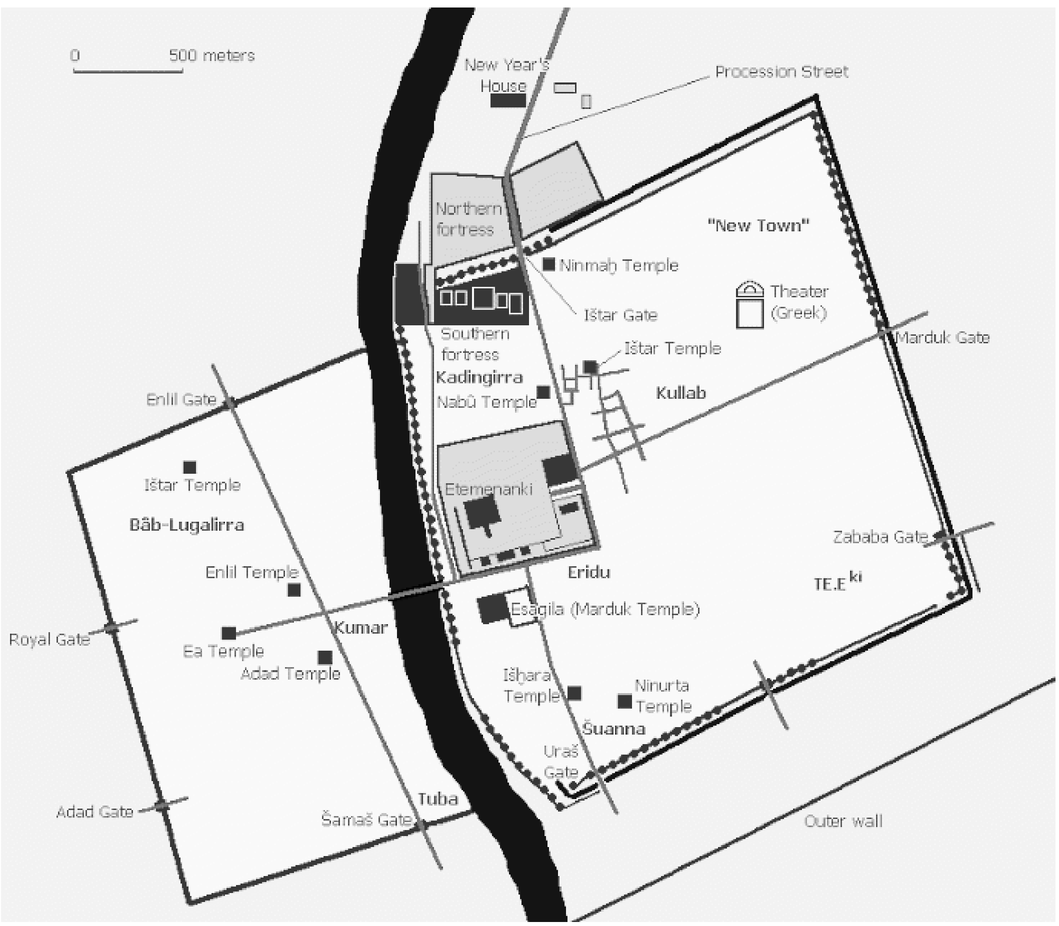
> The temple of Bêl, the Babylonian Zeus [...] was still in existence in my time. It has a solid central tower, one stadium square, with a second erected on top of it and then a third, and so on up to eight. All eight towers can be climbed by a spiral way running round the outside, and about half way up there are seats for those who make the ascent to rest on. On the summit of the topmost tower stands a great temple….

This account contains minor errors (the dimensions of the tower, the number of levels, the shape of the stairs) and belongs to a description of Babylon that contains grave errors. It needs to be stressed, because there are still scholars maintaining that Herodotus visited Babylon, that the Greek researcher does not claim that he has seen the Etemenanki: he merely writes that it "was still in existence" in his time….

The building history suggests that the Babylonians were occupied with the construction of the tower for over a century. It is possible that the ambitious design of a tower of 92 x 92 x 92 meters was too grandiose, so that they needed as much time for their project as the medieval builders of the European cathedrals. For a long time, the tower must have looked unfinished, and this may explain how the Biblical story came into being. It is certainly possible that the sanctuary was never finished at all….

Arabic authors were responsible for keeping the memory of the Etemenanki alive, sometimes comparing the greatness of the ancient city with the humble town Bâbil of their own age. However, they thought that the ancient royal palace, which was the largest ruin on the site, was the tower of Babel. The inhabitants of Bâbil told the same to the first Western visitors, in the sixteenth century.

In the nineteenth century, the real Etemenanki was rediscovered by the native Arab population. People of the nearby village wanted to create a palm garden and discovered ancient bricks when they lowered the groundwater level. German engineers understood the significance and in 1913, Robert Koldewey started the excavation of the Etemenanki. Today, only four channels can be seen; the rest of the site is overgrown with weed.



Map of Babylon

SOURCE: "Etemenanki (the "Tower of Babel")." Livius. April 12, 2018. Accessed July 13, 2018. http://www.livius.org/articles/place/babylon/etemenanki/.

Document 1C

…In the same year [1407] a congress of architects and engineers of the country [Florence] was summoned by the Wardens of Works of S. Maria del Fiore and by the Consuls of the Guild of Wool, to discuss methods for raising the cupola. Among these appeared Filippo [Brunelleschi], giving it as his advice that it was necessary, not to raise the fabric directly from the roof according to the design of Arnolfo, but to make a frieze fifteen braccia ["an arm's length" – approx. 26-27 inches each] in height, with a large round window in the middle of each of its sides, since not only would this take the weight off the supports of the tribunes, but it would become easier to raise the cupola; and models were made in this way, and were put into execution….

By the year 1420, all these ultramontane masters were finally assembled in Florence, and likewise those of Tuscany and all the ingenious craftsmen of design in Florence; and so, Filippo returned from Rome. They all assembled, therefore, in the Office of Works of S. Maria del Fiore, in the presence of the Consuls and of the Wardens, together with a select body of the most ingenious citizens, to the end that these might hear the mind of each master on the question and might decide on a method of vaulting this tribune. Having called them, then, into the audience, they heard the minds of all, one by one, and the plan that each architect had devised for that work. And a fine thing it was to hear their strange and diverse opinions about the matter, for the reason that some said that piers must be built up from the level of the ground, which should have the arches turned upon them and should uphold the wooden bridges for sustaining the weight; others said that it was best to make the cupola of sponge-stone, to the end that the weight might be less; and many were agreed that a pier should be built in the center, and that the cupola should be raised in the shape of a pavilion, like that of S. Giovanni in Florence. Nor were there wanting men who said that it would have been a good thing to fill it with earth mingled with small coins, to the end that, when it had been raised, anyone who wanted some of that earth might be given leave to go and fetch it, and thus the people would carry it away in a moment without any expense. Filippo alone said that it could be raised without so much wood-work, without piers, without earth, without so great expenditure on so many arches, and very easily without any framework….

The Consuls remained in the Audience Chamber all confused, both by the difficult methods of the original masters and by this last method of Filippo's, which they thought absurd, for it appeared to them that he would ruin the work in two ways: first, by making the vaulting double, which would have made it enormous and unwieldy in weight; and secondly, by making it without a framework. On the other hand, Filippo, who had spent so many years in study in order to obtain the commission, knew not what to do and was often tempted to leave Florence. However, wishing to prevail, he was forced to arm himself with patience, having insight enough to know that the brains of the men of that city did not abide very firmly by any one resolution. Filippo could have shown a little model that he had in his possession, but he did not wish to show it, having recognized the small intelligence of the Consuls, the envy of the craftsmen, and the instability of the citizens, who favored now one and now another, according as it pleased each man best; and I do not marvel at this, since every man in that city professes to know as much in these matters as the experienced masters know, although those who truly understand them are but few; and let this be said without offense to those who have the knowledge. What Filippo, therefore, had not been able to achieve before the tribunal, he began to effect with individuals, talking now to a Consul, now to a Warden, and likewise to many citizens; and showing them part of his design, he induced them to determine to allot this work either to him or to one of the foreigners. Wherefore the Consuls, the Wardens of Works, and those citizens, regaining courage, assembled together, and the architects disputed concerning this matter, but all were overcome and conquered by Filippo with many arguments; and here, so it is said, there arose the dispute about the egg, in the following manner. They would have liked Filippo to speak his mind in detail, and to show his model, as they had shown theirs; but this he refused to do, proposing instead to those masters, both the foreign and the native, that whosoever could make an egg stand upright on a flat piece of marble should build the cupola, since thus each man's intellect would be discerned. Taking an egg, therefore, all those masters sought to make it stand upright, but not one could find the way. Whereupon Filippo, being told to make it stand, took it graciously, and, giving one end of it a blow on the flat piece of marble, made it stand upright. The craftsmen protested that they could have done the same; but Filippo answered, laughing, that they could also have raised the cupola, if they had seen the model or the design. And so it was resolved that he should be commissioned to carry out this work, and he was told that he must give fuller information about it to the Consuls and the Wardens of Works.

Going to his house, therefore, he wrote down his mind on a sheet of paper as clearly as he was able, to give to the tribunal, in the following manner: "Having considered the difficulties of this structure, Magnificent Lords Wardens, I find that it is in no way possible to raise the cupola perfectly round, seeing that the surface above, where the lantern is to go, would be so great that the laying of any weight thereupon would soon destroy it. Now it appears to me that those architects who have no regard for the durability of their structures, have no love of lasting memorials, and do not even know why they are made. Wherefore I have determined to turn the inner part of this vault in pointed sections, following the outer sides, and to give to these the proportion and the curve of the quarter-acute arch, for the reason that this curve, when turned, ever pushes upwards, so that, when it is loaded with the lantern, both will unite to make the vaulting durable. At the base it must be three braccia and three quarters in thickness, and it must rise pyramidically, narrowing from without, until it closes at the point where the lantern is to be; and at this junction the vaulting must be one braccio and a quarter in thickness. Then on the outer side there must be another vault, which must be two braccia and a half thick at the base, in order to protect the inner one from the rain. This one must also diminish pyramidically in due proportion, so that it may come together at the foot of the lantern, like the other, in such wise that at the summit it may be two-thirds of a braccio in thickness. At each angle there must be a buttress, making eight in all: and in the middle of every side there must be two buttresses, making sixteen in all: and between the said angles, on every side, both within and without, there must be two buttresses, each four braccia thick at the base. The two said vaults, built in the form of a pyramid, must rise together in equal proportion up to the height of the round window closed by the lantern. There must then be made twenty-four buttresses with the said vaults built round them, and six arches of grey-stone blocks, stout and long, and well braced with irons, which must be covered with tin; and over the said blocks there must be iron ties, binding the said vaulting to its buttresses. The first part of the masonry, up to the height of five braccia and a quarter, must be solid, leaving no vacant space, and then the buttresses must be continued and the two vaults separated. The first and second courses at the base must be strengthened throughout with long blocks of grey-stone laid horizontally across them, in such wise that both vaults of the cupola may rest on the said blocks. At the height of every nine braccia in the said vaults there must be little arches between one buttress and another, with thick ties of oak, to bind together the said buttresses, which support the inner vault; and then the said ties of oak must be covered with plates of iron, for the sake of the staircases. The buttresses must be all built of grey-stone and hard-stone, and all the sides of the cupola must be likewise of hard-stone and bound with the buttresses up to the height of twenty-four braccia; and from there to the top the material must be brick, or rather, spongestone, according to the decision of the builder, who must make the work as light as he is able. A passage must be made on the outside above the windows, forming a gallery below, with an open parapet two braccia in height, proportionately to those of the little tribunes below; or rather, two passages, one above the other, resting on a richly adorned cornice, with the upper passage uncovered. The rain water must flow from the cupola into a gutter of marble, a third of a braccio wide, and must run off through outlets made of hard-stone below the gutter. Eight ribs of marble must be made at the angles in the outer surface of the cupola, of such thickness as may be required, rising one braccio above the cupola, with a cornice above by way of roof, two braccia wide, to serve as gable and eaves to the whole; and these ribs must rise pyramidically from their base up to the summit. The two vaults of the cupola must be built in the manner described above, without framework, up to the height of thirty braccia, and from that point upwards in the manner recommended by those masters who will have the building of them, since practice teaches us what course to pursue."

Filippo, having finished writing all that is above, went in the morning to the tribunal and gave them that paper, which they studied from end to end. And although they could not grasp it all, yet, seeing the readiness of Filippo's mind, and perceiving that not one of the other architects had better ground to stand on—for he showed a manifest confidence in his speech, ever repeating the same thing in such wise that it appeared certain that he had raised ten cupolas—the Consuls, drawing aside, were minded to give him the work, saying only that they would have liked to see something to show how this cupola could be raised without framework, for they approved of everything else….

How beautiful is this building it demonstrates by itself. From the level of the ground to the base of the lantern it is one hundred and fifty-four braccia in height; the body of the lantern is thirty-six braccia; the copper ball, four braccia; the cross, eight braccia; and the whole is two hundred and two braccia. And it can be said with confidence that the ancients never went so high with their buildings, and never exposed themselves to so great a risk as to try to challenge the heavens, even as this structure truly appears to challenge them, seeing that it rises to such a height that the mountains round Florence appear no higher. And it seems, in truth, that the heavens are envious of it, since the lightning keeps on striking it every day. The while that this work was in progress, Filippo made many other buildings, which we will enumerate below in their order.

SOURCE: Vasari, Giorgio. "Lives of the Most Eminent Painters Sculptors and Architects, Vol 2, Berna to Michelozzo Michelozzi." Project Gutenberg. June 11, 2008. Accessed July 13, 2018. http://www.gutenberg.org/files/25759/25759-h/25759-h.htm#Page_193.

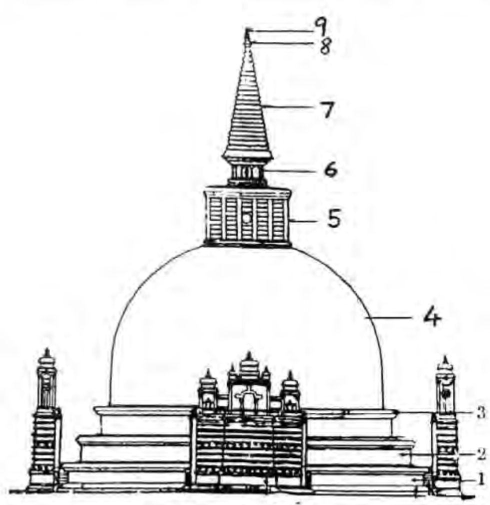
Document 1D

Jetavanaramaya (also known as Jetavana) was built by King Mahasena in 273-301 AD. Situated in the ancient city of Anuradhapura, which was the capital of Sri Lanka during that era. At the time of its inception, Jetavana was appreciated as the third tallest structure in the world followed by the Great Pyramids of Giza. Jetavana currently has a volume of 233,000 cubic meters, which inarguably makes it the largest brick structure in the world. In 1985 Jetavana was named a World Heritage Site by UNESCO.

After its construction, Jetavana stood at 121.9m (400ft). At present, Jetavana stands at 70.7m with a base diameter of 102m. It is a brick stupa, where more than 93,300,000 baked bricks have been used for its construction. Jetavana is a religious monument built to honor the Eight Great Deeds of Lord Buddha and to enshrine the possessions of Lord Buddha. Jetavana is said to enshrine a sash or belt tie which belonged to Lord Buddha. Construction of a stupa is believed to be a great deed in Buddhism; hence countless number of Kings in ancient Sri Lanka built stupas to accumulate good Karma. Furthermore, the presence of a stupa gives one a feeling of stability, strength, nobility, and grandeur.

Jetavana is a solid construction, mostly composing of burnt bricks. The design of the stupa can be broken down into 9 main components. Figure 2 shows the basic components of a Sri Lankan stupa.

Figure 2. Main components of a Sri Lankan stupa.



Main Components of a Stupa

1, 2, 3 - Basal rings

4 - Dome

5 - Square Chamber

6 - Cylinder

7 - Spire

8 - Minaret

9 - Crystal

The dome is the largest and structurally the most important component of the Jetavana. There are many different dome shapes used for stupas such as bell, bubble, paddy, pot, and lotus. In the case of Jetavana, the paddy heap shape was adopted. This dome shape is geometrically similar to an ellipsoid.

The basal rings, square chamber, cylinder and spire are all made of different sizes of burnt bricks, made specifically for each component of the stupa. Like all mega stupas, the location of Jetavana was carefully chosen so that the bed rock was situated close to the surface. In the case of Jetavana, the foundation extends 8.5m (28ft) to the bed rock. No accountable source of the foundation constructions of Jetavana exists. However, the Mahavamsa a chronicle that records the history of Sri Lanka contains a description of the construction of a foundation of a mega stupa similar to Jetavana, called Ruvanvelisaya.

This account states that initially the proposed land was dug out to the bedrock. Then crushed rocks were carried in to fill the space and were compacted by elephants, whose legs were covered with leather. Afterwards, butter clay was used to fill in and level out the surface of crushed rock. This is followed by a course of bricks placed on top of the clay. Over this, a layer of lime paste was reinforced by a network of iron. The last layer was sheets of copper and silver for water proofing. The end product was a reinforced concrete foundation with water proofing. This foundation method might have been used for the construction of the Jetavana foundation, as Ruvanvelisaya was constructed 100 years prior to the construction of Jetavana.

Also according to Mahavamsa there was firm quality control on materials used by the ancient builders. The bricks used in the construction of Jetavana had much better strength and a larger size relative to modern factory-made bricks in Sri Lanka. There were different sized bricks used. This was because various sizes of bricks had to be used for different parts of the stupa.

An analysis done by Abeyratne on the mortar in Jetavana, revealed that the mortar consisted of finely crushed dolomitic lime & sand and clay in a ratio 1:5. The role of mortar was primarily to fill the gaps in between the bricks. Therefore, a thin mortar of slurry consistency was used in the construction. Given that the mortar was of thin consistency, the mortar layer was close to zero. This made better transfer of load between the bricks, virtually by direct contact. A final layer of plaster was used on the outer surface of the brickwork to provide water-proofing for the stupa.

The design of a stupa is far more complicated than that of a pyramid. Thus, builders who worked on Jetavana showed great technological skills and management skills. The site was well supervised and quality control was a major priority for the builders….

According to Prof. M.P. Ranaweera, Department of Civil Engineering, University of Peradeniya, the paddy heap shape of Jetavana was ideal in terms of the structural perspective. This is due to the gradient of the paddy heap being equal to the angle of repose. This in turn creates very low tension in the dome due to self-weight. According to many, ancient builders have discovered this shape from trial and error….

SOURCE: Edirisinghe, Tharindu Ishan. "Largest Brick Structure in the World Jetavanaramaya." Scribd. October 14, 2012. Accessed July 17, 2018. https://www.scribd.com/document/109963356/Largest-Brick-Structure-in-the-World-Jetavanaramaya.

Document 2A

The first skyscrapers -- tall commercial buildings with iron or steel frameworks -- came about in the late-19th and early-20th centuries, and the Chicago Home Insurance Building is generally considered the first modern skyscraper despite being just 10 stories high.

Skyscrapers were made possible through a series of architectural and engineering innovations.

Henry Bessemer (1813-1898) of England, is well-known for inventing the first process to mass-produce steel inexpensively. An American, William Kelly, had held a patent for "a system of air blowing the carbon out of pig iron," but bankruptcy forced Kelly to sell his patent to Bessemer, who had been working on a similar process for making steel. In 1855, Bessemer patented his own "decarbonization process, utilizing a blast of air." This breakthrough opened the door for builders to start making taller and taller structures. Modern steel today is still made using technology based on Bessemer's process.

While “the Bessemer process” kept Bessemer’s name well-known long after his death, lesser known today is the man who actually employed that process to innovate the first skyscraper: George A. Fuller (1851-1900). Fuller had been working on trying to solve the problems of the "load bearing capacities" of tall buildings. At the time, construction techniques called for outside walls to carry the load of a building’s weight. Fuller, however, had a different idea.

Fuller realized that buildings could bear more weight—and therefore soar higher—if he used Bessemer steel beams to give buildings a load-bearing skeleton on the inside of the building. In 1889, Fuller erected the Tacoma Building, a successor to the Home Insurance Building that became the first structure ever built where the outside walls did not carry the weight of the building. Using Bessemer steel beams, Fuller developed his technique for creating his steel cages to support all the weight in his subsequent skyscrapers. The Flatiron Building was one of New York City's first skyscrapers, built in 1902 by Fuller's building company. Daniel H. Burnham was the chief architect.

The term "skyscraper,” as far as existing records show, was first used to refer to a tall building during the 1880s in Chicago, shortly after the first 10 to 20 story buildings were built in the United States. Combining several innovations—steel structures, elevators, central heating, electrical plumbing pumps and the telephone— skyscrapers came to dominate American skylines at the turn of the century. The world's tallest building when it opened in 1913, architect Cass Gilbert's 793-foot Woolworth Building was considered a leading example of tall building design.

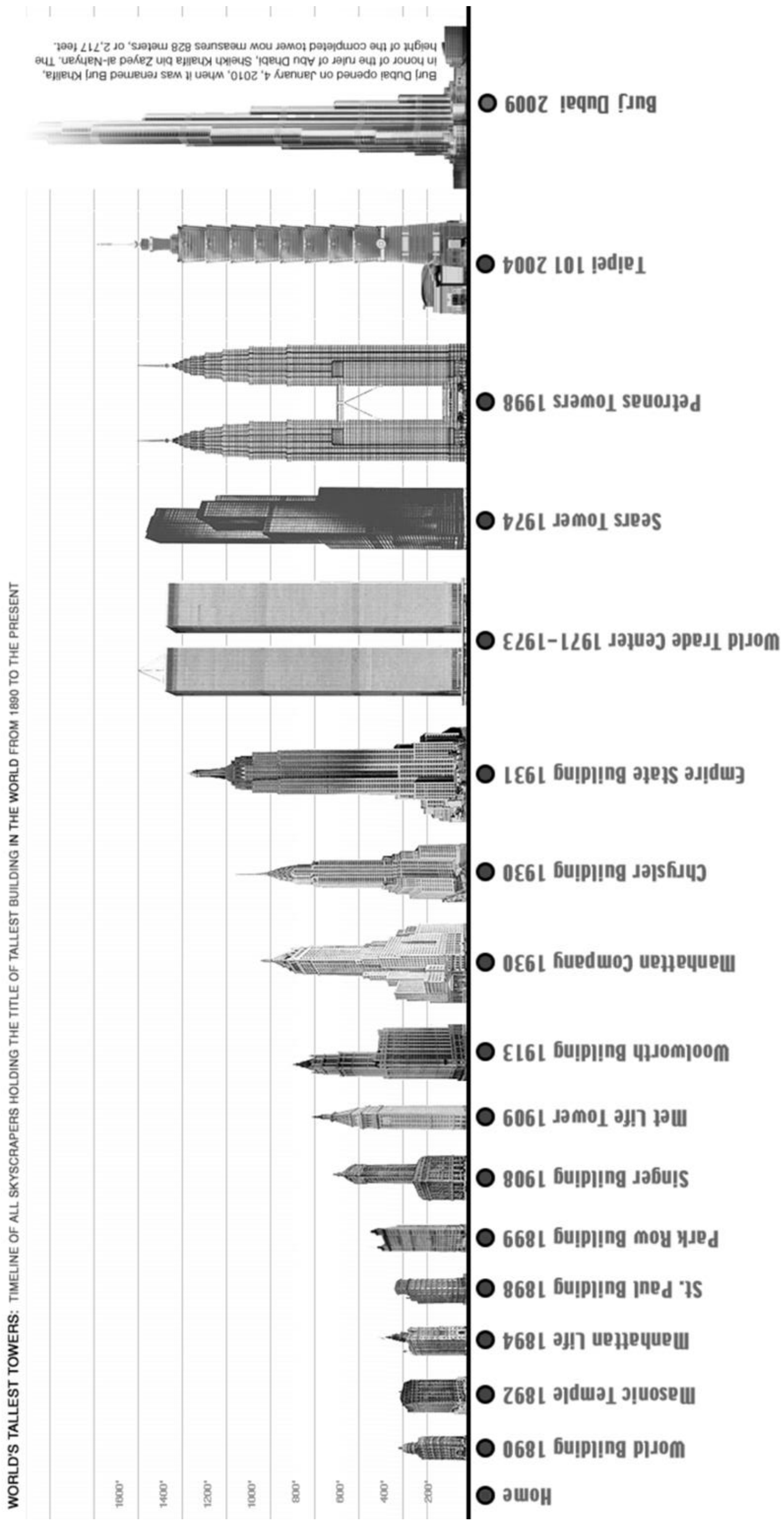
Today, the tallest skyscrapers in the world approach and even exceed heights of 2,000 feet. In 2013, construction began in Saudi Arabia on the Kingdom Tower, originally intended to rise one mile into the sky, its scaled-down design will leave it at about one kilometer high, with more than 200 floors.

SOURCE: Bellis, Mary. "The First Skyscrapers (And How They Became Possible)." ThoughtCo. https://www.thoughtco.com/how-skyscrapers-became-possible-1991649 (accessed July 13, 2018).

Document 2B

SOURCE: "Home Insurance Company Building." Encyclopædia Britannica. Accessed July 13, 2018. https://www.britannica.com/place/Home-Insurance-Company-Building.

Document 2C



SOURCE: "The World's Tallest Skyscrapers." The World Trade Center: Statistics and History. Accessed July 13, 2018. http://skyscraper.org/TALLEST_TOWERS/tallest.htm.

Document 2D

Former Governor Alfred E. Smith will head a company to be incorporated to build the highest building in the world on the site of the Waldorf-Astoria Hotel. The structure, to be known as the Empire State Building, will be an office building, eighty stories high, and will cost, with the $16,000,000 paid for the site, more than $60,000,000. It will occupy more than two acres of land with 200 feet on Fifth Avenue and 425 feet on Thirty-third and Thirty-fourth Streets.

Mr. Smith, who will be president of the Empire State Building Corporation, made the announcement in his suite at the Hotel Biltmore in accordance with a promise made months ago to newspaper reporters that he would announce his business plans as soon as he had determined them. The former Governor said that supervision of the construction of the building and its management would be his main business. Since his retirement from the Governorship Mr. Smith has been elected a director of the Metropolitan Life Insurance Company and the New York County Trust Company, but his duties in these directorates have taken but a small part of his time. Although the Governor made no mention of it in his announcement, it is said by friends that his salary as president of the building company would be about $50,000 a year….

Mr. Smith said that as president of the company he would be in executive control of the erection of the building and its maintenance and operation thereafter. He left during the afternoon for Canoe Place Inn and will return on Sept. 9. Contracts for the demolition of the hotel building will be let soon after his return and the work of tearing down the hotel will begin immediately. Mr. Smith said that engineers consulted have estimated that about a year and a half would be required for the erection of the building.

The proposed building will be the highest in New York City and the highest in the world. The Woolworth Building is sixty stories and 792 feet high, the Metropolitan Life Building fifty stories and 700 feet in height and the Singer Building forty-one stories and 612 feet in height.

The Empire State Building will be nearly 1,000 feet in height, which is nearly equivalent to the length of five city blocks. It will rise fifteen stories on the streets before there is a setback and the great height of eighty stories will be reached by a tower. Under the existing building regulations, which are not likely to be made less stringent, no other building can be erected within 300 feet or more of its upper fifty stories. Mr. Smith said that this meant that the upper fifty floors of the building always would have plenty of light and air.

The Waldorf-Astoria property was sold last December to the Bethlehem Engineering Company by the Boomer-du Pont interests and was taken over subsequently by a syndicate organized by the Chatham & Phenix National Bank and Trust Company…. The original price paid for the hotel property was reported to be $20,000,000. It was first planned to erect a fifty-story building. Tentative plans were then prepared for a sixty-five story building and it finally was decided to increase the height to eighty stories.

In announcing his selection to head the new company, Mr. Smith said that the erection of the building unquestionably was one of the largest real estate undertakings in the history of the country.

The proposed building will be able to house at one time more than 60,000 persons, more than are to be found in more than half the counties of the state. The building will be only two blocks from the

Pennsylvania Station and nine blocks from the Grand Central Station. It will be on the line of the proposed crosstown vehicular tunnel. It will be only a block from the Hudson & Manhattan tubes, with B. M. T. subway and the Sixth Avenue elevated railroad and two blocks on either side of it are Interborough subways.

The building will contain 34,000,000 cubic feet of space and 3,000,000 square feet of floor space. Its tower will rise over one of the busiest sections in the world, and Mr. Smith suggested that it would make a splendid place for a radio station….

SOURCE: "Smith to Help Build Highest Skyscraper." *The New York Times*, August 30, 1929.

Document 2E

In the book of Genesis, the builders of Babel declared, “Come, let us build us a city and a tower with its top in the heavens. And let us make a name for ourselves, lest we be scattered upon the face of the whole earth.” These early developers correctly understood that cities could connect humanity. But God punished them for monumentalizing terrestrial, rather than celestial, glory. For more than 2,000 years, Western city builders took this story’s warning to heart, and the tallest structures they erected were typically church spires. In the late Middle Ages, the wool-making center of Bruges became one of the first places where a secular structure, a 354-foot belfry built to celebrate cloth-making, towered over nearby churches. But elsewhere another four or five centuries passed before secular structures surpassed religious ones. With its 281-foot spire, Trinity Church was the tallest building in New York City until 1890. Perhaps that year, when Trinity’s spire was eclipsed by a skyscraper built to house Joseph Pulitzer’s New York World, should be seen as the true start of the irreligious 20th century. At almost the same time, Paris celebrated its growing wealth by erecting the 1,000-foot Eiffel Tower, which was 700 feet taller than the Cathedral of Notre-Dame.

The ceaseless climb of the world's skyscrapers is a story of ever-evolving challenges. Here's how we reached the heights we have—and where we might go from here.

Since that tower in Babel, height has been seen both as a symbol of power and as a way to provide more space on a fixed amount of land. The belfry of Trinity Church and Gustave Eiffel’s tower did not provide usable space. They were massive monuments to God and to French engineering, respectively. Pulitzer’s World Building was certainly a monument to Pulitzer, but it was also a relatively practical means of getting his growing news operation into a single building.

For centuries, ever taller buildings have made it possible to cram more and more people onto an acre of land. Yet until the 19th century, the move upward was a moderate evolution, in which two-story buildings were gradually replaced by four- and six-story buildings. Until the 19th century, heights were restricted by the cost of building and the limits on our desire to climb stairs. Church spires and belfry towers could pierce the heavens, but only because they were narrow and few people other than the occasional bell-ringer had to climb them. Tall buildings became possible in the 19th century, when American innovators solved the twin problems of safely moving people up and down and creating tall buildings without enormously thick lower walls.

Elisha Otis didn’t invent the elevator; Archimedes is believed to have built one 2,200 years ago. And Louis XV is said to have had a personal lift installed in Versailles so that he could visit his mistress. But before the elevator could become mass transit, it needed a good source of power, and it needed to be safe. Matthew Boulton and James Watt provided the early steam engines used to power industrial elevators, which were either pulled up by ropes or pushed up hydraulically. As engines improved, so did the speed and power of elevators that could haul coal out of mines or grain from boats.

But humans were still wary of traveling long distances upward in a machine that could easily break and send them hurtling downward. Otis, tinkering in a sawmill in Yonkers, took the danger out of vertical transit. He invented a safety brake and presented it in 1854 at New York’s Crystal Palace Exposition. He had himself hoisted on a platform, and then, dramatically, an axman severed the suspending rope. The platform dropped slightly, then came to a halt as the safety brake engaged.

The Otis elevator became a sensation. In the 1870s, it enabled pathbreaking structures, like Richard Morris Hunt's Tribune Building in New York, to reach 10 stories. Across the Atlantic, London's 269-foot St. Pancras Station was taller even than the Tribune Building. But the fortress-like appearance of St. Pancras hints at the building's core problem. It lacks the critical cost-reducing ingredient of the modern skyscraper: a load-bearing steel skeleton. Traditional buildings, like St. Pancras or the Tribune Building, needed extremely strong lower walls to support their weight. The higher a building went, the thicker its lower walls had to be, and that made costs almost prohibitive, unless you were building a really narrow spire.

The load-bearing steel skeleton, which pretty much defines a skyscraper, applies the same engineering principles used in balloon-frame houses, which reduced the costs of building throughout rural 19th-century America. A balloon-frame house uses a light skeleton made of standardized boards to support its weight [similar to the way most houses are built today]. The walls are essentially hung on the frame like a curtain. Skyscrapers also rest their weight on a skeleton frame, but in this case the frame is made of steel, which became increasingly affordable in the late 19th century.

There is a lively architectural debate about who invented the skyscraper—reflecting the fact that the skyscraper, like most other gifts of the city, didn't occur in a social vacuum, and did not occur all at once. William Le Baron Jenney's 138-foot Home Insurance Building, built in Chicago in 1885, is often seen as the first true skyscraper. But Jenney's skyscraper didn't have a complete steel skeleton. It just had two iron-reinforced walls. Other tall buildings in Chicago, such as the Montauk Building, designed by Daniel Burnham and John Root and built two years earlier, had already used steel reinforcement. Industrial structures, like the McCullough Shot and Lead Tower in New York and the St. Ouen dock warehouse near Paris, had used iron frames decades before.

Jenney's proto-skyscraper was a patchwork, stitching together his own innovations with ideas that were in the air in Chicago, a city rich with architects. Other builders, like Burnham and Root, their engineer George Fuller, and Louis Sullivan, a former Jenney apprentice, then further developed the idea. Sullivan's great breakthrough came in 1891, when he put up the Wainwright Building in St. Louis, a skyscraper free from excessive ornamental masonry. Whereas Jenney's buildings evoke the Victorian era, the Wainwright Building points the way toward the modernist towers that now define so many urban skylines.

Ayn Rand's novel *The Fountainhead* is believed to be loosely based on the early life of Sullivan's apprentice Frank Lloyd Wright. Sullivan and Wright are depicted as lone eagles, Gary Cooper heroes, paragons of individualism. They weren't. They were great architects deeply enmeshed in an urban chain of innovation. Wright riffed on Sullivan's idea of form following function, Sullivan riffed on Jenney, and they all borrowed the wisdom of Peter B. Wight, who produced great innovations in fireproofing. Their collective creation—the skyscraper—enabled cities to add vast amounts of floor space using the same amount of ground area. Given the rising demand for center-city real estate, the skyscraper seemed like a godsend. The problem was that those city centers already had buildings on them. Except in places like Chicago, where fire had created a tabula rasa, cities needed to tear down to build up.

The demand for space was even stronger in New York than in Chicago, and skyscrapers were soon springing up in Manhattan. In 1890, Pulitzer's World Building had some steel framing, but its weight was still supported by seven-foot-thick masonry walls. In 1899, the Park Row Building soared over the World Building, to 391 feet, supported by a steel skeleton. Daniel Burnham traveled east to build his iconic

Flatiron Building in 1902, and several years later, Wight's National Academy of Design was torn down to make way for the 700-foot Metropolitan Life tower, then the tallest building in the world. In 1913, the Woolworth Building reached 792 feet, and it remained the world's tallest until the boom of the late '20s.

Those tall buildings were not mere monuments. They enabled New York to grow and industries to expand. They gave factory owners and workers space that was both more humane and more efficient. Manhattan's master builders, such as A. E. Lefcourt, made that possible.

Like a proper Horatio Alger figure, Lefcourt was born poor and started work as a newsboy and bootblack. By his teenage years, he had saved enough cash to buy a $1,000 U.S. Treasury bond, which he kept pinned inside his shirt. At 25, Lefcourt took over his employer's wholesale business, and over the next decade he became a leading figure in the garment industry.

In 1910, Lefcourt began a new career as a real-estate developer, putting all of his capital into a 12-story loft building on West 25th Street for his own company. He built more such buildings, and helped move his industry from the old sweatshops into the modern Garment District. The advantage of the garment industry's old home downtown had been its proximity to the port. Lefcourt's new Garment District lay between Grand Central and Pennsylvania stations, anchored by the rail lines that continued to give New York a transportation advantage. Transportation technologies shape cities, and Midtown Manhattan was built around two great rail stations that could carry in legions of people.

Over the next 20 years, Lefcourt would erect more than 30 edifices, many of them skyscrapers. He used those Otis elevators in soaring towers that covered 150 acres, encased 100 million cubic feet, and contained as many workers as Trenton. "He demolished more historical landmarks in New York City than any other man had dared to contemplate," The Wall Street Journal wrote. In the early 1920s, the New York of slums, tenements, and Gilded Age mansions was transformed into a city of skyscrapers, as builders like Lefcourt erected nearly 100,000 new housing units each year, enabling the city to grow and to stay reasonably affordable.

By 1928, Lefcourt's real-estate wealth had made him a billionaire in today's dollars. He celebrated by opening a national bank bearing his own name. Lefcourt's optimism was undiminished by the stock-market crash, and he planned $50 million of construction for 1930, sure that it would be a "great building year." But as New York's economy collapsed, so did his real-estate empire, which was sold off piecemeal to pay his investors. He died in 1932 worth only $2,500, seemingly punished, like the builders of Babel, for his hubris….

New York's upward trajectory was not without its detractors. In 1913, the distinguished chairman of the Fifth Avenue Commission, who was himself an architect, led a fight to "save Fifth Avenue from ruin." At that time, Fifth Avenue was still a street of stately mansions owned by Carnegies and Rockefellers. The anti-growth activists argued that unless heights were restricted to 125 feet or less, Fifth Avenue would become a canyon, with ruinous results for property values and the city as a whole. Similar arguments have been made by the enemies of change throughout history. The chair of the commission was a better architect than prognosticator, as density has suited Fifth Avenue quite nicely.

In 1915, between Broadway and Nassau Street, in the heart of downtown New York, the Equitable Life Assurance Society constructed a monolith that contained well over a million square feet of office space and, at about 540 feet, cast a seven-acre shadow on the city. The building became a rallying cry for the enemies of height, who wanted to see a little more sun. A political alliance came together and passed the city's landmark 1916 zoning ordinance, which allowed buildings to rise only if they gave up girth. New York's many ziggurat-like structures, which get narrower as they get taller, were constructed to fulfill the setback requirements of that ordinance.

The code changed the shape of buildings, but it did little to stop the construction boom of the 1920s. Really tall buildings provide something of an index of irrational exuberance. Five of the 10 tallest buildings standing in New York City in 2009—including the Empire State Building—were completed between 1930 and '33. In the go-go years of the late '20s, when the city's potential seemed unlimited, builders like Lefcourt were confident they could attract tenants, and their bankers were happy to lend. The builders of the Chrysler Building, 40 Wall Street, and the Empire State Building engaged in a great race to produce the tallest structure in the world. It is an odd fact that two of New York's tallest and most iconic edifices were built with money made from selling the cars that would move America away from vertical cities to sprawling suburbs. As it turned out, the winner, the Empire State Building, was soon nicknamed the "Empty State Building"—it was neither fully occupied nor profitable until the 1940s. Luckily for its financiers, the building's construction had come in way below budget.

SOURCE: Glaeser, Edward. "How Skyscrapers Can Save the City." The Atlantic. February 19, 2014. Accessed July 16, 2018. https://www.theatlantic.com/magazine/archive/2011/03/how-skyscrapers-can-save-the-city/308387/.

Document 2F

A project which, if executed, would render the Paris Exhibition of 1889 forever memorable, has been published by M. Eiffel, the French engineer, and is described in *La Nature*. It is to erect in the grounds of the exhibition an iron tower 300 meters in height, that is twice as high as the Great Pyramid and more than twice as high as the Strasburg Cathedral; 160 meters he considers as the limit of height possible in a structure of which stone is the principal material, and hence iron is proposed. The base of the tower is a pyramidal shape, and is to be 70 meters high, and the superficial area at this height will be 5,000 square meters: above this there are to be three other stages or stories, in which will be rooms which it is proposed to use for various purposes, scientific and other. The towers of Notre Dame will be mere pigmies beside this colossal structure, and will not reach to its first floor. The projector points out that, in addition to its monumental character, the structure will be useful for strategical purposes in war time on account of the vast range of view, for meteorological and astronomical observations, for at such a height the clearness of the air and the absence of fogs would render observations possible which cannot be made on the ground. The tower might also be used for the electric light. The whole exhibition and the surrounding neighborhood might thus be lighted from a central point. Many scientific problems may, it is suggested, be investigated from the tower, such as the resistance of the air to different weights, certain laws of elasticity, the study of the compression of gas or vapors, of the oscillation of the pendulum. In shape it is to resemble an enormous lighthouse, gradually tapering from a wide base to the summit.

SOURCE: "A French Tower of Babel." ***The New York Times*** **(New York), January 4, 1885.**

Document 3A

Philadelphia City Hall was the largest masonry load-bearing wall building in the world at the time of its completion in 1901, stood as the tallest occupied building in the United States until 1909, and still is the largest city hall in the United States. The building covers 14.26 acres, originally contained 634 rooms with over 1 million square feet of space, and with its tower and statue of William Penn rises a total of 548 feet above the ground. The construction of Philadelphia City Hall began in 1872 and was completed in 1901. The bill providing for the erection of a new city hall passed both branches of the Pennsylvania State legislature in early April 1860, and the voters of Philadelphia selected Penn Square as the site of City Hall on October 11, 1870. The building was designed in the Second-Empire Mode of French Renaissance Revival architectural style by architect John McArthur, Jr. with the assistance of Thomas U. Walter, John Ord, and W. Bleddyn Powell.

The walls are brick, faced with white marble, and rise to a height of 337 feet above the ground. Not including the statue of William Penn, the tower rose 173 feet above the top of the building's masonry construction. The building measures 486 feet by 470 feet and rises seven stories high. The 18-foot 3-inch high basement story was constructed of white granite blocks that weigh from two to five tons and form walls up to 22-feet thick. The foundations of the tower rest on a bed of concrete 100 feet square and 8 feet 6 inches thick. The Tacony Iron and Metal Company hired civil engineer C.R. (Carl Robert) Grimm, M. ASCE to design the upper wrought-iron frame, metal-clad portion of the tower, which surmounted the masonry tower and supported the 37-foot-tall, 27-ton bronze statue of William Penn. The tower was designed to carry its dead load along with live loads on three floors and the balcony of 100 lb/ft2 and horizontal wind loads of 50 lb/ft2. The octagonal-prism tower designed by C.R. Grimm consisted of wrought-iron framework that supported the cast iron outer plates, which were electo-plated with copper and then covered with a finish coat of aluminum. The tower's pins and anchor bolts were steel.

SOURCE: "Philadelphia City Hall." American Society of Civil Engineers (ASCE). Accessed July 14, 2018. http://www.asce.org/project/philadelphia-city-hall/.

Document 3B

New York — Former Governor Alfred E Smith will head a company to be incorporated to build what will be the highest building in the world on the site of the Waldorf Astoria hotel. The building will be known as the Empire State Building, and will be eighty stories high, and will cost (with the $16,000,000 paid for the site) more than $66,000,000. It will occupy more than two acres of land, with 200 feet on Fifth Avenue and 425 feet on Thirty-third and Thirty-fourth streets.

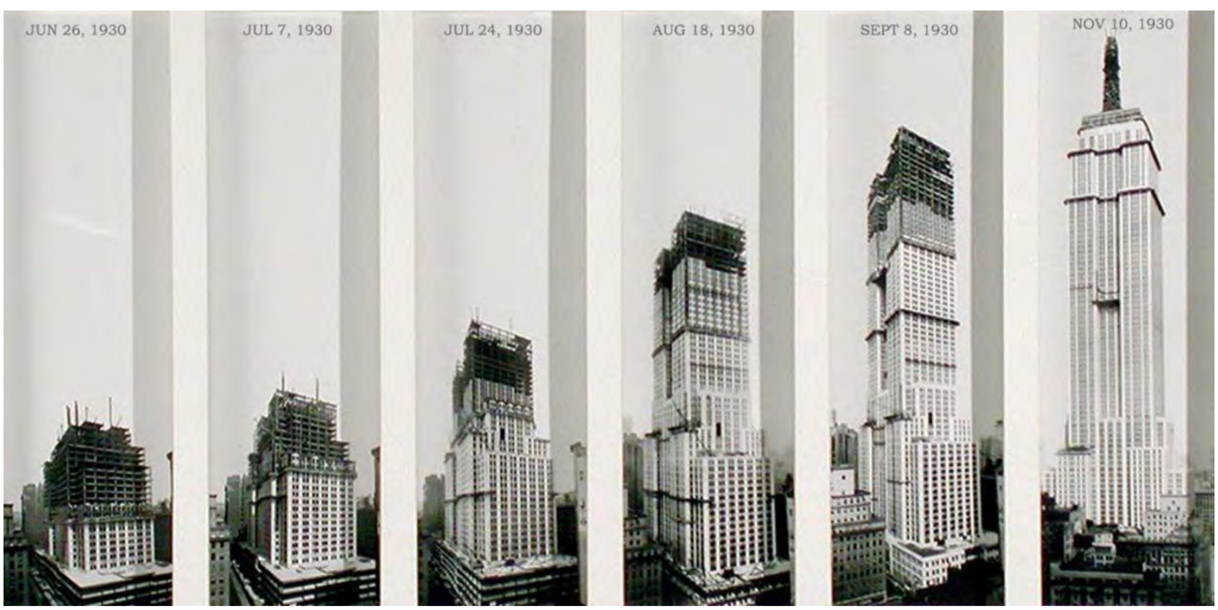
Smith, who will be president of the Empire State Building Corporation, made the announcement in his suite at the Biltmore Hotel, in accordance with a promise made months ago to newspaper reporters that he would announce his business plans as soon as he determined them.

The former governor said that supervision of the construction of the building and its management would be his main business. Since his retirement from the governorship Smith has been elected a director of the Metropolitan Life Insurance Company and the New York County Trust Company, but his duties in these directorates have taken but a small part of his time.

Although the Governor made no mention of it in his announcement, it was said by friends that his salary as president of the building company would be about $50,0000 a year.

Smith said that as president of the company he would be in executive control of the creation of the building and its maintenance and operation thereafter. He left during the afternoon for Canoe Place Inn and will return on September 9.

Contracts for the demolition of the hotel building will be let soon after his return, and the work of tearing down the hotel will begin immediately. Smith said that engineers consulted have estimated that about a year and a half would be required for the erection of the building.



SOURCE: "The Construction of the Empire State Building (1929-1930)." Click Americana. March 25, 2018. Accessed July 13, 2018. https://clickamericana.com/topics/places/announcement-of-the-empire-state-building-1929.

Document 3C

I well remember how anxiously I awaited the blowing of the first 7-cwt. charge of pig iron. I had engaged an iron founder's furnace attendant to manage the cupola and the melting of the charge. When his metal was nearly all melted, he came to me, and said hurriedly: "Where we going to put the metal, master?" I said: "I want you to run it by a gutter into that little furnace," pointing to the converter, "from which you have just raked out all the fuel, and then I shall blow cold air through it to make it hot." The man looked at me in a way in which surprise and pity for my ignorance seemed curiously blended, as he said: "It will soon be all of a lump." Notwithstanding this prediction, the metal was run in, and I awaited with much impatience the result. The first element attacked by the atmospheric oxygen is the silicon, generally present in pig iron to the extent of 1 to 2 percent; it is the white metallic substance of which flint is the acid silicate. Its combustion furnishes a great deal of heat; but it is very undemonstrative, a few sparks and hot gases only indicating the fact that something is going quietly on. But after an interval of ten or twelve minutes, when the carbon contained in grey pig iron to the extent of about 3 percent, is seized on by the oxygen, a voluminous white flame is produced, which rushes out of the openings provided for its escape from the upper chamber, and brilliantly illuminates the whole space around. This chamber proved a perfect cure for the rush of slags and metal from the upper central opening of the first converter. I watched with some anxiety for the expected cessation of the flame as the carbon gradually burnt out. It took place almost suddenly, and thus indicated the entire decarburization of the metal. The furnace was then tapped, when out rushed a limpid stream of incandescent malleable iron, almost too brilliant for the eye to rest upon; it was allowed to flow vertically into the parallel undivided ingot mold. Then came the question, would the ingot shrink enough, and the cold iron mold expand enough, to allow the ingot to be pushed out? An interval of eight or ten minutes was allowed, and then, on the application of hydraulic force to the ram, the ingot rose entirely out of the mold, and stood there ready for removal.

This is all very simple now that it has been accomplished, and many of my readers may, from their intimate knowledge of this subject, have felt impatient at its mere recital. But it is, nevertheless, impossible for me to convey to them any adequate idea of what were my feelings when I saw this incandescent mass rise slowly from the mold: the first large prism of cast malleable iron that the eye of man had ever rested on. This was no mere laboratory experiment. In one compact mass we had as much metal as could be produced by two puddlers and their two assistants, working arduously for hours with an expenditure of much fuel. We had obtained a pure, homogeneous 10-in. ingot as the result of thirty minutes' blowing, wholly unaccompanied by skilled labor or the employment of fuel ; while the outcome of the puddlers' labor would have been ten or a dozen impure, shapeless puddle-balls, saturated with scoria and other impurities, and withal so feebly coherent, as to be utterly incapable of being rendered, by any known means, as cohesive as the metal that had risen from the mold. No wonder, then, that I gazed with delight on the first-born of the many thousands of the square ingots that now come into existence every day. Indeed, at the date I am writing (1897), the world's present production of Bessemer steel, if cast into ingots 10 in. square and 30 in. in length, weighing 7 cwt. each, would make over 90,000 such ingots in every working day of the year.

I had now incontrovertible evidence of the all-important fact that molten pig iron could, without the employment of any combustible matter, except that which it contained, be raised in the space of half an hour to a temperature previously unknown in the manufacturing arts, while it was simultaneously deprived of its carbon and silicon, wholly without skilled manipulation. What all this meant, what a perfect revolution it threatened in every iron-making district in the world, was fully grasped by the mind as I gazed motionless on that glowing ingot, the mere contemplation of which almost overwhelmed me for the time, notwithstanding that I had for weeks looked forward to that moment with a full knowledge that it meant an immense success, or a crushing failure of all my hopes and aspirations. I soon, however, felt a strong desire to test the quality of the metal, but I had no appliances to hammer or roll such a formidable mass; indeed, we had no means at hand even to move it. But I saw that there was one proof possible to which I could subject the ingot where it stood, and calling for an ordinary carpenter's axe, I dealt it three severe blows on the sharp angle of the prism. The cutting edge of the axe penetrated far into the soft metal, bulging the piece forward but not separating it, as shown in the sketch [Fig. 48]. Had it been cast iron those angle-pieces would have been scattered all over the place in red-hot fragments, but their standing firm and undetachable assured me that the metal was malleable.

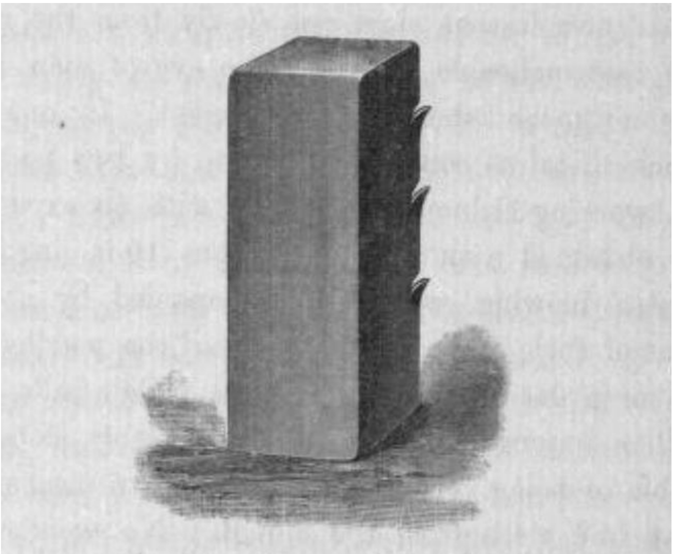


Fig. 48. Malleable Iron Ingot

Notwithstanding the strong views I entertained of the value of my invention, I desired to obtain the unbiassed opinion of some eminent engineer, who might possibly take a very different view from my own. I did not wish to live in a fool's paradise, and was most anxious to know how my ideas would be received by others. I knew Mr. George Rennie very well by reputation, and I invited him to a private view of the process, as carried on in the upright converter. He kindly consented to give me his opinion, came to Baxter House and saw the process, with the result that he took a very deep interest in it. While discussing the subject, after the blow, he said: "This is such an important invention that you ought not to keep the secret another day." "Well," I said, "it is not yet quite a commercial success, and I think I had better perfect it before allowing it to be seen." " Oh," he said, " all the little details requisite will come naturally to the ironmaster; your great principle is an unquestioned success; no fuel, no manipulation, no puddle-balls, no piling and welding; huge masses of any shape made in a few minutes." This truly great engineer was fairly taken by surprise, and his enthusiasm was as great and as genuine as it could have been had he himself been the inventor. All at once he said: "The British Association meets next week at Cheltenham, and I advise you strongly to read a paper on that occasion. I am President this year of the Mechanical Section. I wish I had known of this invention earlier. All our papers are now arranged for the meeting, and yours would be at the bottom of the long list, and it might simply be taken as read and would not be heard at all. But so important is this new process to all engineers that, if you will write a paper, I will take upon myself the responsibility of putting it first on the list." I could not withstand so handsome an offer from so distinguished a source. I told him that I much doubted my ability to write a paper in any way worthy of being read before the British Association, as I had never written or read a paper before any learned society. "Do not fear that," he said. "If you will only put on paper just such a clear and simple account of your process as you have given verbally to me, you will have nothing to fear." Soon after this he took his departure, with many words of encouragement, and I was left face to face with a task that I had not bargained for. I, however, at once set to work, and, having completed my paper in a few days, I left London on Tuesday, the 12th August, 1856, for Cheltenham.

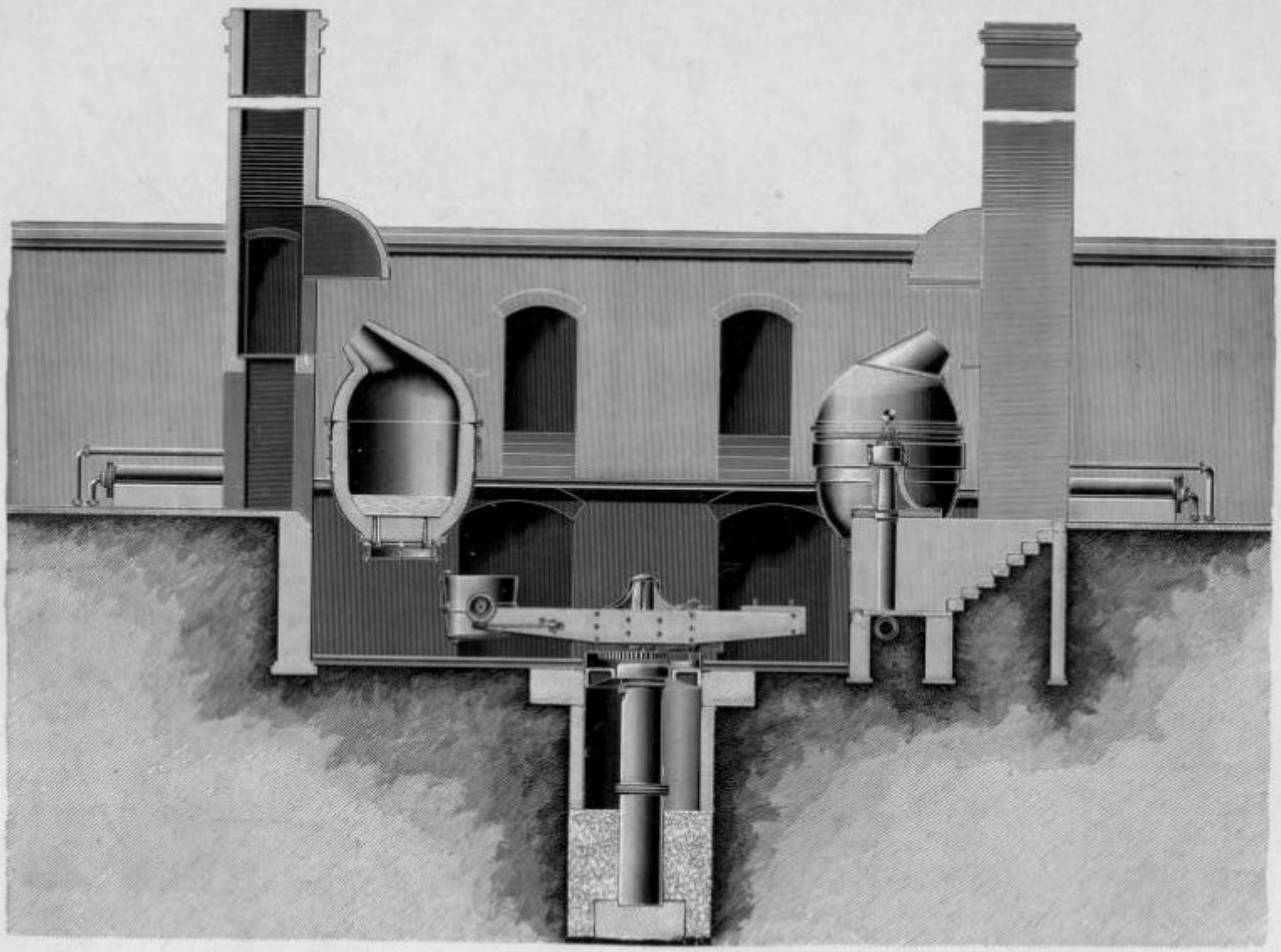


Fig. 45. Bessemer Plant at Sheffield: Converters, Ladle and Crane, and Casting Pit

SOURCE: Bessemer, Henry. "Sir Henry Bessemer, F.R.S.: An Autobiography; with a Concluding Chapter: Bessemer, Henry, Sir, 1813-1898: Free Download, Borrow, and Streaming." Internet Archive. January 01, 1970. Accessed July 14, 2018. https://archive.org/details/sirhenrybessemer00bessuoft.

Document 3D

If we go back to the year 1861, just one-third of a century, we shall find Sheffield by far the largest producer of steel in the world, the greater portion of her annual make of 51,000 tons, realizing from £50 to £60 per ton.

For this purpose the costly bar-iron of Sweden was chiefly employed as the raw material, costing from £15 to £20 per ton; the conversion of this expensive iron into crude steel occupied about ten days – that is, about two days and nights for the gradual heating of the furnace, in which the cold iron bars had been carefully packed in large stone boxes with a layer of charcoal powder between each bar, in these boxes the metal was retained for six days at a white heat, two days more being required to cool down the furnace and get out the converted bars. The steel so produced was broken into small pieces and melted in crucibles holding not more than 40 or 50 lb. each, and consuming from 2 to 3 tons of expensive oven coke for each ton of steel so melted. This steel was excellently adapted for the manufacture of knives, and for all other cutting instruments, but its hard and brittle character, as well as its excessively high price, absolutely precluded its use for the thousands of purposes to which steel is now universally applied.

It was under such conditions of the steel trade that, thirty-three years ago, I endeavored to introduce an entirely novel system of manufacture – so novel, in fact, and so antagonistic to the preconceived notions of practical men, that I was met on all sides with the most stolid incredulity and distrust. Perhaps I ought to make some allowance for this feeling, for I proposed to use as my raw material crude pig-iron costing £3 per ton, instead of the highly purified Swedish bar-iron then used, costing from £15 to £20 per ton. I proposed also to employ no fuel whatever in the converting process, which, in my case, occupied only twenty Jive to thirty minutes, instead of the ten days and nights required by the process then in use ; and I further proposed to make from 5 to tons of steel at a single operation, instead of the small separate batches of 40 or 50 lbs., in which all the Sheffield cast steel was at that time made. What, however, appeared still more incredible was the fact that I proposed to make steel bars at £5 or £6 per ton, instead of £50 or £60 – the then ruling prices of the trade. One and all of these propositions have long since become well-established commercial facts, and Bessemer cast-steel is now produced without resorting to any one of the expensive and laborious processes practiced in making Swedish bar-iron, while the old Sheffield process of converting wrought-iron bars into crude or blister-steel, by ten days' exposure, at a very high temperature, to the action of carbon, is rendered unnecessary. The slow and expensive process of melting 40 or 50 lbs. of steel in separate crucibles is also dispensed with; and in lieu of all these combined processes, from 5 to 10 tons of crude or cast-iron, worth only £S per ton, is converted into Bessemer cast-steel in thirty minutes, wholly without skilled manipulation, or the employment of fuel; and while still retaining its initial heat, can be at once rolled into railway bars or other required forms.

So great was the departure of my invention from all the preconceived notions and practice of the trade, that no steel manufacturer could be induced to adopt it, in fact the whole steel and iron trade of the kingdom had declared it to be the mere dream of a wild enthusiast ; and it was only by building a steelworks of my own in the town of Sheffield, and underselling other manufacturers in the open market, that I was able at last to overcome prejudice and the utter disbelief in the practicability of my invention. But as soon as my works were completed, and I was enabled to throw my cheap steel upon the market, there came a complete panic in the trade, followed by the adoption of my invention at two of the largest works in Sheffield. As an example of the irresistible competition thus established, I may refer to the manufacture of steel railway-wheel tires, which were at that time selling at £60 per ton. These tires we put upon the market at £50, but the extent to which even that price was capable of reduction will be readily understood from the fact that tires made at the present date, by the same process, and by the identical machinery then actually employed, are now sold at £8 per ton with a profit. No sooner were these facts rendered indisputable by the steady commercial working of my process, then it began rapidly to spread throughout England, and thence to every State in Europe. The advantages which my system offered soon attracted the attention of our energetic brethren in the United States, where it advanced by leaps and bounds, and where it has since culminated, in the year 1892, in the production of no less than 4,160,072 tons, or about eighty times the whole production of Sheffield in 1851.

The visit of the Iron and Steel Institute to America in 1890 was quite a revelation. The development of the iron and steel trade of that country, and the enormous extension of their railroad system, has produced economic changes of vast importance both to them and to us, and demands the serious consideration of all thinking men.

We have it on the undoubted authority of Mr. Abram Hewitt that the annual production of steel by the acid and basic treatment of pig-iron in the Bessemer converter in both Europe and America amounted in 1892 to no less than 10,500,000 tons, about two-fifths only of which was made into rails. Now, taking the average price of rails in 1891 and 1892 in England at £4 10*s*. per ton, and in the United States and on the Continent of Europe at £5 10*s*., and adding to this the much higher prices obtained for tires, axles, cranks, sheets, wire-rods, boiler-plates, forgings, castings, &c., we may fairly assume that the average selling price of the whole of this steel would be £8 per ton, taking one article with another, hence yielding a net amount of 84 millions sterling.

It is a curious fact that high numbers like these do not adequately impress themselves on the minds of many people of undoubted intelligence, and it is not until such figures are broken up as it were, and presented pictorially to the mind's eye, that they are fully understood and appreciated. Thus, if, instead of looking at the eight figures which represent the number of tons, we could have that quantity of steel bodily before us, we should form a very different estimate of its importance. Let us use the mind's eye to assist us, and imagine standing erect before us a plain round column or tower of solid steel 20 feet in diameter and 100 feet high; this, no doubt, would impress us as a very large and heavy mass, and but few persons would be prepared at first to accept the simple fact that the production of Bessemer steel in 1892 would make 1,671 such columns and leave a remainder of 5,535 tons. Yet such is the fact. These tall columns would form a goodly row, and, if placed side by side in a straight line, and in contact with each other, would extend to a distance of 6 miles and 580 yards; indeed there is on an average 5 ½ such columns produced on every working day in the year, bringing up each day's production of steel to 33,546 tons, as compared with Sheffield's former production of 51,000 tons annually.

We may put this in another way, and imagine a plain cylindrical solid column of 100 feet in diameter, a good idea of which may be formed by a glance at some of the very large gasometers in the Metropolis; then further imagine this gasometer, not as a thin iron shell, but as a ponderous solid mass rising before you to an altitude of 6,684 feet 6 inches, or nearly one mile and a third in height. Such a huge solid mass would be exactly equal to one year's make of Bessemer steel. But even in this form we must draw powerfully on the imagination; for but few persons can in their mind's eye fully realize a huge solid mass of such heavy matter rising to more than sixteen and a-half times the height of the cross of St. Paul's.

A graphic representation of such a column of steel, standing between St. Paul's Cathedral and the Monument erected to commemorate the Great Fire of London, is shown accurately to scale (see Fig. 107), and will aid the mind in more fully realizing the magnitude of the ponderous masses annually produced, every pound of which, during the brief period of its conversion into steel, has been raised to such an excessively high temperature as to become as brilliantly incandescent as the poles of the electric arc lamp.

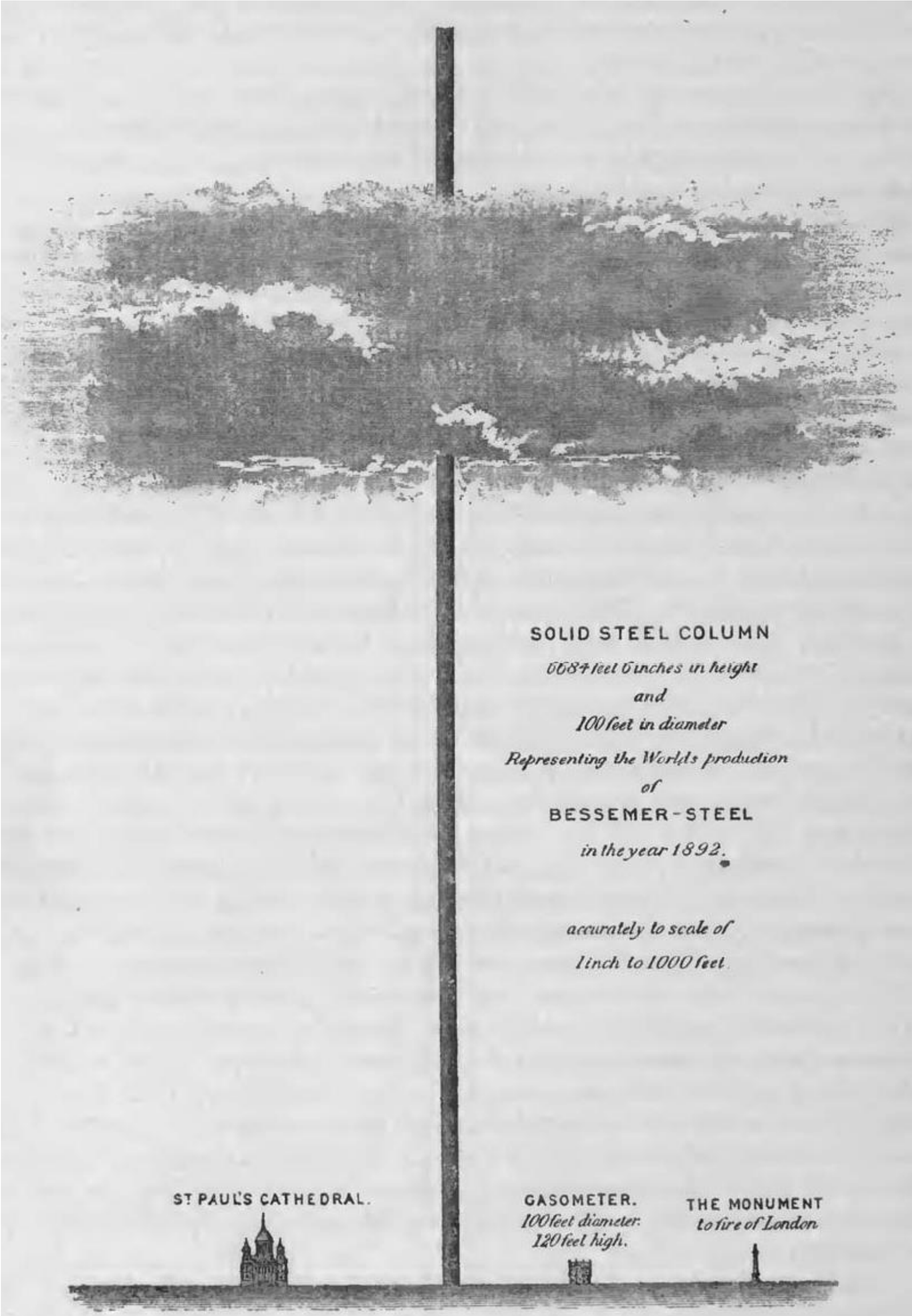


FIG. 107.

It is this new material, so much stronger and tougher than common iron, that now builds our ships of war and our mercantile marine. Steel forms their boilers, their propeller-shafts, their hulls, their masts and spars, their standing rigging, their cable chains and anchors, and also their guns and armor-plating.

This new material has covered with a network of steel rails the surface of every country in Europe, and in America alone there are no less than 175,000 miles of Bessemer steel rails, binding together its widely-scattered cities, and bringing them within easy commercial contact with each other. Over these long stretches of smooth steel road there ceaselessly run hundreds of thousands of steel wheel-tires, impelled by hundreds of locomotive engines, which owe their power and endurance to the same ubiquitous material, the great strength and elasticity of which, as compared with common iron, renders it so especially suitable for the construction of our bridges and viaducts, our steam boilers, and our machinery of every description, while its great resistance to wear and abrasion gives it a dui-ability vastly superior to iron. As an example, I may state that every steel rail now in use will bear at least six times the amount of traffic to pass over it that would suffice to wear out an iron rail. This question of durability is one of vast importance, for it has enabled companies to construct lines in localities where the rapid wearing out of iron rails would not profitably permit of their construction. The increased durability of steel will be better realized when we consider that the 175,000 miles of steel railroads now existing in America would have had to be broken up and laid with new rails six times (if the rails had been made of iron) during the period that the steel rails will last in a safe and workable condition….

We might think of many other object lessons that would be likely to convey to the mind's eye a vivid and realistic picture of the enormous bulk of matter represented by 10,500,000 tons of steel. Let us select one other illustration. Imagine a straight wall 100 miles in length, 5 feet in thickness, and 20 feet in height. Such a wall would stand on 60 ½ acres of land. But suppose that this wall, like a gigantic armor-plate, was formed into a circle, and used to surround London; the enclosure so made would extend to Watford on the north side, to Croydon on the south, to Woolwich on the east, and to Richmond on the west. It would, in point of fact, form a circular enclosure of 31 ¾ miles in diameter, and would embrace an area of 795 square miles. This great wall of London would just be equal to a single year's production of Bessemer steel.

SOURCE: Bessemer, Henry. "A Brief Statistical Sketch of the Bessemer Steel Industry: Past and Present." *Engineering Review*, July 20, 1894.

Document 3E

Primitive elevators were in use as early as the 3rd century BC, operated by human, animal, or water wheel power. From about the middle of the 19th century, power elevators, often steam-operated, were used for conveying materials in factories, mines, and warehouses.

In 1853, American inventor Elisha Otis demonstrated a freight elevator equipped with a safety device to prevent falling in case a supporting cable should break. This increased public confidence in such devices. Otis established a company for manufacturing elevators and patented (1861) a steam elevator. In 1846, Sir William Armstrong introduced the hydraulic crane, and in the early 1870s, hydraulic machines began to replace the steam-powered elevator. The hydraulic elevator is supported by a heavy piston, moving in a cylinder, and operated by the water (or oil) pressure produced by pumps.

Electric elevators came into to use toward the end of the 19th century. The first one was built by the German inventor Werner von Siemens in 1880.

In a typical elevator, the car is raised and lowered by six to eight motor-driven wire ropes that are attached to the top of the car at one end, travel around a pair of sheaves, and are again attached to a counterweight at the other end.

The counterweight adds accelerating force when the elevator car is ascending and provides a retarding effort when the car is descending so that less motor horsepower is required. The counterweight is a collection of metal weights that is equal to the weight of the car containing about 45% of its rated load. A set of chains are looped from the bottom of the counterweight to the underside of the car to help maintain balance by offsetting the weight of the suspension ropes.

Guide rails that run the length of the shaft keep the car and counterweight from swaying or twisting during their travel. Rollers are attached to the car and the counterweight to provide smooth travel along the guide rails.

The traction to raise and lower the car comes from the friction of the wire ropes against the grooved sheaves. The main sheave is driven by an electric motor.

Most elevators use a direct current motor because its speed can be precisely controlled to allow smooth acceleration and deceleration. Motor-generator (M-G) sets typically provide to dc power for the drive motor. Newer systems use a static drive control. The elevator controls vary the motor's speed based on a set of feedback signals that indicate the car's position in the shaftway. As the car approaches its destination, a switch near the landing signals the controls to stop the car at floor level. Additional shaftway limit switches are installed to monitor overtravel conditions.

Elisha Otis invented the "Improvement in Hoisting Apparatus." Elisha Otis didn't actually invent the elevator, he invented the brake used in modern elevators. His brakes made skyscrapers a practical reality.

SOURCE: Bellis, Mary. "The History of the Elevator - Elisha Otis." The Inventors. 2006. Accessed July 15, 2018. http://theinventors.org/library/inventors/blelevator.htm.

Document 3F

Ask a vertical-transportation-industry professional to recall an episode of an elevator in free fall—the cab plummeting in the shaftway, frayed rope ends trailing in the dark—and he will say that he can think of only one. That would be the Empire State Building incident of 1945, in which a B-25 bomber pilot made a wrong turn in the fog and crashed into the seventy-ninth floor, snapping the hoist and safety cables of two elevators. Both of them plunged to the bottom of the shaft. One of them fell from the seventy-fifth floor with a woman aboard—an elevator operator. (The operator of the other one had stepped out for a cigarette.) By the time the car crashed into the buffer in the pit (a hydraulic truncheon designed to be a cushion of last resort), a thousand feet of cable had piled up beneath it, serving as a kind of spring. A pillow of air pressure, as the speeding car compressed the air in the shaft, may have helped ease the impact as well. Still, the landing was not soft. The car's walls buckled, and steel debris tore up through the floor. It was the woman's good fortune to be cowering in a corner when the car hit. She was severely injured but alive.

Traction elevators—the ones hanging from ropes, as opposed to dumbwaiters, or mining elevators, or those lifted by hydraulic pumps—are typically borne aloft by six or eight hoist cables, each of which, according to the national elevator-safety code (and the code determines all), is capable on its own of supporting the full load of the elevator plus twenty-five per cent more weight. Another line, the governor cable, is connected to a device that detects if the elevator car is descending at a rate twenty-five per cent faster than its maximum designed speed. If that happens, the device trips the safeties, bronze shoes that run along vertical rails in the shaft. These brakes are designed to stop the car quickly, but not so abruptly as to cause injury. They work. This is why free falling, at least, is so rare.

Still, elevator lore has its share of horrors: strandings, manglings, fires, drownings, decapitations. An estimated two hundred people were killed in elevators at the World Trade Center on September 11, 2001—some probably in free-fall plunges, but many by fire, smoke, or entrapment and subsequent structural collapse. The elevator industry likes to insist that, short of airplane rammings, most accidents are the result of human error, of passengers or workers doing things they should not….

Nonetheless, elevators are extraordinarily safe—far safer than cars, to say nothing of other forms of vertical transport. Escalators are scary. Statistics are elusive ("Nobody collects them," Edward Donoghue, the managing director of the trade organization National Elevator Industry, said), but the claim, routinely advanced by elevator professionals, that elevators are ten times as safe as escalators seems to arise from fifteen-year-old numbers showing that, while there are roughly twenty times as many elevators as escalators, there are only a third more elevator accidents. An average of twenty-six people die in (or on) elevators in the United States every year, but most of these are people being paid to work on them. That may still seem like a lot, until you consider that that many die in automobiles every five hours. In New York City, home to fifty-eight thousand elevators, there are eleven billion elevator trips a year—thirty million every day—and yet hardly more than two dozen passengers get banged up enough to seek medical attention. The Otis Elevator Company, the world's oldest and biggest elevator manufacturer, claims that its products carry the equivalent of the world's population every five days. As the world urbanizes—every year, in developing countries, sixty million people move into cities—the numbers will go up, and up and down.

Two things make tall buildings possible: the steel frame and the safety elevator. The elevator, underrated and overlooked, is to the city what paper is to reading and gunpowder is to war. Without the elevator, there would be no verticality, no density, and, without these, none of the urban advantages of energy efficiency, economic productivity, and cultural ferment. The population of the earth would ooze out over its surface, like an oil slick, and we would spend even more time stuck in traffic or on trains, traversing a vast carapace of concrete. And the elevator is energy-efficient—the counterweight does a great deal of the work, and the new systems these days regenerate electricity. The elevator is a hybrid, by design.

While anthems have been written to jet travel, locomotives, and the lure of the open road, the poetry of vertical transportation is scant. What is there to say, besides that it goes up and down? In "The Intuitionist," Colson Whitehead's novel about elevator inspectors, the conveyance itself is more conceit than thing; the plot concerns, among other things, the quest for a "black box," a perfect elevator, but the nature of its perfection remains mysterious. Onscreen, there has been "The Shaft" ("Your next stop . . . is hell"), a movie about a deadly malfunctioning elevator system in a Manhattan tower, which had the misfortune of coming out the Friday before September 11th, and a scattering of inaccurate set pieces in action movies, such as "Speed." (There are no ladders or lights in most shafts.) Movies and television programs, such as "Boston Legal" and "Grey's Anatomy," often rely on the elevator to bring characters together, as a kind of artificial enforcement of proximity and conversation. The brevity of the ride suits the need for a stretch of witty or portentous dialogue, for stolen kisses and furtive arguments. For some people, the elevator ride is a social life….

Until recently, one of New York City's most notoriously dysfunctional elevator banks could be found at the Marriott Marquis hotel, a forty-nine-story convention mill in Times Square, built in the early eighties, where glass elevators are arrayed like petals around a stalk of concrete, in the center of a vast atrium. For years, visitors complained of waits of as much as twenty minutes.

One morning not long ago, I met James Fortune, the man who designed that elevator system, in the lobby of the Marriott. Fortune, an affable industrial engineer originally from Pasadena, can reasonably disavow responsibility for the hotel's elevator failings; a decision to put the lobby on the eighth floor essentially doubled the amount of work the elevators had to do to get guests to their rooms. ("The building's underelevatored," he told me, with a grimace. "We did the best we could.") Fortune is probably the world's busiest and best-known elevator consultant, especially in the category of super-tall towers—buildings of more than a hundred stories—which are proliferating around the world, owing in large part to elevator solutions provided by men like Fortune. Elevator consultants come in various guises. Some make the bulk of their living by testifying in court in accident lawsuits. Others collaborate with architects and developers to handle the human traffic in big buildings. Fortune is one of those….

Fortune has done the elevators, as they say, in five of the world's ten tallest buildings. While at Lerch Bates, he did the tallest building in the world, the Taipei 101 Tower, which has the fastest elevators in the world—rising at more than fifty-five feet per second, or about thirty-five miles an hour. The cars are pressurized, to prevent ear damage. He also did Burj Dubai, which, when it is completed, next year, will be the new tallest building, at least until it is supplanted by another one he is working on in the region. Burj Dubai will have forty-six elevators, including two double-deckers that will go straight to the top. ("I love double-decks," Fortune said.) Adrian Smith, the building's architect, has grand designs for towers reaching hundreds of stories—vertical cities—which would require a sophistication of conveyance not yet available. Two weeks ago, a Saudi prince announced a plan for a mile-high tower in a new city being built near Jidda—more than twice as tall as Burj Dubai. Fortune is bidding on that one, too. Frank Lloyd Wright designed a mile-high, five-hundred-and-twenty-eight-story tower, called the Mile-High Illinois, in

1956, a kind of architectural manifesto of density. Wright allowed for seventy-six elevators—atomic-powered quintuple-deckers, rising at sixty miles an hour. "I ran the studies once," Fortune said. "He wasn't even close. He should've had two hundred and fifteen to two hundred and twenty-five elevators."…

In elevatoring, as in life, the essential variables are time and space. A well-elevatored building gets you up and down quickly, without giving up too much square footage to elevator banks. Especially with super-tall towers, the amount of core space that one must devote to elevators, in order to convey so many people so high, can make a building architecturally or economically infeasible. This limitation served to stunt the height of skyscrapers until, in 1973, the designers of the World Trade Center introduced the idea of sky lobbies. A sky lobby is like a transfer station: an express takes you there, and then you switch to a local. (As it happens, Fortune was working on a project to upgrade the Trade Center elevators when the towers were destroyed.)

There are two basic elevatoring metrics. One is handling capacity: your aim is to carry a certain percentage of the building's population in five minutes. Thirteen per cent is a good target. The other is the interval, or frequency of service: the average round-trip time of one elevator, divided by the number of elevators. In an American office building, you want the interval to be below thirty seconds, and the average waiting time to be about sixty per cent of that. Any longer, and people get upset. In a residential building or a hotel, the tolerance goes up, but only by ten or twenty seconds. In the nineteen-sixties, many builders cheated a little—accepting, say, a thirty-four-second interval, and 11.5 per cent handling capacity—and came to regret it. Generally, England is over-elevatored; India is under-elevatored.

Fortune carries a "probable stop" table, which applies probability to the vexation that boils up when each passenger presses a button for a different floor. If there are ten people in an elevator that serves ten floors, it will likely make 6.5 stops. Ten people, thirty floors: 9.5 stops. (The table does not account for the exasperating phantom stop, when no one gets on or off.) Other factors are door open and close time, loading and unloading time, acceleration rate, and deceleration rate, which must be swift but gentle. You hear that interfloor traffic kills—something to mutter, perhaps, when a co-worker boards the elevator to travel one flight, especially if that co-worker is planning, at day's end, to spend half an hour on a StairMaster. It's also disastrous to have a cafeteria on anything but the ground floor, or one floor above or below it, accessible via escalator….

…Destination dispatch assigns passengers to an elevator according to which floors they're going to, in an attempt to send each car to as few floors as possible. You enter your floor number at a central control panel in the lobby and are told which elevator to take.

With destination dispatch, the wait in the lobby may be longer, but the trip is shorter. And the waiting may not grate as much, because you know which car is yours. In Japan, the light over your prospective elevator lights up ("arrival immediate prediction lantern," in the vulgate of vertical transportation), even if the elevator isn't there yet, to account for what the Japanese call "psychological waiting time." It's like a nod of acknowledgment from a busy bartender.

Smart elevators are strange elevators, because there is no control panel in the car; the elevator knows where you are going. People tend to find it unnerving to ride in an elevator with no buttons; they feel as if they had been kidnapped by a Bond villain. Helplessness may exacerbate claustrophobia. In the old system—board elevator, press button—you have an illusion of control; elevator manufacturers have sought to trick the passengers into thinking they're driving the conveyance. In most elevators, at least in any built or installed since the early nineties, the door-close button doesn't work. It is there mainly to make you think it works….

Destination dispatch, strictly speaking, was introduced eighteen years ago, by Schindler, the Swiss conglomerate, but a version of it was developed in the thirties, by the A. B. See Elevator Company, founded by the noted anti-feminist A. B. See ("If the world had had to depend on the inventive and constructive ability of women, we should still be sleeping on the plains"). Without the microprocessor, however, it was hard to implement. Schindler's version, the Miconic 10, was developed by an engineer named Joris Schroeder, who has written dense essays about his "passenger-second minimizing cost-of-service algorithm." Schindler claims that its system is up to thirty per cent more efficient than standard elevators. The other big manufacturers have come out with similar systems and make similar claims. In each, every bank of elevators has its own group-dispatch logic—which elevator picks up whom, and so on. "They have to talk to each other," Fortune said. We have to trust that they are reasonable.

The first American building to use smart elevators, the Ameritech building, in Indianapolis, hired mimes to help people navigate the system. They are still rare enough so that the Marriott has an attendant on hand to assist bewildered guests. "It's tricky putting this system into a building where people are always unfamiliar with it," Fortune said. "By the time they know it, they leave."

Fortune suggested that we go see 7 World Trade Center, a two-year-old building, of unspectacular height (fifty-two stories, seven hundred and fifty feet), because, he said, "it is the most advanced system going." The elevators were Otis—Larry Silverstein, the building's developer, is a longtime Otis man—and their destination-dispatch system is integrated with the security system; it reads your I.D. card at a turnstile and assigns you to an elevator. "The next phase of this is face-recognition biometrics," Fortune said….

We rode up to Floor 38, on Elevator D1. Facing down the urge to press a button in a buttonless elevator felt a little like quitting smoking. Fortune explained that, newfangled as destination dispatch may seem, it is in many respects a reversion to the old ways. "This is going to sound crazy, but we're coming full circle," Fortune said. In the early days, you'd have an operator in each car and a licensed attendant, or dispatcher, in the lobby, who would tell people where to go. The operator typically was a woman and the dispatcher a man, and he tended to know the name, face, and status of each tenant. He could assign elevators to contiguous floors and tell the gals when to leave and direct the boss to an empty, momentarily private elevator. "He was the logic," Fortune said. When systems converted to automatic, in the middle of the last century, and operators and dispatchers disappeared, that central logician was lost, and lobbies descended into randomness.

Fortune and I changed elevators and went to one of the top floors, a vacant expanse with views in every direction: a forest of elevator shafts. The elevator professional sees the city with a kind of X-ray vision, revealing a hidden array of elevator genera—an Otis gearless, a Schindler, a Fujitec. For him, buildings are mere ornaments disguising the elevators that serve them. Below us was the pit where the Freedom Tower would go, but to Fortune it was ThyssenKrupp, which had recently underbid Otis for the job.

SOURCE: Paumgarten, Nick. "Up And Then Down." The New Yorker. August 01, 2017. Accessed July 16, 2018. https://www.newyorker.com/magazine/2008/04/21/up-and-then-down.

Document 4A

The skyscraper was born in the United States, but in recent years, it has grown and flourished in Asia. Countries there recognize that to be seen as a player on the global stage, it helps to have tall buildings.

Over a century ago, New York and Chicago demonstrated that the skyscraper is, fundamentally, a solution to an economic problem: how to allow for hundreds, if not thousands, of people and businesses to be at the same place at the same time. Urban clustering, especially in a high-tech world, is more important than ever. By promoting density, skyscrapers confer a competitive advantage and allow a city to become a beacon of commerce.

In April, President Xi Jinping of China announced plans for a new city, Xiongan, not far from Beijing. A kind of Chinese field of dreams, Xiongan is to be built on what is now hundreds of square miles of farmland and towns, house millions of people and be a center for technology jobs. Like the cities it's being modeled after — Shenzhen, near Hong Kong, and Shanghai, particularly its Pudong neighborhood — it may someday claim the world's tallest skyscrapers. The Ping An Finance tower in Shenzhen, completed this year, at 115 stories, is the fourth-tallest building in the world, while the Shanghai Tower, completed in 2015, at 128 stories, is the second-tallest skyscraper on the planet.

Since the 1990s, the world's tallest buildings have been built in the East. The current prize holder — the Burj Khalifa in Dubai, United Arab Emirates (828 meters, or about 2,717 feet, 2010) — will be soon be surpassed by the Jeddah Tower in Saudi Arabia (1,000 meters, or about 3,281 feet, 2020). Nine of the 10 world's tallest buildings are in Asia. In addition, the continent now has more 150-meter (about 492 feet) or taller buildings than the rest of the continents combined.

An awe-inspiring skyline is a city's announcement that it is open for business and confident in its future growth. Supertall structures stand as "place makers" in the planning process, since they create neighborhood landmarks to draw companies, residents, tourists and foreign direct investment. China is now a nation full of capitalists. Arab workers are no longer just oil drillers, but global traders and financiers.

But just as important, cities that have record-breaking buildings are not just constructing super-tall monoliths. There is a strong correlation between the number of tall buildings of all sizes and the likelihood a city will have a supertall building; heights and frequencies are strongly related. The Burj Khalifa and Shanghai Tower, for example, are the most visible signs that a city embraces skyscrapers more broadly to enhance economic growth and the quality of life of residents and companies.

Consider where these nations stand. Over the last decade, the average annual gross domestic product growth rates in India, China, Indonesia and Malaysia were, in most years, more than three times that of the United States. As part of this development, nations expand their financial and banking sectors; research shows that skyscrapers are needed for this to happen.

Furthermore, China is witnessing what is arguably the greatest internal migration in human history. In 1979, only about 19 percent of its residents lived in urban areas; today that figure is about 57 percent, and this movement shows no sign of slowing. To put this in perspective, the number of Chinese residents who have moved to cities since 1979 (600 million) is greater than the total current population of North America (580 million). By comparison, in 1900, urbanization in the United States was at 40 percent; by 1970, it was up to 74 percent, and has since inched up to 82 percent.

Given this rapid growth, governments generally have two options: They can encourage tall buildings to satisfy the urban demand, or they can restrict building heights, which then increases sprawl, congestion and the distances between people. As a result, Asian governments establish land-use rules that increase density, as well as sponsor international architecture competitions, provide subsidies or simply lend support. Across China, we see a strong correlation between the heights of cities' skyscrapers and the size of their populations and local economies.

Interestingly, the Chinese government has also indirectly created political incentives for their construction. Because of one-party rule, career promotion within the Communist Party is based on the ability to "get things done" — and building skyscrapers can serve that purpose. Recent research suggests that younger local officials build more skyscrapers and invest in more infrastructure to enhance their standing within the government.

In the United States, high-rise construction remains controversial. Though things are starting to change, at its core, the country remains dedicated to promoting single-family homes in the suburbs and sprawling car-dependent office parks. Many municipalities put up hurdles for tall building construction, allowing them only in densest parts of the central city. As a result, we see a flowering of new supertall buildings there, but they are frequently derided as "safe deposit boxes with views." Because of the negative perceptions, it has become difficult to have conversations about how they can make cities more resilient and less dependent on fossil fuels.

What is the future of the skyscraper? As long as Asian countries pursue lifestyles similar to that of the West, skyscrapers will continue to be built, as they not only help foster economic growth, but also establish a city's skyline, which then becomes part of a city's identity and character.

As technological improvements make building skyscrapers easier and faster, the race for the world's tallest building will continue as well. Since 1890, their heights have grown, on average, about 17 feet per year. Statistically speaking, this suggests that a mile-high building will be built in the middle of the 22nd century. But don't tell that to Tokyo, which wants to get there first by 2045.

SOURCE: Barr, Jason M. "Asia Dreams in Skyscrapers." The New York Times. October 11, 2017. Accessed July 16, 2018. https://www.nytimes.com/2017/10/11/opinion/china-asia-skyscrapers.html.

Document 4B

New York slowed its construction of skyscrapers after 1933, and its regulations became ever more complex. Between 1916 and 1960, the city's original zoning code was amended more than 2,500 times. In 1961, the City Planning Commission passed a new zoning resolution that significantly increased the limits on building. The resulting 420-page code replaced a simple classification of space—business, residential, unrestricted—with a dizzying number of different districts, each of which permitted only a narrow range of activities. There were 13 types of residential district, 12 types of manufacturing district, and no fewer than 41 types of commercial district.

The code also removed the system of setbacks and replaced it with a complex system based on the floor-to-area ratio, or FAR, which is the ratio of interior square footage to ground area. A maximum FAR of two, for example, meant that a developer could put a two-story building on his entire plot or a four-story building on half of the plot. In residential districts R1, R2, and R3, the maximum floor-to-area ratio was 0.5. In R9 districts, the maximum FAR was about 7.5, depending on the building height. The height restriction was eased for builders who created plazas or other public spaces at the front of the building. While the standard building created by the 1916 code was a wedding cake that started at the sidewalk, the standard building created by the 1961 code was a glass-and-steel slab with an open plaza in front.

New York's zoning codes were getting more rigorous, but so were other restrictions on development. After World War II, New York made private development more difficult by overregulating construction and rents, while building a bevy of immense public structures, such as Stuyvesant Town and Lincoln Center.

But then, during the 1950s and '60s, both public and private projects ran into growing resistance from grassroots organizers like Jane Jacobs, who were becoming adept at mounting opposition to large-scale development. In 1961, Jacobs published her masterpiece, The Death and Life of Great American Cities, which investigates and celebrates the pedestrian world of mid-20th-century New York. She argued that mixed-use zoning fostered street life, the essence of city living. But Jacobs liked protecting old buildings because of a confused piece of economic reasoning. She thought that preserving older, shorter structures would somehow keep prices affordable for budding entrepreneurs. That's not how supply and demand works. Protecting an older one-story building instead of replacing it with a 40-story building does not preserve affordability. Indeed, opposing new building is the surest way to make a popular area unaffordable. An increase in the supply of houses, or anything else, almost always drives prices down, while restricting the supply of real estate keeps prices high….

Again, the basic economics of housing prices are pretty simple—supply and demand. New York and Mumbai and London all face increasing demand for their housing, but how that demand affects prices depends on supply. Building enough homes eases the impact of rising demand and makes cities more affordable. That's the lesson of both Houston today and New York in the 1920s. In the post-war boom years between 1955 and 1964, Manhattan issued permits for an average of more than 11,000 new housing units each year. Between 1980 and '99, when the city's prices were soaring, Manhattan approved an average of 3,100 new units per year. Fewer new homes meant higher prices; between 1970 and 2000, the median price of a Manhattan housing unit increased by 284 percent in constant dollars.

The other key factor in housing economics is the cost of building a home. The cheapest way to deliver new housing is in the form of mass-produced two-story homes, which typically cost only about $84 a square foot to erect. That low cost explains why Atlanta and Dallas and Houston are able to supply so much new housing at low prices, and why so many Americans have ended up buying affordable homes in those places.

Building up is more costly, especially when elevators start getting involved. And erecting a skyscraper in New York City involves additional costs (site preparation, legal fees, a fancy architect) that can push the price even higher. But many of these are fixed costs that don't increase with the height of the building. In fact, once you've reached the seventh floor or so, building up has its own economic logic, since those fixed costs can be spread over more apartments. Just as the cost of a big factory can be covered by a sufficiently large production run, the cost of site preparation and a hotshot architect can be covered by building up. The actual marginal cost of adding an extra square foot of living space at the top of a skyscraper in New York is typically less than $400. Prices do rise substantially in ultra-tall buildings—say, over 50 stories—but for ordinary skyscrapers, it doesn't cost more than $500,000 to put up a nice 1,200-square-foot apartment. The land costs something, but in a 40-story building with one 1,200-square-foot unit per floor, each unit is using only 30 square feet of Manhattan—less than a thousandth of an acre. At those heights, the land costs become pretty small. If there were no restrictions on new construction, then prices would eventually come down to somewhere near construction costs, about $500,000 for a new apartment. That's a lot more than the $210,000 that it costs to put up a 2,500-square-foot house in Houston—but a lot less than the $1 million or more that such an apartment often costs in Manhattan….

Mumbai is a city of astonishing human energy and entrepreneurship, from the high reaches of finance and film to the jam-packed spaces of the Dharavi slum. All of this private talent deserves a public sector that performs the core tasks of city government—like providing sewers and safe water—without overreaching and overregulating. One curse of the developing world is that governments take on too much and fail at their main responsibilities. A country that cannot provide clean water for its citizens should not be in the business of regulating film dialogue.

The public failures in Mumbai are as obvious as the private successes. Western tourists can avoid the open-air defecation in Mumbai's slums, but they can't avoid the city's failed transportation network. Driving the 15 miles from the airport to the city's old downtown, with its landmark Gateway of India arch, can easily take 90 minutes. There is a train that could speed your trip, but few Westerners have the courage to brave its crowds during rush hour. In 2008, more than three people each working day were pushed out of that train to their death. Average commute times in Mumbai are roughly 50 minutes each way, which is about double the average American commute.

The most cost-effective means of opening up overcrowded city streets would be to follow Singapore and charge more for their use. If you give something away free, people will use too much of it. Mumbai's roads are just too valuable to be clogged up by ox carts at rush hour, and the easiest way to get flexible drivers off the road is to charge them for their use of public space. Congestion charges aren't just for rich cities; they are appropriate anywhere traffic comes to a standstill. After all, Singapore was not wealthy in 1975, when it started charging drivers for using downtown streets. Like Singapore, Mumbai could just require people to buy paper day licenses to drive downtown, and require them to show those licenses in their windows. Politics, however, and not technology, would make this strategy difficult.

Mumbai's traffic problems reflect not just poor transportation policy, but a deeper and more fundamental failure of urban planning. In 1991, Mumbai fixed a maximum floor-to-area ratio of 1.33 in most of the city, meaning that it restricted the height of the average building to 1.33 stories: if you have an acre of land, you can construct a two-story building on two-thirds of an acre, or a three-story building on four-ninths of an acre, provided you leave the rest of the property empty. In those years, India still had a lingering enthusiasm for regulation, and limiting building heights seemed to offer a way to limit urban growth.

But Mumbai's height restrictions meant that, in one of the most densely populated places on Earth, buildings could have an average height of only one and a third stories. People still came; Mumbai's economic energy drew them in, even when living conditions were awful. Limiting heights didn't stop urban growth, it just ensured that more and more migrants would squeeze into squalid, illegal slums rather than occupying legal apartment buildings.

Singapore doesn't prevent the construction of tall buildings, and its downtown functions well because it's tall and connected. Businesspeople work close to one another and can easily trot to a meeting. Hong Kong is even more vertical and even friendlier to pedestrians, who can walk in air-conditioned skywalks from skyscraper to skyscraper. It takes only a few minutes to get around Wall Street or Midtown Manhattan. Even vast Tokyo can be traversed largely on foot. These great cities function because their height enables a huge number of people to work, and sometimes live, on a tiny sliver of land. But Mumbai is short, so everyone sits in traffic and pays dearly for space.

A city of 20 million people occupying a tiny landmass could be housed in corridors of skyscrapers. An abundance of close and connected vertical real estate would decrease the pressure on roads, ease the connections that are the lifeblood of a 21st-century city, and reduce Mumbai's extraordinarily high cost of space. Yet instead of encouraging compact development, Mumbai is pushing people out. Only six buildings in Mumbai rise above 490 feet, and three of them were built last year, with more on the way as some of the height restrictions have been slightly eased, especially outside the traditional downtown. But the continuing power of these requirements explains why many of the new skyscrapers are surrounded by substantial green space. This traps tall buildings in splendid isolation, so that cars, rather than feet, are still needed to get around. If Mumbai wants to promote affordability and ease congestion, it should make developers use their land area to the fullest, requiring any new downtown building to have at least 40 stories. By requiring developers to create more, not less, floor space, the government would encourage more housing, less sprawl, and lower prices….

The success of our cities, the world's economic engines, increasingly depends on abstruse decisions made by zoning boards and preservation committees. It certainly makes sense to control construction in dense urban spaces, but I would replace the maze of regulations now limiting new construction with three simple rules.

First, cities should replace the lengthy and uncertain permitting processes now in place with a simple system of fees. If tall buildings create costs by blocking out light or views, then form a reasonable estimate of those costs and charge the builder appropriately. The money from those fees could then be given to the people who are suffering, such as the neighbors who lose light from a new construction project.

I don't mean to suggest that such a system would be easy to design. There is plenty of room for debate about the costs associated with buildings of different heights. People would certainly disagree about the size of the neighboring areas that should receive compensation. But reasonable rules could be developed that would then be universally applied; for instance, every new building in New York would pay some amount per square foot in compensation costs, in exchange for a speedy permit. Some share of the money could go to the city treasury, and the rest would go to people within a block of the new edifice.

A simple tax system would be far more transparent and targeted than the current regulatory maze. Today, many builders negotiate our system by hiring expensive lawyers and lobbyists and buying political influence. It would be far better for them to just write a check to the rest of us. Allowing more building doesn't have to be a windfall for developers; sensible, straightforward regulations can make new development good for the neighborhood and the city.

Second, historic preservation should be limited and well defined. Landmarking a masterpiece like the Flatiron Building or the old Penn Station is sensible. Preserving a post-war glazed-brick building is absurd. But where do you draw the line between those two extremes? My own preference is that, in a city like New York, the Landmarks Preservation Commission should have a fixed number of buildings, perhaps 5,000, that it may protect. The commission can change its chosen architectural gems, but it needs to do so slowly. It shouldn't be able to change its rules overnight to stop construction in some previously unprotected area. If the commission wants to preserve a whole district, then let it spread its 5,000-building mandate across the area. Perhaps 5,000 buildings are too few; but without some sort of limit, any regulatory agency will constantly try to increase its scope. The problem gets thornier in places like Paris, practically all of which is beloved worldwide. In such cases, the key is to find some sizable area, reasonably close to the city center, that can be used for ultra-dense development. Ideally, this space would be near enough to let its residents enjoy walking to the beautiful streets of the older city.

Finally, individual neighborhoods should have more power to protect their special character. Some blocks might want to exclude bars. Others might want to encourage them. Rather than regulate neighborhoods entirely from the top down, let individual neighborhoods enforce their own, limited rules that are adopted only with the approval of a large share of residents. In this way, ordinary citizens, rather than the planners in City Hall, would get a say over what happens around them.

Great cities are not static—they constantly change, and they take the world along with them. When New York and Chicago and Paris experienced great spurts of creativity and growth, they reshaped themselves to provide new structures that could house new talent and new ideas. Cities can't force change with new buildings—as the Rust Belt's experience clearly shows. But if change is already happening, new building can speed the process along.

Yet many of the world's old and new cities have increasingly arrayed rules that prevent construction that would accommodate higher densities. Sometimes these rules have a good justification, such as preserving truly important works of architecture. Sometimes, they are mindless NIMBYism or a misguided attempt at stopping urban growth. In all cases, restricting construction ties cities to their past and limits the possibilities for their future. If cities can't build up, then they will build out. If building in a city is frozen, then growth will happen somewhere else.

Land-use regulations may seem like urban arcana. But these rules matter because they shape our structures, and our structures shape our societies—often in unexpected ways. Consider that carbon emissions are significantly lower in big cities than in outlying suburbs, and that, as of 2007, life expectancy in New York City was 1.5 years higher than in the nation as a whole. As America struggles to regain its economic footing, we would do well to remember that dense cities are also far more productive than suburbs, and offer better-paying jobs. Globalization and new technologies seem to have only made urban proximity more valuable—young workers gain many of the skills they need in a competitive global marketplace by watching the people around them. Those tall buildings enable the human interactions that are at the heart of economic innovation, and of progress itself.

SOURCE: Glaeser, Edward. "How Skyscrapers Can Save the City." The Atlantic. February 19, 2014. Accessed July 16, 2018. https://www.theatlantic.com/magazine/archive/2011/03/how-skyscrapers-can-save-the-city/308387/.

Document 4C

For the second time in 2018, YIMBY has a new look for Five World Trade Center. The latest rendering was found by a reader on the project's fencing in the Financial District. The image shows a glassy building with a triangular motif reminiscent of the David Childs-designed 1 WTC. The depiction is roughly 70 stories in height, which could indicate yet another supertall is planned for the area.

Incredibly, the future for this potentially lucrative site seems bleak. The Port Authority is not known for its momentum, and according to an individual within the Port Authority, "there are no building plans for a Tower 5 at this point." This falls in line with a Reuters report from 2012, which stated that the organization has considered selling the site, given a fruitless search for anchor tenants.

The glassy design could prove similar to the other Silverstein-developed edifices around the memorial, but the firm gave control of 5 WTC to the Port Authority as per a 2006 redevelopment agreement.

This new rendering comes after YIMBY uncovered now-defunct plans showing a Chinese developer's concept for a mixed-use supertall at the site, back in March.

Site 5 is the only plot within the WTC complex that allows residential or hotel use. The most recent moribund proposal by Wanda Group featured a design by Kohn Pedersen Fox. Construction would have added 1.4 million square feet to lower Manhattan, including 240 hotel rooms, 200,000 square feet of retail, and 850,000 square feet for condominiums on the higher floors.

In related news, Larry Silverstein confirmed during the opening of 3 WTC that construction of 2 WTC is on hold until they can secure an anchor tenant.

SOURCE: Nelson, Andrew. "New Renderings Appear for Supertall 5 World Trade Center." New York YIMBY. June 14, 2018. Accessed July 17, 2018. https://newyorkyimby.com/2018/06/new-renderings-appear-for-supertall-5-world-trade-center.html.

Document 4D

The paychecks come on Thursday. When the walking boss calls quitting time, the ironworkers stuff their tool belts into empty bolt buckets and stash them near the columns.

They cram themselves into the freight elevator and someone is wearing cologne. They descend to the dressing shacks and change into their street clothes. Some go to the banks and cash their checks and put the money in their pockets. Others go directly to the saloon and see the bartender, who takes 5 percent.

They line up at the bar, and slowly the backaches and joint pains are dulled by cigarette smoke and beer bubbles. The white men joke about their ex-wives, their alimony checks and their bad habits. The Indian men also drink on Thursday but never on Friday.

Friday at quitting time, the Mohawks will pile into their Buicks and Fords and drive 400 miles to Canada to visit their wives and children on the Kahnawake reservation, eight miles from Montreal on the south shore of the St. Lawrence River.

There is a construction boom going on in New York City, and all over town there are the sounds of pneumatic guns, hammers tolling against steel girders and ice cubes clinking in whiskey glasses. Three skyscrapers have gone up in Times Square in the last two years, and there is enough work scheduled to last three more. Local 40, representing 1,200 city ironworkers, is at full employment. Nonlocal men like the Mohawks have boomed out -- chased the work -- and landed in town, earning $33.45 an hour plus benefits.

They are the grandsons and great-grandsons of Mohawk ironworkers who helped build the Empire State Building, the George Washington Bridge, the Triborough Bridge, the Waldorf-Astoria, the Henry Hudson Parkway, the RCA Building, the Verrazano-Narrows Bridge, the World Trade Center and any other major project in New York that involved heavy steel construction.

The Indians of past generations had a bustling neighborhood of their own in Brooklyn, supported by the construction dollars. But then came the building bust from 1985 to 1995. While the locals were kept employed with bridge repair work, there were no jobs for ironworkers like the Mohawks, whose union ties were on the Canadian side of the border. So they boomed out to places like Kentucky and Detroit where power plants were going up and bridges were needed to span water.

They went wherever there was money to be had and hell to be raised. Some went home and retired. When there was absolutely no work anywhere, some trafficked in cigarettes from the United States.

Now they are back. There are about 250 Mohawks from Kahnawake (pronounced ga-nuh-WAH-gay) working in the city. They are working on the Brooklyn courthouse, the Ernst & Young building in Times Square, the 155th Street overpass in the Bronx, Kennedy Airport -- wherever new steel is being laid. And next month, work should begin in earnest on the massive AOL Time Warner building in Columbus Circle that will be 2.1 million square feet and have double towers. It will be a monument to this generation of ironworkers, just as Rockefeller Center is to their grandfathers.

At 3:30 Friday afternoon, the Phillips cousins -- J. R., 31, and Jeffrey, 40 -- and Joe Horn walked briskly from the Ernst & Young job site to a nearby parking lot. They climbed into an old Bonneville and rolled out for Kahnawake. The trip would take seven hours, slowed by the snow and a burning Jeep that stopped traffic for two miles. Another Mohawk would be smashed by a tractor-trailer that evening, and by sunrise the news of it would pass around the 8,000-person village like the measles.

They rolled past the Canadian Pacific railroad bridge silhouetted in the moonlight. It is a double-humped cantilever bridge built in 1886 that spans the St. Lawrence Seaway and runs through part of the reservation.

It is the bridge that gave the Mohawks their start in ironwork. In exchange for running a railroad through Indian territory, the company hired the Mohawks as laborers, allowing them to tote pails but not to work on the bridge. But when the foremen were not looking, the Indians began climbing all over the span as if they had been born to it. Soon they were working the iron. It took them away from their lives as timber rafters and traveling circus performers. (The Phillips name, in fact, was purchased in 1885 from a rodeo timekeeper for $2.75 in Philadelphia. Their great-grandfather, Kanadagero, was a wild west performer. Their grandfather, James Taheratie Phillips, was an ironworker who fell two floors and crippled his knees while working in Detroit.)

They drove past the iron cross on the western edge of the reservation, erected in honor of the 35 Mohawk men who died in the 1907 Quebec Bridge collapse. Five Kahnawake family names went down with the bridge: Leaf, Lee, Blue, Bruce and Mitchell.

''It nearly wiped out the village,'' said Stuart Phillips, a white-haired elder, former ironworker and tribal historian. ''But instead of scaring the men away from the work, it attracted them to it.''

Ironwork became the stuff that Mohawk men were made of, offering a little excitement and big money. ''When the bridge collapsed, the women of the village decreed that all men may not work on the same job, eliminating the possibility that the reservation would be made up solely of widows and orphans,'' said Mr. Phillips, who is J. R.'s father. More than 1,000 men from Kahnawake are ironworkers or are drawing pensions from that work. It has become as much a part of the Mohawk tradition as the longhouse and Brooklyn.

More than 700 Indians once lived near the Local 361 union hall in Boerum Hill, a Brooklyn neighborhood. They brought their wives, their children went to public school, and they attended Roman Catholic Masses. During the summers, after a season of saving money, they piled into their cars and made the 12-hour trip back home to the reservation.

Then they were gone. Extinct it seemed. The local mail drops like the Wigwam bar closed, and the last Mohawk at 375 State Street, an apartment building where for decades there was a Mohawk name on every buzzer, moved out five years ago. The Indians just packed up and moved away.

There was the building bust. But before that, the neighborhood went bad with drugs and crime. And in 1967, the last 172 miles of [an extension of Interstate 87, also known as the Northway] to the Canadian border were completed. The men no longer needed to tear their families away from home. They began to leave them and make what was now a six-hour commute on the weekends.

Instead of brownstones, the Indians nowadays take rooms in boarding houses or cram themselves into apartments or shabby motels. They are scattered across the metropolitan region, living in places like

New Rochelle, N.Y., Hoboken, N.J., and the West Village. A group of about 70 men live in Bay Ridge, Brooklyn.

And on Friday night, as the Phillips cousins pulled into the reservation, the lamps burned bright in the living rooms of the square white homes. The man of the house had arrived and he had a fistful of American money for the wife and toys in his bag for the kids.

These men will tell the children later, maybe over breakfast, the stories from the city and then tell them that they must work hard in school. But the older boys do not pay attention. It doesn't make sense. They know where they are going. Up on the steel.

Some men went to bed when they got home; others went down to the legionnaires' hall to drink beer with some of the other ironworkers. A group of women danced in the back of the hall without men. The bar gave $26 Canadian for $20 U.S. and everyone in the place knew it was a swindle, but the men wanted to drink and catch up. They complained, like older men do, about the younger generation.

''It took a lot of years and a lot of lives for the Mohawk to develop a reputation as good as it is,'' said an ironworker known as Bunny Eyes McComber. ''The truth is the white guys, the Irish and the Norwegians, work as good and hard as the Indians. The problem with our younger guys is that they don't understand that. They walk on the job demanding respect because they're Kahnawake, which they do not deserve. This destroys the whole thing, see?''

The hall was filled with portraits of the warriors who served in the Canadian and American armed forces as the Indians are allowed to cross the border freely. The names are Phillips, McComber, Jacobs, Diabo, and at least half of them are -- or were -- ironworkers, said Jeff Phillips, himself a former paratrooper with the 82nd Airborne.

On Sunday, he watched movies with his children and then ate a traditional meal of steak and boiled bread called ka-na-ta-rok. As the evening grew long, his children cried as they do every Sunday. ''Daddy, please don't go,'' they said. And he kissed them and sent them to bed.

He looked through his father's things. His father, Michael, was a movie actor and an ironworker, and he died last year. Mr. Phillips caressed his father's old Bible, wrapped it in plastic and put it away. ''He was a very good man,'' the son said of the father.

At midnight Sunday, the village lit up with headlamps, and the rides arrived and the dogs in the village howled. Mr. Phillips kissed his wife, Wendy, goodbye, and the steelwork took her man away as it will probably take her son.

They drove all night and arrived at the job site just in time to begin the workday. They were bleary-eyed, worn-out and homesick.

SOURCE: Leduff, Charlie. "A Mohawk Trail To the Skyline; Indian Ironworkers Return, Lured by Building Boom." The New York Times. March 16, 2001. Accessed July 17, 2018. https://www.nytimes.com/2001/03/16/nyregion/a-mohawk-trail-to-the-skyline-indian-ironworkers-return-lured-by-building-boom.html.