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To See the World in a Building: A Little Big History of Tiananmen

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Abstract

This article is about Big History. Yet it is also about something that is, at least as seen from a Big History perspective, very small. It is about one single building, which is now called Tiananmen. It is tiny when compared to many of the other structures Big History deals with, and it has been around for only a fraction of the time that has passed since the Big Bang. Big History will be combined with an analysis of this specific building by linking Tiananmen to aspects of three major phases in Big History: inanimate history, the history of life, and human history. These kinds of combinations have become known as Little Big Histories. Although Little Big Histories can seem a bit odd at first – after all, what could for instance the history of our universe possibly tell us about Tiananmen and vice versa? – Little Big Histories can help us understand both Big History and the small-scale subjects they deal with in new and unexpected ways.

Keywords: *Little Big History, Tiananmen, architecture, animal building.*

Little Big Histories can enrich our understanding of small-scale subjects and also the grand narrative in two ways. One, it connects the rather small to larger processes that have shaped cosmological, biological and human history. Two, it enables us to comprehend how even the seemingly most mundane subjects have been influenced by far-reaching historical processes and in some cases have influenced those very processes. In the words of the English poet William Blake, this can help us 'see a world in a grain of sand, and heaven in wild flower' (Blake 2004 [1803]: 15). It can lead to a different kind of appreciation for the small-scale subject that is being analyzed. For instance, in many cases our appreciation for a grain of sand changes after realizing how the sand grains constituents were cooked in the centers of stars, how its minerals travelled through the Earth's mantle, over its surface and perhaps even through the guts of earthworms before being described by a human being in a poem (Zalasiewics 2010: chs 1–3 and Hansell 2007: 32). The sand grain stops being 'just' a sand grain, and becomes something that inspires awe and triggers curiosity. This is one way in which Little Big Histories can change our understanding of the particular subjects they study and of Big History in general.

A second way in which Little Big Histories can change our understanding of both Big History and the small-scale subjects they deal with is best explained with the aid of a short history of the Little Big History approach. I first developed Little Big Histories in 2007 as an assignment for students in the Big History courses I have been teaching for the past years together with my colleague Fred Spier.[1, 2] I asked students to link a subject that interested them to an aspect of each lecture in their Big History course.[3] As a consequence, students started to write about the connections between their chosen subjects (*e.g.*, beer, quantum computing, or the Mona Lisa) and the lectures (*e.g.*, the Solar System, the origin of life, or human evolution). Once they are past the initial confusion ('are you serious you want us to do that?') most students have a lot of fun. Moreover, the ability to recognize abstract Big History concepts in subjects that students cared about helped many of them to understand these concepts better. And, perhaps most importantly, because students were able to see all kinds of connections they had not realized existed, they started to see how rich and remarkable their subjects really were. As a result, they started to ask more and more questions about them. Some students even started to ask questions that few people had ever asked before. In a way this was not surprising, because students were looking at their subjects in ways few people had ever done before. This made it easy for them to discover questions that had been previously overlooked by other scientists and scholars and made it exciting to look for corresponding answers.

This is not only the case for students. Little Big Histories allow anybody to explore the uncharted territories of the sciences and the humanities with greater ease. For this reason, the Little Big History approach cannot only be used as a stimulating pedagogical tool, but also as a fruitful research method that can reveal new things about small-scale subjects and Big History, and therefore change our understanding of both.

Perhaps partly for this reason, over the past years a handful of scientists and scholars have begun to use something quite similar to the

[1] Fred has been tremendously helpful during these past years, while I was trying to figure out how to teach and research Big History in my own way. This article has also been greatly influenced by his book on Big History (Spier 2010).

[2] Although I first came up with the idea for the Little Big History approach, Fred later coined the term 'Little Big History'.

[3] A somewhat similar approach was developed around the same time by Jonathan Markley for his Californian students. At the 2010 conference, Jonathan told me he was asking his students in a history of food class to trace back one food product as far as they could in time. As a result, his students were also trying to link a subject of their choice to several major phases in Big History, albeit in a slightly different way.

Little Big History approach, often without calling their work a Little Big History. For instance, in 2002, astrophysicist Lawrence Krauss published a book called *Atom: A Single Oxygen Atom's Journey from the Big Bang to Life on Earth... and Beyond*, a title that speaks more or less for itself (Krauss 2002). More recently paleobiologist Jan Zalasiewicz published *The Planet in a Pebble: A Journey into Earth's Deep History*, a book that describes how different characteristics of a pebble have been shaped by billions of years of history (Zalasiewicz 2010). And my Big History colleague Jonathan Markley is currently working on a book on grasses as seen from the perspective of Big History, based on his 2009 article 'A Child said: "What is the grass?": Reflections on the Big History of the *Poaceae*' (Markley 2009). In this article he describes how different orders of grasses have rivaled each other for world dominance and shaped human history while doing so. These studies are wonderful eyewitness accounts that provide a fresh perspective on atoms, pebbles, and grasses and on the history of everything.

The existence of such studies indicates that in a sense, Little Big Histories are not new. Yet so far, they have not been used for in-depth studies of subjects that, unlike atoms, pebbles and even grasses, have not been around for a significant portion of Big History. They have not been used for in-depth studies of subjects like Tiananmen, which has been around for only six centuries or so (Zhu 2004: ch. 2).[4] For such a subject, the eyewitness approach that has been used in the previously mentioned publications will not work. Surely, it would be possible to write a fascinating novel by having a subject like the gate tell us what it saw, heard and felt over the past centuries, but because its experience would only cover the final fractions of Big History, its account would not really be a Little Big History. To study a subject like Tiananmen, a different approach that links the building to periods in time in which nothing like human buildings or even building behavior in general existed is necessary. Over the years, such an approach has been tested by hundreds of students, but it has not been used to write a more extensive research article yet. This article on Tiananmen is therefore a bit of an experiment, that aims at testing the limits of the Little Big History approach by tracing to roots of the gate all the way back to the beginnings of Big History – the Big Bang.

[4] When the gate in the Beijing's southern imperial city wall that is now called Tiananmen was first built six centuries ago, it was actually called Chengtianmen and looked rather different than Tiananmen as we know it today.

Fig. 1. Tiananmen, photographed in 2009. *Source:* Wikimedia Commons

Tiananmen and the History of the Cosmos, the Solar System and our Planet[5]

During the first fraction of a second after the Big Bang, the fundamental forces emerged. These forces split off from one grand unified force that had existed right after the Big Bang. Gravity went its own way first. The strong nuclear force split off a bit later. And the weak nuclear force and electromagnetism split up last (Chaisson 2005: ch. 1). Gravity and electromagnetism are particularly relevant for this story about Tiananmen. In fact, any building, including Tiananmen, can be seen as a precarious balancing act between these two forces.

Gravity makes sure that masses attract each other. The strength of attraction between masses is dependent on the amount of mass involved in the attraction. As a result, gravity works on large scales and is responsible for creating stars and planets and for keeping them together, amongst other things. Electromagnetism is much stronger than gravity. It makes sure that opposite electrical charges attract each other and that similar electrical charges repel each other. Yet despite its higher strength, electromagnetism works on much smaller scales than gravity, because electromagnetism leads to a rather homogenous distribution of charges that cancel each other out. The electromagnetic force is responsible for creating and keeping atoms, molecules, and groups of molecules together (Trefil and Hazen 2010: 282).

[5] While trying to connect Tiananmen to the history of non-living things, to the history of life and to human history, I have not focused on all the important processes that have taken place during the 13.8 billion years that have passed since our universe first emerged. Instead, I have been selective and have only discussed things that seem most important for my subject. I think this is a necessary strategy for people writing a Little Big History; after all, not all things are equally interesting for every subject.

Buildings are smaller than the scales on which gravity exerts its greatest influence, and bigger than the scales on which electromagnetism generally works. It is not possible to build without both of these forces. But if the influence of gravity becomes either too great or too small compared to the influence of electromagnetism, building becomes difficult as well.

It is probably quite obvious that both gravity and electromagnetism were required for building Tiananmen. Without gravity, the elements from which Tiananmen is built, like the silicon and oxygen on the planet, bricks, plaster, and tiles and the carbon and oxygen in wood would not have been concentrated on Earth. Instead, the predecessors of these elements would still be floating around in space, more or less by themselves, not meeting their fellow elements most of the time.[6, 7] Gravity alone is not enough to build though. Earth would have been a rather boring place had it not been shaped by electromagnetism as well. The electromagnetic force made sure that silicon and oxygen and in many cases some other elements as well combined into silicates, that these silicates formed into minerals like, for instance, feldspars and that people were able to glue these minerals together into bricks and even the plastered brick walls and vaults that characterize the base of Tiananmen (Hazen 2012: ch. 5). Likewise, it ensured that carbon and oxygen combined into carbon dioxide, it enabled life to use this carbon dioxide to synthesize organic molecules like lignin and allowed lignin to bond with other organic molecules like cellulose and hemicellulose to form the complex molecular structures that give the wooden post and beams in Tiananmen's gatehouse their strength (McDonald and Donaldson 2001: 9612–9615). Without electromagnetism, no strange clumps of matter protruding from the Earth's surface like Tiananmen's base, Tiananmen's gatehouse and a whole range of other objects would have formed and the Earth would have remained a rather featureless sphere.

It may be less obvious why the influence of gravity cannot become too great or too small when compared to the influence of electromagnetism in order to be able to build. A thought experiment may help. Imagine trying to build Tiananmen on a planet very similar to Earth, but with a higher mass, like on one of the recently discovered Gliese 667C super-Earths, that circle a nearby star some 22 light years away from us (Science Daily 2013). On such a planet, the effect of gravity would be

[6] The word 'predecessors' is used here, because without gravity, elements like carbon, oxygen and silicon would not have existed, but their predecessors, hydrogen and helium, might have.

[7] After all, on average our universe is rather empty, containing only one proton per four cubic meters (NASA 2013).

stronger, which would allow the gravitational force to break down some crucial electromagnetic bonds and to cause the collapse of large parts of Tiananmen. It would be particularly easy for gravity to overwhelm electromagnetism in places where both forces work in opposite directions. For instance, this is the case with Tiananmen's gatehouse, which consists of an elegant post and beam structure topped with a tiled roof. The higher weight of this structure on one of the Gliese super-Earths would lead to a greater curvature in its beams. This would mean that in the base of the beams, bonds between molecules would be ripped apart by the effect of gravity. If too many of these bonds would fail, the beams would crack and the roof structure would disintegrate.

A way to prevent such a collapse would be to make sure that gravity and electromagnetism work in the same direction. This is what the Chinese builders aimed for when they constructed the vaulted passageways in Tiananmen's base that provided access to the imperial city north of Tiananmen. These builders tried to make sure that the shape of their construction matched the natural distribution of forces within the construction. The result of such a match was a structure dominated by compression stress, or, in other words, a structure in which both gravitational and electromagnetic forces were trying to keep together the materials the structure was made of.[8] Tiananmen's builders partly used this strategy because the base of Tiananmen mainly consists of silicon oxygen minerals, in contrast to, for instance, the wooden gatehouse which mainly consists out of carbon oxygen compounds. Silicon is chemically quite similar to carbon but it is a lot heavier. Therefore, the effects of gravity are stronger within silicon-based structures, which make it easier for gravity to overwhelm electromagnetism if these forces work in opposite directions.

The strategy to align gravitational and electromagnetic forces within constructions in order to prevent collapse was not only used by Tiananmen's builders, but is used by many other animals that build with earth or rocky materials as well. Of course, most of these animals do not build elaborate arches, vaults or domes the way humans do. Instead, they burrow.[9] Burrowing seems to be the default strategy for building with earth or rocks and is used by many arthropods, fish,

[8] For a nice interactive explanation of how forces are distributed within stone arches, see the Nova site Physics of Stone Arches (PBS Learning Media 1996).

[9] It could be argued that animals like mud daubers or certain types of swallows and martins build something resembling domes in a human-like way (Hansell 2000: 64–67). The technique these animals use is a bit different from human dome-building though, because they rely more heavily on sufficiently strong electromagnetic bonds to keep their structure together than on gravity.

birds, and mammals (Hansell 2007). It enables these animals to 'accidentally' create vaults and domes by excavating the space below these arched roofs. Burrowing may be a better option for most animals than actually building vaults or domes because burrowing is technically easier than constructing the arched roofs themselves. The latter task can be quite complex, partly because arch-shaped structures often are not stable until a keystone or similar object is put into place. Only after that is done, the gravitational forces within the structure line up with the shape of the structure, resulting in a structure dominated by compression stress. Before a keystone or something similar is put into place, however, additional support may be required to prevent the incomplete structure from collapsing. This construction process may therefore require an ability to plan ahead that many animals do not seem to possess.[10] They may therefore have few other choices than burrowing when it comes to building with earth or rocks, even though burrowing has important drawback when compared to constructing the vaults and domes themselves. In many cases, burrowing requires the movement of more materials than building vaults or domes does, and therefore, requires more energy, simply because the interior of a vaulted or domed structure is usually more voluminous than its surrounding shell.

Following the examples set by the builders of Tiananmen's base and by burrowing animals, builders on one of the Gliese super-Earths would probably be able to build something. Yet their options would be much more limited than they are on Earth. This raises questions about the possibilities for building on planets where the effects of gravity are less strong than they are on Earth, like on our sibling planet Mars. Would the potential for building on such a planet be greater, leading to the development of buildings our own planet's inhabitants can only dream about?

Perhaps, it would, but there is one catch. When the influence of gravity becomes too small compared to the influence of electromagnetism, building options increase but building incentives may decrease. To understand why, it is necessary to first consider what building actually is. Many dictionaries mention that building involves assembling materials to form a structure, but these definitions miss an important point.[11] Building involves assembling materials to form a structure that

[10] Animals probably do not need large brains to build in general: Mike Hansell has demonstrated in various books and articles that they really do not and can often evolve all kinds of hard-wired complex building behavior. Yet the ability to build arches, vaults and domes in all likelihood does not evolve easily, because the stages leading up to an arch, vault or dome would be useless as they would easily collapse.

[11] For instance, according to the New Oxford American Dictionary app, building is 'the process or business of constructing something'. According to Merriam Webster, build-

its builders can easily leave behind. Such a definition excludes structures like body parts that organisms usually assemble by growing and not by building. One could argue that it also excludes clothing. The definition does include many kinds of webs, nests, tools, roads, dams, bridges and 'regular buildings' that are normally considered to be built by humans and other animals.

So how does this definition relate to the idea that the incentive to build is stronger when the influence of gravity is sufficiently strong? If the effects of gravity are sufficiently strong, it makes more sense to leave a structure behind. After all, even though in such situations a lot of energy is required to assemble a building, even more energy is required to carry it with you all the time. If, in contrast, the effects of gravity are not that strong, carrying a structure around becomes a more sensible option. Carrying a structure around makes it much easier to reach and use the structure when needed. This benefit may outweigh the costs of having to carry a structure around, especially when those costs are fairly limited.

When it comes to building on Red Planet, this may mean that even though hypothetical builders would have the option to build something like Tiananmen, or even a much more fantastical version of the gate, incentives to do so might be lacking. Instead of buildings like Tiananmen, builders might prefer portable structures. Organisms that rely on biological evolution to adapt to their environment would, perhaps, grow such structures instead of building them. After all, that is what many animals on Earth do. They grow furs to protect themselves from harsh climates, instead of building a structure that keeps the cold out. They grow spikes, venom producing organs, or fast legs to defend themselves, instead of building structures that protect them from their enemies. They grow powerful beaks or claws to catch prey instead of building traps. And they grow colorful feathers to impress members of their own species instead of building 'monuments'. For organisms that rely on cultural evolution to adapt to their environment, the situation might be slightly different. Because through cultural evolution, such organisms might be able to build structures faster than growing ones (given that one process happens well within a lifetime and the other over millions of years of evolution), they might actually prefer such built structures and construct the hypothetical Martian equivalent of armor and all kinds of easily transportable tools. Like those theoretical organisms of Mars that

ing is 'the art or business of assembling materials into a structure' (Merriam Webster 2013). And according to Collins English Dictionary, building means 'to make, construct, or form by joining parts or materials' (Collins Dictionaries 2013).

rely on biological evolution though, builders would probably prefer portable structures over buildings like Tiananmen.

Of course, it goes without saying that this thought experiment involving building on a Gliese super-Earth and Mars is rather speculative. Nevertheless, it helps to elucidate some fundamental concepts that have had an enormous influence on why building is the way it is on Earth. A few examples of such Earthly building behavior, like burrowing, have already been mentioned. But there is much more to explore. In order to do so, the history of life on Earth will be discussed next.

Tiananmen and the History of Life

On our own planet, the incentives to build, caused by the sufficiently strong (but not too strong) effects of gravity, are particularly critical in three specific situations.

Protection

First of all, building seems to be particularly useful in some circumstances when protection from enemies is vital. This may be the case because protective structures need to be quite heavy to function properly. For instance, structures that are too light can be easily picked up or cracked by predators and other opponents. Heavier structures are much safer. But they are also much more difficult to move around. It is therefore a big advantage if they can be left behind, for instance, when an animal needs to go on a foraging trip or needs to go out to find a mate. Heavy protective structures that are fixed to an animal's body and cannot be left behind would severely limit such endeavors. Snails and tortoises, for example, seem to be hampered in their movement by the shells and carapaces they carry around. It is, therefore, not surprising that many of these animals are so slow.[12]

This may partly explain why, if animals build something, they usually build protective structures and not much else. Only humans and certain invertebrate species, most notably spiders and certain larvae, build traps (Hansell 2007: 149–150). Hardly any animals, with the exception of humans, chimpanzees, birds like the New Caledonian crow and again certain spiders, build tools.[13] And just two animal species, hu-

[12] The fact that tortoises and snails carry around a carapace or shell may not have caused them to be slow. Instead, a reduced need to move around, slower metabolic rates and carapaces or shells may have evolved together.

[13] There are several more species that use tools, such as gorillas, certain monkeys, dolphins, and several insects. Yet these animals do not really build them; they just use sticks, rocks or other objects the way they find them and do not modify them in any way (Hansell 2007: ch. 7).

mans and bowerbirds, build ornamental structures (Hansell 2007: ch. 8). The fact that most animals do not build such things is often attributed to a general lack of cognitive capacities. Yet that argument may be too simplistic. It cannot account for the fact that many of the most complex traps and tools are built by organisms that do not seem to possess advanced cognitive capabilities. For instance, the complexity of traps built by the tiny sea-squirt *Oikopleura dioica*, that look like mucus houses containing inlet funnels and different kinds of filter nets, seems much greater than tools and traps built by early humans (*Ibid*.: 69). So, perhaps, something else is going on. Perhaps, in many cases only protective structures are sufficiently important for an animal's survival to assemble and leave behind. Many other structures that are important to animals, like traps, tools, and ornaments, can be lighter and therefore carried around all the time. If there is no need to leave such structures behind, in many cases it may be a better option to grow such structures than to build them. After all, through biological evolution animals are able to synthesize better materials for such structures than materials that are available in nature to build with, such as woody or rocky materials. Wood decays easily and must therefore be protected, while rocky materials are heavy and crumble, and therefore often require gluing them together in one way or another. Grown structures often consist of materials that are better adapted to their function. Of course, not all animals are willing to wait until biological evolution provides them with suitable structures that enable them, for example, to catch prey or impress a mate. For animals that can adapt to their environment a lot quicker with the aid of cultural evolution, building traps, tools and ornaments can be a good option. Yet there seem to be few animal species besides our own capable of this type of evolution.

Frequently staying in one place

Building is often worthwhile when animals frequently stay in one place. In such situations, it is not necessary to spend a lot of energy just to reach a building that has been left in a specific place. As a result, using the building is cheaper in terms of expended energy. This consideration may have led to the building behavior in animals that stay in one place while metamorphosing or hibernating. It also may have contributed to the development of building in species that are caring for immobile young or attending to the needs of a eusocial colony. Perhaps, it may even mean that animals that roam large areas to find sufficient food or suitable mates will be less inclined to build. After all, if, due to large territories, animals cannot return to a building frequently enough, what is the use of building in the first place?

Thinking about the way animals use their territories may have implications for ideas about the origin of human building in general, and about human tool building in particular. Evidence indicates that when our Oldowan ancestors first started to build stone tools, they left clusters of them in specific places. It has been suggested that these early humans partly did so because the places where such tools were left served as centers where food could be processed, thus preventing them to have to carry their heavy tools with them all the time (Potts 1991, 1994). This suggestion fits in quite well with the idea described above and may partly explain why our Oldowan ancestors started to build tools whereas very few other animals did so. Unlike other animals, they had come up with a way of using the landscape that maximized tool use potential. Ultimately, this may have enabled them and later members of the genus *Homo*, including ourselves, to use building in a more flexible way than any other animal does, by creating different types of traps, tools, and protective and decorative structures, positioning them in well thought of places and using them when needed without too much hassle. According to paleoanthropologist Richard Potts, such flexibility may well have been one of the reasons why our ancestors survived the rapid climate fluctuations that are characteristic of the Pleistocene, whereas many other animals, including hominin species who probably did not use tools, such as our robust *Paranthropus* cousins, went extinct (Potts 1996: 121).

This tale about human evolution is relevant for Tiananmen in three ways. First of all, obviously, building anything like Tiananmen is impossible without the varied and elaborate set of tools humans eventually developed. Secondly, if the hypothesis about early human building behavior is correct, such behavior may have contributed to types of spatial thinking that have been extremely important during the conception and construction of the gate that would later become known as Tiananmen. After all, Tiananmen is not just a gate, but part of a carefully laid out city plan in which different parts had different functions and symbolic meanings (Zhu 2004: ch. 2). Thirdly and most importantly, the fact that humans started to use their built structures in more and more varied and flexible ways could well be one of the most distinctive features that separates human building behavior from animal building. It may have given human building a unique dynamic that has helped shape Tiananmen in critical ways. This dynamic will be explained in more detail in the part of this article on Tiananmen and human history.

Once animals start to stay in one place more frequently, whether to create and use tools or to metamorphose, hibernate, care for offspring, or attend to the needs of a eusocial colony, protection often becomes more vital. Such animals may otherwise become easier prey or targets. This also works the other way round – at least when adding building to the mix. If protection is vital, building a protective structure is a good survival option. Once such a structure is in place, animals are likely to stay there more often, especially when animals start to 'store' things in their structures like young or food sources. Staying in one place can make protection more vital, and, alternately, building out of greater need for protection can make animals stay in one place more frequently. In some cases a positive feedback loop may have emerged that may have stimulated evolution (*e.g.*, insect cocoons, birds' nests, rodent burrows and beaver lodes). It may also have helped trigger specialization among members of some social species.[14] After all, it is difficult, and perhaps even impossible, to support individuals that have specialized duties beyond gathering or producing food without having a fixed and protected place where food can be stored or grown for them. Specialization, either in the form of a simple differentiation between reproducing and non-reproducing community members, or in the form of more elaborate distinctions between all kinds of workers, soldiers, and royalty, only seems to have emerged in social animals whose ancestors were in all likelihood already building defensible structures in which they stored, grew, or had direct access to ample amounts of food.[15] Examples of such animals include termites, members of the hymenoptera family like eusocial wasps, bees and ants, certain types of beetles, shrimps and mole rats, and, of course, humans living in sedentary communities. It is interesting to note that such specialization, in turn, seems to have stimulated large-scale building projects. The world's most elaborate building complexes, such as termite mounds that are about twice as high to a termite as the tallest building in the world is to us. Elaborate imperial cities, like the one Tiananmen used to be a part of, are all built by animals that created specialized roles for some members of their communities.[16]

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[14] Specialization based on gender differences is probably the result of very different processes.

[15] For instance: termites seem to descent from type of sub-social roach that lived in and off nests in trees (Korb and Heinze 2008: 162), eusocial hymenoptera in all likelihood descent from groups of primitive hymenoptera that collectively build defensible and valuable nests (Nowak, Tarnita, and Wilson 2010: 1062), *Austroplatypus incompertus* is a member of a family of social beetles that live in nests in trees in which they 'grow' fungi they eat (Choe and Crespi 1997: 181–215), the shrimp *Synalpheus regalis* lives in group nests in sponges it eats (Duffy 1996: 513) and certain mole rats live in group burrows in which they store tubers (Jarvis and Bennett 1993: 253).

[16] This estimate is based on data from Hansell (2007: 93).

Conspicuous consumption

At least in human state societies, specialization has led to a third situation in which building seems to be particularly useful. Building seems to be a good idea when the costs of building, imposed by gravity amongst other things, can be used to affirm certain privileged positions within a society. People in such privileged positions are often able to command large energy flows and in order to show off this ability to the people around them, they sometimes consume parts of these energy flows conspicuously (Veblen 2008). There are several ways to do so, but building can be a very good option, partly because it requires so much effort to lift and move large amounts of often heavy materials. For instance, Ming emperors made sure that the pillars of the most important buildings in Beijing's imperial city were made out of gigantic trunks of precious Sichuanese hardwood, which had to be transported over thousands of kilometers to Beijing (Barmé 2008: 32, 33 and 159). Likewise, the floors of the most important halls and gates in the imperial city were made out of valuable 'gold bricks' that were mainly made in Suzhou, a city located more than 1000 kilometers to the south of Beijing (Lou and Li 2002: 22). Of course there are other reasons to consume conspicuously with the aid of building, besides the wish to demonstrate one's ability to counter gravity. Buildings, especially tall ones, are very visible component of the urban landscape and partly for this reason they are good places to showcase valuable resources. The citizens of Beijing, for example, used to be able to see the gilded sides of the roof of Tiananmen from many locations in the city.

When talking about 'gold bricks' and gilding, it may be interesting to take a few steps back, back to the history of the cosmos. Most precious elements like gold formed a long time ago, in dying stars much heavier than our own Sun. When such stars ran out of fuel, they started to collapse under their own weight. During these collapses, large amounts of energy were created, eventually causing the stars to explode. Only during the brief cosmic fireworks that resulted from such processes was it possible to form elements heavier than iron, like copper, silver and gold (Chaisson 2005: ch. 3). Since the circumstances under which these elements formed were so exceptional, elements heavier than iron are very rare. Things that are very rare are often difficult to acquire, expensive and therefore a good indicator of one's position within a society. It has been suggested by many, including Charles Darwin, that for this reason, humans have evolved an aesthetic appreciation for rare things, including rare elements (Miller 2001: ch. 8). So in a way, dying stars may be responsible for Tiananmen builders' preference for bricks that shine like gold and roof decorations made of the precious yellow metal. They may even have caused the Chinese to start to see golden-yellow as the most important color, which, during the times when Tiananmen was built, could only be used for imperial purposes.[17] This explains why the tiles on Tiananmen's roof, like those on the roofs of other buildings that were part of the imperial city complex, are golden yellow, whereas the roofs of most other buildings in China were not.[18]

Although humans are the only animals that use conspicuous building with heavy, exotic or rare materials to affirm their own social status, they are not the only animals to consume conspicuously with the aid of building. In rare situations, other animal species do the same, mostly to confirm their biological rather than their social fitness. Examples of such builders are bowerbirds that live in Australia and Papua New Guinea. This bird family features several types of builders, but Vogelkop bowerbirds are perhaps the most enthusiastic ones. Some males of this species build bowers that consist of a moss platform, on which they erect a maypole assembled out of hundreds of twigs. They encase their platform and maypole with a hut that can measure up to 1.8 meters in diameter and can become almost 0.8 meters high (Gould and Grant 2007: 241). As if building such a structure is not impressive enough for a 25 cm creature, the bird then goes on to decorate his bower with large amounts of ornaments. The ornaments, that can range from colorful fruits and flowers to shiny black stones and insect parts, depending on the taste of the particular male, are arranged by type and color, displayed in and around the bower, and replaced when necessary (*Ibid.*: 241–246). Assembling such an enormous and elaborate structure obviously requires a lot of energy. The males seem to spend all this energy to convince female bowerbirds that they are sufficiently fit and therefore a good potential mate. In a way, the bowerbirds' strategy is similar to the strategy followed by the Chinese emperor who ordered the construction of a huge imperial city complex out of rare materials from far away to demonstrate to his people that he was sufficiently powerful and could continue to serve as a good ruler. Of course, there is also a difference. Whereas the bowerbirds are trying to convince females looking for a mate, the Chinese emperor was trying to convince a broader set of followers. Yet both were or are trying to convince others by using restric-

[17] There may be other reasons for this choice as well. Joseph Needham, amongst others, has suggested that the central position of yellow in Chinese culture may have been derived from the color of the loess soils that has dominated the heartland of the Chinese civilization for centuries (Needham 1956: 261).

[18] There were a few exceptions to this pattern. The predecessors of the Qing emperors, for instance, broke with this tradition (Guo 2000: 350).

tions imposed on building by physical forces like gravity and physical processes like the formation of elements in stars to their advantage.

Only bowerbirds and humans seem to have discovered ways to use buildings as a means to consume conspicuously. This raises the question of what sets these animals apart from other animals that are also able to build complex structures, but do so for very different reasons. There may be several answers to this question. One characteristic of bowerbirds that seems particularly intriguing is the fact that they live in an environment where there are relatively few other species competing for the same food and relatively few predators (Diamond 1988: 650). Humans in general, and people in privileged social positions in particular, often live in a very similar environment. Such an environment may have enabled both bowerbirds and humans to spend a lot of energy on conspicuous building behavior. Bowerbirds and humans do not only live in rather similar environments, both species also possess relatively large brains. Birds that build bowers generally have larger brains then birds from the same family that do not, and in birds that build more complex bowers the brain areas associated with learning from observation and experience and with exploring new situations tend to be larger (Hansell 2007: 244). As was mentioned before, such larger brains may not be required for all types of building. Yet they may be necessary to build in the varied and flexible ways necessary to consume conspicuously with the aid of building. As was also mentioned before, humans have become particularly good at building in varied and flexible ways, possibly partly because positioning their tools, traps, and protective structures in strategically fixed locations made it easier for them to reach and use these structures. Humans may have even become too good at this. It seems that at a certain point in history, the human ability to build in more varied and flexible ways than any other creature has created completely novel challenges for human builders, which will be described in the next part of this article.

Tiananmen and Human History

One of the reasons why I think the human ability to build in such varied and flexible ways has caused problems for some human builders is the fact that I have encountered such problems myself as an architect. When presented with a design task, I often found that there were thousands of different ways to tackle such a task. This is the case because over the past few millennia a wide variety of building practices accumulated in humanity's collective memory.[19] As a result, all kind of ancient and

[19] This is, of course, not only due to the fact that reaching and using buildings became easier for humans during their evolution. It is mostly due to the process that has been

modern materials, construction techniques, types of spatial organization, aesthetic effects, symbolic meanings and economic considerations have become available for any builder to use and combine in lots and lots of different ways. All of these options are a testimony to humanity's incredible ingenuity and are wonderful resources for contemporary architects. But how do you, as an architect, know which ones to choose? How do you know which combination yields the best results in a specific situation? Quite often, that question is hard to answer. Nevertheless, it is central to the architectural discipline. It is difficult to come up with a good design without trying to answer the question. Doing so has been difficult for me, but probably also for builders in the past.

From quite early on in human history, ideas about building were retained in the buildings themselves and in stories, figures, images, and manuals that circulated widely and could travel long distances. Admittedly, in the case of China, buildings themselves were and are not always the best source of information, mainly because many of them did not survive that long since they were built out of perishable woods. Other Chinese sources of building information were much more persistent though. Stories about ancient buildings like the legendary palaces of China's first emperors were passed on from generation to generation long before the oldest remaining buildings were built. Elaborate pottery models of various buildings that were created during the Han and sometimes even earlier dynasties also stood the test of time, as did paintings of buildings that survived in the Mogao Caves along the silk road (Guo 2010: 1 and Steinhardt 2004: 228–254). Perhaps most importantly, ideas about building were transmitted from person to person by informal and formal training programs, and by various building manuals. The most famous manual, one that has survived intact until today, is the Yingzao Fashi. It was first published by a government official called Li Jie in 1103 CE and commonly used by builders after that time (Guo 1998: 1). The manual can be seen as a compendium of architectural knowledge, containing 34 chapters composed of information about for example materials, technical details, decorations, and labor organization (*Ibid*.: 4–6). All of this information from the Yingzao Fashi, other manuals and other sources could have easily been combined by Tiananmen's builders into a number of very different versions of Tiananmen. But for some reason, the people who constructed the gate chose one specific design. Why did they do so?

A possible answer to this question involves the emergence of the architectural profession and architectural styles. While more and more

described by David Christian as collective learning, although the former process could have influenced the latter (and vice versa) (Christian 2004: ch. 7; see also in this volume).

ways to build something accumulated in our societies' memory, architects became more important. It is easy to see why. When more options to build became available, it became difficult to master them all and even more difficult to find the most suitable combination of building options in a specific situation. Therefore, at a certain point in history and for certain building projects, specialized architects became necessary to help people make sensible and in some cases also interesting building choices. An overload of options may not only have created greater need for architects, but may also have led to emergence of building styles. Put a bit crudely, applying a certain building style can be seen as largely sticking to something that structurally, socially, aesthetically, symbolically, and economically 'works' while adding relatively small variations. Therefore, applying a certain style usually results in a fairly safe design solution, even though such a solution may not always be the optimal one given a specific situation. Nevertheless, in many cases people seem to prefer such a safe solution to the application of completely new and experimental combinations of building practices that sometimes work out marvelously and sometimes fail miserably.

When thinking about building styles like this, using them actually seems a bit similar to building standardization in the wider animal world. Most animals use fixed methods and sometimes even standardized materials to construct their building, simply because reinventing the wheel all the time can be risky. Moreover, trying to reinvent the wheel can be costly, because large and energy guzzling 'inventor brains' are required. In contrast, when non-human animals build with fixed methods and materials, such behavior is generally hard-wired and does not require large brains (Hansell 2007: ch. 3). Likewise, in the human world not sticking to established building styles may require expensive expert architects, whereas sticking to culturally hard-wired styles can be a bit cheaper because it requires less innovation and, therefore, fewer innovative specialists.

When it comes to the relation between architects and building styles, it may be interesting to note that overall, the influence of the main architect of the imperial city of which Tiananmen was a part seems to have been rather limited when compared to the importance attributed to building styles and traditions. This situation becomes particularly intriguing when contrasted to the situation on the other side of the Eurasian continent. In Europe, building styles were important too, but they seem to have been much more volatile than the Chinese traditions were. Unlike Chinese traditions, European styles could change drastically within hundred years or so. Famous examples of such transitions include the change from fairly modest Romanesque to extravagant

Gothic and from extravagant Gothic to classical Renaissance styles (Kostof 1995: chs 14 and 17). In China, architectural styles were much more stable. I do not mean to imply that these styles did not change, but changes, like roof lines that obtained slightly different curvatures, were smaller and appeared more gradually (Boyd 1962: ch. 2). The role of architects in China is probably closely linked to this. Architects in China, including Cai Xin and Nguyen An, the people who were responsible for the construction of the imperial city complex, were more or less government officials, intellectuals responsible for the design and planning of large complexes (Zhu 2004: ch. 2; Mallas 2001: 42; Mote and Twitchett 1998: 240; and Boyd 1962: ch. 2). Such people usually did not design individual buildings. That task was left to master craftsmen. While designing individual buildings, such master craftsmen based themselves on manuals like the previously mentioned Yingzao Fashi, which did not only include a long list of all kinds of building practices, but also prescribed in detail which sets of practices should be used in which specific situations. For instance, it contained rules about the exact dimensions different types of buildings, like palaces, mansions and pavilion halls, should have and which structural details should be applied to which building types (Guo 1998: 8). Master craftsmen, therefore, had little room to experiment with all kinds of new ideas. Consequently, buildings did not change that much over the centuries, and the image of architects as innovative artists did not emerge in China like it did in the West.

There may be several reasons why the values attached to architects and building styles differed in the East and West. To me and many other scholars it seems that during much of Chinese history, people have put greater emphasis on groups and less emphasis on individuals than people, for instance, in Europe did (Nisbett 2003). This greater emphasis on groups has been linked to the types of agriculture that dominated Chinese societies, leading people to be more dependent on the group they lived in than people elsewhere were (McNeill J. and McNeill W. 2003: 32–33). A greater emphasis on groups can, perhaps, also be linked to the geography of China. When you look at China on a map, you can see that the country is bordered by the highest mountains on Earth to its west, by the largest ocean on the planet to its east, by an immense steppe where only nomads could survive to its north, and inhospitable mountainous jungle to its south. Therefore, influences coming from the outside have been fairly limited, at least when compared to the effects ideas from other regions had on the development of, for example, Europe. This may have made it easier to keep Chinese culture unified and Chinese society stable after the formation of the first Chinese empires. Both a greater emphasis on groups, on a unified culture and on the stability of social structures that prevailed during much of the Chinese history may have influenced the development of Chinese architecture, as the need to distinguish oneself from predecessors or competitors was not that great. In fact, distinguishing oneself from the rest of a group or society could easily backfire, because it could negatively influence group dynamics and threaten social stability. This may be one of the reasons why the Chinese, including the emperors who ordered the construction of Tiananmen, may have preferred sticking to traditional styles. For European rulers, on the other hand, distinguishing themselves from their predecessors and competitors with the aid of building often was worthwhile, and one of the main reasons why the French kings became the patrons of early Gothic builders like Abbot Suger and Italian merchants and bankers became the patrons of early Renaissance architects like Filippo Brunelleschi (Kostof 1995: 329 and 403).

A difference in emphasis on individual architects and buildings styles may have put European and Chinese architectural history each onto their own unique paths. The starting points of these paths may not have been too dissimilar. It is remarkable how much many ancient Greek or Roman dwellings resemble traditional Chinese houses. All of these houses generally consisted of a series of one or two-storied compartments or halls, organized around one or a few courtyards and closed off from the outside world by a wall. The way the roofs were supported and the decorations differed in the east and west, but apart from that, ancient housing traditions in Europe and China were quite alike (Kostof 1995: 141, 197–201 and 232; Boyd 1962: chs 2 and 4). It seems that from these starting points, the Western architecture went on to develop lots of different types of buildings and corresponding building styles, introducing new ideas and changing styles with every alteration in social structure. In China, on the other hand, people preferred to refine existing styles instead. As a result, many traditional Chinese buildings, including temples and palaces, still look a bit like the traditional courtyard house.

Tiananmen fits into this tradition: it is part of a wall surrounding a gigantic imperial courtyard complex that housed smaller courtyard complexes like the Forbidden City and gardens, altars, palaces, offices and royal workshops and warehouses (Zhu 2004: ch. 2). Of course, the scale of the complex, the use of materials and the richness of decorations are not comparable to those of ordinary houses, but the spatial organization of the imperial city, the nature of its halls and the applied building techniques most definitely are. Furthermore, the gatehouse itself is quite similar to the halls that are also present in traditional courtyard houses. Like almost all other halls in China it consists of a wooden post and beam structure that supports a curved roof and envelops one single space.

It is tempting to expand this argument much further by analyzing how more detailed characteristics of Tiananmen do or do not fit into this story. Yet for the purpose of this article, the short description given above must suffice. For the purpose of this article it has been more important to demonstrate how the reasons why people built Tiananmen the way they did can be linked to broader trends, like the emergence of architects and architectural styles, the varied and flexible building strategies developed by humans, the development of building strategies by life in general and the fundamental forces and processes that shaped these strategies.

Reflection

Now that we have completed a journey that covered 13.8 billion years of history, it may be a good time to reflect briefly on it.

Trying to see 'a world in a grain of sand', or in this case in Tiananmen, definitely changed my appreciation for it, and triggered my curiosity. It led to all kinds of questions people who usually study subjects like the gate have not asked before. For example, architects or architectural historians generally do not wonder about the delicate balance between gravity and electromagnetism that enables us to build. They also do not ask themselves why some animals, including humans, build whereas other animals do not. And few of them think about why architects or architectural styles exist in the first place. Trying to see a world in a building also led to some Big History questions big historians have not asked before. For instance, the question how energy considerations involved in early tool use and building may have helped shape human evolution and human history has not been examined yet. This Little Big History made it easy to discover such questions. It can therefore serve as an example of how Little Big Histories can be used as fruitful research tools, perhaps in the way Albert Einstein had in mind when he wrote: 'To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science' (Einstein and Infeld 1938: 92).

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