Bats

There are certain things in life that just happen even though no one really knows why. For example, take an evening taxi ride. It is inevitable that shortly after getting into a taxi you will ask the driver two questions: 1) Have you been busy? and 2) What time do you finish tonight? They're not the only questions you might ask, but sooner or later as you run out of things to talk about and the silence becomes unbearable you will hear yourself reaching for these tried and trusted favourites.

A similar inevitability applies to asking or being asked what you do for a living. Whether it be at a dinner party, school event, or some other function where you are forced to make polite conversation with a stranger, it is inevitable that sooner or later someone will ask about your occupation. Knowing this in advance can be a big advantage as it gives you the ideal opportunity to bring the conversation to an end if you so wish. Just choose any occupation from the following list and see how much further the conversation goes:

Estate Agent; Accountant; Traffic Warden; Tax Collector; Speed Camera Operative;

Some occupations leave us in no doubt as to what the person does whereas others have a strange vagueness about them which leaves us wondering what someone really does. My personal favourite is 'property developer.' What exactly is a 'property developer'?

In my experience there is a vast difference between what a property developer actually is or does and what they want you to think they are or do. When it comes to impressions we are led to believe that all property developers make lots of money and own hugely impressive property portfolios which double in value every year. In reality that is not always the case. I once met a man who owned a one-bedroom flat in which he was fitting a new kitchen with a view to increasing its value and who unhesitatingly referred to himself as a property developer!

The odd imposter aside, I satisfied myself many years ago that property developers earn lots of money for doing very little work and expending very little effort. As these were three qualities I held in very high regard I determined that I would become a property developer at the earliest possible opportunity! And as it involved little work I could keep my day job as a lawyer just in case for some unimaginable reason I didn't make a fortune from property development.

At the back of my office was a large underused car park that was an ideal candidate for my first development. The ground was flat and the office was situated in the town centre so building properties there would be easy (my knowledge of building amounted to flat land equals easy to build on) and demand for town centre properties would be high. The only small problem was an old brick outbuilding we used for storing office furniture. It was pretty dilapidated, with bricks missing from the external walls and several holes in the roof from missing slates. It was going to have to be demolished.

Imagine my surprise when I learned that you can't just demolish a building that you own. It turned out that planning permission was required and that entailed an on-site meeting with a planning officer. Which reminds me that 'planning officer' should have been included in that list of occupations above!

One thing I did know is that it was important to keep on the right side of the planning officer, as I was hoping he or she was going to approve my imminent application to turn my car park into houses. I therefore arranged a meeting over the 'phone and dutifully met the planning officer outside my office at the entrance to the car park. Having glanced round the car park her eyes settled on the outbuilding, a frown formed on her face, before she asked me whether I had seen any bats in the building.

I must pause here in order momentarily to return to the subject of teenage boys. In case I did not make it clear, another feature of teenage boys is that although a man officially ceases to be a teenager when he hits twenty, it is in fact impossible ever to take the teenage boy's mind and thinking process entirely out of the man. This means that when a roughly forty-year-old man meets a female planning inspector for the first time he will be quite confident that, if necessary, he will be able to charm her round to his way of thinking by the use of witty remarks and laddish humour.

It turns out that when a female planning officer asks you whether you have seen bats in a building the correct answer is not ‘well there are a couple of old ones who work in the accounts department and my mother-in-law sometimes pops in for a coffee.’ That undeniably funny remark cost me £750, being the cost of the official bat survey report I had to commission to establish whether there were any signs of bats living in my outbuilding.

Allow me to introduce you to *Pipistrellus pipistrellus*, otherwise known as Pipistrelle or more commonly known as a bat. For the bargain price of £750 I was able to discover that *Pipistrellus pipistrellus* is in fact one of the most common species of bat in the UK. As bats go it is apparently quite small and can be found in numerous habitats such as agricultural land, woodland, and suburban and urban habitats (so basically everywhere). More importantly, some of its favourite roosting sites are the crevices around the outside of houses and brick outbuildings.

Up to the end of the nineteenth century Pipistrelle was fairly common throughout Europe, but in the twentieth century there was a drastic reduction in its numbers, which experts believe was due to more intensive farming methods and building development. Which basically means that farmers and property developers are to blame for there being far fewer flying rats in the UK than there were one hundred years ago.

In order to arrest this slide in numbers Parliament passed legislation which requires all local planning authorities to take into account bat conservation issues when making planning decisions. As a result, property developers like me often have to commission a biodiversity survey prior to any planning permission being granted to demolish even a small brick outbuilding in an obvious state of disrepair. This is so that the local planning authority can make decisions which try to ‘conserve and enhance biodiversity’ and can require a course of action that protects the interests of bats, as defined within the Conservation of Habitats & Species Regulations 2010 (as amended).

This begs the rather obvious question as to what exactly is the point? Bats are quite clearly hugely unattractive creatures which, owing to the fact they only come out at night, we hardly ever see and they would therefore not be missed at all if their numbers slid all the way to nil.

To my shame, that is almost certainly what I would have thought about bats in my teenage years. And I would be lying if I said there wasn't a little bit of me that still thought it when their possible presence in my brick outbuilding cost me £750 and threatened to derail my inaugural property development. However, when you scratch beneath first impressions you very quickly discover that bats are truly quite remarkable creatures that have the ability to perform tasks which are far beyond the most technologically advanced systems we humans have ever managed to cobble together.

One of the most fascinating areas of scientific research is known as Biomimetics, where scientists try to imitate structures or systems that are found in nature. The logic behind this is fairly obvious. Take, for example, flying. Since the Wright Brothers first took to the skies humans have spent vast amounts of time and effort in order to come up with better, more efficient ways of flying. As a result we can now fly thousands of miles in relative comfort, where the level of comfort is directly related to whether someone has brought a crying baby with them. However, you do not need to be an expert in aeronautical engineering to know that the best human efforts at flying cannot sensibly be compared with what we see in nature. Given that many animals exist in the natural world that can fly far better than any machine engineered by us, it is not surprising that scientists spend time examining the flying methods and systems of those animals in the hope that the 'technology' in the animal can be copied or mimicked by us.

It doesn't take a great deal of thought to come up with more examples of where humans have looked, or could look, to nature to try to solve technological problems. It is also the case that some animals can be studied for more than one thing, which brings me back to Pipistrelle.

The Wright brothers were not the first to think about making flying machines. Back in the fifteenth century Leonardo da Vinci produced a set of drawings which look remarkably like a modern-day helicopter. It is also widely accepted that his drawings for a flying machine showed wings which were based on the structure of wings in bats. In fact da Vinci produced numerous flying related sketches, including designs for take-off and landing gear for a flying machine and studies on articulated wings. And since then countless others have studied bats wings and how they fly in an effort to improve man-made flying machines.

But the wonder of flight is not the bat's only claim to fame. In fact, notwithstanding the amazing flying capability of bats, many would say it is not their finest achievement. For in addition to being able to fly, bats possess a quite mind-boggling ability to see in the dark, or more specifically, to see without using eyes! And it is this ability that I want to focus on for the purpose of establishing the facts: the details of life around us.

Just as the Wright brothers were not the first to try to copy the flying ability of bats, I am nowhere near the first to consider or write about their ability to 'see' in the dark. In addition, my fondness for doing as little work as possible extends far beyond the role of being a property developer. Accordingly, I see little point in trying to reinvent the wheel by writing about something that others have already done, and done far better than I could ever hope to do. I am also slightly concerned that I have got over three chapters into a book on Darwinian Evolution without once mentioning the world-famous champion of all that is Darwinian, Professor Richard Dawkins. As no book on Darwinian Evolution would be complete without referring to him, and as I am keen to reduce my workload when it comes to dealing with the intricacies of how bats 'see' in the dark, this is the perfect opportunity to kill two birds (or bats) with one stone.

In 1986 Richard Dawkins published a book called 'The Blind Watchmaker.' It very quickly became an international bestseller and is perhaps the most widely known and read defence of the modern theory of Darwinian Evolution in the world today. For reasons that will become clear in later chapters, I do not share Dawkins' confidence in the explanatory or creative powers of Darwinian Evolution. But I have no hesitation in saying that The Blind Watchmaker is a fantastically well written book and one in which Dawkins has not tried to minimise the scale of the task facing any theory which is trying to explain the origins of the world around us. In fact, Dawkins deliberately sets out to paint as complicated a picture as possible of the natural world in order to show just what exactly has to be explained, and he does so in the second chapter of his book, entitled 'Good Design', by setting out a quite masterful description of how bats 'see' in the dark.

In my view Dawkins' description of how bats 'see' in the dark is worth the price of his book alone. I have summarised what appear to me to be the main points from his chapter below, but would urge anyone who finds what follows to be remotely interesting to read his chapter for themselves in order to comprehend fully the magnificent system found in bats such as Pipistrelle. I would also draw to your attention the very important point that the facts I am seeking to establish, the details of life around us, are not in dispute. There is no controversy or disagreement when it comes to stage one of the evidence-based approach: establishing the facts. The controversy comes when we look at stages two and three: defining the assertion and determining whether the assertion is true, at which point I'll be referring to Richard Dawkins in somewhat less complimentary terms.

Bats have a problem: they hunt at night. To us this may not seem too big a problem as depending on our budget we can always fall back on things such as torches or night vision goggles. As bats do not have these options available to them the fact they hunt at night really is a problem. Bats need to eat in order to live and in order to eat they need to be able to hunt successfully. As bats hunt at night, they need to be able to hunt successfully in the dark or they will die. So as problems go this really could be said to be a matter of life or death.

One of the interesting things about Biomimetics is that scientists have sometimes developed what they believed to be a totally new system or technology, only later to discover that it was already present in nature and that nature's version was far superior to theirs. One such example of this is sonar, or what is sometimes referred to as echolocation.

Sonar is the man-made system which is used to detect the presence of objects on or under water. Put simply, it's the water equivalent of radar, although the real difference is that sonar uses sound waves and radar uses radio waves. The word 'sonar' is an acronym for Sound Navigation And Ranging.

According to Wikipedia (and therefore 100% true), '*the use of sound to 'echo locate' underwater in the same way as bats use sound for aerial navigation seems to have been prompted by the Titanic disaster of 1912*.' Not surprisingly, the onset of the First and Second World Wars led to an intensification of efforts to develop sonar technology, on the one hand to assist with submarine navigation and on the other to assist with locating submarines so they could be blown up.

The principle behind sonar is relatively straightforward. Assuming you are on the submarine, your sonar would start by sending out a sound, known as a pulse or a ping. I prefer 'ping' as it reminds me of the great scene in the film 'The Hunt for Red October', when Sean Connery plays a Russian submarine commander who speaks Russian with a Scottish accent and tells his navigator to 'give me a ping, one ping only.'

The ping travels through the water until it arrives at an object, say another submarine. The sound wave bounces back off that object and travels back to your submarine. Luckily your submarine has both a ping sender and a ping receiver, so you are able to detect the ping returning. Even more luckily, you are able to remember from your GCSE maths syllabus that you are now able to work out the distance to the object by measuring the time that passed between you sending the ping and it coming back to you. You are able to do this because you also remember the speed of sound.

Most, but not all bats use sonar or echolocation, and of those that do, most use very high-pitched sound which is not audible to the human ear. There is one species of bat, called Rousettus, which makes clicking noises with its tongue which humans can hear.

There can be no doubt that those bats which use sonar are extremely impressive creatures. As Dawkins says:

> *'These bats are like miniature spy planes, bristling with sophisticated instrumentation. Their brains are delicately tuned packages of miniaturised electronic wizardry, programmed with the elaborate software necessary to decode a world of echoes in real time. Their faces are often distorted into gargoyle shapes that appear hideous to us until we see them for what they are, exquisitely fashioned instruments for beaming ultrasound in desired directions.'*

Through the wonders of modern technology scientists have been able to study various species of bats to find out more about how they use their sonar systems. As a result we now know that the species of bat known as 'Myotis' produces a 'ping rate' of approximately ten pings (or clicks) per second. On the assumption that each ping provides the bat with updating information, this means the bat's knowledge of its location and environment is being updated ten times per second.

If you are the sort of person who is not easily impressed, the figure of ten pings per second may not strike you as all that special. But you should bear in mind that this figure only applies to Myotis when it is merely cruising around. When Myotis detects an insect and moves in for the kill its ping rate will increase to up to two hundred pings per second.

As the frequency of the sound is so high as to be undetectable by the human ear (ultrasound), one very significant feature and requirement of the sonar system is not immediately obvious: volume. Each ping has to be loud enough to travel from the bat to the object, bounce back off the object, and travel back to the bat. Its volume on arriving back at the bat has to be loud enough to be detected by the bat, otherwise the ping is useless to the bat. However, the volume of the ping on arrival back at the bat will be significantly lower than the volume when it first leaves the bat, and to see just how much of a difference in volume there is we need to return to GCSE maths and an explanation from Dawkins:

> *'When the sound is broadcast its wavefront advances as an ever-expanding sphere. The intensity of the sound is distributed and, in a sense, 'diluted' over the whole surface of the sphere. The surface area of any sphere is proportional to the radius squared. The intensity of the sound at any particular point on the sphere therefore decreases, not in proportion to the distance (the radius) but in proportion to the square of the distance from the sound source, as the wavefront advances and the sphere swells. This means that the sound gets quieter pretty fast, as it travels away from its source, in this case the bat.*
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> *When this diluted sound hits an object, say a fly, it bounces off the fly. This reflected sound now, in its turn, radiates away from the fly in an expanding spherical wavefront. For the same reason as in the case of the original sound, it decays at the square of the distance from the fly. By the time the echo reaches the bat again, the decay in its intensity is proportional, not to the distance of the fly from the bat, not even to the square of that distance, but to something more like the square of*

the square – the fourth power, of the distance. This means that it is very quiet indeed.'

This means the drop in volume between send and receive is very significant indeed. And that brings us to a problem and takes me back to Wembley Stadium in 1991 and a concert by Guns N' Roses.

I was still a teenager and this was my first stadium concert. With something like 80,000 people in attendance I was keen to get as good a view as possible and that meant getting close to the stage. Unfortunately the area right in front of the stage was occupied by a lot of very mean looking 'bigger boys', so I decided to aim for the area just in front but to the left of the stage. This was occupied by much more friendly looking people and I was very pleased and excited to be able to manoeuvre myself to within twenty feet of the stage just before Guns N' Roses were due to perform.

Within a few hundredths of a second of Guns N' Roses starting their first song I realised I had in fact manoeuvred myself to a point twenty feet in front of one of the two main speaker racks for the whole of Wembley stadium. I was of course used to very loud music emanating from the parcel shelf of my Fiat Uno (turbo), but not even that had prepared me for this. The volume was just unbelievable. Now I knew why people had been so accommodating of my efforts to get to the front, and why they were far less accommodating of my efforts to move away. I think my abiding memory of that concert is the ringing in my ears that continued all the way home and was still going when I woke up the next morning.

If you're wondering what this has got to do with bats it's this. Any instrument which is sensitive enough to hear quiet sounds is likely to be damaged or broken if it is subjected to very loud sounds. And this poses a dilemma because the bat's sonar system will only work if it can send out a very loud sound at the start and hear a much quieter sound when it comes back. As a result, the equipment used for hearing the returning sound (the ear) will need to be sensitive enough to hear quiet sounds. But that same equipment may be damaged or broken by the very loud sound.

Obviously this problem did not prove insurmountable because bats have very successful sonar systems. Again, the wonders of modern technology have enabled scientists to discover that bats have what might be called ‘*send/receive switching technology’*, which simply means that at the precise moment the very loud ping is sent the very sensitive ear is turned off, only then to be turned on again in time to hear the returning now quiet ping. And when I say ‘precise moment’ I really do mean precise because, for example, scientists have discovered that the species of bat known as Tadarida can perform this send/receive switching fifty times per second!

But the problems don’t stop there. As will now be obvious, the system works by sending a ping and then hearing its echo. This means that the initial ping has to be short enough in time frame so that it has finished before its echo returns. If the initial ping is still being transmitted when its echo returns it would become difficult, if not impossible, to hear the echo; a) because the ping would drown out the echo and b) because the ear will either still be turned off or broken because it was turned on before the loud ping had stopped.

At first blush this problem can be very easily solved simply by making sure the pings are short enough in time frame such as to prevent the problem arising. However, this does not take account of the fact that the system relies on producing an echo which can be heard and as Dawkins says, ‘*the briefer a sound is, the more difficult it is to make it energetic enough to produce a decent echo.*’

It turns out that there are two solutions to this problem and scientists used both solutions when they developed man-made sonar and radar systems. The first solution is known as ‘chirp radar.’ In essence, each ping is sent out with a changing frequency, or pitch. In musical terms this would be like starting the ping on middle C on the piano but then going up an octave during the ping so that by the time the ping stops you are on the C an octave higher. This means that you do not have to have finished sending the ping before its echo arrives back, as by the time the start of the ping arrives back, pitched at middle C, the bit of the ping still being sent will be several notes higher in pitch, meaning it is easy to distinguish between the ping and its echo, just as it is easy to distinguish between a middle C and the C one octave higher.

However, whilst this solution would solve the problem of the ping drowning out the echo, it would not solve the problem of the ear having to be switched on at the same time as the very loud ping being sent. Indeed, whilst bats do send out pings which vary in pitch, scientists believe they do this in order to be able to differentiate between different echoes, as opposed to between a ping and its echo. This means they may just solve the problem of brief sounds producing poor echoes by making sure the brief sound is really really loud!

The second solution involves making use of what is known as the 'Doppler Shift.' For present purposes I do not need to address this, but I would once again point you to Dawkins' chapter which contains a full explanation of how it works.

Up until now we have been considering the problems faced by a single sonar system, or by a single bat. But bats do not live in isolation and as anyone who has ever been to certain parts of Africa will tell you, bats live and fly with lots and lots of other bats! This means there may be hundreds of bats present in one place, all sending out pings and listening for echoes, which is all very well but does rather beg the question of how on earth does a bat tell the difference between one of its pings/echoes and the pings/echoes from hundreds of other bats? Put another way, how does a bat stop its 'radar' from being 'jammed' by another bat?

Dawkins' answer to the question of how bats avoid being jammed by other bats is to say that it is 'not well understood', which to me sounds suspiciously like another way of saying 'we don't know.' Here's a taster of what Dawkins goes on to say:

> *'……not well understood, but an interesting clue comes from experiments on trying to put bats off. It turns out you can actively deceive some bats if you play back to them their own cries with an artificial delay. Give them, in other words, false echoes of their own cries.'*

And he continues:

> *'It seems that bats may be using something that we could call a 'strangeness filter.' Each successive echo from a bat's own cries produces a picture of the world that makes sense in terms of the previous picture of the world built up with earlier echoes. If the bat's brain hears an echo from another bat's cry, and attempts to incorporate it into the picture of the world that it has previously built*

up, it will make no sense. It will appear as though objects in the real world have suddenly jumped in various random directions. Objects in the real world do not behave in such a crazy way, so the brain can safely filter out the apparent echo as background noise.'

Whatever the correct answer might be there is no denying the fact that bats possess a navigation system which has solved every problem scientists have faced when they have tried to produce a man-made sonar system. And it is worth remembering that even the most sophisticated man-made sonar system is nothing but a cheap and inefficient imitation of the quite magnificent and awe-inspiring system found in those ugly little creatures that look like flying rats!

All of which takes us back to the question of 'How did we get here?' or rather, how did the bat get here? A small number of facts are as set out above and as they are part of the biological world they fall to be explained. But can they be explained by the assertion that is known as Darwinian Evolution?

There are a few more facts to set out before we turn to the assertion, but there is also an interesting postscript in respect of Dawkins' chapter on bats. Just after the extract I quoted above, Dawkins goes on to refer to a '*well-known paper by the philosopher Thomas Nagel called 'What is it like to be a bat?*' As I stated earlier, Dawkins was writing back in 1986. It is unlikely that Dawkins would make the same reference to Nagel if he was writing his book now, as no doubt much to Dawkins' annoyance Nagel has very famously and publicly turned his back on Darwinian Evolution, declaring that as a theory it is simply incapable of explaining the facts. But don't just take my word for it, read it for yourself in Nagel's book which he wrote in 2012 '*Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature is Almost Certainly False.*'