Counting your Ancestors

Many of us are interested in where our families come from as well as who our ancestors were. What and where are our 'roots'? Some of you might even have researched your genealogy or family history. Yet have you ever seriously considered how many direct ancestors you really have? Obviously, it's a lot, but how many? You might have even heard statements to the effect that all Europeans are descendants of Charlemagne in the eighth century or that all people of English ancestry are descended from 86% of the people living in England at the time of William the Conqueror almost a thousand years ago. If you live in North America and have English or European ancestors the same questions apply. Indeed, wherever you live and whatever your ethnic ancestry the questions of descent and ancestry are the same. This short article attempts, in a non-mathematical way, to answer or at least elucidate some of these issues.

Exponential growth – an explosion of ancestors?

On the surface the question of how many ancestors you have might seem simple to answer. After all you have two parents, four grandparents, eight great grandparents and sixteen great-great-grandparents do you not? The number of your ancestors doubles every generation. Surely you just need to do a simple mathematical calculation to work out the number of your direct ancestors who were living and breeding so many generations ago? The numbers surely just double in each generation: 2, 4, 8, 16, 32, 64 and so on. They would a form a pyramid – with you at the top of course!

After 10 generations you 'should have had' 1,024 ninth great grandparents. When was ten generations ago? Throughout this paper I will assume that you were born in 1947 (such a date has been used extensively in population studies) and that the average length of a generation is 30 years (this is an average inter-generational length not the age at which our ancestors had their first child – which is lower). So ten generations prior to 1947 takes us back to the mid seventeenth century – to around the time of the English Civil War and to the early days of British settlement in North America.

You might also be interested in working out how many direct ancestors you might have had in total between a certain date in the past and now. You can just add up the numbers for each generation. For instance from the time of your great-great-grandparents you could have had 30 direct ancestors in total: 2+4+8+16=30. Going back ten generations the total is 2,046 direct ancestors.

If you have ever had an interest in family history and genealogy you will very likely have quickly discovered how the number of your own direct ancestors does seem to explode the further back you look. You might even, as I did, have had to buy a software package to keep track! So 1,024 direct ancestors going back ten generations might not seem too many.

Given the available records, being able to trace our family back ten generations, down every line, would for most of us be a notable achievement. But let's extend our calculation yet further back – to twenty and thirty generations – a mere blip in our genealogical and genetic history. Twenty generations ago, in the mid-fourteenth century at around the time of the Black Death in Europe and about 150 years before Columbus 'discovered' America, a simple doubling of the number of your direct ancestors in each generation would imply that you had 1,048,576 nineteenth great grandparents at the time. In Britain at that time the total population was probably no more than three million – and that even before the Black Death reduced the population by a third or more. This suggests that if your ancestor numbers always doubled in each generation by the mid-fourteenth century they would account for one third of the total British population. A lot but not inconceivable.

But the number of people alive at any one time didn't just consist of one generation. Depending on your own age you are likely to have parents and grandparents who are still alive and/or children and grandchildren of your own. So in any individual's ancestry the number of his or her direct ancestors, in any generation, alive at a particular time is only a fraction of the total number of direct ancestors alive at that time. The precise fraction will vary from location to location and through time. It will also vary somewhat between different individuals' ancestry. Overall for Britain over the last thousand years it has been estimated that the fraction of the total population comprising 'one' generation has been, in percentage terms, somewhere around 40%. Putting this another way, this means that on average in any individual's ancestry there are about 2.5 'generations' alive at any one time. I will use this assumption. But you should be aware that within reason the analysis that will follow would still be valid if we were to use even quite

different assumptions. Looking back 20 generations to the mid-fourteenth century, if the maximum population of Britain at that time was, as mentioned, about three million, this means that there were only roughly 40% of this number, i.e. about 1.2 million people who could in fact have been your direct ancestors – compared to the 1,048,576 we theoretically need – still credible but only just.

So let's see what the doubling of our ancestors leads to after 30 generations, i.e. going back to around the time of the Norman Conquest in 1066. After thirty generations we would seem to have needed 1.1 billion direct and distinct ancestors! Yes more than one thousand million direct ancestors at the time of William the Conqueror! Obviously this is impossible as the total world population in the eleventh century has been estimated to have been only about 250 to 300 million.

So the number of our ancestors can't really have kept on doubling in an exponential manner as we go further and further back. Consider just one additional fact: it has been shown that the human race, *homo sapiens*, went through at least one population bottleneck during our history. At certain times it appears that humankind almost went extinct. Around 70,000 years ago scientists have suggested that the total world population dwindled to only a few thousand – the so-called Toba catastrophe. So sooner or later the number of your ancestors must have stopped exploding and had to have started to shrink, and shrink fast.

Such a phenomenon is called 'Pedigree Collapse', a phrase coined by Robert C. Gunderson. The mathematics of this are quite complex; I will attempt to explain what it all means without using maths. Essentially there are two interrelated reasons why the number of your direct ancestors does not keep on exploding and why their number will sooner or later start to contract. The first has to do with 'cousin marriage'. When you look back at your ancestry you will find that again and again your ancestors married, or better said, bred with their 'cousins'. This is not a conjecture, this is a fact. Although there will be much to say on the level of cousin marriage. Second, we need to understand the nature of the available 'breeding pool' that our ancestors had; and this means considering issues of migration.

The first factor, cousin marriage or inbreeding if you like, can help us explain why the number of your ancestors first grows and then will eventually shrink. The second factor, migration or 'outbreeding', helps us to understand why the onset of this narrowing and shrinkage is sometimes pushed farther back in time.

Inbreeding with your cousins

Nowadays we rarely marry or breed with a close relation. In some societies it is either illegal or societally unacceptable. In England since the time of Henry VIII there has been no law restricting who you can marry (remember he wanted to marry Catherine Howard and thus abolished religious consanguinity restrictions so that he could), but this is not the same everywhere in the world. In England today cousin marriage is very rare indeed, yet as we will see this was decidedly not the case in the past. In fact not only was 'some form' of cousin marriage likely, it had to have been extremely prevalent. Without it we couldn't even attempt to make sense of the development of human numbers over the centuries and millennia.

The first effect of cousin marriage is to reduce the rate of growth of the actual number of our ancestors, as compared to the theoretical maximum.

Before we look at a simple example let me explain a little of the genealogical nomenclature involved. When you think of your cousin you are usually thinking of your so-called 'first cousin'. This means that you and your cousin are related because one of your parents and one of your cousin's parents are or were siblings. And that means that you share one common pair of grandparents. A second cousin just pushes the relationship back another generation. You and your second cousin share a common pair of great grandparents. And so on through third, fourth and fifth cousins. In terms of relationships, we can even quite easily take into account such relationships as a 'third cousin once removed' or even various types of 'half cousins' or even, God forbid, intergenerational marriages with nieces and grandnieces etc. Mathematically and genealogically these relations can be expressed as the equivalent of first, second or more cousins. For example a third cousin once removed is mathematically equivalent to a fourth cousin.

So what happens to the number of your ancestors when cousins marry or breed? Let me build this up one step at a time. The first steps will no doubt be obvious, subsequent steps perhaps less so.

In the unlikely event that your own parents were first cousins we know this means that they shared a common pair of grandparents – this in turn means some of your ancestors are 'duplicates'. Think about your own family for a minute. Rather than your parents having the maximum of 8 grandparents between them they would in fact have had only 6! This is a 25% reduction in their grandparental ancestry – i.e. 6 is 25% lower than the maximum of 8. Now even if that were the only case of cousin marriage in your entire ancestry it would start to reduce the number of your distinct or non-duplicated ancestors. Starting from your great grandparents ('Generation 3' in the terminology I am using) your ancestors would double in every generation back from there. This means for you that you would have 6 great grandparents, 12 great great grandparents and so on. You can quickly see that the number of your ancestors decreases by 25% in each and every generation back from there. Note that for you this reduction, stemming from one unique first cousin marriage of your parents, only starts with the generation of your great grandparents. You still would have two distinct parents and four distinct grandparents but only 6 great grandparents.
On the other hand, if your parents were only second cousins the reduction in the rate of increase in the number of your ancestors would start one generation earlier and would be less severe. They would have a common pair of great grandparents. This means that you would have two parents, four grandparents and eight great grandparents, but only 14 rather than 16 great great grandparents. This is only a one eighth or 12.5% reduction. Such a one eighth reduction would then continue throughout your own ancestor line. Are you still with me?

But still the relentless doubling of the number of your ancestors would proceed apace, even if the start of the doubling is pushed back a generation or two. If your parents were first cousins then you would still theoretically have about 802 million distinct direct ancestors 30 generations ago, or 936 million if they were second cousins. Still far too many for it to be true. So I guess it's pretty clear that the occasional marriage of cousins can't explain the problem of 'missing ancestors'.

Let's take the next step and, perhaps rather extremely, assume that every single one of your ancestors married a second cousin. This seems extreme because historically the level of second cousin marriage was nowhere near as high. What would such 100% second cousin marriage mean for the number of your ancestors? Could this explain our conundrum of having too few ancestors? It turns out that it can't. Remember than if your parents were second cousins this would lower the number of your distinct ancestors by one eighth in each generation – so you would have 14 great great grandparents rather than 16 and so on. Now if all your grandparents were also second cousins then rather than you having 28 great great great grandparents (i.e. 14 great great grandparents x 2) you would have only 24, that is one eighth lower than 28. Each generation reduces the number of your ancestors by one eighth and these reductions cumulate as we go back. Once we look back thirty generations to around the time of the Norman Conquest, although 100% second cousin marriage reduces the actual number of your direct ancestors by a staggering 96% from the theoretical maximum of over about 1.1 billion, it would still mean that you should have had about 4,356,616 distinct direct ancestors (from one generation) alive at the time! Still well more than the estimated total British population – even without taking account of the fraction of the population accounted for by one generation and the percentage of people alive at the time who had no descendants or whose descendant line died out.

To recap so far: I have tried to demonstrate without using any complicated mathematics that the number of your direct ancestors does not double every generation. This is because they tended to marry, or at least breed with, their own relatives. Visualize if you can your own ancestor pyramid. One or a few marriages of cousins (of whatever degree) will have the effect, from a particular point on, of narrowing the pyramid of the number of your ancestors. It will not however stop the inextricable increase in their number. The pyramid starts to become narrower, more pointed, but it's still a pyramid. Not only that, even though the growth in the number of your ancestors can slow down very fast, for example if all your ancestors married second cousins, it still wouldn't go into reverse.

So no matter how much individual cousin marriage there was in your ancestry this doesn't on its own seem to be able to explain why, when you go back far enough, you always seem to need more ancestors than there were people in the country, on the planet or even more than the number of people who have ever lived! Yet we know that sooner or later the number of your ancestors needs to start to stop increasingly, even at a slower pace, and needs to go into reverse and start (quickly) declining. At some point in history the number of your ancestors absolutely must contract.

The reason why the pyramid becomes a diamond is that when your ancestors married or bred with a cousin (of whatever degree) they also very often had more than one cousin relationship with their spouse – sometimes many more.

Let's use a very simple hypothetical example to elucidate this. Imagine again that your parents were first cousins, so they share a common pair of grandparents. But they could also be second cousins as well, in which case they would also share a common pair of great grandparents. As we have seen, the first cousin relationship would reduce the number of your ancestors in Generation 3 from 8 to 6 and in Generation 4 from 16 to 12. The addition of the

second cousin relationship between them would reduce the number in Generation 4 further – from 12 to 10. As we go back in time such multiple relationships between spouses proliferate. Spouses might be second cousins twice over and third cousins and fourth cousins three times over for example. Such multiple relationships have an additive effect on the reduction in the number of your ancestors. The further we go back into your history the more likely you will find that this has been the case – in fact it is absolutely inevitable. At least intuitively for now I hope you can see that with enough multiple relationships, with if you like enough inbreeding, the cumulative effect of removing duplicate ancestors will at some point eventually outweigh the doubling-effect and the number of your discreet ancestors will start to shrink. The pyramid will at some point become a diamond.

Again without using mathematics, one way to illustrate the effect of such inbreeding on the number of your ancestors is to stop thinking about going back in time and consider a hypothetical example moving forward.

Imagine a Mr. and Mrs. Robinson Crusoe abandoned on a remote desert island many centuries ago. (You could name them Adam and Eve if you want). This might seem a very unlikely example, but history and genetics is riddled with such so-called 'founder events'. Perhaps Mr. and Mrs. Crusoe enjoyed their new environment and happily produced several healthy children. Let's imagine they produce four children who live to sexual maturity, two girls and two boys. Of course, unless these children want to mate with one of their parents (which is not out of the question) they will need to pair up with each other – possibly (though not necessarily) monogamously – one boy with one girl. All these children's children will now be first cousins. They will share the same grandparents. Subsequent generations will all be second, third and fourth cousins and so on. Not only that but as time passes they (the breeding couples) will all be related to each other in multiple ways. Ignoring for the moment the fact that such an inbred family would after some generations quickly start to show genetic degeneration, similar to various Royal families, Mr. and Mrs. Crusoe could have thousands upon thousands of descendants – indeed theoretically they could have millions of descendants after 30 generations. Take any one of these descendants and you would find that his or her ancestry would, by mathematical logic, have at first expanded and then contracted to only two – Mr. and Mrs. Crusoe themselves. This is an unavoidable fact and is, as we have seen, due to the cumulative effects of inbreeding. I think that you might also notice from this illustrative example that the expansion and subsequent contraction in ancestor numbers can even happen more than once. All Mr. and Mrs. Crusoe's thousands if not millions of descendants would be able to prove that the number of their direct ancestors first increased and then fell to just two. But as the 'founder' couple themselves had many ancestors of their own (unless you literally believe in Adam and Eve) then the numbers would start growing again; before reversing yet again as the effects of multiple inbreeding kicked in again, and so on. But that would take us further back in time than I can consider in this short essay.

In the real history of Britain there were certainly many founder effects similar to the Robinson Crusoe example, but most of them happened thousands of years ago in the period after the end of the last Ice Age when Britain started to be repopulated from a number of Ice Age refuges. Once a decent size British population was again established such genealogical (as opposed to older genetic) founder effects were rare.

Given the many gaps in the available genealogical records, and the fact that in Britain systematic records of births, marriages and deaths only started in the sixteen century and only achieved a reasonably full coverage a century or so later, it would be extremely hard, and in most cases impossible, to demonstrate for your ancestors or mine when exactly your ancestor 'pyramid' reversed to become a 'diamond'. As I suggested earlier, accurately tracing your ancestry back to the middle of the seventeenth century (i.e. 10 generations from 1947) following only some of your lines is itself a major achievement. Doing it with any certainly along all your lines is for most of us impossible. To the extent that you have managed to do so you will have undoubtedly found that some families keep marrying each other. But can you precisely identify all the cousin relationships? More importantly, can you always spot when some of your ancestors in a particular generation were the same people? To the extent that you can then you could also probably show how the rate of increase in the number of your direct ancestors had already started to slow down somewhat over the last three hundred years, but it is very unlikely that you could demonstrate an actual shrinkage in ancestor numbers over such a period – although it is theoretically conceivable that there was one. The major problem is that 10 generations isn't very long in genealogical terms and it's only a blink of the eye in genetic terms.

Over a longer generational time-span we can illustrate how inbreeding will lead to pedigree collapse by considering the case of breeders of pedigree horses and dogs. Because both horses and dogs both live much shorter lives than humans and start to breed at a much earlier age, breeders of 'pedigree' animals often have detailed 'stud books' recording parentage – sometimes going back thirty generations or more. They are therefore often able to definitively and graphically demonstrate how pedigree collapse has played out. Not only how ancestor numbers first expanded and then contracted but also how this can happen more than once. Such studies demonstrate unequivocally that inbreeding on its own, if severe enough, can and will lead to pedigree collapse.

The main problem with applying this analogy to humans is that animal breeders are usually consciously trying to breed pedigree animals; they are artificially and deliberately restricting the opportunities for dogs or horses to breed outside a very restricted group. Just as in a similar way how the inhabitants of our hypothetical Robinson Island have also been restricted in their breeding – by geographic separation.

Migration and outbreeding

How could this narrowing of the ancestral base have been attenuated? To put it another way, how could the available ancestor pool have been increased between the present day person and Mr. and Mrs. Crusoe, so that their descendant alive today has more than just two ancestors thirty generations back? Here we have to address the issue of the available 'breeding pool' at different points in the past – and how migration leads to outbreeding.

Perhaps some time over the past few hundred years another man or woman arrived by canoe on Robinson Island and bred with one or more of the people there. Or perhaps a Viking came and raped someone. The immediate effect would have been to expand the number of actual ancestors represented in the Robinson Island population. Every time this happened the number of ancestors for the descendants of Mr. and Mrs. Crusoe would have increased significantly. If an immigrant came from Africa or a Viking from Scandinavia he or she would inject the genealogical inheritance of countless people in Africa or Scandinavia. Every such immigrant or migrant adds considerably to the pool of collective ancestor diversity and the numbers of possible ancestors of future generations.

Every time that one of my or your ancestors moved, into or out of one of their 'ancestral' areas, whether a few miles or hundreds or thousands of miles, they brought or took with them an untold number of ancestors of their own. These ancestors have become your own. If people hadn't moved at all we would all be able to trace our descendants to one 'Adam and Eve' founder couple in the not too distant past, just like in our Robinson Crusoe example.

In the British or English examples I used earlier I was implicitly assuming that the total available pool of a British person's ancestors was limited, throughout the generations and within a particular generation, to <u>all the people alive in Britain</u>. Of course this is not necessarily true. It might be that the available breeding pool of your family was less than this or more than this. For any individual's ancestry this will depend on how often and how far your ancestors tended to move from their ancestral homes. If for many centuries your ancestors really were somehow hermetically sealed within a closed community (a walled village or district similar to Robinson Island) then the narrowing of your ancestor pyramid could have been quite fast and it might be that their numbers started to shrink sometime in the last few hundred years. In reality, however, such a degree of cousin marriage, and therefore resultant inbreeding, was probably quite rare.

I'll try to illustrate this by referring to my own ancestry. I am English. In fact I am so English it is somewhat embarrassing. For at least 400 years that I know of, my ancestors almost all originate from very specific locales in the English counties of Shropshire, Lancashire, Cumbria and Norfolk. During all this time I had no known ancestor who came from outside the British Isles – and just a few from Wales plus a couple from Scotland and Ireland. The great majority of my ancestors were born and were raised in a very limited number of specific areas – a village or a few villages. For hundreds of years most of them married others from within only a few miles radius. Generally of course couples married in the parish of the woman; but they tended to live thereafter in the husband's home. But move they did. They had access to a breeding pool much larger than that available to the descendants of Mr. and Mrs. Robinson Crusoe. In fact from time to time they moved further away. Why else would my own family (and probably yours too) originate from several places? In the 19th century my ancestors moved from Norfolk, Shropshire and Cumbria to Lancashire, to join other ancestors already settled there since at least the 17th century.

If I were able to go back another ten or twenty generations and identify all the connections, it's pretty clear that because people moved I would find some of my ancestors from nearly everywhere in Britain (or at least England) and probably quite a lot from abroad as well. Although there is a lot more to be said on the issue of migration, I think for now it is true to say that even for an English person such as myself, having recent ancestors from only a few specific and limited locales, over say a thousand years my ancestral' breeding pool' did probably encompass the whole of the country and possibly some of Europe as well.

When did the reversal in ancestor numbers happen?

There is a general rule involved here, based on the mathematics of genealogy and demographics:

When and how the number of your direct ancestors stops growing and starts to shrink is determined by the interplay of the cumulative negative effects of inbreeding and the positive effects of expanding the 'breeding pool' – via migration or so-called outbreeding.
How do these two opposing forces play out in reality? More particularly at what point in history did this inevitable reversal in the number of ancestors happen – in your family and in general?

Over a period of about ten generations in my family tree I can certainly notice that I had some 'duplicate' ancestors because of cousin marriage, and there are surely many more I haven't spotted. Yet I think it is clear that over this ten generation time period the degree of inbreeding in my family was is no way large enough to have had a very significant effect on the dramatic increase in my direct ancestor numbers, and it certainly wasn't enough to reverse the process.
But let's look at the numbers again. Depending on our assumptions regarding generational length, historic population numbers, the percentage of a population accounted for by one generation and the percentage of people who have left no descendants, then at some point in Britain or England, probably in the High Middle Ages as we shall see, the cumulative effects of inbreeding must have become large enough to reverse the tendency for anyone's ancestors to double in each generation. As I demonstrated earlier, this can be seen by the simple fact that at about this time the maximum number of an English or British person's direct ancestors would exceed the possible pool of their ancestors in the country.

At this point I would like to highlight one of the seminal articles on this subject, called *Ancestors at the Norman Conquest*, published in 1980 by Kenneth W Wachter, a Berkeley statistician and demographer. Wachter assumed that 'England' was a closed society, with basically no international immigration. He uses the example of a hypothetical, strictly English, person born in 1947 (let's please not open a debate on what 'English' means) and assumes an intergenerational length of thirty years. He then makes some assumptions about the average degree of cousin marriage based on an analysis of his own family tree – such cousin marriage being in fact quite rare. He then uses these assumptions in a mathematical model which calculates a probability distribution for the actual numbers of distinct (or unique if you like) ancestors in each generation. Such distributions obviously have an average or 'mean' value. He could then compare this average number with both the theoretical maximum number of any individual's ancestors (i.e. the simple doubling in each generation) and the estimated total population in England at different points in time. The results are illuminating to say the least.

For example, even 15 generations ago in 1527 the mean calculated number of distinct ancestors is still 31,438, not much less than the theoretical maximum of 32,768, and only about 1.5% of Wachter's estimated English population of 2.2 million at the time. To put this in another way, fully 96% of this person's ancestors in the 15th generation are distinct people and only 4% are duplicates or 'non-distinct'. This seems to accord quite well with my earlier observations regarding my own ancestry. But then something peculiar starts to happen.

Going back only five more generations (to Generation 20), or to about the year 1377, the number of distinct ancestors has grown enormously, to 628,576, but this is now 'only' 60% of the theoretical maximum of 1,048,576 – meaning that 40% of the theoretically available ancestor 'slots' are now duplicates or better said non-distinct. Also if the English population at the time was about 2.25 million as Wachter assumes (remember the Black Death decimated the English population starting at about this time) then this individual's ancestors in 1377 (and only in one generation) now account for fully 28% of the total population alive at the time.

25 generations ago, in about 1227, this individual would seem to have 2,012,114 distinct ancestors; or 80% of the estimated English population of 2.5 million. Not only that but only about one sixteenth of his/her ancestors are distinct people, this rest are at least duplicates.

Going back 30 generations to around 1077, to just after the Norman Conquest, we saw earlier that the maximum number of ancestors in that one generation was just over one billion (i.e. 1,000 million). Wachter's model calculates that this individual would have 952,279 distinct ancestors in 1077 – only around 0.09% of the maximum but representing fully 86% of the total estimated English population of 1.1 million. *This is ultimately the basis for the assertion highlighted at the beginning of this essay that everyone with English ancestry today is descended from 86% of people alive in the country at the time of William the Conqueror.*

In terms of the theme of 'Pedigree Collapse', the important point to notice is that between 1227 (i.e. generation 25) and 1077 (generation 30) the number of distinct ancestors more than halved, from just over two million to just under one million – and that means precisely and unequivocally that the 'pyramid' became a 'diamond'! In his model the reversal point takes place somewhere around 1200. So even with an extremely modest level of historical cousin marriage this model clearly shows that such marriages of relatives will first narrow the pyramid and then put it into reverse – i.e. it clearly demonstrates the phenomenon of Pedigree Collapse.

You might ask, as I did, how can this be so? I showed earlier that even if every single one of your direct ancestors married a second cousin this couldn't explain the seeming lack of ancestors. By 1077, under this scheme of 100% second cousin marriage, you should still have had around 4.3 million ancestors, way more than the population at the time. So how is it that with only very limited assumed cousin marriage Wachter's model reduces the number of distinct ancestors to just under one million over the same period? The answer is logically (and mathematically) the result of the cumulative effects over many generations of the effects of <u>multiple cousin relationships</u> between couples. After a few hundred years these cumulative effects really start to bite – the remorseless effect of knocking out potential ancestor 'slots' does actually outweigh the generational doubling. The problem with the hypothetical 100% cousin marriage example wasn't that the assumption was unrealistic (which it was) but rather that each marriage was independent and had only one effect on the number of ancestors, whereas in fact it would likely have had many.

Just as an aside, according to anthropologist Professor Robin Fox of Rutgers University, in his 2011 book *The Tribal Imagination: Civilization and the Savage Mind*, it is in fact likely that 80% of all marriages <u>in all of history</u> have been between second cousins or closer. In the context of our present discussion, and for now, I take this to mean <u>not</u> that during the time period we have been considering (and this is important) more than 80% of couples really were second cousins or closer (which they weren't) but that the cumulative cousin relationship effect was equivalent to this.

In a very interesting and informative series of popular articles, based partly on Kenneth Wachter's analysis, Brain Pears, a genealogist and physicist, argued that in general 'the number of ancestors in any generation will be little different from that obtained by our simple doubling scheme', (mitigated only slightly by a relatively modest level of cousin marriage) back to a point, around 1300 in his analysis, at which you are descended from almost everyone alive in the country at that time. He argued that further back from there the number of your ancestors would then have followed the (declining) total population (to be strict the total population per generation). Given the evidence for the limited degree of cousin marriage in Britain or England over the course of the last few hundred years, and even allowing for the fact that it no doubt was more prevalent further back in history, this would seem a reasonable conclusion.

However, a point worth highlighting is that this 'reversal point', in about 1200 in Wachter's model, can only have happened because of inbreeding, <u>there in no other mechanism</u> – notwithstanding periodic bouts of the Plague. Pears states: 'I accept that every couple will be related distantly many times over but not to anything like the extent necessary to limit the number or distribution of our ancestors significantly – it would only affect the timing. As we go back through the generations the number and distribution of ancestors will always increase until they cannot increase further. That limitation occurs when the ancestry encompasses the whole population. In earlier generations we would expect the number of ancestors to follow the population size.' But again remember that the reversal of the pyramid to a diamond can only happen due to inbreeding, indeed being 'limited by population size' and 'inbreeding' amount to exactly the same thing. In fact assuming only limited cousin marriage (as we all do) but not accepting the cumulative effects of multiple relationships would leave us, I suggest, in a tricky position. If our ancestors really did keep on 'nearly' doubling until a 'population limit' was reached, then when that limit is reached what then? Wouldn't we need a sudden and massive change in the pattern of inbreeding from very little to enormous to put the trend in the number of our ancestors into reverse? I don't find this credible. In fact Wachter's model clearly showed that before the point of reversal our ancestor pyramid had already narrowed enormously. For example, by the year 1227 the width of the bottom of the pyramid after 25 generations (when the number of distinct ancestors reaches a peak) is only one sixteenth as wide as if would be if doubling or near doubling had occurred!

Conclusions and what about our descent from Charlemagne and so on?

So how many direct ancestors do you have?

The answer is I am afraid that you will never be able to calculate a precise number. On the one hand the number might be more than you imagined, as the seemingly relentless doubling goes on. Yet on the other hand we have seen that sooner or later your ancestor numbers will start to decline. It might be, though it is extremely unlikely in the time frames we have been considering, that your ancestry goes back to only one locale at a certain point in history or even to one 'founder' couple.

At the beginning of this article I highlighted just two of the many bold assertions that have been made about our ancestry: such as that everyone in Europe is probably descended from Charlemagne and that every person in England can trace their ancestry to 86% of the people alive in the country at the time of William the Conqueror. Are such claims really true? For 100% of the people presently living in either Europe or England today they are obviously not. For example many English or Europeans are very recent, or even first generation, immigrants – from Asia or Africa and elsewhere. Even though everybody's lineage will have significantly reduced at some point in the not so distant past because of inbreeding, it is not mathematically self-evident that every English person will be descended from 86% of people in England at the time of William the Conqueror nor that not every European is descended from Charlemagne. Even if we 'exclude' such recent immigrants from our analysis and only consider 'indigenous' English or Europeans (whatever that might mean) such descent is still not completely certain in every single case, though it has to be said that it is highly probable. Such statements are about probabilities and averages not certainties!
Let's finish by returning to the question of migration and our supposed common descent from Charlemagne. England, Britain or any other country are obviously not, nor ever were, 'closed' or hermetically sealed countries such as the hypothetical Robinson Island. People always moved 'internationally' – although the concept of 'international' becomes anachronistic as we go further back. At any point to the extent that international migration took place it would have had the effect for any individual we are concerned with today of increasing his or her pool of ancestors. As the whole science of 'Small World' networks shows us it only takes a few 'long leaps' to connect us in fact with the rest of the world – hence the term 'Six Degrees of Separation'. So without being able to explore this issue further here (maybe another time) because breeding across borders (i.e. migration) happened over the 1,200 years separating us from Charlemagne it is quite conceivable that the bulk of people in Europe might be able to 'claim' ancestry from him.

So overall and 'on average' it has to be maintained that both these statements are probably true! We are all much more related than we might think.

But let's look at things another way. If you or I are indeed descended directly from Charlemagne then we are also inevitably descended from his gardener and cook as well. Maybe one of our zigzagging lines will take us back to Charlemagne, but 99.99% or more of our ancestry lines will show that we descend from countless numbers of simple, poor and exploited people – living in Europe around the year 800. People who ploughed the fields, built the ships, served in the armies or simply looked after their families. Whether we want to highlight the one or the many of our ancestors is a personal decision. For me what I find inspiring and humbling is that the vast majority of my ancestors were just simple people trying to make a living as best they could and trying to care for their families – often in the face of severe economic, social and political exploitation and repression. That they managed somehow to do so well enough so that I came into the world is, I would suggest, a testament to the greatness of human perseverance and the human spirit.

Sources

Kenneth W. Wachter, *Ancestors of the Norman Conquest*, in *Genealogical Demography*, ed. B. Dyke and W.T Morrill, Academic Press 1980; Brian Pears, *Our ancestors, conceptions, misconceptions and a paradox*, *The ancestor paradox revisited* and *The ancestor paradox yet again*,(available on internet); Douglas L. T. Rohde, *On the Common Ancestors of All Living Humans*, Massachusetts Institute of Technology, November 2003; Robin Fox, *The Tribal Imagination: Civilization and the Savage Mind*, Harvard 2011.