**The Bow and Arrow Script**

Hi. Good morning everybody. How are you today? This week, I want to talk to you about the bow and arrow, and something called the archer’s paradox, which I think is rather interesting. Before that, as always, don't forget, if you click on the link in the About section below here, you can find the script for this talk, you can find questions and you can find answers. And, if you have any ideas for topics you'd like me to talk about, please put them in the comments below. And as always, if you like these talks, please subscribe and you can get them every week.

OK. So, a bow and arrow. Where … when were the bow and arrow invented? Well, we don't actually know, to be honest. They probably existed about 64,000 years ago, probably. Why don't we know? Well, because, what is a bow and what is an arrow made of? They are mostly made of wood, and the string is made of animal parts, dried animal sinew, and the arrow is made of wood as well. And what happens to wood? Well, it disintegrates. If you put it on the ground it biodegrades. It gets eaten by bacteria and it disappears. The same with trees outside that die. However, the arrowhead, the top of the arrow, those sometimes last, and they last because they're basically made of stone, or flint, or obsidian, which is a type of volcanic rock, I think. And, if you get shot with an arrow, the shaft of the arrow very well may biodegrade, but the stone will not. Now, generally, those stones look like regular stones, but quite often, if they're found inside somebody, you can say, “Ah. That was an arrowhead.” And, of course, arrows and spears are different because a spear head is much bigger than an arrowhead, because it has to be weighted for the spear to fly correctly, which means an arrowhead is much smaller. So, if somebody … if you find a skeleton with obsidian blades inside them, most likely they were shot by an arrow. So, we can guess that arrows and … bows and arrows existed about 64 – 65,000 years ago, which was the Upper Paleolithic period of human life.

Now, these people were basically hunter gatherers. The bow and arrow, they were used for fighting, but more than that, they were used for killing animals. Spears are good. Spears can be thrown pretty far, but you’ve got to be quite strong to throw a spear and it takes a lot of practice to be accurate. A bow and arrow, you can fire a lot more arrows quickly and you don't have to be that talented … that skilled to hit your target. If you can fire ten arrows, one of them may actually hit your target. So, as I said, bows and arrows generally don't survive. So, from thousands of years ago, these don't exist. Unlike swords. I mean, swords are made of metal. If you drop a sword, it's probably going to survive a few thousand years. If you drop a bow and arrow, it will have disappeared within a few years. So, we don't have any bows and arrows really. Also, we don't have any record of them because people back then didn't have a written tradition. So, it's very difficult to say when they actually came into existence.

We do know that they started in central Africa. We have found flint and obsidian blades in Central Africa from thousands of years ago, so we … well, from actually … er … about fifty thousand years ago. So, we know that that's where they started. And they spread around the world from there. Interestingly enough, they didn't actually get as far as Australia. Australia … the aborigines in Australia, they don't have a tradition of bow and arrow. They use boomerangs instead. Boomerangs actually have an advantage over a bow and arrow in that they can be lethal at a greater distance. If you're highly trained with a boomerang and you throw it, you can kill a kangaroo 2 – 300m away from you, where a bow and arrow probably couldn't reach that far. And, if it could reach that far, you’d very … you’d be very unlikely to actually hit your target. So, a boomerang can be lethal at a greater distance. Of course, a boomerang does take more training than a bow and arrow does, but that's probably why bows and arrows never developed in Australia. Also, Australia being an isolated island is probably another reason for that.

Anyway, we do have a bow and an arrow from about 9,000 B.C., about 11,000 years ago. That was found in Denmark. It's called the Holmegaard Bow, and it was found in a bog. When it fell into the bog, it was protected from the bacteria … protected from the things that biodegrade wood … and it was preserved as it is. So, the oldest bow we have in existence is from 11,000 years ago in Denmark.

OK. Now, the type of bow we found in Denmark was a straight bow. Basically, a straight bow is about the length of a person. It's made from one piece of wood. Either elm, or maple, or cedar, or bamboo in Asia. And that piece of wood was flexible, obviously, and it was strung with a piece … with a … with a bow string. And this was usually made of animal sinew, dried animal intestines, or dried animal muscle that was stretched. And when you pull it, the piece of wood is flexible, it bends, it transfers energy to the arrow. And when you release it, it fires the arrow. Now, bows like this, they have to be pretty big, basically, about the height of me. Longbows like that could fire an arrow very very far, but you had to be extremely strong to do it. Now, these types of bows and arrows were the most common to begin with. However, a bow that is as big as me is very difficult to use. It's very unwieldy. It's quite large. So, when people started to ride horses, when you had the invention of the cavalry, you couldn't ride a horse and use a longbow … a full-sized bow. So, the people in Asia, the Mongols basically, the nomadic peoples in Asia, they came up with a different type of bow. About 2500 B.C., they came up with a bow that is called a composite bow. Now, what that is … the basic straight bow is one piece of wood. It's one single piece of wood. A composite bow is made up of different pieces. You have a piece of wood in the middle, then you have a piece of horn on the inside, and then you have multiple layers of glued animal hide on the outside like this. Now, a bow like that can be much much shorter because the horn, when you pull the drawstring, the horn compresses and it stores energy. And the hide on the other side expands. And, because it is elastic, it will contract back to the original position. So, a bow like that can transfer the same amount of energy to an arrow as a longbow. And also be much much shorter. You can use a composite bow while you're riding a horse. However, composite bows are very very difficult to make. They take a long time to make. You have to season the wood, then you have to layer the wood with glues, and then you have to layer the horn and glue that on, and then you have to layer the pieces of hide and glue each one on separately as well. It takes a long time to make. And also, bows … composite bows are very very susceptible to humidity. If you live in a humid environment your bow is very likely to either warp or the glue can actually come unstuck. So, composite bows tended to exist in drier climates because they're not very strong in humid climates. And the Mongols were obviously famous for using the composite bows. Genghis Khan, with his cavalry on horses, they were famous for being able to fire arrows extremely quickly and extremely accurately. And they of course used compound bows. So that's the bow.

An arrow. Arrows were generally made of wood again. Ash, elm, willow, oak, bamboo, if you live in Asia of course. That wood had to be flexible. We'll talk about that in a second. What do you call the basic parts of an arrow? Well, up here at the end, where it nocks on to the drawstring, you have what's called the nock. Then the feathers. My arrow doesn't have any feathers, of course. Those are called the fletching. The main part of the arrow is called the shaft. And at the head, at the end, you have the head, the arrowhead. A lot of names in England and America came from professions like this. There is the name Fletcher. A fletcher was the person who put the feathers on to the arrows. There is a name Archer. An archer was somebody that fired the arrow, of course. A lot of professions from olden days have become names. Like Goldsmith, or just Smith in general, I suppose. Anyway, those are the parts of the arrow.

OK. So, bows and arrows are extremely effective. With a little bit of training, your average trooper, your average soldier, can fire it quite a long way and can cause a lot of damage to an opposing army. So, general battle would have archers in the distance who would fire arrows at each other, and then the infantry, the basic people, would charge at each other, and they would fight with swords and knives. The archers of course, would stop firing once that happened because they didn't want to hit their own troops. However, of course, in the fourteenth century, guns started to be developed and once the gun was invented the arrow stopped being so effective … stopped being so popular of course. However, in the beginning, in the fourteenth century, when guns were invented, they were too ineffective, they were too slow. It took about a minute to load and fire a gun. You had to put the charge down the barrel, then you had to put the ball down the barrel, then you had to put the kindling on the top here, then you had to light it and spark it and fire it. It took about a minute all together. Not very easy to fire of course. However, in the eighteenth century, guns started to improve. They became a little bit better and you could fire them a little bit faster. Although, still not so fast. Warfare starts to change around about then. You have … you have fewer of the two armies charging each other and more of two armies shooting at each other. basically. Then, of course, the nineteenth century, guns were changed again. You had the invention of the cartridge, the bullet and threaded barrels. A threaded barrel means that when you fire the bullet it rotates, and it can go straight. Before then, you basically had a ball, and the ball would spin everywhere, and you had no idea where it was going to go. Maybe, one out of ten bullets would actually hit the target. But, once you have rifling … a spiraled groove up the barrel … you make the bullet spin this way and it will go exactly where you want it to go. Very very straight. So, once that happened of course, the bow and the arrow disappeared. Nobody has fought with these for hundreds of years. Now, we just use them for sport and for hunting, of course.

All right. I want to talk to you about something called the “Archer’s Paradox” today. A paradox, of course, is when two or more statements contradict each other. For example, in time travel, we talked about the grandfather paradox. You cannot go back in time and kill your own grandfather because that would negate your being in the present and you couldn't make the time machine to go back and kill your grandfather and it’s a circle. That's a paradox. Well, the archer’s paradox is this: If you have … if you notch an arrow on your bow, and you pull it … generally the arrow goes this side of the bow ... where is my arrow pointing? It's pointing off to the left, over there. My bow is pointing at the target. If I point the arrow at the target, my bow is pointing off over there. So, the archer’s paradox is this: How can an arrow that’s pointing away from the target, hit the target? That's the paradox.

Now, there are three ways that this paradox is solved. Well, it's not really a paradox, I suppose, but there are three ways this works. The first way is with a general longbow. When you fire the arrow, because the arrow is made of a very flexible wood, the arrow bends like this. So, when I transfer the energy from the drawstring to the arrow, what actually happens is the arrow bends like this. The drawstring comes over here. The arrow flexes this way, and bends like that, and then when it goes past the bow it flexes back again, and it flexes through the air like this, as a snake, all the way down until it hits the target. So, because the arrow is flexible, the archer’s paradox is not a paradox. The arrow goes round the bow and hits the target. People obviously knew that even though you were aiming at the target you could still hit the target, but it wasn't actually proven … people didn't know why that was until the 1920’s. And what made it possible to prove was the existence of slow motion filming, of course. Up until the 1920’s, people couldn't video slow motion. You can't see an arrow. It goes too fast. But, with slow motion video, you can actually see this movement. And, if you look on YouTube, you can find lots of videos of an arrow doing this through the air. It’s very very impressive. So, the first way that the paradox was solved, well, the first natural way the paradox was solved, was that: using a flexible arrow that curves itself around the bow.

The second way is done in Asia, in basic Japanese archery, kyudo. What happens there is, the arrow is on the other side of the bow. When you have an arrow on this side of the bow, as in most archery, the drawstring will always hit your wrist here. Like that. So, you have to have a leather pad here on your wrist to protect your wrist. In Japanese archery, the bow … the arrow is on the far side of the bow, like this, and you fire, like this. And you pull the arrow back, past your head. You pull your arrow back to about here. So, generally, you have this kind of posture, with the arrow pulled back almost as far as your ear. And when you release it, again, you have the same problem. The bow is pointing at the target, the arrow is pointing away from the target. So, how can the arrow hit the target? This is the archer’s paradox again. Now, the Japanese way of overcoming this problem is thus. When you grip the bow in Japanese archery, you keep your hand very very tight, but not on the bow itself. You basically form a shape like this with your hand and your fingers press tight together, but they leave a space in the middle there, and that space holds the bow. So, when you pull the drawstring, the bow is resting against the space between your thumb and your forefinger there. You don't actually have to hold the bow. Now, as you pull the bow, you start like this, as you draw the bow, it ro … …Ah! I broke my bow! This is my daughter's bow! Oh dear. She’s not going to be happy! … As you pull the bow … as you pull the drawstring, the bow rotates in your hand, and it catches against the loose skin and it becomes under tension. And, when you fire the arrow … when you release the arrow, the bow rotates in your hand. So, you fire the arrow this way, but the bow rotates, putting the arrow in line with the target. You fire and the bow rotates in your hand and the arrow goes round, comes around in line with the target, and does the same thing as a Western bow: it snakes through the air like that, and hits the target. So, that's the second way of overcoming the archer’s paradox.

The third way of overcoming it. Modern bows, of course, are not made of wood, they're made of many different materials. And, because modern materials are much stronger than wood, are much stronger than composite bows, you don't have to worry about the shape so much, so you can actually cut a space out of the middle of the bow. If you look at an Olympic archer, they pull their arrow … they draw their arrow right in the middle of the bow. It goes through a space cut out of the bow, like this. So, they are actually firing directly at the target. So, the archer’s paradox doesn't exist anymore with modern bows. You can fire an arrow straight at a target. I’m not very good at that.

OK. That's basically the archer’s paradox, and the history of the bow, which I thought was quite interesting thank you for watching.

I thought I’d show you a little bit more about how to use a Japanese bow. This is the arrow, of course. Here’s the nock, here’s the fletching, the feathers, the shaft, and the arrowhead. This is a Japanese bow. This is a glove. It’s called a “kake”. This glove is made of deer hide and this is basically for catching the drawstring. This is a hay bale over here. You’re not supposed to fire an arrow with feathers into a hay bale, but I'm going to do it just so I can show you the arrow with feathers, itself. As I was saying earlier, you don't hold the bow as tight as you do a Western bow. And also, you fire the arrow on this side not on this side. I'll try and show you. I’m not very good, but I'll do my best.

OK. So, we start like this. We raise the bow. We notch the arrow at eye height. Hooking it to the drawstring. It’s quite a long bow, as you can see. Ok. The hand down here. We look at the target. Check the bow is OK. And then we hook the thumb part of our glove on the drawstring here. Then we grip the bow here, but as I said, you've got to be careful not to grip the bow too tight. It basically just rests in your hand, and as you turn it, it pulls the skin in your fingers. Ok? So, we raise the bow up. I'm supposed to be looking at the target, but I’m looking at the camera. You raise the bow up. Then first we turn our hand. And then if you can see, but right now I don't need my fingers here, the bow is just resting in the crook between my thumb and my forefinger. Ok? We pull the arrow down. And it should be resting about your mouth height. And then as I fire, the bow should rotate. And that's it. That's how you fire a Japanese arrow. If I play that in slow motion, you might be able to see it. I'll try.

Anyway, thanks for watching. Don't forget, if you look at the About section down here, you can find the link to the script for this, and questions and answers. You can practice listening, your writing, your reading, and even your speaking if you did the answers out loud. If you liked it, click like. Share it. If you want to subscribe, that's over here somewhere, it looks like my head. Please subscribe. These are every week. You can watch and learn and improve your English and learn something. Thank you. Have a nice day. Bye.

**The Bow and Arrow Questions**

1. Why don’t we have any very old bows and arrows left?

A: Because wood disintegrates.

B: Because swords survive.

C: Because they were too expensive.

D: Because people burned them.

2. Which of these is not a material arrowheads are made of?

A: Flint

B: Wood

C: Stone

D: Obsidian

3. What advantage does a bow and arrow have over a spear?

A: A bow and arrow takes a lot of training.

B: You can easily throw ten spears in a minute.

C: Bow and arrows are much easier to make than spears.

D: You don’t have to be as strong to use a bow and arrow.

4. What advantage does a boomerang have over a bow and arrow?

A: A boomerang can be lethal at a greater distance.

B: A boomerang takes a lot more training.

C: A bow and arrow is much easier to make.

D: A bow and arrow can go much farther.

5. Why was the composite bow necessary?

A: Because it could fire an arrow as far as a longbow.

B: Because you couldn’t use it in humid countries.

C: Because you could use it while you rode a horse.

D: Because it was very difficult to make.

6. What was the purpose of the horn on a composite bow?

A: It compresses and stores energy.

B: It makes the bow look good.

C: It is very elastic.

D: It is difficult to find.

7. What is the fletching on an arrow?

A: The main piece of wood.

B: The notch at the top.

C: The feathers.

D: The point at the head.

8. In a battle, why would archers stop firing when the two sides met in the middle to fight?

A: Because they would run out of arrows.

B: Because they did not want to hit their own troops.

C: Because they couldn’t fire that far.

D: Because they wanted to get more arrows.

9. What is rifling?

A: A spiral groove in a gun barrel.

B: A type of bullet for a gun.

C: A method of firing a ball.

D: A large gun that replaced bows.

10. To cope with the archer’s paradox, which of these arrows would hit the target?

A: A short one.

B: A long one.

C: A stiff one.

D: A flexible one.

11. What helped people to see the way an arrow moves?

A: Slow motion video.

B: YouTube.

C: The invention of the gun.

D: Using multiple cameras.

12. How does a Japanese archer overcome the archer’s paradox?

A: By using a shorter bow.

B: By using different arrows.

C: By turning the bow.

D: By using a longer drawstring.

13. Why did it take 64,000 years to find an improvement over the bow?

14. Warfare has evolved over the last few centuries. How do you think warfare will evolve into the future?

15. Will we ever have a society where weapons are not necessary?

**The Bow and Arrow Answers**

1. A 2. B 3. D 4. A 5. C 6. A 7. C 8. B 9. A 10. D 11. A 12. C

13. Why did it take 64,000 years to find an improvement over the bow?

There are two reasons why the bow wasn’t superseded for millennia. Firstly, there is the old adage: if it isn’t broken, don’t fix it. The bow worked perfectly. It did the job it was intended for and it did it well. With a bow you could kill animals, you could kill people, and you could do it at a sufficiently great distance that you were safe from attack. You could fire arrows very quickly. The army with the larger number of archers stood a very good chance of winning. Armies developed techniques such as shield formations in order to advance under arrow fire, but there was no great solution. A rain of arrows was lethal. So, there was just no need to replace the bow and arrow with something else.

The second reason, until the discovery of gunpowder, there was nothing else. Why did it take 64,000 years? Because that’s how long it took to discover gunpowder. You might just as well ask, why did it take a million years to make the wheel. Because that’s how long it took. There is no deeper reason. And, once you have gunpowder, you can start making projectiles go farther. But, even with gunpowder, it was a few hundred years before the gun could out shoot a bow and arrow.

So, the bow was replaced. But, it was the best long distance available for thousands of years.

14. Warfare has evolved over the last few centuries. How do you think warfare will evolve into the future?

Warfare will become automated as we go into this century. We are already beginning to see that with autonomous drones. They are controlled by a “pilot” back in the home country, but they are also capable of flying on their own. There are also autonomous gun robots that the US army are using. These are basically a small, wheeled vehicle with guns. This mini-tank is capable of operating on its own for hours at a time, and even has the capability of selecting its own targets. This is rather a scary prospect, but it exists and is currently in use. These two things exist at the moment, so the logical assumption is that the trend will continue and more of the army will be automated, until the human element is all but completely removed.

This has advantages and disadvantages. An obvious advantage is that the number of human causalities will be greatly reduced. If people are safely in their home countries and fighting with proxy robots, there will be fewer deaths. Wars would presumably be shorter as well. Robots wouldn’t tire, and a battle would be over in a fraction of the time it would take a human force.

There are also numerous disadvantages. The obvious one being, if AI systems can select their own targets, how do we trust them? How do we know that they won’t turn on us? Another disadvantage would be the lack of humanity. An autonomous machine would decide to kill or not, based on an algorithm. There would be no humanity involved. A third disadvantage would be the lack of fairness. If, at some future date, wars are simply fought out between robots, then all well and good. However, until then, the side with the money (most probably the US) will have access to these autonomous machines, and they would send them against the simple soldiers of poorer countries. Soldiers from rich countries would be safer than those from poor countries.

As you can see, there are both advantages and disadvantages. However, whatever we feel, the first steps towards this future have been taken, and there is no way to turn back.

15. Will we ever have a society where weapons are not necessary?

I would like to think that we will, but it is very difficult to imagine. First, to discuss this, we need to define “weapon”. I don’t see a weapon as something that is used to hunt or for sport. A weapon is a tool used to inflict harm or death on another person. Thus, a bow and arrow can be a weapon or not a weapon depending on its intended use.

We will stop using weapons if we have no need of them. Where does the need come from? It comes from want. Want of something you do not have. That can be wanting a country, wanting someone’s money, wanting someone to believe the same thing that you do, wanting to be richer, and so on. So, to remove weapons, we must remove want. If everybody in the world were truly equal, then there would be no weapons. A world like that would be truly splendid and truly peaceful.

Can we every reach that point in our evolution. I don’t know, but I think not. Human nature imbues us with an unconscious need to compare ourselves to those around us. And countless studies have shown that our happiness is based not one what we have, but one whether what we have is better or more than what our friends have. If you want to make a world without weapons, then you either need to find a way to suppress human nature, or you need to find a way to give all people on Earth exactly the same things. Neither of which I see happening anytime soon.