Volume 1: July 2017

Scholars

SCIENCE

A journal of scientific and technological thought by JFS Scholars

Editor's introduction to *Scholars*

I recently came across a music protest video of a young American rapper. In it he comes before the jury and deplores that in a hundred years communication technology has progressed from telegraphs to email, vehicles have developed from steam engines to bullet trains and yet the education system remains strikingly similar to the Victorian era with pen on paper, rote learning and standardised curriculum and testing. 'Ladies and gentleman of the jury' he protests 'the intellectual activity is limited in this ancient institution.'

This journal you are about to read is a response to that disgruntled rapper. The JFS Scholars programme recruits the most ambitious and committed intellectuals in JFS and trains them into burgeoning academics. In Scholars there is no dictated curriculum, nor easy answers to be rote learned. Everything is student led. Students select their own line of enquiry, seek answers to their own pressing questions and synthesise their findings independently. The result is two fascinating journals: *Scholars - Arts* and *Scholars – Science*.

Our scholars share a thirst for knowledge, a critical mind, and a meticulousness approach to detail, and above all a keenness to share their understanding. These students have collaborated with each other – Year 12 have provided coaching to Years 7-9 and Year 10 have peer reviewed each other's articles. This is a very dedicated and important cohort in JFS and I am so delighted to share with you their inspirational and expert research.

Miss Sassoon – Curriculum Enrichment Coordinator,
July 2017

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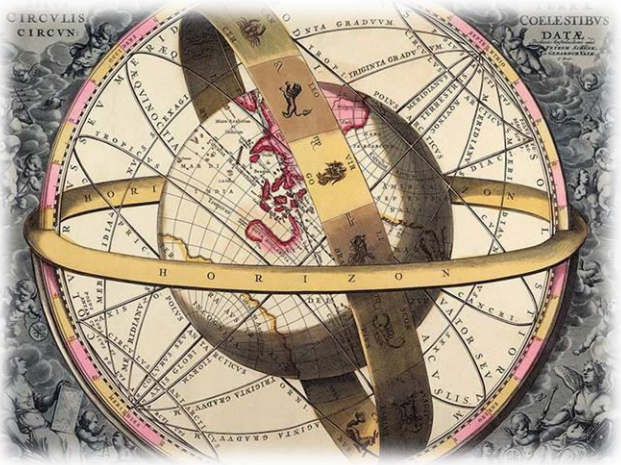


The Bermuda Triangle: Fact or Fantasy?

Ryan Bentley 7AS

Located between the Bermuda Island, Miami, and Puerto Rico, The Bermuda Triangle – also known as Devil`s Triangle – is the +-cause of much dispute. Numerous planes and ships have disappeared in this area under 'mysterious circumstances', leading many to wonder whether there is a logical explanation for this correlation. Much dispute has erupted over the reason for these odd occurrences: some blame UFO`s and time travelling, whilst others blame methane levels. So; what really is the cause of all these disappearances?

Strange happenings were first observed by Christopher Columbus, who, in 1492[1] wrote about bizarre compass readings in his log of the area. Despite this, the triangle did not receive its name until 1964, when Vincent Gaddis used the term 'Bermuda Triangle' in an article about the disappearance of Flight 19. In December 1945 five avenger torpedo bombers were on a routine training exercise, the plan being for them to fly to the Bahamas, where they would practice dropping their bombs, and then return to the Fort Lauderdale Naval Air Station. The flight squadron called 'Flight 19`, made their last communication with the control tower at 19:04 on December 5th 1945.

So what happened to these five avenger bombers who were mysteriously never seen again? Ninety minutes after take-off, Lt. Charles C. Taylor, the squadron commander, announced over the radio, that his compass was malfunctioning and he thought they were somewhere around the Florida Keys, a chain of islands to the south of Florida. Taylor thought that due to compass problems they had flown south instead of east, along the path they were meant to take. The control tower then commanded the squadron to head north to Miami; Taylor followed this command and unintentionally drove the squadron further out to sea. Flight 19 was never seen again. This is just one of many mysterious cases of ships and planes disappearing within The Bermuda Triangle.

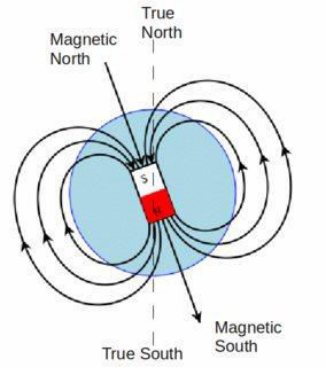
"Some people believe that Unidentified Flying Objects (UFO`s) have been abducting ships and planes"

A more modern example includes The Cyclops (one of the Navy`s largest fuel ships) was journeying from Brazil to Baltimore when it became a 'victim' of the Bermuda Triangle. Last spotted on 4th March 1918 in the West Indies, neither the ship, nor the three hundred passengers and staff onboard ever arrived in Baltimore. This incident was especially mysterious since, according to a 'New York Times` account[2], the captain never sent any type of distress signal. In addition to this, 'The Times' alleged that, at the time, there were no strong storms, indicating that extreme weather was not to blame.

Furthermore Flight 441 was a huge carrier plane (R7V-1) belonging to the US Navy. The airplane was the best of its time. On the 30th October 1954, Flight 441 took-off from a Naval Air Station in California, bound for Lajes, Azores. Like many other Bermuda Triangle incidences, the plane never arrived at Lajes. Initially, regular communication occurred between the carrier and the control tower. Their last transmission was a regular location update, informing the control tower that they were 400 miles off the coast. That was at 23:30; the ship and all its 42 passengers were never heard or seen again. The disappearance of Flight 441 remains as one of The Bermuda Triangle`s biggest mysteries. No debris or flotation devices were ever found during the long, extensive searches, which is why many speculate that something bigger than a simple plane crash is the explanation for this.

There are many theories as to what causes the strange phenomena's in The Bermuda Triangle. Many scientists believe that the calamities that occur in the Bermuda Triangle are caused by a rare formation of hexagonal shaped clouds[3]. Meteorologists have confirmed that these clouds are like air bombs, which can send winds to the ocean, of up to 170MPH causing catastrophic events.

Another scientific explanation is Compass Malfunctioning. This explanation uses the distinction between magnetic north, the north a compass will point to, and true geographical north, which is the direction of the North Pole. Ships and planes always make an adjustment to their map in order to make sure they are heading in the correct direction. In The Bermuda Triangle however, there is a thin strip where both these Norths are the same, and therefore no adjustment is needed. As we don't know exactly where that thin 'strip' is, some say that ships and planes in this region go off track and get lost, or run into difficulty.



Electronic Fog - This theory is that ships and planes get engulfed in an electronic fog which follows them, eventually causing all electronic equipment to fail. It is said that the ship or plane either disintegrates or disappears without a trace. Canadian Scientist John Hutchison[4] has proven that this electronic fog does cause some strange phenomena.

UFOs - Some people believe that **U**nidentified **F**lying **O**bjects (UFO's) have been abducting ships and planes with all their passengers, leaving no trace. This idea was first introduced by Steven Spielberg, in his sci-fi film, 'Close Encounters of The Third Kind'. However, one can quite easily conclude that this could not possibly be the explanation for the many calamities.

There are sceptics who believe that there is no mystery at all, they say that there is no difference between these disappearances and those in other areas of the sea as there is no evidence pointing to whether there is a cause or not for these disappearances.

I would agree with the theory of 'Magnetic and True North'. This is because it is clearly the most probable explanation for the many disasters that occur in The Bermuda Triangle. This theory stands out from the rest as it is one of the only theories that can be proven with scientific reasoning. Whereas, UFO's cannot be proven in any way.

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Black Holes and M-Theory Explained.

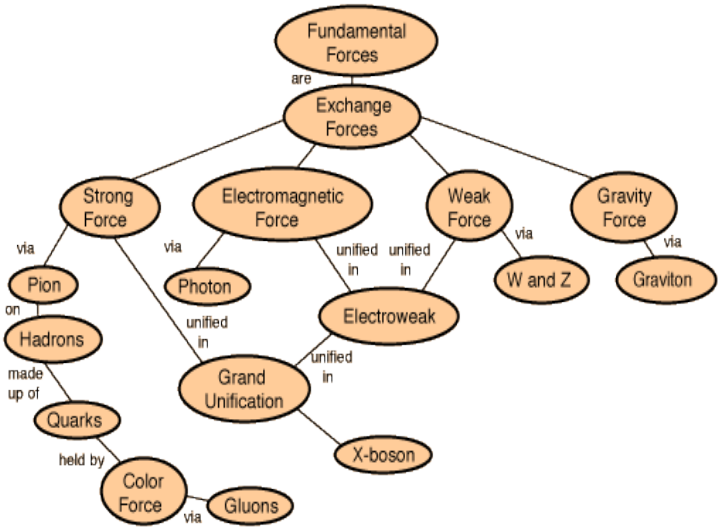
Asher Jayson 8AK

What do you think is the smallest thing? You might think that it is an atom. If you know science in a bit more detail you might know that it is a proton or neutron. However there is something smaller, these are called quarks, which make up protons and neutrons. All of these particles are proven by evidence. But what's more interesting is that there is a theory that there could be a particle even smaller than quarks. These are called super-strings and come under a theory called M-theory. Some people say this is Einstein unfinished work. It was based on the work that to try and connect the macro world of relativity (things like gravity) to the complex micro world of quantum physics (things like particles).

"if you theoretically went into a black hole and then after one year you came out then Earth would be thousands of years older than when you left"

In this article I'm going to explain how M-Theory works. Many theoretical physicists wanted to continue Einstein's work, this became known as M-Theory, which is the general name for theories using one-dimensional fundamental strings. It is also sometimes called String Theory. This started in the 1960s. Firstly, we need to understand how fundamental forces work through diagram 1. This diagram shows that there are four fundamental forces. Three of which we understand how they work e.g. the electromagnetic force is shown via photons. The forth force is gravity; physicist predict that it is shown via the 'graviton'. This is part of what M-Theory is trying to investigate.

Black Holes are a famous phenomenon; I am going to explain what they are and how they link to M-Theory. Black holes are what are left from 'dead' giant stars.



Why is gravity the only one that physicists do not know?

This diagram shows that at the big bang there was one fundamental force however we cannot trace any evidence of this force even though we do find traces of a 'Grand Unification' stage where all known fundamental forces apart from Gravity were one.

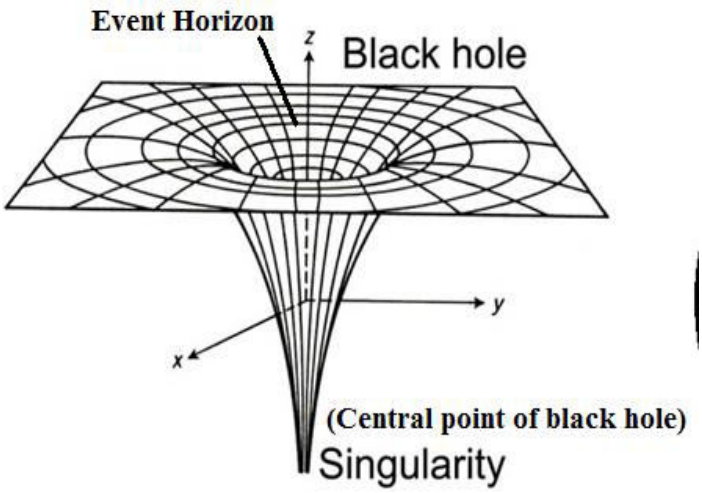
After this stage the 'Strong Nuclear' forces breaks off causing there to be an 'Electroweak force', the only known multi-force left at that time. However on this diagram, X-bosons and Gravitons are theoretical. This is related to M-theory as this is one of the 'mysteries' that need to be answered. The Strong nuclear force (the force related to holding together nuclei) works with gluons,

Weak nuclear force (the force that changes quarks into different types of quarks) with W± and Z° bosons and Electromagnetism with the Photon. These are the forces that make up every force in the universe

Much of the time, galaxies orbit around a Black hole in the centre. Black holes are called Black holes because nothing can escape them even light, once something gets past the event horizon. Because of Black holes giant gravitational pull and bending of space time the closer something gets to the singularity (centre) of the black hole the faster time is for that thing near the singularity relative to objects further away from the singularity (see diagrams 2 and 3). This means that if you theoretically went into a black hole and then after one year you

came out (this is impossible) then Earth would be thousands of years older than when you left (if you instantly teleported to the black hole and then instantly teleported back to Earth). So you can time travel if you could survive a black hole.

Diagram 2



Black holes link to M-Theory because: Black holes could be an interlocking of branes. Branes are objects that have any number of dimensions, which is part of M-theory. Theset could have edges or even be spikey from a certain point of view, not whole or spherical as we usually perceive black holes to be. However this 'knot' is unknown, but with recent works within M-Theory means that there are stronger and stronger theories are being made about this 'knot'. However it must be noted that Einstein proved Black Holes exist mathematically; and now we can spot them with large telescopes but branes still remain theoretical as they are an element of M-Theory.

Diagram 3

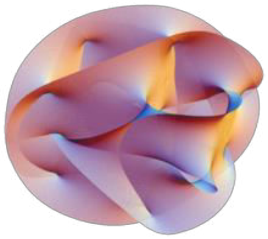
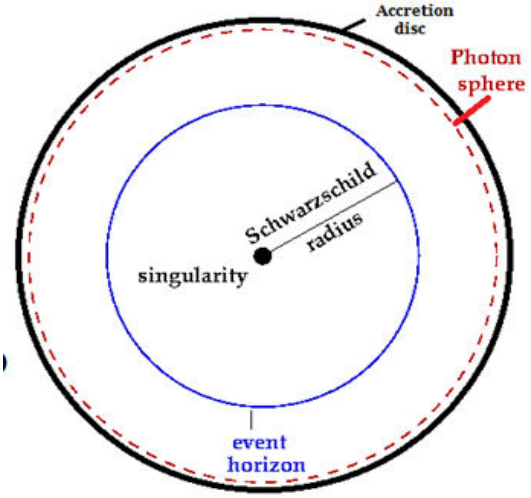


Diagram 4



Glossary for black hole diagrams

Singularity: Where a gravitational field is infinite and everything merges to one point physical laws are indistinguishable

Event Horizon: The boundary around a Black hole where once pass nothing can escape

Schwarzschild radius: The radius of a sphere where if all the mass of an object is compressed into that space then then the escape velocity (minimum speed to leave an objects gravitational pull) is the speed of light.

Photon Sphere: The area around such a large gravitational pull that it's strong enough to force photons into orbit

Accretion disc: A disk of orbiting matter that because of friction and gravity increase in temperature, causing electromagnetic radiation

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Do Quantum Computers Hold The Key To Secure Communication?

Natalie Shapiro 9WM

In 2015, over 177 million personal records were exposed worldwide in 780 publicized breaches[1]. 46% of global organisations said that they expected a cyber attack in the next year, with only 38% claiming they are prepared to handle one[2]. Across the globe cybersecurity is becoming an increasing problem, as important data are being uploaded to the internet every day, and thus becoming potentially vulnerable to hackers.

One of the most common algorithms used online to encrypt data is the RSA algorithm, based on the difficulty of factoring large numbers. However, as computing power increases, the RSA algorithm is becoming far less secure. In particular, recent breakthroughs in quantum computers bring us closer to revolutionarily powerful machines which would render RSA and similar algorithms completely unsafe[3]. However, quantum computing also provides an alternative method of encryption. By exploiting the laws of quantum mechanics, a cryptography system could be created that is provably un-hackable, governed by the laws of physics.

The concept of quantum computers stems from one of the most fundamental concepts of quantum physics - the idea of superposition of states. This idea is demonstrated in the famous Double Slit experiment, first devised by Thomas Young.

The experiment consists of a light source, a barrier with two slits for the light to pass through, and a screen to reflect the light hitting it. As light is made up of particles called photons, we would expect it to act as any other particle, ball or bullet would. This is shown in Figure 1 – the photons, shot one at a time from the light source, would pass through the slits, continue in straight lines and form vertical lines on the back screen.

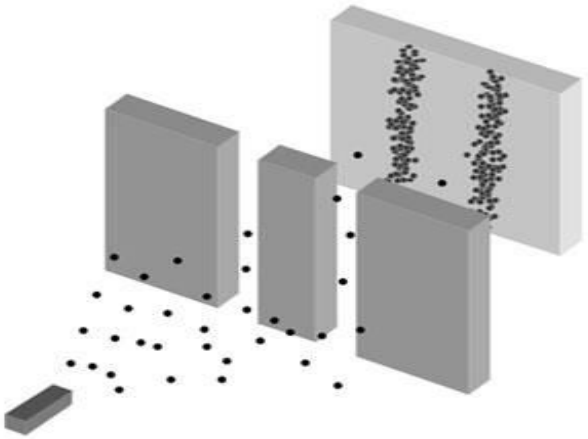

Figure 1 - Expected Result of Double Slit Experiment

However, the light does not behave as expected. As the light waves pass through the slits, they spread out. Where the waves touch, or intersect (as represented by the interlocking circles in Figure 2), interference occurs - where the trough of one wave meets the peak of another, the waves cancel each other out. However, if two troughs or two peaks are combined, the amplitude increases. This causes an interference pattern on the back screen, as seen in Figure 3, with intense light where the waves superpose, and darkness where they cancel each other out. This pattern also occurs with other types of waves, such as water, and seems to prove that light is a wave.

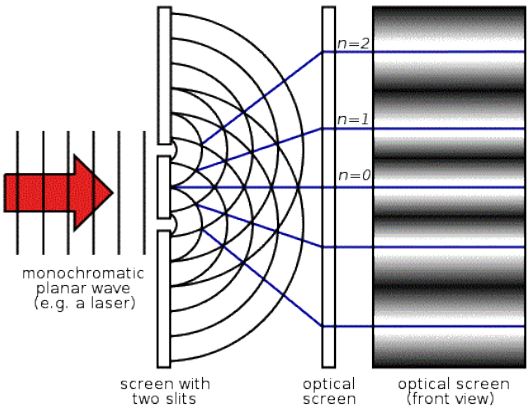

Figure 2 - Actual Result of Double Slit Experiment

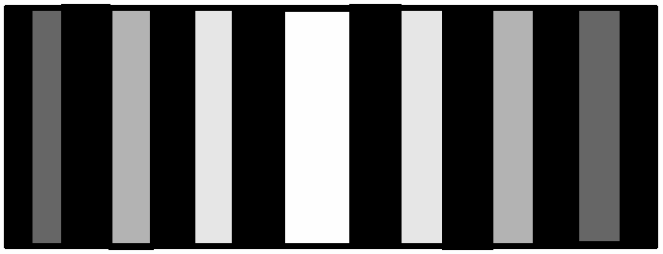

Figure 3 - Interference Pattern

In summary, we see that when photons are fired at the screen, one by one, the same interference patterns is made as with waves. This cannot be explained by classical physics, so quantum theory must be used instead.

"By exploiting the laws of quantum mechanics, a cryptography system could be created that is provably un-hackable"

Quantum theory explains that as we do not know which slit the photon went through, we should assume that it went through both at the same time. When the photon does this, it is said to be in a superposition of states. This superposition can explain the interference pattern, as the particle is fired, goes through both slits at once, interferes with itself, and finally chooses a state as it hits the screen.

Quantum theory has many applications, but one of the most important, particularly in the near future, is quantum computing. One of the main advantages of this is that the superposition of states allows them to perform multiple tasks at the same time. For example, classical bits can be either set to 0 or 1. As a result, 4 bits could be set to one of 16 options (0000,0001,0010,0011, etc.).

However, as long as quantum bits, or qubits, are unobserved, they remain in a superposition of states. Their definite state, which will be discovered when measured, cannot be predicted. [4] This means that 4 qubits in superposition could theoretically be in all 16 states at once. This number grows exponentially, meaning that 10 qubits can already be in 1024 states, and only 30 can be in over 1 billion configurations at once. This massively increases the computing power, and mathematicians have created methods to use this power efficiently, especially for cryptanalysis. This all stems from the fundamental concept that photons can be in a superstition of states, or act as if they are in two places at once.

An interesting application of this is Shor's algorithm, devised by Peter Shor in 1994. It explains how a quantum computer could be used to factor large numbers, which is exactly what is needed to break the RSA algorithm. In 1993-1994 it took 600 computers 8 months to factor a 129 digit integer [5]. It is estimated that Shor's algorithm would be able to factor a number a million times bigger in one millionth of the time. This would enable access to encoded information sent across the internet, and would create huge privacy and security concerns.

Luckily, by the time that quantum computers are powerful enough to break these ciphers, they should also be able to provide us with an alternative, much more secure and fundamentally different method of encryption.

"Companies such as ID Quantique, MagiQ Technologies, SeQure Net and QinteiQ already offer commercial QKD products."

The main mechanism works by sharing a long list of random numbers between two parties, Alice and Bob. The list can then be added to a numerical representation of the data, encoding it. For Bob, decoding the information is easy, as he simply has to subtract the numbers in the list from the encoded data. However, for a third party eavesdropper, Eve, who doesn't have the list of numbers, decoding the message is impossible. This generic process of encoding the message with a list of numbers is called the One-Time Pad algorithm, and was invented by Gilbert Vernam in 1917[4 Pg. 194, 195].

However, the problem with this process has always been sharing the list of numbers, often called a key, in a secure way, which is where quantum physics comes in useful, in a process called quantum key distribution (QKD). The next few paragraphs will explain this process in detail.

The most common protocol used for QKD is the BB84 Protocol, invented by Charles Bennet and Gilles Brass in 1984. In this protocol, information is sent by changing the vibration angle of the photon being sent, also known as the polarisation. BB84 uses four polarisations - represented as ↕,↔, \ and / There are two schemes used to encode the data - rectilinear (+) and diagonal (×). In the rectilinear scheme, ↕ represents 1 and ↔ represents 0, while in the diagonal scheme / represents 1 and \ represents 0. The polarisation of a photon can be set using polarisers and measured using Polaroid filters[4 Pg. 332, 333, 6 Pg. 195-197]. Figure 4 shows these.

Just as Alice must choose a scheme to encode the data, Bob must choose a scheme to measure it in. If he uses the correct scheme, e.g. the diagonal filter for a diagonally polarised photon, he will receive the correct data. However, if the wrong scheme is used, in this case the rectilinear filter for the same diagonally polarised

Figure 4 - Polarisers(Left) and Filters(Right)

photon, the photon will randomly choose a polarisation that matches the filter used, becoming polarised vertically half the time and horizontally polarised the rest. Alice can use this to convert a randomly generated binary key into photons. For each bit, she picks a scheme to encode it in, switching between them at random.

When Bob receives the photons, he has no way of knowing which schemes Alice used, so he also chooses at random, and converts them into a string of binary digits. He then sends Alice the list of which schemes he used to measure the photons (over a regular, insecure, network) and she sends the ones she used back to him. They discard the ones that were different, leaving them with just the bits where Bob used the correct filter. This can now be used as the correct key.

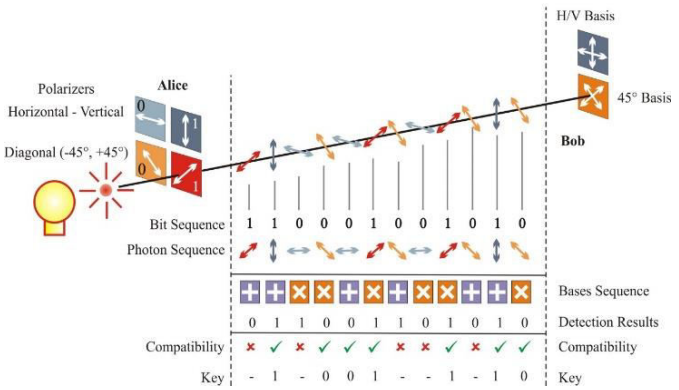

Figure 5 - Diagram of the BB84 Protocol (7)

In this method, demonstrated in Figure 5, even if Eve intercepts the photons and the message, she would have used different filters to Bob. If he uses the wrong scheme it doesn't matter, as it can just be discarded. However, if Eve uses the wrong filter and Bob uses the correct one, she will not have that part of the key and so will not be able to decipher the message.

Perhaps even more importantly, though, is the fact that if Eve uses the wrong filter for a particular photon, the polarisation has a 50% chance of changing. This could lead to a scenario where Bob uses the correct filter, but due to Eve's interference does not receive the correct bit. By comparing some of the bits that they have confirmed should be correct (after communicating which filters they used, also with the insecure system), Alice and Bob can use detect whether someone is trying to intercept their communication. If at least one of the bits is different, they simply start the process again. If they compare a significant number of bits, which are all correct, they can be almost 100% certain that their key is secure - with just 73, the chance of Eve being undetected is less than 1 in a billion. They should discard the digits shared, as they are insecure, and now have a key that can be used to communicate securely using the one-time pad algorithm.

While QKD is un-hackable in theory, weaknesses in the hardware can be exploited. One kind of attack is the Trojan Horse Attack, where Eve shines a light back towards Alice after she polarises the photon [8]. This allows Eve to see which of the 4 polarisers was used. However, measures can be taken to prevent this, such

as using filters that only allow certain types of light and only allowing light to pass through at specific times. Even if these fail, Alice will still know that they are being intercepted and can just start again. Other methods involve tampering with Alice's software, such as copying and sending the information before it is encrypted, or a random number generator attack, where the key is not randomly generated, and instead becomes a list of numbers that Eve has previously chosen.

QKD is already being used, with experiments being carried out to try and extend the range. In June 2016, a group from the University of Science and Technology of China in Hefei managed to successfully use QKD over 311 km of standard optic fibre cables, and 404 km of ultralow-loss optic fibre [9]. Companies such as ID Quantique, MagiQ Technologies, SeQure Net and QinteiQ already offer commercial QKD products [10, 11]. Most notably, ID Quantique's QKD system was used in the 2007 Geneva elections in the first real-world application of quantum cryptography [12].

Quantum computing and cryptography are still in their early stages, and with quantum computers at their current level it could still be many years before they are widely used. However, the systems do exist, and once they do become more commonly used they will surely revolutionise cryptography forever.

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Homo Egoisticus *or* Being Human

Gideon Bernstein 10BG

Man rules the world. The belief in humanity's superiority has been ingrained in us as individuals and as a society for thousands of years. 3200 years ago, it was enshrined in the most popular book of all time, fervently believed in by 2.2 billion people worldwide 'Let Us make man in Our image, according to Our likeness; and let them rule over the fish of the sea and over the birds of the sky and over the cattle and over all the earth, and over every creeping thing that creeps on the earth.[1]' It is only recently with the popularisation of secularism that this sentiment has been removed from large parts of society, and it has come to be accepted (in the west) that animals and nature deserve at least some protection from cruelty and abuse, as seen by the proliferation of charities aiming to save nature from ourselves. And with this advancement of animal rights movements, knowledge and interest, we have come to realise that maybe we are not so different from the 'lower orders' as we thought.

"Hariri says there is precious little that sets humans apart from animals, and in many respects humans are actually inferior, being weaker and slower and possessing fewer weapons than most animals."

Although it may be only recently that we have begun to come close to discovering the root of our differences with animals, it is not a new question. In the 4th century BCE, Aristotle pondered this problem, and came to the conclusion that only man is capable of reasoned judgment, and this sets him apart from animals [11]It is almost certainly true that the intelligence of human beings is greater than that of animals, however, we are discovering more and more evidence that suggests many animals possess more reasoning skills and have greater intelligence than we had previously believed. Experiments with rhesus monkeys, chickens and robins have shown that they have an ability to use basic arithmetic and count[2], animals as varied as crows, octopi and elephants have been shown to use tools[3], and chimpanzees have been shown to be able to learn how to cook food – a skill that requires planning, an ability to delay gratification, and the ability to use fairly sophisticated tools[4]. Chimpanzees have even been observed behaving in ways that seem to imply a kind of cult – building 'shrines' of rocks beneath some trees, in behaviour that many scientists believe to be at least proto-ritualistic, and at most religious[5]. but even with this knowledge of the wide range of cognitive ability that animals can display, it is undeniable that humans are able to perform all these tasks to a higher level than animals can, after all, it is hard to imagine that a chimpanzee would be capable of producing a steam engine or making cloth, for example, even though they may display many the necessary cognitive traits to perform these tasks (the ability to plan, solve problems, use and adapt tools, and some sense of arithmetic). Therefore we can say that although Aristotle may not be correct when he says that only man can reason, it may be reasonable to suggest that humans can reason on a higher level than most animals.

Another aspect of the human condition that has in the past been cited as that which sets man apart from animals is consciousness. And here we encounter problems. Consciousness is best defined as 'The having of perceptions, thoughts, and feelings; awareness.'[6] In truth, it is impossible to define consciousness in a way that someone with no experience of it would be able to understand it. This makes it very difficult to assess whether animals, or even other humans, are conscious. The most we can ever prove for certain about consciousness is that our own consciousness exists, as Descartes famously said 'cogito ergo sum'-I think

therefore I am[7]. The logic of this is that for you to be able to think, there must be a thinker, and therefore your consciousness exists. Says Descartes, it is impossible to prove for certain the existence of anything else. We know, however, that nobody would seriously believe that other humans are not conscious, demonstrating the impossibility of proving consciousness (even though it exists). However, as with all things, we can give it a pretty good try. A possible explanation of the phenomena of consciousness could be that 'consciousness' in the abstract, spiritual sense does not exist at all. Rather, it is simply the product of a certain arrangement of neurons in the brain. This has large implications, because it suggests that we are not unique in being conscious. If consciousness is simply the product of a certain arrangement of neurones, then we would be able to compare the brains of animals and humans, and find out whether it is likely that they are conscious. This is what neuroscientists have already done. At the Francis Crick memorial conference in 2012, a group of the most prominent neuroscientists created the Cambridge declaration of consciousness, which stated that based on evidence, mammals, birds and some other animals like octopus are probably conscious[8]. So it can now be said that although it is impossible to prove with 100% surety that it is the case, the weight of evidence points to animals being conscious, and so this, too, cannot be stated as the thing which separates animals from humans.

"And yet, even as the evidence that we are not so different to animals stacks up, we still persist in our destruction of the natural world."

Yuval Noah Harari, author of the book *sapiens: a brief history of humankind* has a different theory on what separates humans from the rest of the animal kingdom. He says that on a one-to-one basis, there is precious little that sets humans apart from animals, and in many respects humans are actually inferior, being weaker and slower and possessing fewer weapons than most animals. Instead, he says that the advantage of humans is our ability to coordinate flexibly, and in large numbers. This seems to make sense when we look at the animal world. Colony animals like bees and termites can cooperate in very large numbers, but do so very inflexibly. Most termite mounds and beehives are constructed in the same way, and they are almost entirely unable to adapt their social structure or home design in order to exploit new circumstances or opportunities, so they survive well, but will not come to dominate or control their environment in the same way humans can. Chimpanzees, wolves, and lions on the other hand, cooperate very flexibly. They are able to adapt their social structure to achieve the strongest pack/group, and can adapt to changing circumstances in order to exploit them to their advantage. But they cannot do so in large numbers. You will never find wolf packs with 1000 wolves, or prides of 1000 lions, and as a result they too cannot dominate their environment as humans do. So why can humans cooperate in large numbers and flexibly, where other animals cannot?

Harari argues that the key difference between human social interaction and that of wolves or chimpanzees is that the animals' interactions are based on an intimate knowledge of one another. If a chimpanzee knows that another chimpanzee is kind and will help them in the future, then they may share their food with that chimpanzee, knowing that the favour will be reciprocated. Humans, however, are able to create abstracts to 'stand in' for a personal knowledge of one another; we have the ability to create and believe in imagined versions of reality. If everyone believes in the same imaginary realities, like a certain religious belief, money, or nations, then they will be able to cooperate with other people who believe in the same story. If everyone believes they will suffer for eternity when they die if they steal, then nobody will steal, and so people will be able to trust everyone else who shares these beliefs, even complete strangers, and so cooperate with them to build the whole of human civilisation as we know it. This could not work for animals. No chimpanzee can be persuaded to share their things with

you by saying that they will go to heaven when they die if they do. The chimpanzee must have a close knowledge of you in order to know whether it is safe to share things with you. This is what allows human societies to grow so much bigger than others, and it is this ability for technology, ideas, and goods to be shared between many people who do not personally know each other that have allowed human society to develop as it has.

So what makes us different from animals? The answer is still unclear. Besides for our ability to believe in fictions and therefore cooperate flexibly and in large numbers, there is very little that we can even halfway prove makes us different from animals. We are more intelligent, perhaps, but we are always discovering more and more that surprises us about animal intelligence, and we know that it is at least impossible to look at the evidence and say as Aristotle did, with certainty, that man is the only animal that can reason. And we don't know if humans are the only conscious animal, too. The latest research seems to suggest that this long-held assumption about human nature may in the end turn out to be wrong.

And yet, even as the evidence that we are not so different to animals stacks up, we still persist in our destruction of the natural world. Recent figures suggest that in the last 40 years, the number of wild animals has halved. More and more species are threatened by extinction, or have already become extinct due to human activity. We have reached the point where even fish stocks that have been a source of livelihood and income for centuries are threatened. Very soon, there may well be 'no more fish in the sea'. As humans, we have given ourselves the name '*homo sapiens'*-wise man, but really it is not our intellect that sets us apart. What sets us apart is our unique ability to destroy all life around us, for our own pleasure (as was the case with the passenger pigeon and North American bison or the way in which the Australian government has sacrificed the Great Barrier Reef in order to make more money from selling coal[9]). At some point in the future, we will suffer from the loss of valuable knowledge, medicines that never were, food sources that are depleted[10], plants that have no pollinators, the beauty of nature that will be gone forever. Our descendants will wonder why we failed to act. They will not know *Homo sapiens*; they will see no wisdom in what we have done, they will only know *Homo Egoisticus* –selfish man.

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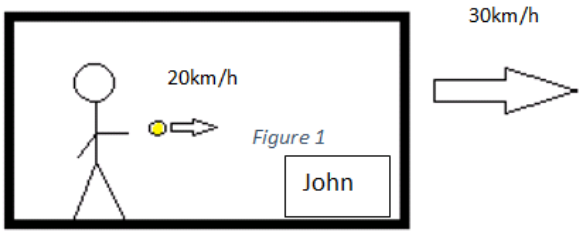
Relativity: the little equations that can enlarge your mind.

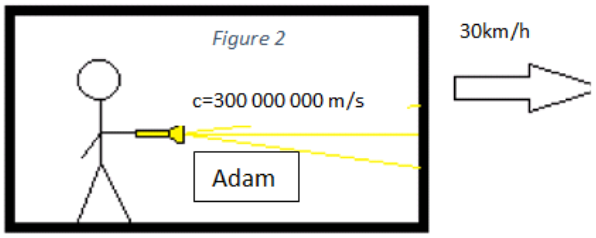
Gilad Fibeesh 10AK

It is not uncommon to hear the word 'physics' and immediately think of long incomprehensible equations and so often dismiss it as the subject of unnecessarily abstract concepts that will not affect us. It does not have to be nor is it, in truth, this way. Physics explained correctly can blow the mind of any audience as it can often turn something we thought obvious upside down, turning it into a captivating concept with the sheer mass of counterintuitive facts that physics stores and turn it into an innovative idea widely applicable in all aspects of our lives. Shown in the right way, not only can everybody understand physics, but with that they can also understand some of the most fascinating truths of the universe. Relativity is a perfect example of this, the concepts of relativity exist almost entirely outside the human intuition, but perhaps over the course of this article, I will be able to help one to understand and see how the concepts of relativity tie into place.

"The important lesson to learn from Einstein's work is the value of theory. Einstein worked purely with his and his peers' minds."

The most ground-breaking of the discoveries of Albert Einstein are the theories of special and general relativity and the former is what led him to remarkable fame with the renowned $E = mc^2$. What was special about the work of Albert Einstein was his philosophical approach to science; instead of the random crunching of numbers together, Einstein devised thought experiments similar to the ones which I will soon illustrate. Einstein was a great scientist and a profound thinker which more than anything [2], I believe, contributed to his scientific breakthroughs. The lack of integration of philosophy and physics today is perhaps the reason for the absence of monumental shifts in our understanding of physics in the past several decades. To return to special relativity, the main postulate of it is that the





speed of light is always constant. To prove this, consider the following scenario.

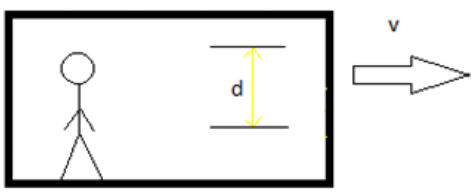
(Refer to Figure 1) Suppose John is on a train moving at 30 km/h. On the train, he throws a tennis ball at 20 km/h. To him, the tennis ball looks as though it is travelling at 20 km/h because that is its relative motion compared to him (it is moving 20 km/h faster than he is). Now suppose Adam is observing the train from outside and is standing still. Adam would see the ball as travelling at 20km/h plus the 30 km/h of the train and so its relative motion is 50 km/h (as it is travelling 50 km/h faster than him in the direction that the train is travelling). Therefore, we see that speed is relative. Both John and Adam are correct in their measurements of the speed of the ball, but due to the different speeds of the reference frames they are observing from the speed of the ball is different. The speed of a ball is relative[1].

Now suppose we alter the scenario slightly, instead of a ball being thrown we have light being shone (Refer to figure 2). The scenario is the same otherwise but the results are different. When John observes, the light travelling in the train; the speed of it is c (the speed of light). When Adam looks from the outside, the speed observed is not c+30 like in the previous scenario, rather it is exactly the same as the speed observed by John, c. We therefore see that the speed of light is not relative, it is always the same for all observers and so it, in a sense, bends in order to remain constant and be in keeping with the laws of physics.

This has some interesting repercussions, namely, special relativity. This is especially important on a planetary scale, when dealing with the speed of light as we shall see. Understanding the main aspect of special relativity only requires the knowledge of two equations: distance = speed/time; and Pythagoras' theorem: the equation that states that the sides of a right-angle triangle meet the following condition; $a^2 + b^2 = c^2$ with c being the longest side of the right angle. *The following explanation will show why.*

Consider the following scenario: suppose John is now in a spaceship. The space ship is equipped with a piece of equipment called a light clock. The way the light clock works is, there are two mirrors and a ray of light is shot in between them as shown by the yellow arrow in Figure 4. There is a known distance between the mirrors, d, and a known speed, c. And so, from the time=distance/speed equation we know the time it takes the light to travel and so a counter can count the amount of times the light hits it as a measurement for time.

Figure 4



What is happening in Figure 3, is rather subtler. This is similar to train situation described previously but has the handed component of being observed from earth to out of space. Adam is situated on Earth and is watching John's spaceship. What he sees instead of the up and down motion of the light, is the movement of the light in a diagonal direction due to the fact that the space ship is moving forwards as the light moving up. Therefore, it must travel much more distance than for John (d' is longer than d). If the light must travel more distance but stays at the same speed (as we concluded is the case previously), then time itself must decrease, i.e. it is the case that time slows down. How much, specifically? Well this can be worked out through application of Pythagoras' theorem together with the relationship between speed, distance and time, as will be shown below. This is called the Lorentz Transform and it shows that time stops when travelling at the speed of light.

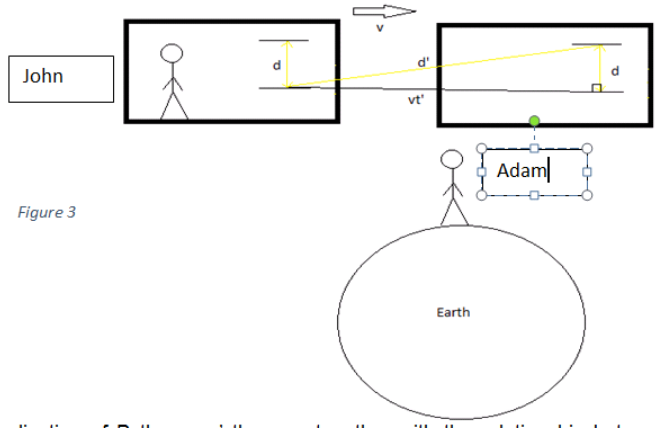


Figure 3

To explain Special Relativity in detail, we must know that distance is equal to speed multiplied by time or that time is equal to distance divided by speed. Let us therefore define that *t*, is the time that John in the spaceship records on his stopwatch that the light takes to travel between the mirrors. *t'*, is the time that Adam, observing from Earth, records the light taking to travel between the two mirrors. *d*, is the distance between the two mirrors. *d'*, is the diagonal distance that Adam observes the light taking to travel from one clock to the other taking into account the speed of the spaceship, *v*. The distance travelled by the spaceship shall be called *vt'*, as it is the distance that the spaceship travels in the time that it takes the light to travel from one mirror to the other; *v*, the speed of the spaceship, is multiplied by time *t'*, as that is the time that Adam observes that the light takes to travel from one clock to another and so is the duration that we are trying to express. The triangle with sides *d'*, *vt'* and *d* is a right-angle triangle and so we can say that, considering that $a^2 + b^2 = c^2$:

$$d'^2 = (vt')^2 + d^2$$

d', can now be rewritten as *c*, the speed of light, multiplied by *t'*, which is the time that Adam observes that the light is travelling at and so it is *ct'*. *d*, can also be rewritten as simply *ct*, as it is the speed of light multiplied by the time that John observes that the light takes to travel between the mirrors, *t*. Now let us substitute these changes:

$$(ct')^2 = (vt')^2 + (ct)^2$$

The goal now is to make t the subject of the equation and so see the distance between t and t'. The reason for this is that this difference is one of the great conclusions of special relativity – that time is different from different observers (see Appendix I for full workings).

$$c^2t'^2 = v^2t'^2 + c^2t^2$$

$$t = t'\sqrt{1 - \frac{v^2}{c^2}}$$

The equation is now rearranged and we can now see that the relationship between time between different observers called the Lorentz Transform. Suppose that John is travelling at the speed of light let us substitute this in to this rearranged equation (see Appendix II for full workings):

$$t = t'\sqrt{1 - \frac{c^2}{c^2}}$$

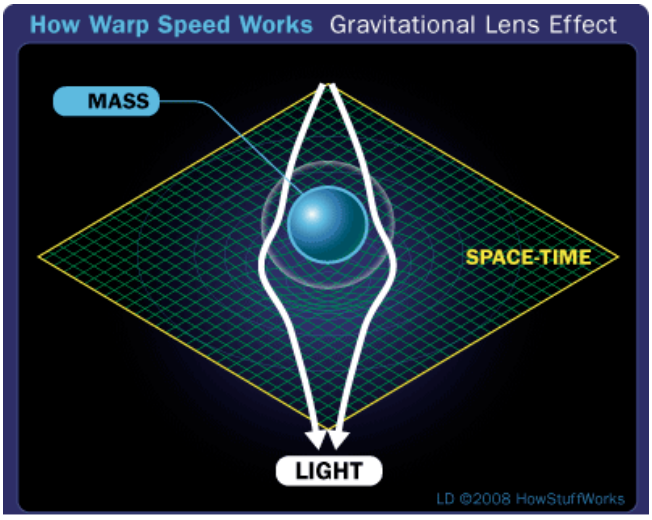
$$t = 0$$

It is hence that we say that time stops when one is travelling at the speed of light. This shows that Regardless of the time that Adam observes that the light to travel from one clock to the other, John will record it as absolutely instant.

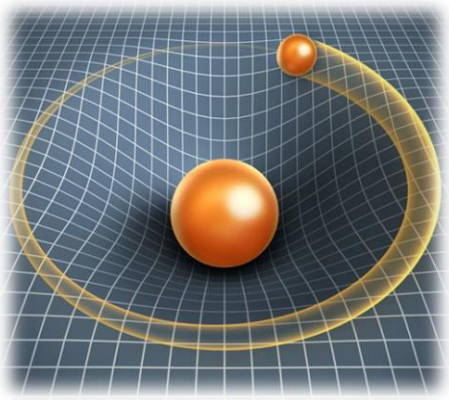
This is indeed the essence of special relativity: that time dilates, or slows down "elapses at different rates when an observer is travelling in relative motion (faster to those who travel faster in relative motion to another observer and slower for the observer who watches someone travel in relative motion and thus is slower)". Real-life examples may help to make the effects of special relativity clearer. Experiments have been carried out where two identical super-accurate atomic clocks were synchronized, and then one was flown around the world on an airplane while the other stayed at home. The clock which travelled recorded marginally less passage of time than the other (as predicted by the theory), although the difference was of course minimal due to the relatively slow speeds involved. [4]

This also led to the famous twin's paradox is an excellent representation of these findings."Imagine if two twins are born and it would be possible for one to be taken on a high-speed space trek for 10 years, he will come home to find the twin that stayed at home significantly older than him.

General Relativity, another of Einstein's remarkable discoveries, is perhaps not as simple to comprehend and required some of the greatest mathematicians (Bernhard Riemann amongst others) to derive. This is because it cannot truly be shown in real life outside of the context of mathematics and in this way, is almost completely counterintuitive. The principle is that our categorisation of time and speed from special relativity only works in inertial reference frames (objects travelling at constant speed in a constant direction). If an object is accelerating, the laws of physics that apply to it are completely different to if it were stationary. Einstein developed field equations which he redefined Newton's gravity as a geometrical fabric of space-time in which mass creates dips in (refer to diagrams below). The reason for this change was that he discovered that light was affected by gravity despite having no mass itself. In Newton's equation, if an object has no mass, there is no gravitational force acting on it, and this was proven incorrect. Einstein redefined gravity and made staggering leaps forward in topology with general relativity. This is the physics that starts to explain black holes.



Light being affected by gravity in Einstein's geometrical space-time model despite having no massrbi



Orbits in the space-time fabric plane

The important lesson to learn from Einstein's work is the value of theory. Einstein worked purely with his and his peers' minds. This was because he understood that instead of experimenting endlessly, one must exhaust what can be thought of with the experimental knowledge known to him and so refine the future experiments. Einstein's tools in his discoveries were his thoughts and it was his revolutionary philosophies of creativity which caused him to think in a manner that obtained various discoveries amongst the most famous and widely applied. It is perhaps not by coincidence that Newton, another of the greatest minds in science, dedicated a Book III of his greatest work, the P*rincipia*, to general philosophy. Philosophy is the study of the manner in which we think, and it is thinking, beyond any other device, which brings about scientific success.

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Appendix I

Workings for deriving Lorentz Transform

$$c^2t'^2 = v^2t'^2 + c^2t^2$$

$$c^2t^2 = c^2t'^2 - v^2t'^2$$

$$c^2t^2 = t'^2(c^2 - v^2)$$

$$t^2 = t'^2\left(\frac{c^2}{c^2} - \frac{v^2}{c^2}\right)$$

$$t^2 = t'^2(1 - \frac{v^2}{c^2})$$

$$t = t'\sqrt{1 - \frac{v^2}{c^2}}$$

Appendix II

Workings for finding that time do not pass when travelling at the speed of light

$$t = t'\sqrt{1 - \frac{c^2}{c^2}}$$

$$t = t'\sqrt{1 - 1}$$

$$t = t'\sqrt{0}$$

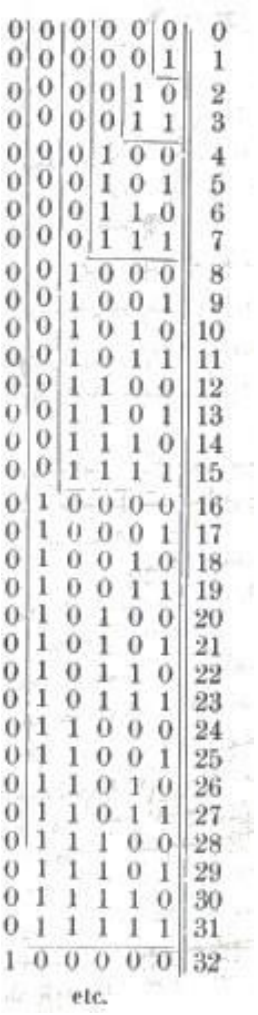
The Simple Logic that has changed the World of Technology

Daniel Leboff 10ZL

It is astonishing to think that our lives have changed so significantly over the past few hundred years but it has. Converting from an agricultural society to a developed country based largely on the tertiary sector, the United Kingdom along with the rest of the developed civilisation now seem to be incapacitated without a technological appliance within a 10 metre radius. It started with the invention of the telephone in 1876 (although technological advancements have obviously taken place throughout history) and has led to a world revolved around technology with the IT sector worth £58 billion annually in the UK [1]. It can sometimes be hard to contemplate the extent that our lives are taken up (and arguably controlled) by technology. I, however, find it extraordinary to find that all of this comes from just two values, true and false.

Binary is the system that controls every computer in the world even though it was developed over 200 years before any form of modern day computer was invented. The person we have to thank for binary is the German mathematician and philosopher, Gottfried Wilhelm Leibniz. Towards the end of his illustrious career (which includes the invention of calculus in 1675), Leibniz released a short article explaining the fundamental basics of binary. Released in 1703, Explication de l'Arithmétique Binaire (Explanation of Binary Arithmetic) explained how *"I use no characters in it bar 0 and 1"* [2]. The image shown on the right depicts how numbers work in a binary system (also known as base 2). But before understanding how and why binary is the most central component of a computer, one must first truly understand how it works.

Figure 1 - the original text Leibniz wrote in Explication de l' Arithmétique Binaire



0	0	0	0	0	0	0
0	0	0	0	0	1	1
0	0	0	0	1	0	2
0	0	0	0	1	1	3
0	0	0	1	0	0	4
0	0	0	1	0	1	5
0	0	0	1	1	0	6
0	0	0	1	1	1	7
0	0	1	0	0	0	8
0	0	1	0	0	1	9
0	0	1	0	1	0	10
0	0	1	0	1	1	11
0	0	1	1	0	0	12
0	0	1	1	0	1	13
0	0	1	1	1	0	14
0	0	1	1	1	1	15
0	1	0	0	0	0	16
0	1	0	0	0	1	17
0	1	0	0	1	0	18
0	1	0	0	1	1	19
0	1	0	1	0	0	20
0	1	0	1	0	1	21
0	1	0	1	1	0	22
0	1	0	1	1	1	23
0	1	1	0	0	0	24
0	1	1	0	0	1	25
0	1	1	0	1	0	26
0	1	1	0	1	1	27
0	1	1	1	0	0	28
0	1	1	1	0	1	29
0	1	1	1	1	0	30
0	1	1	1	1	1	31
1	0	0	0	0	0	32

etc.

Similar to how Leibniz commenced his lengthy explanation, it must first be explained how humans count. However, before handing this journal over to your five year old child, I beg of you to have faith in both me and Leibniz to expand your mind even if this does look like Grade 1 mathematics at first glance. We live in a world of what is called base 10 (or more commonly the decimal system). In base 10 there are ten digits that exist. These are: 0,1,2,3,4,5,6,7,8 and 9. Add one to nine and we reach a complication. There are no more numbers so what do we do? We use two digits next to each other in order to symbolise a larger number and we give it the value of 10.

Binary is a world where there is no such thing as an 8. Nor does the number 5 exist. In fact, the only numbers that do exist are 0 and 1. Therefore the value of two would be written in digits as 10 and the number six

hundred and eighty two in base 10 would be the equal to 1010101010 in base 2. However, as delightfully exciting as this new mathematical 'dimension' is, it so far has no relationship whatsoever with the bright and wonderful technological appliances of which we have learnt to survive upon.

"Computers and other digital devices use the binary system to manipulate and store all of their data including numbers, words, videos, graphics, and music."[3] Computers cannot think like humans (at least not right now), yet we computer users expect them to somehow understand what we are telling it to do. It cannot understand words, numbers or symbols. Alas we have reached the reason for using a system with only two values. It is easy to create something which has two states. It is simply 'on' and 'off' and that is how transistors work. If binary is the most essential theoretical component of a computer then transistors are by far the most fundamentally important practical and physical component.

A transistor is a microscopic device (as small as 1 nanometre) that can open and close electrical circuits to allow/prevent the communication of electrical signals which are used to carry data for the computer. The 'brain' of a computer is the CPU (Central Processing Unit) and contains billions of transistors. Therefore a transistor is at all times one of two values, on or off, true or false. In the computer science industry, these are called Boolean values, named after the English mathematician George Boole (1815-1864).

```
0100101 -> % (Percent Sign - 37)
1000001 -> A (Capital letter A - 65)
1000010 -> B (Capital letter B - 66)
1000011 -> C (Capital letter C - 67)
```

Figure 2 - Examples of binary numbers converted into well-known characters

So how is it that these two values – now 'saved' on a computer – can join together to form non-integer values such as letters and symbols. The answer is simply by using lots and lots of binary numbers in which each binary number represents a different character. There are two main standards for how this works. (Since different companies could choose different characters for each binary number there is a standard which most companies stick to.) These standards are ASCII and Unicode (which is a 'better' version of ASCII). The above image shows binary numbers and the well-known character in which that applies. So when a user types the letter 'A' (remembering that 'a' is a completely unrelated character), the computer encodes that in what is called 8 bits with the number 1000001. Therefore the letter 'A' and any other letter, number or symbol represented with ASCII would require eight transistors and any Unicode character could be anything up to 16 since; consequently Unicode can allow for 65,536 characters (although the number is actually higher) whereas ASCII only allows 128.

"The advantages for using synthetic DNA above silicon transistors are endless"

Once we can store characters, it is just a matter of displaying it. Unfortunately there are multiple things to think about including the shape, size, font and colour of the characters, all of which are determined – since they're on a computer of course – by binary. It would take much more than this article to be able to delve fully into the workings of a computer and how it 'thinks' but the most important thing to remember is that all we need are '0's, '1's and an awful lot of electricity to power our computer. Some people say that we will one day be taken over by robots and artificial intelligence. I say that, if indeed that happens, we will not be controlled by a robot but by two digits: '0' and '1'.

But for how long will binary last as the fundamental component that keeps a computer working. Well the future of data storage could go to the biological level. That's right. We're using DNA!

Last July, researchers at Microsoft and the University of Washington successfully stored 200MB of data (including a music video) on synthetic DNA strands [5]. The amazing accomplishment includes converting the data from binary to the "letters" of the four nucleotide bases of a DNA strand – (**A**)denine, (**C**)ytosine, (**G**)uanine and (**T**)hymine. They then translate those

letters into the molecules whilst still in electronic form before retrieving them when required and decoding them back to binary. At first glance this may seem "cool" or "fascinating" but in reality it could change the way we store data. The reason for this is that there is currently a serious lack of supply for the amount of demand there is for data storage as shown in Figure 3.

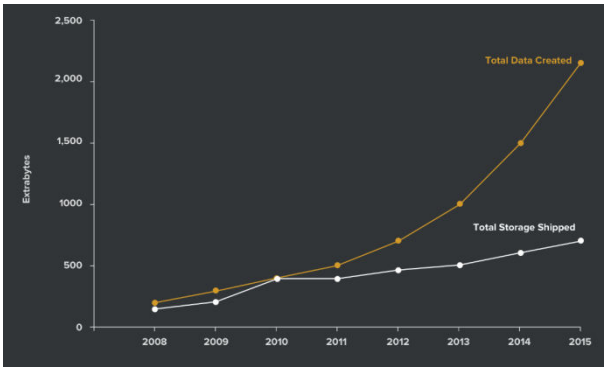


Figure 3 Graph showing the amount of data created and the amount of storage shipped underlining a desperate need for more storage.

The advantages for using synthetic DNA above silicon transistors are endless. First it is dense enough to fit the entire internet in a shoebox [6]. Secondly, it requires extraordinarily small levels of energy with it requiring less than a light bulb's worth of power per year. In addition each piece of data will last hundreds of years and it is simple to make redundant storage. Finally, and possibly the most important given the current climate, it will allow us to encrypt and conceal confidential data better. Victor Zhirnov, the chief scientist at the Semiconductor Research Corporation, said that DNA can hold 1,000,000,000,000,000,000 bytes of information in $1mm^3$ [7].

The only issue, as with most things in life, is the cost. Experts say that it would cost $800,000 to buy the 13,448,372 unique pieces of DNA that was used for this project and Microsoft themselves acknowledged that the cost of DNA storage would have to reduce by a factor of 10,000 before the system can be widely adopted. Another problem, again similar to many things in life, is speed. Based on loose facts, it is estimated that the rate of flow into the DNA was a mere 400 bytes per second and again Microsoft have acknowledged that this must be increased to 100MB per second before it can be used worldwide.

It may be many years to go before we can witness synthetic DNA storage being commercially used. It is something we can all look forward to but until then, the world will gladly stick to Gottfried Leibniz's remarkable "invention" of binary and Boolean transistors.

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'Hello, can you hear me?' Evaluating the Fermi Paradox

Adam Wolf 10BG

To quote Douglas Adams 'Space is big. Really big. You just won't believe how vastly hugely mindbogglingly big it is'[1]. And well, he's not wrong, the universe is about 90 billion light-years in diameter, yet here humans are, sitting on this not-so-big rock, hurtling around a less than average star, in a very average galaxy of about 100,000 light years across. For centuries, little insignificant people have looked up in the night sky asking themselves if there is another little insignificant person, on a distant planet, looking back at them. For many, this notion that there is intelligent, alien life, more advanced than our own, out in the universe searching for us cultivates a strong curiosity for which humans are known best.

"The Fermi paradox states that we should have encountered an alien species already."

The Fermi Paradox is the infamous contradiction that states the following: given the billions upon billions of galaxies in the universe, the billions of stars within each galaxies and the working estimate is that 22% of stars observed have habitable 'exoplanets' that orbit them, surely a sentient species must have come into contact with humans (or at least institutions would have seen evidence of their existence).

Although the Drake equation[1] was created in 1961 and Enrico Fermi stated his paradox in 1950, the equation is instrumental in the understanding of this paradox. The Drake equation is denoted as the following by SETI[2] ;

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

(N = the number of civilizations in the Milky Way galaxy whose electromagnetic emissions are detectable) [2]

This states: all the required fields for first contact[3] with an alien species are multiplied by each other to work out the number of civilisations in the Milky Way whose electromagnetic emissions are detectable. This number cannot be found for sure but regardless, essentially demonstrates the Fermi Paradox as first contact has not been made. Current sceptical guesses place N at 1, us, whereas optimistic estimates are placed at around 72,800 species [3].

However, seeing as Earth is the only piece of evidence astro-biologists have on the development of life in any form, we really can't be sure what N actually equals.

The first explanation as to why there aren't millions of different species, circumnavigating the universe, leading to first contact, uses the theory of 'great filters'. This is the idea that for a civilisation to flourish, a planet and its inhabitants need to overcome various sets of hurdles that could prohibit life from developing further. The first of these metaphorical hurdles that a

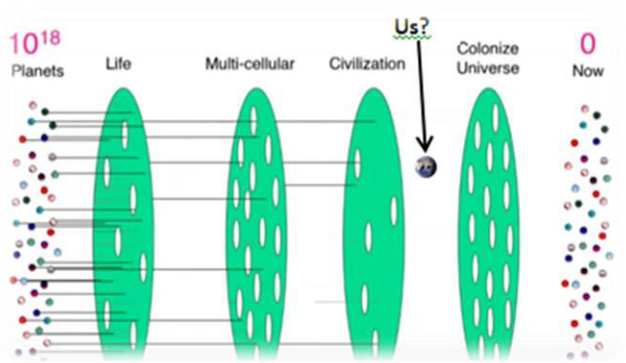
[1] The letters in the Drake equation mean the following:

- R* =the rate of formation of stars suitable for the development of intelligent life.
- f_p = the fraction of those stars with planetary systems.
- n_e = the number of planets, per solar system, with an environment suitable for life.
- f_l = the fraction of suitable planets on which life actually appears.
- f_i = the fraction of life bearing planets on which intelligent life emerges.
- f_c = the fraction of civilizations that develop a technology that releases detectable signs of their existence into space.
- L = the length of time such civilizations release detectable signals into space.

[2] SETI is the 'Search for Extra-Terrestrial Intelligence, founded by Frank Drake and Carl Sagan in 1984

[3] 'First contact' is the meeting of two cultures that were previously unaware of each other and in this context, it refers to us meeting extra-terrestrial, intelligent life.

planet needs to jump over is its location, more specifically its size and relative proximity to the star it orbits in order to be at a stable temperature to contain liquid water, this ultimately is a key factor for the support of life. From here is the evolution of multi cellular organisms that are eukaryotes[4]. Following on is the building of an advanced civilisation by a unified species, working towards a single goal (in our case self-preservation).



Up to this point, the Earth seems to be the only planet that to have come so far. Yet, to initiate first contact, one of the two parties involved needs to pass the fourth filter; cross-[solar] system travel (the ability to traverse vast distances across the expanse that is space) which out of the 10^{18} planets seen so far, none have passed (to our knowledge). From here, it is evident that there has been a huge set of obstacles to get from where humans were (in the formation of Earth) to what we want to become, seeing as we are the most advanced civilisation that we know of.

However, the most disconcerting notion is that whist having overcome barriers in the past from which humans are the sole survivors, the image above only shows barriers to us meeting aliens. What the diagram does not show all the potential things in the universe that could bring an end to humanity.

By the fact that factors that could end humanity are omitted from the great filter theory, it leads to the suggestion that they are not relevant in this model. As seen with all great empires and civilisations in the past, nothing last for ever – 'for it is the tallest trees which Zeus strikes'. The hubristic nature that Homo *sapiens* have accumulated over their few million years on this rock of theirs has placed humanity on the decline, which could well make it a matter of when, rather than if, humans will cease to roam the Earth.

It is possible to argue that unless first contact is made to alien species, humans are destined to die out eventually and therefore peaceful cooperation on part of the human race is a prerequisite to having any chance of making this a success.

Often, a scale is used to measure the future development of an alien species in a qualitative way, using energy consumption and thus technological advancement. The levels of civilisation are split up from 0 to 3. Type 1 is called a planetary civilisation and it is able to use and store energy that it can gain from the planet itself as well as what it receives form its neighbouring star. Type 2 refers to one that is able to use and contain all the total energy that is released by its home star and a type 3 civilisation is able to harness all the potential energy in its galaxy.

> "I see no reason why advanced civilisation would be interested in making contact with a people who are notorious for driving new species to extinction."

To us, a type 3, if they did in fact exist, would seem like technological gods but seeing as there haven't been any aliens steeling energy from the sun as of yet, it is unlikely that such a civilisation is present in our galaxy. The point of creating such a scale as this is to

[4] An advanced type of cell which contains a nucleus.

demonstrate that if an alien species were to present itself overnight, it would almost certainly be superior to humans in almost every way. But seeing as first contact has not been made, using all the empirical evidence at the disposal of astronomers, they can only assume that humans are the only developed species in the galaxy, answering the question as to why we are alone.

On the other hand, assuming that as humans we are not some $1/10^{18}$ miracle as the only race in the cosmos, and as stated in the Drake Equation that we cannot be alone, is it not inconceivable that we are in fact too primitive for a peaceful species to be interested in us? For one, humans are not unified; not in an alliance-type of unity, but through a purpose. Whilst all humans have self-preservation instilled deep within them, as of now, this only extends out, unto artificial borders created to settle disputes, without this, what assurance does a peaceful alien species have that we won't see them as a threat.

As humans, I would argue, we have a fundamentally inward mind-set; too focused on personal needs to look beyond disputes in the name of global progress. An example of this is the discrepancy in funding between the largest military in the world and that of the largest space programme to a multiplier of thirty one[5]. This inward mind-set is more focused on competing for the planet's limited resources to the point of exhaustion than actual progress as a species- a notion that I believe will soon lead humans to extinction.

Until humans as a species are able to unite in a global quest for self-betterment, I see no reason why advanced civilisation would be interested in making contact with a people who are notorious for driving new species to extinction (or even ourselves).

As to answer the question that prefaced this essay- are we alone? I can't possibly know with absolute certainty, and nor can anyone else for that matter, given the information we have. But much like anything else humans do, we do it for incentive- the strongest of which being our own preservation. Whilst the Fermi paradox states that we should have encountered an alien species already (a claim supported by the Drake equation) and yet we haven't, we can only turn to the single thing that distinguishes humans from all other animals on the face of this not-so-big rock, hurtling around a less than average star- fiction. Human's capacity to imagine has led to an obsession of what isn't, but just might be. This trait has brought humans to accomplish the greatest of feats; medicine, flight, architectural wonders, but our fiction will only bring us so far.

The Earth is under excessive stress. It is being exhausted of natural resources at an unprecedented rate to the effect that an estimated 150-200 species are becoming extinct every 24 hours[6].

I would argue that humans need to better themselves and unify in the purpose of progress in order to make this species more attractive to another (assuming that there are more advanced species lingering in the cosmos); and maybe just then, the little green men hiding below our horizon will show themselves and see what humanity has to offer.

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"Climate change – not just about hot air" – How will a global temperature rise influence complex weather patterns?

Liora Lederman 12AD

The 194 countries who signed The Paris Agreement in 2015 agreed to contribute to efforts to keep the global temperature rise beneath the two degrees Celsius threshold this century by reducing their carbon emissions. But this rise is a global average which means that the impacts of climate change may include both extreme temperature rises and temperature falls although the temperature falls will not be as severe.

Global warming is increasingly changing weather patterns as a whole, due to the fact that there is an increased average temperature in the global weather system, shown by the bell curve graph below. The graph shows that an increase in global average temperatures will increase the frequency of extreme hot weather events, yet will decrease the frequency of extreme cold weather events. This is portrayed by a shift in the original curve (representing the current climate) to the warmer end of the climate spectrum (representing a new hotter climate created by global warming.

Two bell curves representing the current climate and the possible future climate resulting from a global temperature increase.

An increase in global temperature has led to a change in wind patterns which are usually driven by temperature differences between the poles and the tropics:. Arctic areas are heating up faster than lower latitudes and land areas are heating up faster than oceans. As a result each winter, the ice caps of the Arctic region are shrinking due to rising temperatures, and this winter 2016-17, their size had reached a 38-year- low of 14.4 sq km[7]. The size of the ice caps usually increases in winter, but due to a very warm autumn and winter, temperatures were 2.5 degrees Celsius above average across the Arctic Ocean creating polar 'heatwaves'. These heatwaves result in ice retreat in the Arctic, meaning a loss of habitat for species like polar bears, which could lead to their extinction. It is not just in the northern hemisphere where we are seeing the impacts of ice loss. Antarctica's sea ice is similarly experiencing increasing ice loss. In March 2017 the size of Antarctic ice reached a record low of 2.1m sq km.

"Climate change also means that extreme weather events such as heatwaves, droughts and floods are more likely,"

Though it is at the poles where the degree of change is most extreme, given the high level of biodiversity in the tropics, minor changes can be said to be having a greater ecological impact in these lower latitudes. Notably, the bleaching and subsequent destruction of coral reefs. Increasing water temperatures have put heat stress on the coral which forces corals to expel their photosynthetic algae. This deprives them of their colour and bleaches them white. Prolonged exposure to heat stress can eventually kill the coral. These bleaching events are becoming more frequent and of increased severity over time. The Great Barrier Reef in Australia has become particularly vulnerable to these bleaching events and suffered its worst ever damage to date in 2016 when 22% of coral was killed in a single[8] bleaching

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event. Typically bleaching events can also be caused by El Nino weather patterns – a condition in which the main ocean currents invert on certain years, causing a temporary warming of the South Pacific. However, recent research has shown that the latest event was not caused by El Nino. The study focused on mass bleaching events in 1998, 2002 and 2016 and eliminated any other factors other than climate change as the cause of the bleaching. It concluded that these events are not caused by poor water quality or fishing activity and that underwater heatwaves took place regardless of these conditions[9]. Instead it is evidence of the fact that the danger of climate change is real and is posing a threat to marine ecosystems.

Climate change also means that extreme weather events such as heatwaves, droughts and floods are more likely, which is portrayed by the bell curve previously mentioned, as an increased input of heat in the global weather system results in a shift in the bell curve. An increase in global temperature has not directly caused these events to occur, but makes the weather patterns that cause these events more likely. A recent study has analysed 'planetary waves' which, under certain conditions, cause extreme weather events to occur. These planetary waves are a pattern of winds, which includes the Northern Hemisphere jet stream,. Normally, the whole wave moves eastwards, but under certain conditions, the wave can stop its movement, leaving whole regions under the same climate for long periods. This can explain the prolonged cold and wet weather in the European spring of 2013, or the heatwaves of 2006[10] . These extreme weather events have increased in frequency over time. The study found that the conditions which resulted in the waves being halted were significantly more likely to be created as a result of climate change[11].

> "It concluded that these events are not caused by poor water quality or fishing activity. Instead it is evidence of the fact that the danger of climate change is real."

In conclusion global warming does not simply mean more warm weather and the impacts will be felt differently in different parts of the world. The most drastic changes will be felt in the polar regions, whilst the most severe ecological impacts will be seen in the tropical regions due to the high biodiversity. The bell curve has further demonstrated that, due to increased heat in the system, there are more extreme weather events overall, which work through indirect mechanisms such as planetary waves. I believe that in order to limit the already devastating impacts of climate change, action needs to be taken to limit carbon emissions and thus global temperature levels before it is too late.

-barrier-reef-coral-bleaching-worsens-as-scientists-fear-heatwaves-impact> [12 June 2017]

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Life of a lion: The argument against zoos.

Miki Friend 12BT

In an ideal world, zoos would not be the same. All animals would not only have access to food, but would encounter challenges that they would in the wild in order to attain it; anteaters would forage in the foliage, and elephants would grub for their grass. This stimulation would provide an environment where the inhabitants can adequately develop intellectually and physically, as they would in the wild. They would have sufficient space to roam and carry out their daily duties in peace- lions would have lustrous lands, and polar bears would patrol the piercing cold. In an ideal world, animals would not be inmates.

"We cannot say that zoos are a place of refuge for animals, when they are exploited for cash, and suffering from a lack of what makes them animals."

Rather than lustrous lands, lions are kept under lock and key. Polar bears are prisoners, not patrollers. It is clear that zoos are unable to accommodate enriched lives as they have very limited space; it is arguable that no captive condition can compare with the animal's natural habitat, regardless of size. In the Silverback Gorilla enclosure at London Zoo, one of the inhabitants was spotted exhibiting strange behaviours- he was rocking back and forwards, and pacing. In turn, the zoo put a sign out so that visitors were aware of the strange actions, but did not close off the enclosure to patrons. A great number of studies have shown that a combination of enclosed space, and observation, cause many animals, such as primates, to become stressed and perform these rocking motions, and repetitive tasks- it is all well and good that the visitors were aware of the situation, however it is not acceptable that the Silverback was left on public display when his distress was acknowledged. I wish I could say that this occurrence was an anomaly, but this is common practice in zoos[1]. Helpless animals are deprived of the space and privacy that they need and deserve.

Animals are suffering in captivity , but it serves a purpose. In the wild, many species face dangers that, without human intervention, would result in their extinction; for example, the Black African Rhinoceros is commonly poached for its horn. The horn is said to have medicinal properties in traditional Chinese medicine, with the ability to cure anything from a hangover, to hallucinations. This illegal trade has resulted in the death of 7,137 Black Rhinos in the last decade alone, with only an estimated 4,050 left in the wild. Organisations such as WWF (World Wide Fund for Nature) have been working to defend the dwindling population through a multitude of methods- one of which is captive breeding programmes within the invulnerable walls of zoos around the world. Due to these efforts, the percentage loss has decreased over the years.

The Pangolin however, has the other end of the stick. It is also hunted for its apparent healing properties, and is considered the most illegally trafficked animal on Earth, but it is not preserved in zoos. The population is rapidly deteriorating- between 2011 and 2013, an estimated 17,812 Pangolins were killed, and however it's difficult to be certain of numbers as they can only be calculated by those that have been caught by authorities. Unfortunately, the plight of the Pangolin continues as they're not present in zoos- the ZSL has various futile programmes and tactics to preserve the species, however they're not as effective as ex situ techniques, perhaps relocating to a zoo could preserve the species. Animals are surviving in captivity, but it comes at a cost.

It is important to recognise the counter argument. There are three main cases for the continuation of zoos and safari parks; conservation, education and research. That endangered species can be preserved and protected against shocks, that in a world of more and more urban dwellers, that an opportunity to get in touch with wildlife is important, and thirdly, that these institution provide a suitable controlled environment in which to study species that in the long term can lead to their continued healthy existence.

Yet, are we preserving these species for their benefit or for ours? Behind bars, these creatures are nothing but trophies to those that put them there, proof of how far humanity has come. We watch these animals in awe, pondering our greatness, and how excellent it is that we have saved these lives. Their misery acts as evidence for our own success, but this is in fact, a failure. These animals may be alive, but they are not really living; to be born and raised in captivity, deprived of adventure and intellectual stimulation is not a life. A miniscule fraction of zoo animals are rehabilitated into the wild after their populations have stabilised; they are kept there for our amusement, and to draw in visitors to feed corporate greed.

We cannot say that zoos are a place of refuge for animals, when they are exploited for cash, and suffering from a lack of what makes them animals. Orca are able, and supposed to, be able to dive 1000ft in the wild, but at Seaworld[2], tanks are only 35ft deep, but don't fret just yet, they have proposed a tank expansion to allow 15ft more. It should not have to be said that this is cruelty. This animal's existence is defined by its ability to entertain and pay the bills, rather than its freedom, and natural grace. There is little to no porpoise 'rescuing' these animals if they're only going to be exploited and reduced to an existence, not a life.

Something needs to be done. The human race has a duty to those we have wronged; rather than giving the animals a substandard place to live once we've destroyed their homes, we should stop them from getting there in the first place. We should be working harder to preserve their natural habitats, as opposed to substituting it. Deforestation for the purpose of creating human lodgings, or urbanisation, has led to the clearing of over half of the world's tropical forests; this means that animals like the Pygmy Three-Toed Sloth are forced into captivity[3]. I am not proposing that there should be an immediate ban of keeping animals in zoos, as this would result in the inhabitants being killed, or not being ready to be released into the wild, however, we should be phasing out the use of captive environments by limiting or stopping the damage we do that put animals in zoos in the first place.

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