The Invention of Right-Angle Construction in the Paleolithic Era

Including a picture essay that illustrates the capabilities of right-angle woven-fiber technology and basketry

By Rick Doble

You can view other papers by Rick Doble about art and time at:
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ABSTRACT:
We live in a world of right-angle structures. Cloth is made this way, as is furniture, homes, and even skyscrapers. In fact, they are just about everywhere in the modern world. Yet right-angle construction is a human invention and not natural. Nevertheless, there has been virtually nothing written about this important discovery. When early humans began to understand the power of this concept, it was a major advance in their technology. When applied to basket weaving and related crafts, it led to the development of hundreds of products. It gave human-kind a powerful tool that helped them survive and prevail and eventually build civilizations.

INTRODUCTION

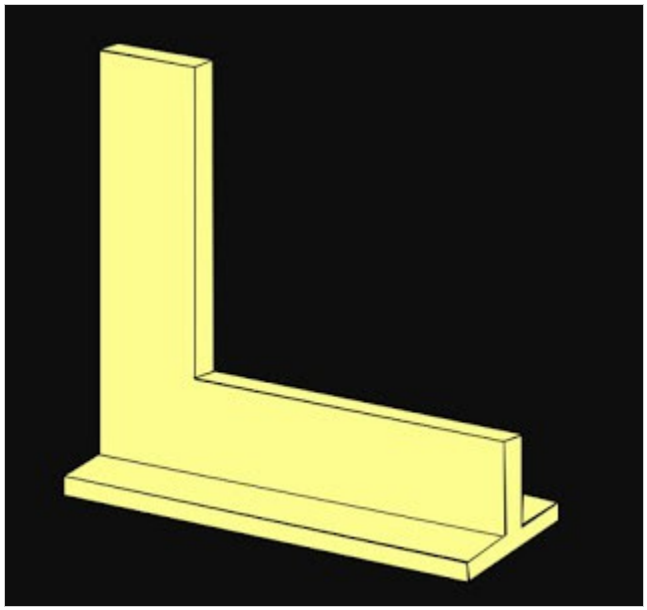
Ironworkers (as these skyscraper workers are called) having lunch on a horizontal crossbeam supported by vertical steel columns 840 feet up. Modern steel-framed construction uses horizontal beams and vertical columns at right angles to build today's highrise and skyscraper buildings. This picture is from the construction of Rockefeller Plaza in 1932 in New York City. Below the ironworkers is the entire city built with right-angle construction.
Clyde, Charles."Lunch atop a Skyscraper."
New York Herald-Tribune, published Oct. 2, 1932.

In the distant past, early humans made a major technological breakthrough that has been overlooked. It is something that we use every day and that in many ways has built the modern world. Because it is everywhere, it seems natural; however, it is anything but. I am talking about right-angle construction -- the structure that is at the heart of weaving and textiles and the clothes you wear, the furniture you sit in and at the center of a skyscraper's construction and even your own home.

I tried to research this idea and could find almost nothing that dealt with this technology as an invention and discovery that humans had made.

(Left) Painting of Archimedes in deep thought.
(Right) Detail of painting showing right-angle square tool.
Archimedes of Syracuse contemplates the properties of the right angle. Archimedes is considered one of the greatest scientific thinkers; he was an ancient Greek mathematician, engineer, and inventor.
Painting by Domenico Fetti. "Archimedes Thoughtful." 1620.

“There are no...right angles in nature,”
Antoni Gaudi, the famous Spanish architect declared.



Square (Tool). A square is a basic and essential right-angle tool used in construction. Carpenters and builders use it to ensure the accuracy of construction right angles and it is also used for marking lines on materials before making a cut. It is so fundamental it is often used in heraldry and on construction logos.

While Gaudi's declaration is an overstatement, as some trees grow straight up, perpendicular to the ground, and we as humans generally walk at right angles to the earth, natural right-angle complex structures are almost non-existent. In particular, I am talking about interlocking, interwoven perpendicular structures that do not occur in nature but which humans construct.

(Left) Steel-framed construction showing the basic right-angle skeleton structure.
(Right) A modern complex built using right-angle steel-framed construction.
Most modern highrise and skyscrapers are built using steel-framed construction. A horizontal and vertical steel skeleton is built which is strong enough to support the windows, floors, and walls.

ABOUT RIGHT-ANGLE CONSTRUCTIONS

At some point in the past, humans realized that fiber items made with a right-angle design were strong, durable, and flexible. Moreover, they could be easily made with local plant materials.

> **NOTE:** Of course, with a dome-like structure and non-rectangular shapes, all the elements of a frame or the structure are not always at a strict right angle in relation to each other, nevertheless a consistent perpendicular opposition is a key part of these structures.

This was a major advance in human technology. When and how this happened is open to debate. But that it did happen is undeniable and most important.

While a number of developing skills may have contributed to this technology, my guess is that basket weaving was one of the major areas where this insight was both discovered and implemented.

> "From basket weaving to loom-weaving, the process of weaving was already known in the Paleolithic era, as early as 27,000 years ago. Weaving, the process of joining individual threads together at RIGHT ANGLES [ED: my emphasis] to one another, has been around for millennia."
> BSAMPLY. "WHAT ARE WOVEN FABRICS?"
> https://bsamply.com/what-are-woven-fabrics/ Accessed August 7, 2020.

HOW WAS RIGHT-ANGLE CONSTRUCTION DISCOVERED?

The discovery or invention of right-angle construction must have been preceded by an earlier woven-fiber technology. I have again searched the Internet and could only find vague references to the origins of basket weaving or woven-fiber technology, as I have called it, such as the following quote.

> "The idea of interlacing materials together to create a weave was probably inspired by nature; by observing birds' nests, spider webs and various animal constructions..."
> Wild Tussah. "The History of Weaving." September 2014. https://wildtussah.com/history-weaving-2/ Accessed August 7, 2020.

If weaving was inspired by nature, the origins of weaving may have begun as follows:

It has been well established [1] that early hominids spent a good deal of time around baobab trees on the savannas of Africa. This tree was also used by weaverbirds who built elaborate nests. So, as I have written, it seems quite likely that at some time in the past, hominids learned how to weave by watching weaverbirds build their nests and by observing the completed nests and handling abandoned nests when they fell down.

Just how much could early hominids have learned from the weaverbirds and their skills at nest building? Quite a lot.

Weaverbirds building nests.
(Left) A male bird working to complete a nest.
(Right) A completed nest with a male and female weaverbird ready to move in.

ABOUT THE WEAVERBIRD

"The nest is made from long strips torn from the leaves of grasses, which are intertwined in a regular lattice formed by passing successive strips over and under, and in a direction orthogonal to, strips already laid. It is held together, and attached to the substrate, by a variety of stitches and fastenings... The bird uses its beak rather like a needle in sewing or darning."

Ingold, Tim. "Chapter Nineteen Of string bags and birds' nests Skill and the construction of artifacts." The Perception of the Environment, Essays on Livelihood, Dwelling and Skill. Taylor & Francis Group.

A weaverbird starting to build a nest. He is creating the basic skeleton that the nest will be built around.

Weaverbirds gave hominids good initial instructions which included most of the basics of basket weaving such as creating a regular lattice, tearing then placing long strips at an opposing angle to already existing strips, passing the strips over and under and tying this all together with a variety of knots. Eventually, hominids would have been able to expand on this craft.

THE FIRST HOMINID BASKETS WERE PROBABLY 'RANDOM WEAVE' CONSTRUCTIONS

Assuming that the model for early basket-like containers and carriers was bird nests and such, the most likely human-made designs were probably made with a 'random weave.' This is due to the fact that a random weave in many ways imitated the process that birds used to build nests such as the construction process of weaverbirds who were common in Africa then and now [2].

Two random weave baskets. Photos and baskets by Nan Bowles.

A random weave basket generally starts with a circular or oval bare-bones open skeleton made of strong thick branches or vines which are intertwined. The branches might be green so that they are pliable. The sides are then laced with smaller more flexible (often green) branches and vines that are woven over and under the skeleton frame and over and under each other and at opposing angles to existing strands. When allowed to dry out, a simple basket like this is remarkably strong and can hold two to six kilograms, in my experience. It is also quite light, so carrying it for a long-distance would not have been a problem.

Such technology would have given early hominids a distinct survival advantage. For example, it would have allowed hominins to forage much further from their base because they could bring back a large amount of food from distant locations.

(Left) A fallen abandoned weaverbird nest.
(Right) A simple basket using opposing strands.

Over time this basic construction could have evolved into a more regular and standard right-angle structure, the kind that we are familiar with. And once mastered this design could have been expanded and developed to create a wide range of items.

Master craftsmen, at different stages, weaving baskets and other items.

The principle of regular basket weaving is quite simple. A set of strands is placed at right angles to another set of strands. In basket weaving the vertical stands, known as spokes, are fairly hard. Then the opposing strands, called weaver strands, are more flexible and wrap over and under around the spokes to make the walls of the basket. While the term 'basket' and 'basket weaving' is used, the ancient craft applies to mats, flexible bags and sacks, wide gauge and fine gauge baskets, different styles of weaving, and a large variety of fiber articles from sandals to boats and houses. In short, the 'basket weaver' was/is a fiber craftsman.

This photo shows the huge variation possible with even a simple basket design.

However, the historic time-table is unclear. When humans first began to make random weave baskets and how long this went on is unclear. Yet, logically, this would have been the craft that preceded sophisticated right-angle woven structures.

It was no accident that the two earliest civilizations Sumer and Egypt employed weaving as a key technology throughout their empires. Both had plants that could be used for a variety of woven-fiber structures. In Sumer, the primary materials were the reeds that grew abundantly in the mashes as well as esparto for rugged baskets and the best rope. In Egypt, it was papyrus and flax which could be used to make sacks, cloth, baskets, sandals, and even boats. Egypt's granaries, for example, were managed with sacks of grain. Quite simply, neither civilization would have been able to function without woven-fiber technology.

In the *Elementary Sumerian Glossary* the hihgly respected 'basket weaver' is defined as: "a reed craftsman, basket and mat weaver"
Foxvog, Daniel A. Elementary Sumerian Glossary. University of California at Berkeley, revised 2008. SumerianGlossaryFoxvog.pdf

PICTURE ESSAY

It is my educated guess that humans probably discovered the power of right-angle construction with basket weaving and then expanded that technology to make larger, stronger, and/or more complex woven structures.

Yet in a sense, it does not matter if this insight came from basket weaving. What does matter is that at some point it became part of and central to basket weaving and when it did it allowed a huge variety of objects to be constructed. Then this technology gave humans a distinct advantage in the struggle for survival.

Moreover, we can say with certainty that eventually new woven designs were invented for a wide variety of uses such as making fish traps with an open type of weaving, and hats, and sandals, and mats, i.e., myriads of items small to large. This was possible because right-angle technology was scalable. As you will see in the following picture gallery, small one-person boats could be made with this technology as well as huge boats for commercial purposes. I believe it started small and evolved into many small things and then later evolved into bigger things.

The following images illustrate just how versatile this technology became, a technology that we do know was in place at least by the Neolithic era -- but probably much earlier.

ABOUT THESE IMAGES

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SCALABLE: Many right-angle woven-fiber designs can be made in a wide range of sizes

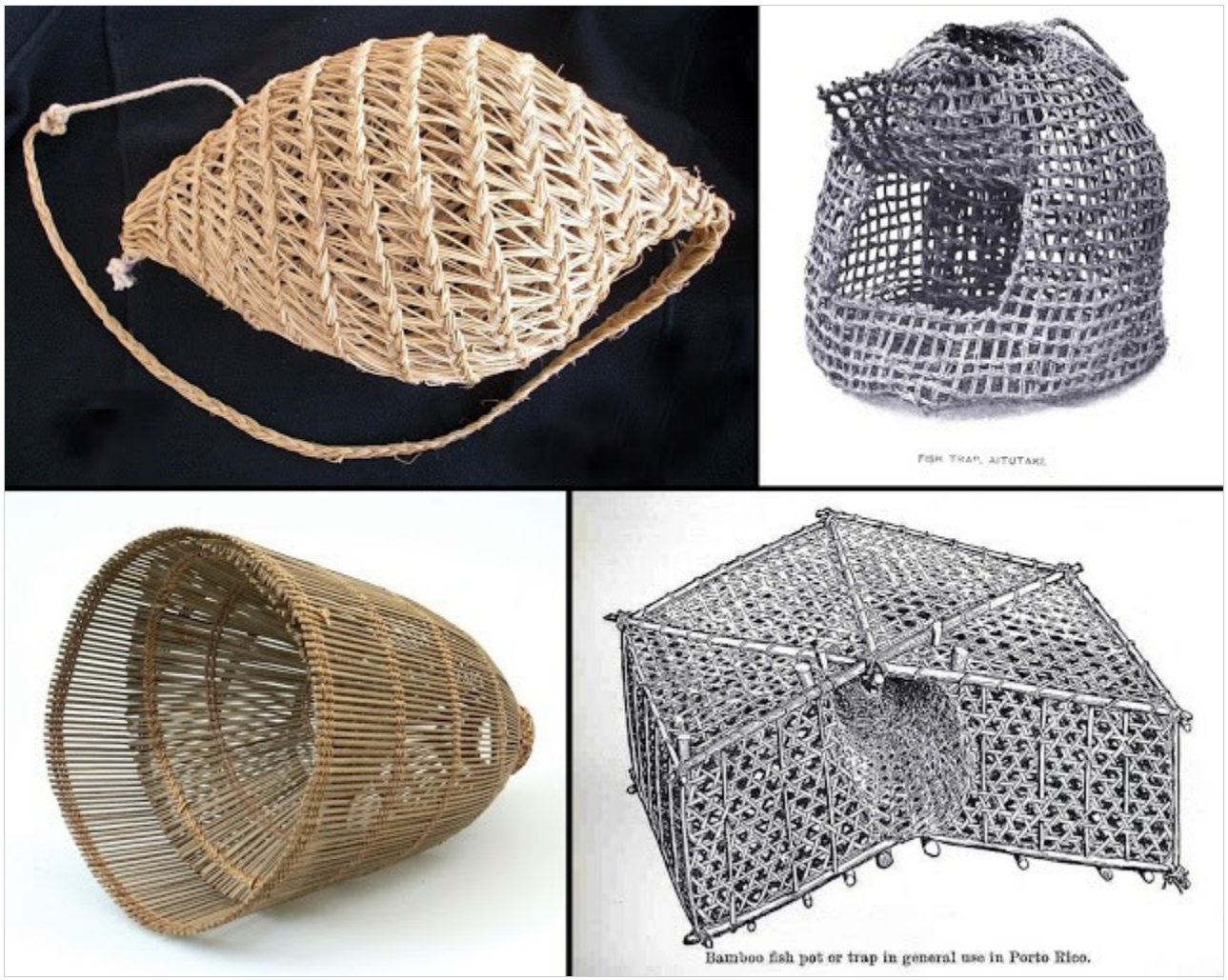
(Left) Small Neolithic baskets, about 5000 years old. They were found in a dry cave, Cueva de los Murciélagos (Albuñol, Granada), which is why they are so well preserved.
(Middle) Working medium-sized traditional panniers baskets on a donkey (the second basket is not visible on the other side of the donkey).
(Right) Large baskets in a boat, ready to be filled with grain.

VERSATILE: Right-angle woven-fiber technology can create a large number of shapes and configurations

(Left) A wicker sewing basket.
(Middle) A rattan chair.
(Right) Walls in Swaziland, Africa.

VOLUME: Items can be produced in large quantities.

(Top) Sandal Maker, Tomb of Rekhmire, Egypt, about 3500 years ago, This is a facsimile from a wall painting.
(Bottom) A pair of ancient sandals made from the papyrus reed and from about the same time period as the painting above. These were made in quantity.

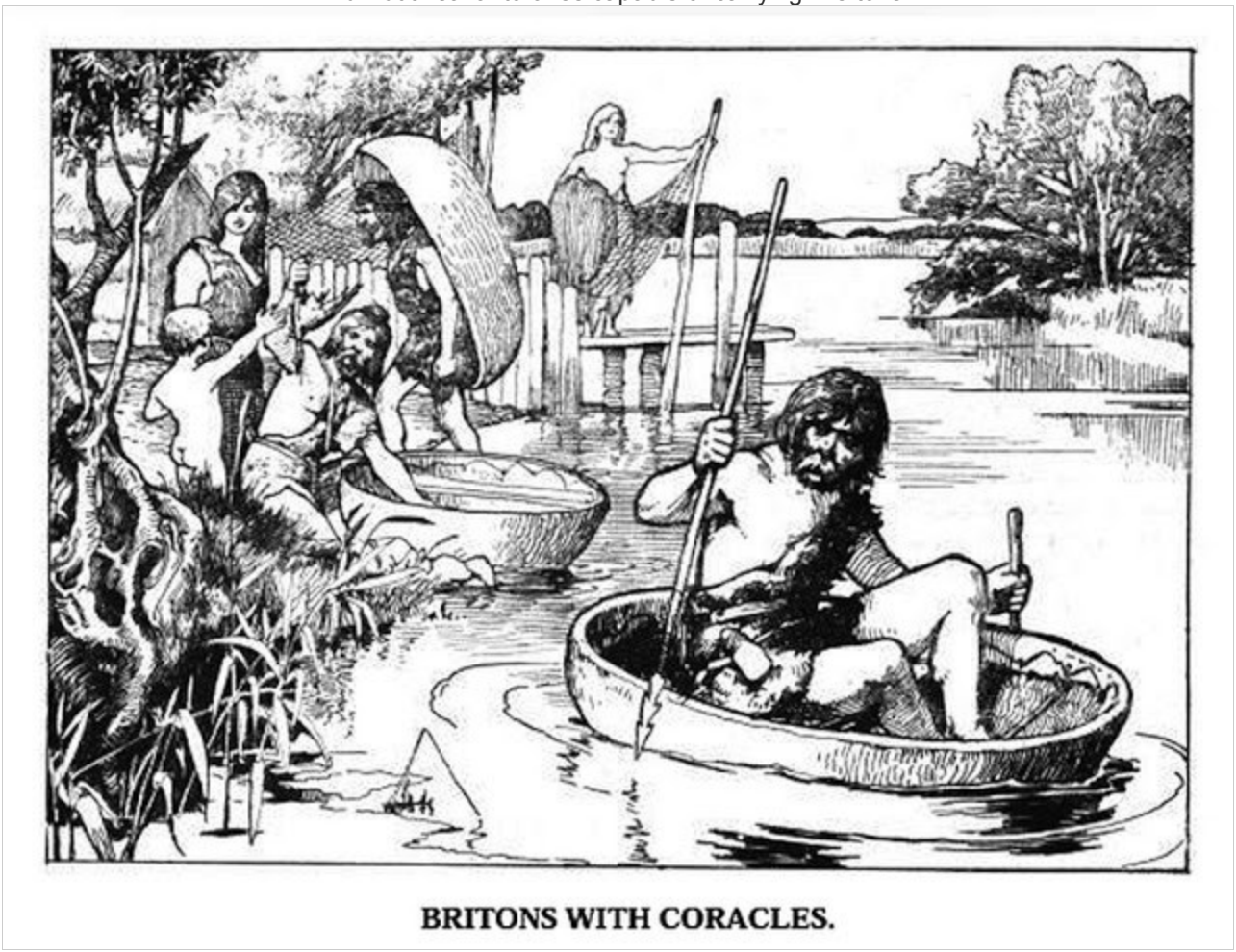


A VARIETY OF DESIGNS TO ACCOMPLISH A TASK: FISH TRAPS
(Top Left) A traditional basket for gathering snails in Southern Spain.
(Top Right) Fish Trap, Aitutaki (Cook Islands)
(Bottom Left) Braided fish trap.
(Bottom Right) "Bamboo fish pot or trap in general use in Porto Rico."

WATERCRAFT

---- Basket Boats (Coracles) ----

These boats are based on a basket-like structure that is then covered with animal hides and sealed with waterproofing materials such as bitumen which occurred naturally in Mesopotamia. These boats are quite seaworthy and have been used throughout the world for thousands of years. They are light and strong and can be made in a wide range of sizes from small boats for an individual sailor to ones capable of carrying five tons.



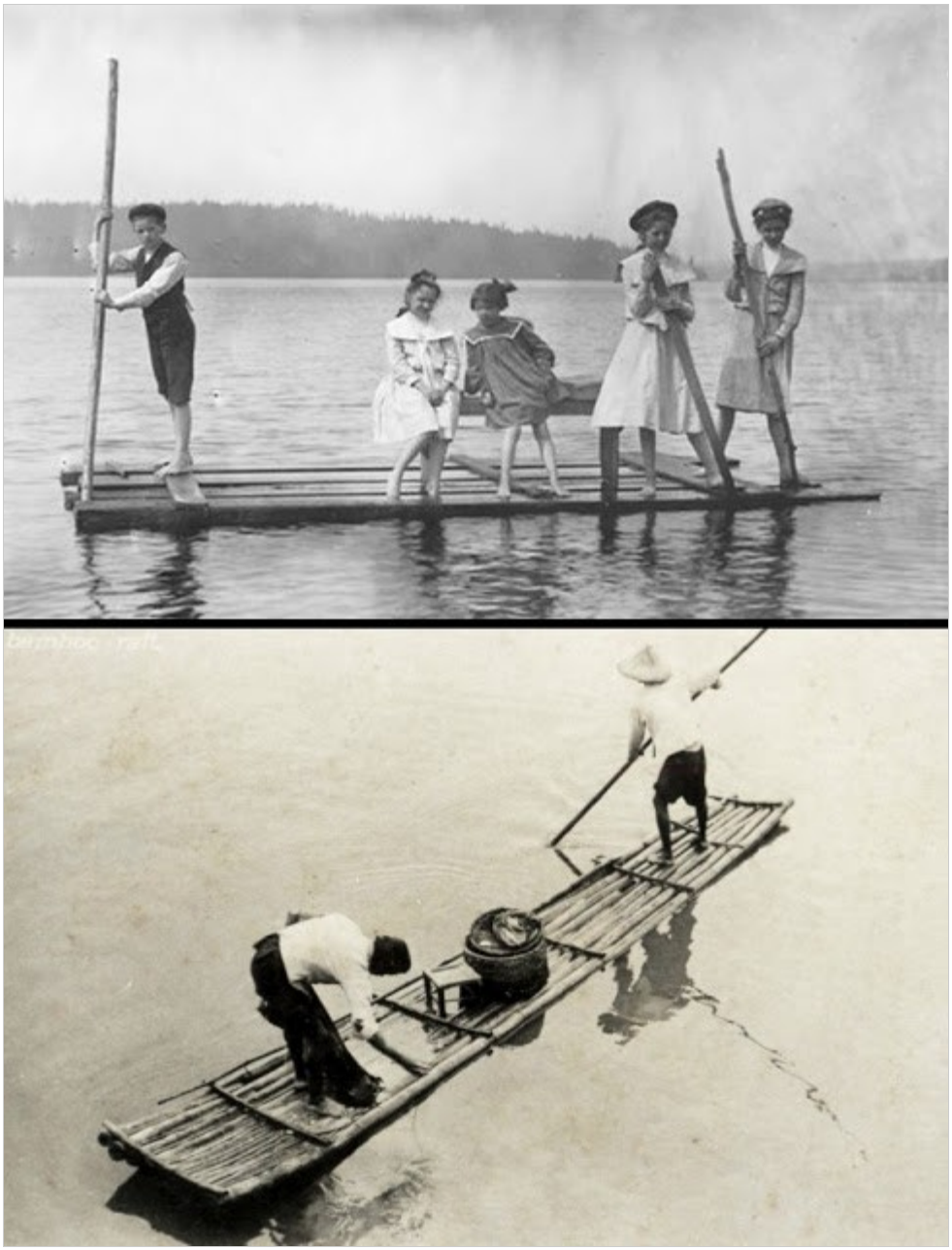
BRITONS WITH CORACLES.

Coracles have been used in England, Wales, Scotland, and Ireland for centuries and are still in use today. One person can easily carry a light coracle on his back and take the boat to a lake or river.

(Left) The basket structure of this boat is visible.
(Right) Large basket boats can carry twenty people.

---- Rafts ----

The right-angled horizontal crossbeams hold a raft together and are the basis for its integrity. As these pictures show, it does not matter if the raft is small or large.



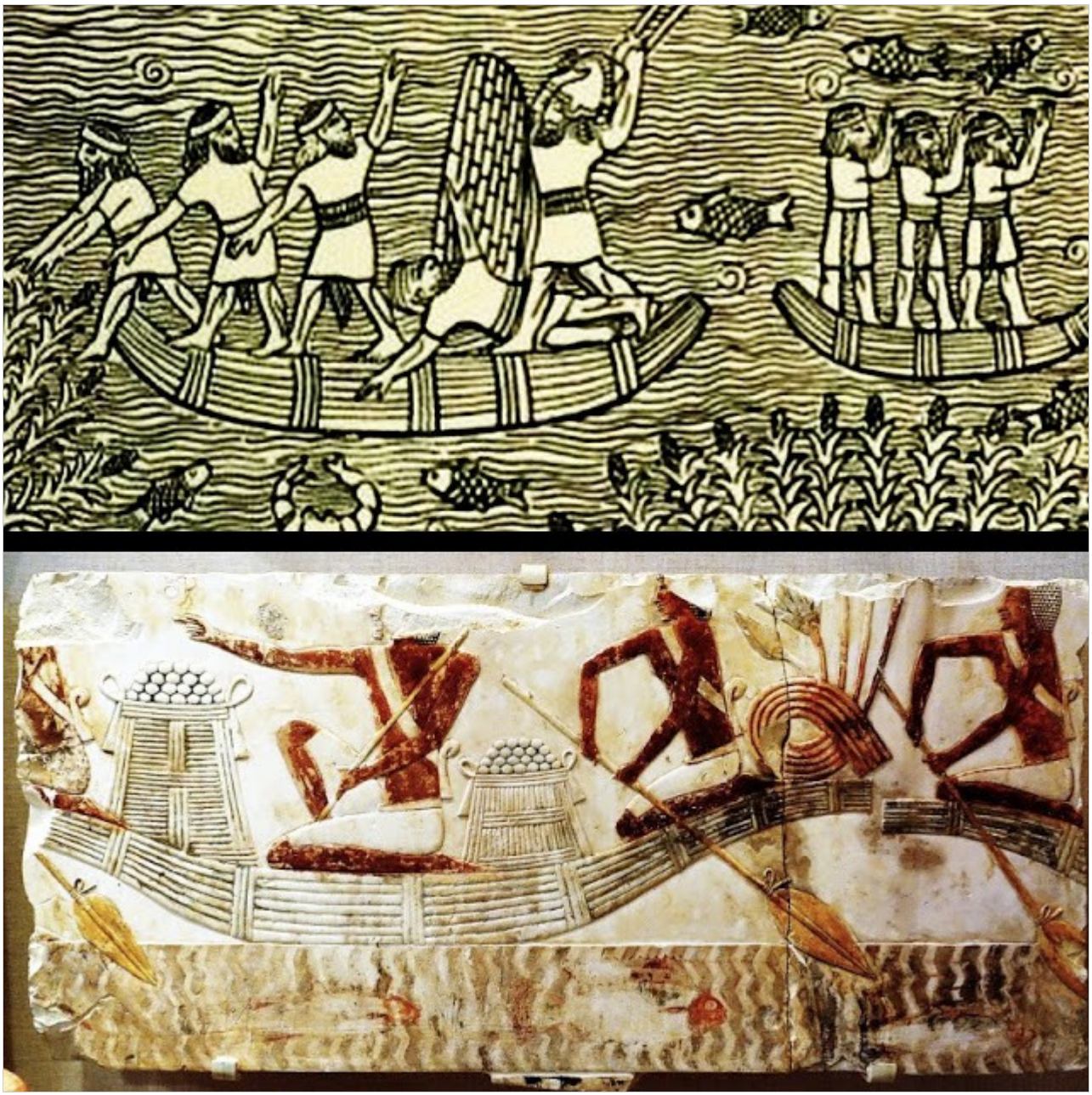
(Top) Children on a raft -- the crossbeams are clearly visible and keep the raft together.
(Bottom) A common working bamboo raft in Taiwan. The horizontal right-angled slats are visible.

This model of a balsa raft is a model of a traditional Peruvian raft, sailed by pre-Columbian people, as drawn by the Spanish around 1600. The raft is made of large balsa logs and is a "double-decker" in that there are two levels that are held together by horizontal bamboo crossbeams that are lashed to the vertical balsa logs and the deck above. This design was the inspiration for the famous South American raft, Kon-Tiki.

---- Reed Boats & Ships ----

Reed boats are made by bundling and tying reeds together in columns and then securing them with right-angle horizontal binding. Common in Egypt and Sumer/Babylon, they were made of marsh reeds in Babylon and papyrus in Egypt. As with other boats in this section, they can be quite small for an individual sailor or sixty feet long with a crew of eleven as was the case with the reproduction of an ancient Mesopotamian boat seen below.

(Top) A small reed boat.
(Bottom) Named the Tigris, this is a model of the Mesopotamian reed boat built by Thor Heyerdahl of Kon-Tiki fame. He believed that a boat similar to this had been used in the early days of the Sumerian/Babylonian civilizations. The Tigris was almost 60 feet long, had a crew of eleven, and sailed more than 4,000 miles without any serious problems.

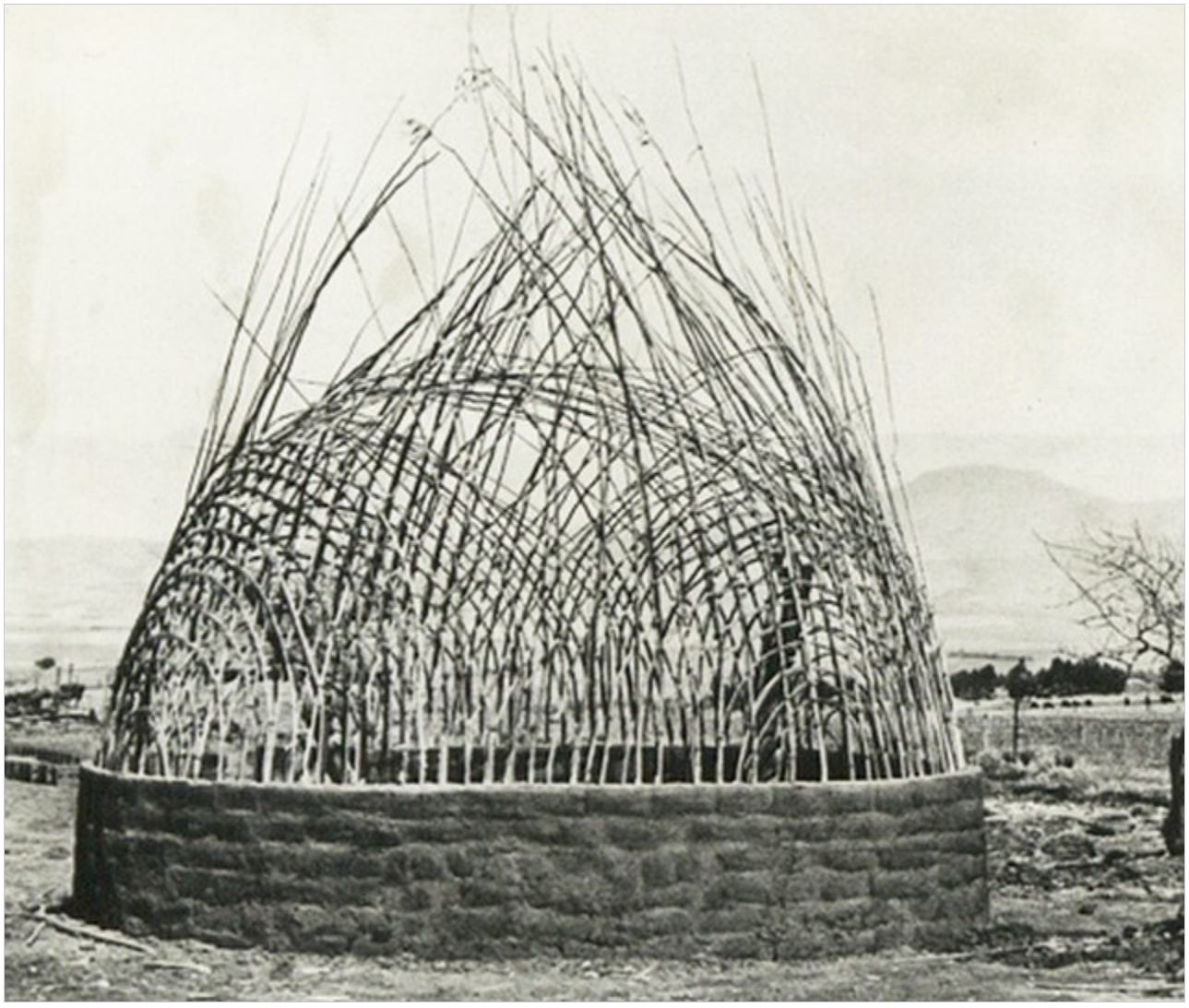


In these ancient depictions, the right-angle cross-weaving is evident for these reed boats.
(Top) This image clearly shows that the Mesopotamian boats used a right-angle cross-weaving in their boats. The drawing is after an ancient bas-relief from Nineveh Babylon dated to about 600 BCE. This was one of the pictures that inspired Thor Heyerdahl to build the Tigris.
(Bottom) The cross-weaving is also evident in this image of an Egyptian boat more than 2500 years ago.

HOUSING

---- African Huts ----

These traditional huts are based on a basket-type right-angle design. They are essentially large upside-down baskets which are then covered with a robust woven outer layer that keeps out the wind and the rain.



"Swazi type hut under construction."
This shows the skeleton structure over which a covering is placed.

Traditional African Huts

(Top Left) "Frame slats of a Swazi hut, at a cultural village at Jeppes Reef border post."
(Top Right) A rural hut inside the Zululand Museum, showing the basic structure, over which a covering is placed.
(Bottom Left) "The replica Zulu Hut at the Voortrekker Monument is typical of the dwellings found in Zululand, which were traditionally constructed by men."
(Bottom Right) A traditional African hut.

Detail of thatching of the replica Zulu hut (full view of Zulu hut is above bottom left).

Large mudhif buildings made entirely of reeds.

Weaving technology once mastered can be scaled up to make quite large structures such as these traditional mudhif reed houses that have been made for centuries by the Mudan people in the marshes of southern Iraq. These are used for community gatherings.

(Left) Interior of mudhif. "A mudhif, a traditional Marsh Arab guesthouse made entirely out of reeds. The Marsh Arabs live a lifestyle that dates back 5,000 years."

(Right) Very large mudhif building in Nasiriyah Iraq.

(Left) Local contractors begin the job of building a mudhif. "The reeds are gathered from marshlands near the Euphrates River."

(Middle) "Local contractors construct the main reed arches of a marsh Arab mudhif."

(Right) Almost completed, the mudhif exterior.

---- Neolithic Reconstructions ----

Early Neolithic houses in Europe.
(Top) Archeon Museum Park, Netherlands "showing a replica of a house 8000 years BC."
(Bottom) "Stone Age village of Kussow, Damshagen municipality, Germany."

LATER NEOLITHIC BUILDINGS WITH FULL RIGHT-ANGLE ENGINEERING

(Top) "Neolithic model dwelling, from an excavation in Hungary of the 5th millenium . Musée des tumulus de Bougon"
(Bottom) Model: "Wels (Upper Austria). City Museum - Minoritenkloster: Model of a neolithic village."

(Left) Building detail, interior. "Neolithical village Heldenberg."
(Right) From the Pfahlbaumuseum Unteruhldingen in Germany. The open-air museum comprises several reconstructions such as this.

(Left) Reconstruction of Lakeside Neolithic settlement in Dispilio, Greece.
(Right) Archeoparc, Germany (Schnals valley/South Tyrol). Reconstruction of a neolithic hut.

---- Neolithic Looms ----

(Left) Reconstruction. "Neolithic loom, Vinca, Serbia."
(Right) "Cucuteni Vertical Loom Reconstruction Piatra nNamt."

Textiles were invented using the same structure. The famous Anni Albers of the Bauhaus School had this to say.

"During the 4,500 years or, in some estimates, even 8,000 years [ED: there is now concrete evidence that it is at least 27,000 years old] **that we believe mankind has been weaving, the process itself has been unaffected by the various devices that contributed to greater speed of execution. We still deal in weaving, as at the time of its beginning, with a rigid set of parallel threads in tension and a mobile one that transverses it at RIGHT ANGLES.** [ED: My emphasis]"

This basic insight about right angles has never been overshadowed. Anni Albers went on to say, "And weaving, even the most elaborate, can be done, given time, with a minimum of equipment....Fabrics of great accuracy have been executed without much mechanical aid."

WHEN DID THE DISCOVERY OF RIGHT-ANGLE CONSTRUCTION TAKE PLACE?

Right-angle design was probably discovered by basket-weaving craftsmen or was discovered in other technologies as well and then applied to basket weaving. In any case, basket weaving made full use of it.

Nevertheless, it may have taken thousands of years to derive a general principle that could be applied to a number of different weaves, different materials, strands of different gauges, different sizes, different uses, etc. Inventing something original from scratch would not have been easy. For example, with a basket, the forces are intertwined together, but in a building, the additional force of gravity is a key element even though the basic structure is similar.

It is also important to note that working with baskets and weaving patterns and styles would have allowed people to 'play' with these structures. Playing with inventions is important just as it is with children. Overtime a general understanding might have emerged. I assume that it was not mathematical as we would know it, but perhaps proto-mathematical in which strands of different strengths and thicknesses were put in 'opposition' to each other, for example.

Yet making baskets was one thing, and building larger items was something quite different, i.e., designing such things as walls or roofs and boats. This again would probably have taken thousands of years.

A BASKET-WEAVING TIMELINE?

I think it is very unlikely that sophisticated right-angle basket weaving began by itself and did not evolve from something earlier. But because woven-fiber constructions decay, they have left little evidence; as one paleoanthropologist wrote, their past existence is invisible [3] -- for the most part (more about trace evidence in a future article.)

Nevertheless, another anthropologist has asserted that what we have found so far -- i.e., artifacts that have survived such as stone tools -- are only about 10% of the tools and items that were made and used in Paleolithic cultures.[4]

While microscopic trace evidence on stone tools has shown wear patterns that were caused by cutting plants and wood, this is about the only direct evidence we have. We might be forced to use other means such as computer simulations or simple logic.

SUMMARY OF A POSSIBLE TIMELINE

For example, using logic as our tool, the following timeline makes sense.

Early on -- it could be tens of thousands of years ago or a million years ago -- hominids began making the first baskets with a random weave based on models from nature such as birds' nests. Then, after thousands of years, they gradually discovered the power of right-angle design which again, after thousands of years, allowed them to make a wide variety of well-crafted items from sandals to large boats and houses and played a major role in the emergence of civilizations such as Egypt and Sumer.

But the exact timing is not the most important thing, the progression is the most important thing.

CONCLUSION

It is quite clear that the first civilizations of Sumer, Babylon, and Egypt could not have functioned without a sophisticated woven-fiber technology which included an understanding of right-angle construction. This crucial technology included baskets and sacks for a wide variety of agricultural tasks, along with mats, shoes, containers, cordage, houses, boats, clothing, and much more. This means that woven-fiber constructions were critical to the emergence of civilization. Therefore it is important to understand the origins and development of this technology as it played a major role in the ascendence of humanity.

Egyptian agriculture used woven-fiber sacks and baskets for planting, harvesting, transporting, storing, and processing. Without woven-fiber technology, Egyptian civilization could not have functioned.
(Left) Ancient Egyptian model of a granary with scribes. This model was found in a tomb and shows men delivering grain in woven sacks which is being recorded by scribes.
(Right) Ancient Egyptian painting of men carrying and delivering sacks, from the Tomb of Oumsou.

Right now there is almost no information about the origins of basket-weaving and the discovery of right-angle construction. If we are to understand the development of human culture and the accompanying technologies, woven-fiber technology needs to be at the top of the list. Clearly, it warrants more consideration than it has been given in the past.

(Left) Typical Egyptian work basket.
(Right) The Egyptian God Heh kneeling on a basket. He is often shown with a basket emphasizing its importance. Medium: "Egyptian faience with pale green glaze" dated "between 1070 and 332 BC (Third Intermediate-Late Period)."

SPECIAL NOTE: An important new article has just been published about similar subject matter. Entitled "Mobile containers in human cognitive evolution studies: Understudied and underrepresented" by Michelle C. Langley and Thomas Suddendorf, it was published in Evolutionary Anthropology, 2020.

FOOTNOTES

#1. Please see my blog:
Homo Habilis Learned Basket Making from Weaverbirds
https://deconstructingtime.blogspot.com/2020/04/oldowan-weaverbirds-homo-habilis-basket-making.html

#2. See the above blog-article for information about weaverbirds.

#3. “Thus far, the use-wear on the quartz and quartzite subsample of Kanjera artifacts confirms that animal butchery was conducted on-site, but also demonstrates the processing of a variety of plant tissues, including wood (for making wooden tools?) and tubers. This is significant, because the processing of plant materials appears to have been quite important, but would otherwise have been archaeologically invisible”.
Popular Archaeology, June 12, 2012, quoting Dr. Thomas Plummer of Queens College, City University of New York.

#4. Dr. Adovasio has made the point that there is "ample ethnographic evidence that perishable technologies form the bulk of hunter-gatherer material culture even in arctic and sub-arctic environments (e.g. Damas 1984; Helm 1981). Archaeologists working with materials recovered from environmental contexts with ideal preservation clearly confirm that this is also true for the past as well. Taylor (1966:73), for example, notes that in dry caves he recovered 20 times more fiber artifacts than those made of stone, Croes (1997:536) reports that wet sites yield inventories where >95% of prehistoric material culture is made of wood and fiber, and Collins (1937) confirms the same for sites in Alaskan permafrost."

> Soffer O, Adovasio JM, Hyland DC, Klíma B, Svoboda J. "Perishable Industries from Dolní Vestonice I: New Insights into the Nature and Origin of the Gravettian." Paper Prepared for the 63rd Annual Meeting of the Society for American Archaeology Seattle, Washington, 25–29 March 1998. DolniVestonice.pdf.

PICTURE ESSAY LINKS

Please copy and paste these links into your browser.
Links are in the same order as the pictures in the essay.

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VERSATILE
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-- for the Babylonian drawing see the note at the end of this section
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https://commons.wikimedia.org/wiki/File:ZA-MP-matsamo-huette.jpg
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https://commons.wikimedia.org/wiki/File:Replica_Zulu_Hut,_Voortrekker_Monument.jpg
https://commons.wikimedia.org/wiki/File:Une_hutte_traditionnelle.jpg

DETAIL: Replica_Zulu_Hut_thatch
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MUDHIF
https://commons.wikimedia.org/wiki/File:Iraqi_mudhif_interior.jpg
"A mudhif, a traditional Marsh Arab guesthouse made entirely out of reeds. The Marsh Arab live a lifestyle that dates back 5,000 years."
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https://commons.wikimedia.org/wiki/File:Model_of_a_Granary_with_Scribes_MET_DP351557.jpg
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The drawing of boats from Babylon came from:
King, Leonard. A History of Babylon, From the Foundation of the Monarchy to the Persian Conquest, Vol. 2. London, Chatto and Windus, 1915.
https://www.gutenberg.org/ebooks/56667 -- page 322 in the ebook.