

THE INVENTION OF THE WHEEL

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ABSTRACT

Prehistoric jewelry included necklaces with strings carrying holed beads which essentially are miniature wheels. Any crafts person, or a child putting a stick through the bead holes would immediately have wheels with axles that could be rolled on a surface. Playing with these in the different ways described in this article would easily bring up the notion of wheelbarrows or carts.

THE INVENTION OF THE WHEEL

The question of how the wheel was invented has never been answered. Books and articles often discuss, basing it on archaeological finds, when wheel first appeared, but exactly how the invention came about is less frequently asked, and that is the topic we are investigating here.

Actually, there are two parts to this question: first, how and why was the wheel first made, and second, how did it come to be applied to create the wheeled vehicle. The first question is not really difficult to answer, and this may surprise you—the wheel was not invented—it was already there, only waiting to be **discovered**. The term "uniformitarian" refers to processes, like those that have occurred

throughout geological history, shaping and reshaping the landscape of the Earth, that go on today just as they have gone on in the past. The idea presented here also has uniformitarian characteristics: what may have led to the discovery of the wheel could most certainly happen today.

Rolling megaliths

The most intuitive theory is that the wheel derives from hauling large stones on wooden rollers. The reason behind this might be that seeing a big solid object moving along with smaller round pieces (logs) revolving under it seems to be a close analog of a wheeled vehicle, which is nothing but a squarish mobile object with smaller round parts (wheels) turning around near its base, fig. 1.

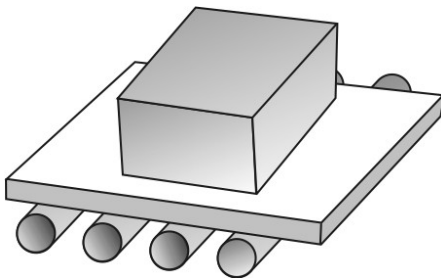


Fig. 1. Transport on rollers

However, as their paintings show, the Egyptians used sleds, not rollers to transport massive stones to build their monuments. To begin with, trees in Egypt, except for palms, were in low supply; lumber had to be imported from far off places like Lebanon. In addition, trunks for rollers would have to be all the same diameter. This would be difficult

to find in nature, and to plane them to the same diameter would require special work. For this reason alone the derivation of wheels from rollers is historically not supported, at least in the case of Egypt. The method used in transporting the stones to build the monuments at Stonehenge is not known. One theory is that the stones were moved on rollers; according to another proposal the transport was accomplished with the use of sleds.

It is true, on the other hand, that in modern times engineers have made use of rollers to move such things as the obelisk at the Vatican in Rome, in 1590. But this was for the relatively short distance of 841 feet, and it was a one time enterprise.

The fact is that sleds are far more practical because they do not require re-feeding the rollers from back to front of the load as it progresses. The sled is a single piece to be operated, unlike a load consisting of a megalith laid on top of a number of logs which are not firmly attached to either the stone or to each other. In any case, in hauling the enormous stones up on ramps supported on logs would have risked rolling back down in case of mishaps involving ropes that slipped or broke.

Let us suppose that wheels were added to sleds. These, carrying stones weighing upward from 2-3 tons would have not only created problems with wheels getting stuck, but such great loads would have deformed or even crushed wheels made of wood. Owing to the great weight assigned to them, the axles would also meet extreme resistance to rotation in their slots, even if lubricated. Of course, if the wooden wheel was also gigantic, it could withstand the weight of the load. But first, their own weight would increase the total weight of the enterprise, and second, wheels were cut from tree trunks, and the diameter of most trees rarely exceeds three or four feet. If, on the other hand, a large wheel was constructed from two or more pieces, but without metal

reinforcement, it would have fault lines ready to split. Since sleds have convex bottoms, they can be turned, whereas rotating a setup with rollers is considerably more involved. The use of sleds in Egypt was also assisted by modifying the ground surface. Whereas lubrication is not possible, nor is it necessary for roller based transport, sleds must run on special surfaces, such as snow, mud, or sand, which in Egypt was certainly not wanting. In addition, greasy substances, such as oil could also be applied. Turning would have brought on problems even if the carrying platform moved not on rollers, but on wheels. Axles that can pivot and cause the wheels to turn left and right came about as a later invention, and turning a vehicle without this ability is not a simple operation. In the end we can safely conclude that proposing rollers to be the source of wheeled transport is not a good idea.

The discovery of the wheel or Inventing without meaning to

Inventions have often been accidental, as it was with x-rays, radiation, penicillin, saccharin, teflon, just to name a few modern ones. As for more traditional ones, many of our most useful materials and devices have come about as a result of what nature dictated; overripe fruit or wet grain left unattended fermented to produce alcohol, chewing willow twigs helped headaches, and so led to aspirin, playing with magnetic ore gave the compass, and so on.

In the same way, we can imagine a scenario where the idea of the wheel or the wheel-with-axle would immediately enter the mind without wishing to invent anything. Evolution employs color and design to an astonishing extent in the design of plants and animals; this fact is ubiquitous among invertebrates, insects, fish, amphibians, reptiles, birds, and mammals. Numerous families of monkeys wear extraordinary patterns and hues on the face and in body covering, on

both the front and the back. It does not come as a surprise, then, that human beings have a marked propensity for decorating the face and the body, covering it in a wide variety of styles of clothing and hairdo, in facial makeup and jewelry. Objects of jewelry, made of relatively imperishable materials, are shown by the latest archaeological records to have been present in our early prehistory, as far back as 82,000 B.C. Our ancient ancestors made ornaments of all kinds; they were even able to cut and drill hard stones. For the present argument it is important to emphasize that the manufacture of jewelry most certainly predates the earliest known example of a wheel, dating from the fourth millennium B.C. Archaeological finds indicate that beads and discs were one of the most commonly made artifacts of jewelry. **Stone** beads from the Natufian period, from c. 10,000-8000, include circular **discs**. Researches conducted in Southeast Anatolia and Mesopotamia at a site from the Halaf period, which covered the period 6000-5000 B.C., the objects unearthed include many perforated discs made of obsidian. Obviously, these objects were created before the period from which the earliest known wheel originates, figs. 2a, 2b and 2c.



Fig. 2a. Prehistoric beads from the Halaf period, including beads and disks. Beads 8 and 9 are doughnut shaped disks.
(Source: <http://journals.ed.ac.uk/lithicstudies/article/view/966/1584>)



Fig. 2b. Prehistoric beads from Carrowkeel, Ireland, dated at c. 3800 - 2400 BC. These objects are later than the earliest wheel of the fourth millennium B.C., but they demonstrate a continuity in manufacturing beads. (Source: www.carrowkeel.com)

The jewelry maker

Necklaces and bracelets are the most basic articles of jewelry, and they are simple to make; they are beads or other small shapes threaded on a string. Beads come in various sizes and shapes, many are spherical, but they can also come in the shape of flattened balls, like a donuts, or as flat disks. In any case, they always have a hole in the center through which they were strung. And here comes the essential point: who can fail to notice that the disk shaped beads are, in fact, none other than small wheels. In addition, looking at the necklace dated c. 2600-2500 BC, from Ur, shown in fig. 2c, we can see that sections of the beaded string can, just for the fun of it, be rolled on some flat surface, and the disks lying between the long beads then serve as wheels on a soft axle.



Fig. 2c. Necklace from Ur in Mesopotamia, dated c. 2600-2500 BC.

(Source: www.metmuseum.org/art/collection/search/322912)

It is hard to think that across the long eons of prehistory there would not turn up some people working at jewelry and bead making who were handy and creative with materials and who liked to experiment and assemble things in different ways. Human beings, and most especially children are apt to handle and play with objects. These may be toys or tools or weapons. Suppose a crafts person or a youngster whiled away time playing with beads that were lying around in the work area. Sooner or later, as we all would, he or she would poke a stick through the hole in a bead. Such an action is innate in us. Chimpanzees put stems into termite holes, many birds and mammals press beaks, muzzles or hands into cavities in searching for food. Packing more than one bead on a stick would also happen quite naturally, considering that lining them up on a string is already a routine part in assembling them into bracelets or necklaces. Now, if the stick is put through two beads with some distance between them, we arrive at the prototype of paired wheels with an axle. Two disk shaped beads on an axle can be placed on a flat surface and can be rolled while holding one or both ends of the stick. It is often seen how small boys with toy cars are sure to roll it not only on a table or on the ground but on the wall, on door frames, along a fence, or on anything else with a suitable surface. This behavior is spontaneous, it could not have been different in our earliest history, and so we can safely assume that a youngster or even an adult pushing a stick through a bead would be apt to engage in rolling the contraption, fig. 3.

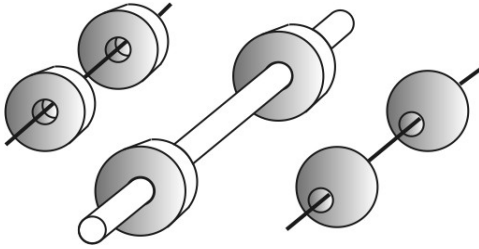


Fig. 3. Stick or rod passed through beads

The person involved in such activity would have at this point arrived at the accidental discovery of the wheel as a potentially usable article: if some hard flat object, a rectangular slab or a board, were placed on the axle with two beads which snugly fitted inside the holes in the wheels, and this object was pressed down on the axle and also pushed back and forth, the wheels would turn and the whole contraption would start to roll. This, in turn, could readily bring to mind the idea of using the axle and wheel carry a load. Building, piling things on top of each other is an action commonly found both in play and in everyday chores, and so if some object, perhaps another bead, or a pebble or a figurine is placed on the flat surface, this object becomes the prototype of a transported load.

Since the plate would not be firmly attached on the axle, it would have to be somehow combined with it. The axles could have been pushed through the flat piece if that was bulky enough, perhaps a soft block of clay, or a small gourd, etc. Craft persons like to solve problems, and can end up finding clever methods. For instance, a hollow reed that was glued to the bottom of the board would have provided a sleeve in which to house the axle. Having accomplished this, a mechanically minded person could, with high probability, construct the first basic wheel barrow, fig. 4.

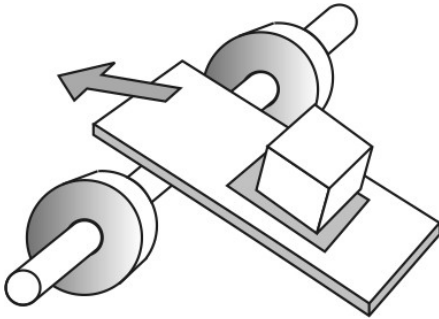


Fig. 4. Primitive wheel barrow concept

A note may be added this point. There was a device, called the travois, used by North American Plains Indians, which was a simple framework of poles tied together forming two or all three sides of triangle. Loads tied on it were dragged either by humans or horses. The travois is, of course, made of wooden branches and is therefore perishable. For this reason we can be certain whether if a prehistoric culture in the Old World had ever made use of such a tool of transportation. But if they had, then adding wheels to it, in some way as described above, would have immediately given rise to the wheel borrow.

The four-wheeled vehicle

Naturally, the invention of the four-wheeled vehicle presents no mystery because once the wheel barrow with two wheels came into existence, adding a second set of wheels would be only a matter of time. In fact, both could have been simultaneously created. In the hypothesis presented above, in which the wheel barrow prototype appears, the four wheeled cart could also have been assembled just as readily in the course of tinkering with beads, sticks and a flat piece. It was necessary only to use two pairs of wheels with axles and to lay the

flat piece over them, fig. 5.

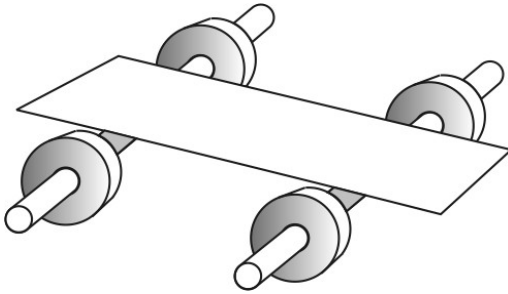


Fig. 5. Four wheeled vehicle concept

We can imagine how a toy vehicle, a model, might have been constructed, either of the two or the four wheeled one.

There are two stages in the assembly, the first is making the wheel-axle unit, and then comes adding it to the chassis. Two wheels plus an axle can be combined into a single piece if the stick or rod fits tightly in the bead hole, or if it is glued in with materials like clay, tar or resin. Before adding the wheels the axle has to be passed through the hole in the chassis, where it would be free to turn. This could be accomplished by taking a block of semi-soft clay and making a hole that goes through it. When clay dries it shrinks and so the hole would enlarge to allow the axles to turn. Alternately a woven basket or perhaps a gourd may be used as the chassis. After this the axle would be put through the hole and the wheels would be firmly attached to it on both sides. At this point, simply adding another pair of wheels with an axle would create a four-wheeled vehicle.

The role of play in inventions

We can hardly imagine that across the sea of prehistoric time persons

talented in crafts would have developed an altogether novel trait as they grew up; but rather, they would have been no different as children, and they would have played with and put together objects out of curiosity and for fun. Of course, today's technology is too far advanced; things a child or anyone else plays with are too simple for making revolutionary discoveries. However, the opportunities were certainly there in prehistory, and so was an innate inclination to make things roll. Why? Because there is a sense of entertainment when we see things rolling. In addition, for some reason we get a degree of enjoyment when by moving one object we cause another one to move in different ways and directions. For instance, we hold a pin wheel pointing forward, whereas the wheel rotates in the vertical plane; the bicycle which is driven by rotating the pedal carries the rider forward; pulling back the arrow causes it to fly forward; on the typewriter pressing down a key makes the type bar strike up and forward; you hit the ball and it flies forward, and when it hits the ground or a wall it bounces off at an angle. Rolling a ball, or a bead is no different, you give it a forward or backward effort and besides continuing on a straight path it also rotates around its own axis; the scooter or the skate or skate board gets propelled by backward foot stride, yet the resulting movement is forward. We have an ingrained interest in watching and manipulating these actions. Perhaps this is partly born out of our primate origins: when you climb a tree, after taking hold of a branch your arms pull down, but that propels your body upwards. A sense of entertainment coming from such causations is present not only in active, conscious play, but also in absent minded handling of objects.

At this time we can revisit the idea that the discovery of the wheel, as presented here, appears to fall in line with **uniformitarianism**, as mentioned at the beginning. It can be said that a person playing with beads or round perforated objects, and also with sticks or pencils, would sooner or later poke a stick through the bead and make it roll.

However, the major point to be emphasized is that wheel utilization,

unlike megalith transport, could easily have been accidentally discovered by a person occupied with handling objects at the **toy** and model size. The reason for this is clear: it is always far easier to tinker with small things, and not with big ones. Assembling a ten-inch long model ship does not demand the same time, labor, energy and cost as would constructing a life-size one measured at two-hundred feet.

The pre-Columbian wheel

The possibilities afforded by working at a small scale is definitely corroborated by the find of a wheeled toy from pre-Columbian Mexico, dated c. 1500 BC, created in a culture that did not know the wheel of utility, fig. 6. (from Ekholm, Gordon F (1945). "Wheeled Toys in Mexico". *American Antiquity* 11), <http://en.wikipedia.org/wiki/Wheel>). Apparently, without any importation from the Old World, a four-wheeled rolling toy animal had been constructed at a miniature size. It is often surmised that the wheel never became seriously utilized in these cultures perhaps owing to the lack of draft animals. However, we might argue that if pre-Columbian people were able to haul oversized stone blocks to erect monumental architecture without using animals, the same people could have equally well pulled wheeled carts. Why they were familiar with the wheel and yet not ready to put it to use remains a mystery, fig. 6.



Fig. 6. Toy with wheels from Mexico, c. 1500 B.C.

The wheel and the potter's wheel—which one came first?

The latest archaeological discoveries indicate that the potter's wheel first appeared at the close of the era from which comes the earliest example of a wooden wheel, pierced by a central hole that would have held the axle. Following this evidence we can assume that the introduction of four-wheeled vehicle preceded the introduction of the potter's wheel. On the other hand, because ongoing archaeological research has been known to revise established chronologies, and just as a matter of curiosity we can pose the question: could it have been possible for the potter's wheel to give rise to wheeled vehicles? After all, it is the simpler of the two and a simpler apparatus is easier to invent.

Is it possible that in same way as the vehicular wheel, the potter's wheel, might have come about from manipulating circular pieces of jewelry? This notion can be immediately refuted because a circular decorative disk from a necklace or bracelet, typically less than an inch across, would hardly be large enough for shaping clay pots.

But if the potter's wheel is still intuitively suspected to be in some way

related, as a sibling, with the origin of wheeled vehicles, some points ought to be considered. Once the wheel came into use, being an independent round slice of wood before it was further assembled, a potter seeing it could think of using it as the flat base for ceramic work. The earliest pottery was built with clay coils, and it is assumed that the working base would have been a bowl or a dish, since the bottoms of the pots are rounded. At one time, however, flat bottomed vessels became common and producing them required flat work bases. In this case, then, once again, it is the vehicular wheel that would have preceded the potter's wheel.

When a short rod was fixed into the center of a flat circular platform, and the rod was inserted into a hole in some stable block, the platform became a turntable which could be rotated in a symmetrical fashion, just like a wheel. But the necessarily massive block was not a wheel, and so any connection with transportation using two wheels would hardly suggest itself.

Later on came the foot operated potter's wheel. Here the axle is long, and has a second wheel attached at the lower end. When it is built into in a work table, the feet can turn the lower, or kick wheel, making the upper "throwing", that is, shaping wheel also rotate at the same time. This made it possible to throw, that is, to create perfectly round vessels, fig. 7.

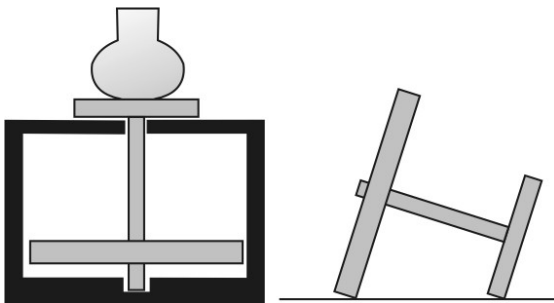


Fig. 7. The potter's wheel

Unfortunately, in proposing the potter's wheel as a possible source of wheeled vehicles, two facts need to be pointed out. True, while still a single piece, either the throwing wheel or the kick wheel, not united by an axle, could be turned on its edge and rolled the way children or adults roll hoops or barrels or other round objects. But a rolling wheel soon tilts over and falls on its side—and there is little in this event to suggest a path towards inventing wheeled transportation.

What about the foot driven version, where we have an axle that is equipped with two wheels? Here the problem is that the kick wheel needs to be considerably larger than the throwing wheel. There are two reasons for this. First, enough surface area has to be provided for the foot, and second, if the kick wheel is large and heavy, it will keep on rotating by its own momentum for a while once it has been sufficiently speeded up. The two wheels of disparate size connected by the axle, would not roll in a straight line, but in a circle. In addition, the axle would tilt at a slant, which fact would not invite one to place anything on it.

As it appears then, it is unlikely that the potter's wheel came first and led to the invention of the wheel of transport.

P.S. The Abacus

In its final form the abacus, the traditional calculating machine, appears to have first appeared in China around 1200 A.D. Therefore, it was still far in the future when the wheel was discovered. Still, it is interesting to think that had it for some reason been around in human prehistory, it would probably have brought about the wheeled vehicle. The abacus consists of counters (wheels), wires (axles) and a frame (chassis). In

the shop of the abacus maker loose abacus components would be in immediate reach. Assembling parts is a common human action; children put together blocks, Leggo pieces, jigsaw puzzles, and so on. If during play or in experimentation a person had put together an abacus in which the counter diameters exceeded the height of the frame, so that it was not the frame, but the counters that made contact with the work surface, then this abacus could be rolled, being nothing less than a rectangular chassis equipped with several rows of wheels. We can say that in this case, as well, an adult or a child tinkering with the components of an abacus could have inadvertently put together the prototype of the wheeled vehicle, fig. 8.

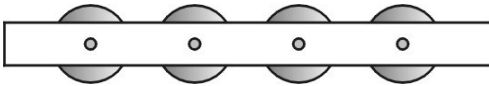


Fig. 8. Side view of an abacus with oversized counters

The end