Ulster Med J 2021;**90(3):**175-181

Annual Oration

The Rime of the Ancient Imager: Plato's Cave and Other Shadows Royal Victoria Hospital, September 2019

Barry Kelly

Accepted July 2021

Picture the scene. It's a wedding and the guests are milling around in the garden outside the church. Suddenly, a wizened old man appears in their midst and makes a beeline for one of the guests.

It is an ancyent Marinere,
And he stoppeth one of three.
'By thy long grey beard and glittering eye,
Now wherefore stoppest me?

The mariner locks eyes on a young man and he can't escape. The mariner presses on:

At length did cross an Albatross,
Thorough the fog it came;
As if it had been a Christian soul,
We hailed it in God's name.

However, as he tells his story, the mariner speaks in an increasingly agitated tone, which concerns the wedding guest…

'God save thee, ancient Mariner!
From the fiends, that plague thee thus—
Why look'st thou so?'—with my cross-bow
I shot the Albatross!

The mariner has ensnared the young guest and continues to tell his story; the mistakes he has made, and the lessons learnt. Now his life's penance is to find the person who is about to do the same, tell him what he has learnt and warn him.

I pass, like night, from land to land;
I have strange power of speech;
That moment that his face I see,
I know the man that must hear me:
To him my tale I teach.

My pleasant task today is to address those of you about to begin your clinical studies. I thought that, like that flawed and wizened old mariner, I would offer some pointers, as I have learnt them.

Part 1: Fiat Lux

Let's start at the very beginning. Where do we live? How long have we been here? Our home, our galaxy - The Milky Way – is named for the milk of the goddess Hera. We live, as Douglas Adams wrote, in its *unfashionable* Western spiral arm. Our galaxy is between 150 - 200,000 light years across. The speed of light is 186,000 miles/sec; so, in a year, it travels 5.9 trillion miles. Our nearest star is Proxima Centauri, 4.3 light years away. We orbit an unimportant star with our eight neighbours. Approximately 800 of our little solar systems would fit into one light year. Feeling small enough, yet?

How long have we lived here?

The universe is infinite. Its explosive and inflationary origin was first proposed in 1927 by George Lemaître, a Belgian mathematician and Jesuit priest working at MIT. His mathematics had led him to conclude that a primeval 'atom' had burst forth into light, like fireworks, in what he himself called 'A Day Without Yesterday.' For subsequent decades of the 20th century, like *West Side Story's* Sharks and Jets, inflationary theorists argued about this with their steady-state opponents. One of the latter, Fred Hoyle in a radio broadcast, coined the term 'Big Bang', to pour scorn on it.

The problem for inflation theorists was leftover radiation. If, as Lemaître and the other inflation proponents argued, the universe had burst forth from *a singularity*, the energy generated should have left a residue. Given the enormity of time and space involved, it had been calculated that this would now be three degrees of microwave radiation. "Where is the radiation?" taunted Hoyle, "You can't find it because it isn't there."

Actually, a Russian astronomer named George Gamow had already, in a 1949 scientific paper, predicted precisely how this radiation might be identified and from where. It required a very specific piece of equipment and there was only one place that had it; The Bell Antenna. His paper unfortunately was in Russian, and the main players outside Russia hadn't read it.

In 1965, two astronomers, Arno Penzius and Robert Wilson inadvertently discovered a mysterious hiss in the night sky. It was constant and ubiquitous. It proved to be that elusive three degrees of microwave radiation; the last piece of evidence, making The Big Bang a fact. They had been working at the

Consultant Radiologist
Royal Victoria Hospital
Grosvenor Road,
Belfast BT12 6BA
Email: barry.kelly@belfasttrust.hscni.net
Correspondence to: Professor Barry Kelly

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.

Bell Antenna in New Jersey and using the specific telescope that Gamow had suggested in his Russian paper 16 years earlier. We will learn more of Bell laboratories later.
A few weeks before he died in June 1966, hospitalised with leukaemia, news reached Lemaître of Wilson and Penzius' discovery, thus confirming the validity of his Fireworks Theory.

When did we make our entrance?
Archaeological evidence suggests the following timeline for us: tools were in use by our ancestors two million years ago; fire first burned 300,000 years ago; we began to speak 80,000 years ago; agriculture began 10,000 years ago and we began to write, only 5000 years ago.

That's a lot of information and the numbers given are so large that it they are difficult to process. Suppose, as Carl Sagan has suggested in *Cosmos*, we consider this slightly differently. What if we compress the 13 billion year history of the universe into one calendar year? If this calendar were the size of a football pitch, all of human history would be the size of your fist. Our current location is 31 December and we are approaching midnight. Our starting point is January 1st. In this Cosmic Calendar, each month represents 1.25 billion years; each day, 40 million years; each hour, 1.8 million years; each minute, 30 thousand years and each second, 500 years.
On January 1st, The Big Bang happens (13.8 billion years ago). On January 10th, the first stars are born. On January 13th, stars coalesce to form galaxies. On May 15th, The Milky Way is formed. On August 31st, our sun is born. On September 15th, the earth is born (4.5 billion years ago). On September 21st: life begins on earth. On December 24th the dinosaurs appear. On December 28th, the dinosaurs disappear again just as our first flowers bloom.

As we approach December 31st, things get busy. Just over two hours ago, at 9.45pm; our ancestors, the first hominids, stand upright. One hour ago, the first tools are made. Fifteen minutes ago (450,000 years ago) the Neanderthals arrive (and disappear 1.3 minutes ago. I regret to inform you that we probably ate them.) Fourteen minutes ago, at 11.46pm, fire is tamed. Twelve minutes ago (350,000 years) *Homo sapiens* appears. Three minutes ago (80,000 years) we begin to speak. Forty seconds ago, we domesticate plants and animals. Twenty-five seconds ago, we build our first cities. Only sixteen seconds ago, writing begins. As Carl Sagan wrote, "All of recorded history; everyone about whom we have ever known; every hero and coward, every saint and sinner are contained within the last 16 seconds of our cosmic year." Ten seconds ago, we invent the wheel. Seven seconds ago, Moses is born (1700 BCE). Six seconds ago, Buddha is born (500 BCE). Four seconds ago, Jesus is born. Three seconds ago, Mohammad is born. One second ago, Martin Luther and Galileo are born. Finally, one-fifth of a second ago, radiation is discovered.

So first we had The Geosphere, our planet; next The Biosphere, when life began to bloom (mid-September) and then The Noosphere, a termed first used by the French philosopher and paleontologist, Teilhard du Chardin, when we began to *think*. To paraphrase du Chardin, 'We are the animals who know, and *know* that we know.' We do indeed. We are a young species, fragile and curious. Drilling down into our world of human endeavour, we now approach our own particular discipline: medicine.

Part 2: Medicine

The Origins of the National Health Service
In the early part of the 20th century, a young Glaswegian doctor began working as a GP in a South Wales mining town. His name was Archibald Joseph Cronin. Later in his career he would write *The Adventures of a Black Bag* that many of us remember as *Dr Finlay's Casebook*. But let us return to South Wales. Cronin was appalled by the inequality of what he saw and in 1937, he wrote a semi-biographical novel: *The Citadel*. This book is considered by many to be the single most important literary work that inspired Aneurin Bevan to create the National Health Service in 1948. Cronin wrote:

"I have written in *The Citadel* all I feel about the medical profession; its injustices, its hide-bound unscientific stubbornness, its humbug. The horrors and inequities detailed in the story, I have personally witnessed. This is not an attack against individuals, but against a system."

Bevin continued, "No society can legitimately call itself civilised if a sick person is denied medical aid because of a lack of means. Illness is neither an indulgence for which people have to pay, nor an offence for which they should be penalised, but a misfortune the cost of which should be shared by the community." Interestingly, Bevan anticipated that his great social experiment would last for about five years. By that time, he reasoned, most diseases would be cured. As you will have observed, ladies and gentlemen, that has not proven to be the case.

What makes a doctor?
I believe that a good doctor requires only three attributes: industry, integrity and compassion (or sympathy, if you prefer). Sympathy is the perception, understanding and reaction to the distress or need *of someone else*. Empathy is the capacity to understand or *feel* what another person is experiencing. Empathy is currently often prioritised by medical educators but I am wary of this. For me, empathy is being able to step into the shoes of another person, or indeed, having been in those shoes oneself. It is challenging to accept that a young medical graduate, often from a privileged background, could really have commonality with the life experiences of a much older person, possibly from a different social and economic group. As Seamus O'Mahony has said in his book *Can Medicine Be Cured*, "Hold my hand while you misdiagnose me." However, it is very possible and indeed desirable to be sympathetic. There is an older and less fashionable word for this: compassion. Words are our scalpels. We need to be careful with them.

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.

Knowledge and Wisdom

What is the difference between knowledge and wisdom? According to Myles Kington, knowledge is knowing that a tomato is a fruit. Wisdom is not putting it in a fruit salad. It is disconcerting to think that today's expert may become tomorrow's relic. Age, however, can bring experience and often wisdom with it; both useful attributes for the young to seek out in the old.

The Failing Doctor

The moving finger writes; and having writ, moves on.
Nor all thy piety nor wit;
Shall lure it back to cancel half a line
Nor all thy tears wash out a word of it.

The Rubáiyát of Omar Khayyám

The past cannot be undone and we all make mistakes. That's the price we pay for being human. I console myself with the thought that it is very difficult to make an original mistake. As far as I know, just over 170 doctors were erased from the GMC register last year. The question is: how many were erased for technical failures and their inability to carry out their specialist skill? The answer is, practically none. The vast majority of doctors erased from the register, were so for reasons we often don't like to discuss or even admit, exist. At least ten percent of medical students and doctors have significant psychological issues. These are widespread and various but include addiction, personality issues, stress, burnout and so on. Two percent of us are bipolar and we know that one percent are potentially suicidal. There are about 300 people in this audience, so you can all do the mathematics.

If you work in a department with nine other people, the chances are that one of them will fall into this psychological category. If you can't think of who that person might be, it just might be *you*. In my view, historically this is an area about which we have devoted little time. Graduate medical students for example are particularly susceptible. Focused, dedicated, tenacious and usually successful, they will also have debt, may have several jobs, a partner and children, so therefore are much more likely to come to grief than the wide-eyed school leavers, excited to explore their new freedom and the extra-curricular possibilities of third level education

The 'at risk' practitioner isn't necessarily an obstetrician about to embark upon an emergency procedure, it can simply be the person staring at a normal ECG or unable to don their surgical gloves. Worse, it might be the person in the hospital car park, catatonic with dread, that is at most risk. We know that this problem is ubiquitous and increasing, particularly for junior doctors due to what has been named the Toxic Environment of Uncertainty. In their earlier school and university days there was always a solution and they would find it. In our chaotic world of 21st-century medicine with its multifactorial problems, understaffing and budgetary restrictions, they can crumble all too easily. We need to do much better here.

Plato's Cave

Imagine that you are in a cave. You and others are chained to a wall within the cave, facing its back wall. Onto it, project the silhouettes of the outside world. This is all you have ever known. Those dancing black-and-white shadows are your comprehension of the world. One day, a mysterious individual comes and unchains you. He takes you outside and demonstrates reality. Life in all its variety, colours and dimensions is revealed to you for the first time. This, of course, is overwhelming and extraordinary. Suddenly, you are brought back into the cave and, once more, chained to the wall. "Where have you been?" asks one of your companions. "I've been outside" you reply. "But there is no outside," he laughs. With increasing desperation, you explain that the shadows visible on the cave wall are simply that; a two-dimensional reflection of our three-dimensional world. The allegorical story illustrates the philosopher's frustration when she has an epiphany into the cosmos's workings. Despite her protestations, those around her dismiss her as a lunatic. Such is the philosopher's lot. However, I would suggest that Plato's cave also works as a metaphor for radiology. The shadows that we see on the wall aren't *real*, but simply represent the sketchy shadows of our actual patients. So, it's to Radiology next that we turn.

Part 3: Radiology

A question I occasionally ask non-clinical medical colleagues is, 'What did your mobile phone look like when you were last on call in an acute hospital?' That telephonic metaphor: the older the phone; the quainter the view of radiology, reflects the rapid advances made due to Gordon Moore and his eponymous law, to which I shall return. When I qualified, the dictum was, 'This patient is too sick to go to radiology.' Now it's, 'This patient is too sick <u>not</u> to go to radiology.' Radiology is technologically driven and is advancing ever faster. Godfrey Hounsfield's first CT brain image took hours to produce but now an abdominal CT takes about 20 seconds.

Discrepancy and Error

Radiology is primarily a visual medical specialty operating on the basis of pattern recognition. It helps to understand the code. In this 15th century woodcut by Albrecht Dürer, one sees Adam and Eve in the Garden of Eden. But if one looks carefully, the artist has included symbols of both allegory and The Four Humours. (*Fig 1a, and b*. *Adam and Eve in the Garden of Eden, Albrecht Dürer,*) There are several animals. There is a parrot, an ox, an elk, a goat, a cat, a mouse and a rabbit. The artist's contemporaries would have understood this code. The parrot's call was believed to sound like 'Eva Ave' ('Hail Mary') and the bird, symbolic of the Virgin Birth. The goat represents the Bible's scapegoat, ritually burdened and routinely banished. The others are the four humors: the elk is black bile or melancholia; the cat is choleric or yellow bile; the rabbit is blood and the ox, phlegm. Dürer is telling us that the four humours are momentarily balanced, and the goat is still on his hill; representing a moment of perfection and harmony. Not knowing this code is termed an error of cognition.

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.

Fig 1a. Adam and Eve

Now let us consider errors of perception. Here are two chest radiographs, each concealing a cancer. The question is: where is it? In this first case, there is loss of normal apical symmetry. (*Fig 2 a,b,c. Left apical tumour).* This is

Fig 1b. Adam and Eve decoded

not unusual and is often quite innocent. A second, simple, apical view demonstrates however that there is a mass. The subsequent CT confirms this and no doctor in this room would miss it. In the second case, all appears well. (*Fig 3. a, b. Right basal tumour*). There is however a concealed ten-centimetre tumour at the right lung base, where there is a density that shouldn't be there. Again, the CT makes it obvious.

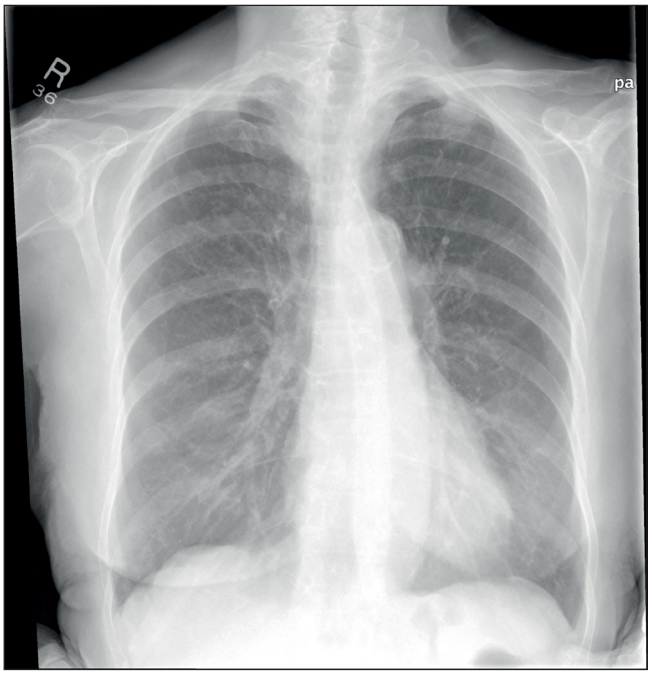

Fig 2a. left Apical Tumour, chest radiograph

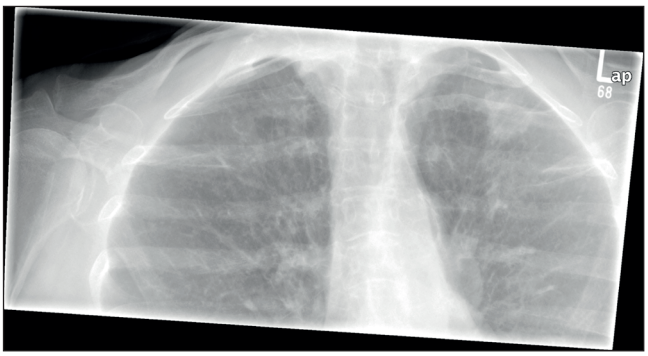

Fig 2b. left Apical Tumour, apical projection

Fig 2c. left Apical Tumour, CT imag

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.

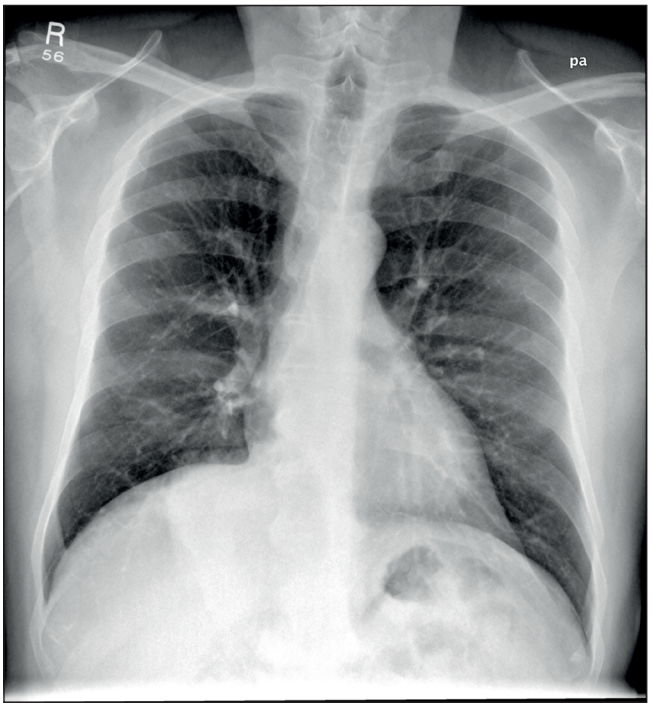

Fig 3a. Right Basal Tumour, chest radiograph

Fig 3b. Right Basal Tumour CT

Sometimes though, we see things that simply aren't there. Unsurprisingly, if you look at a chest radiograph for less than five seconds, you will miss things. However, if you look for more than 60 seconds you may start to imagine shapes that aren't there. This phenomenon is called Pareidolia. Pareidolia is our tendency to interpret a vague stimulus as something known to the observer, such as seeing shapes in clouds, seeing faces in inanimate objects or abstract patterns, or hearing hidden messages in music. It is not confined to humans. Scientists have for years programmed computers to use visual clues to 'see' faces and other images.

Part four: Technology and The Future.

What are humanity's most important inventions? I will suggest three. The first is the sewing needle, probably about 50,000 years old, which allowed us to make clothes that kept us warm and survive the ice ages. The second is the wheel about 5000 years ago which got us on the move. The third would completely change the world.

Its inventor was a man named Johannes Gansefleisch (John Gooseflesh). He was a serial inventor with a variable success rate. His current invention was so radical that he thought his name Gansefleisch wasn't appropriate. So, he changed it to the street in which he now lived, Gutenberg Street. The invention was, of course, the printing press with movable type. The exponential explosion of information that emanated from the press marked the dawn of The Information Age.

In 1854, George Boole, professor of mathematics at University College Cork, published *The Laws of Thought* and this contained his Boolean Logic. Boolean Logic is credited with laying the foundations for The Information Age. It is based on entirely on two numbers: one and zero (true and false) and would become the basis for all computer language. Although Charles Babbage conceptualised and built the first mechanical computer in 1833, modern computing really began with in 1936 with Alan Turing. In 1948, Claude Shannon, the Father of Information Theory, postulated that electrical switches could open and close as per Boolean logic. William Shockey, at Bell Laboratories, subsequently devised solid state energy-efficient semiconductors, thereby replacing the cumbersome vacuum tube. He came from, and returned to, a small town in California; Palo Alto, founding Shockley's Semiconductors and Silicon Valley. His silicon transistor, a word that is a composite of *trans conductance* and *varistor*, used approximately one millionth of a vacuum tube's power. For this discovery, he was awarded the Nobel prize. Two of his coworkers, Robert Noyce and Gordon Moore left to form a new company which they called Integrated Electronics. We now know this company as Intel. Their new integrated circuits were known as microchips or microprocessors. In 1965, Gordon Moore propounded his famous law that "Processing speed or capacity will double every 18-24 months."

The pernicious advance of Artificial Intelligence (AI)

Chess had always been considered the apotheosis of human intelligence and therefore the defeat of a human by a computer marked a watershed. In 1996, Garry Kasparov was defeated by IBM's Deep Blue. To give some idea of the permutations (known as game tree complexities) involved, in chess this is calculated to be 10 to the power of 120 moves. By comparison, the number of atoms in the universe has been calculated at 10 to the power of 80. These numbers incidentally are called Shannon Numbers, after Claude Shannon. Deep Blue could calculate 200 million chess moves a second. In 2016, all of that computing power was available in a Sony PlayStation. All that in 20 years, or, if you prefer, ten to thirteen 'Moores.'

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.

In 2011, IBM's Watson computer competed on the US quiz-show, *Jeopardy* against two reigning champions and won. Watson could process the equivalent of a million books per second. In 2016, Google's Deep Mind computer, Alpha Go defeated the reigning world champion at the ancient Chinese game of Go. Go, considered the world's toughest game, is played on a 19 x 19 square board and has 10 to the power of 360 moves. The Universe, remember, has 10 to the power of 80 atoms.

Deep Blue had been built for one purpose; to play chess. It couldn't do anything else. Google's Alpha Go on the other hand was built *to learn*. Six months before it played Go's world champion, it had been ranked 400th in the world. In six months, it had taught *itself*. It had learned and improved to the extent that it had beaten the world champion.

There is no question that medicine like every other discipline will be changed utterly by computers However, at the heart of what we do, one constant will always remain: a doctor and a patient. Both will be flawed and exhibit human frailty, but the relationship will be charged with our one unique advantage: humanity. I suggest that the impact of AI on medicine can be summarized as follows: numbers, pictures, gloves and hunches. I would like to consider each of these in turn.

Numbers

Noam Chomsky observed that, "a computer winning chess is no more surprising than a forklift truck winning a weightlifting competition." So it is with numbers. Number-based medical specialties (e.g. nephrology) will utterly transform within the next five years.

Pictures

The algorithms required to interrogate pictures are more complex, but as we all know from facial recognition and our mobile phone thumbprint access, this isn't science fiction. Radiology, histopathology and dermatology sit within this group. Our imaging now is almost exclusively digital, therefore Boolean and increasingly easily deciphered by computers. Radiology will change dramatically in the next decade and I caution our trainees that they must put on a pair of gloves to have a career. This brings me to the next section.

Gloves

Practitioners and specialisms that routinely use gloves like surgery, obstetrics, anaesthetics, interventionalists and endoscopists require more complex and intricate motor skills than computers can currently provide. Besides, even if they could replace the practitioner, we generally appreciate a human pilot on our plane!

Hunches

Hunches are a much higher order event. Many here will remember walking into a room, seeing a patient and instantly thinking "This lady is really sick." Our diagnosis has been made in milliseconds. How do we do this? We know it because experience, non-verbal cues, non-linear, non-Boolean information stored in our frontal lobes and memory centres inform us that - no matter what the results and tests say - there is *something badly wrong* here. It is, in effect, a hunch. Medical specialties that work with rapid diagnosis and intuition sit here: a GP is required to make her diagnosis within minutes. Emergency Medicine is another. Perhaps one of the most interesting specialties to consider is psychiatry, where the diagnosis is formulated based on what the patient is saying (or not saying); how they are saying it; how they are sitting; what their eye contact is like and a host of other human factors that, as matters currently stand, are very difficult for a computer to evaluate. It will take some time for AI to get there.

The Flaw in The Law.

Moore's Law is predicated on the fact that computers are built by us. The premise therefore follows that when computers are building *themselves* and are self-learning, Moore's doubling times are very likely to contract. Because I learn to ride a bike, it doesn't mean that *you* can benefit from *my* knowledge. Tesla cars on the other hand, upload what they've learned each night to The Cloud, so that *every* car learns.

The point at which all physical laws break down is called The Singularity. At the beginning of time, with the creation of our universe, the first singularity was replaced by these laws. At the end of time, they will once again dissolve. Some devotees of artificial intelligence called The Rationalists describe another singularity. This is when artificial intelligence, computing speeds, machine learning and neural nets all converge. What space will there be then for us? The answer is likely to be the same as that received from Zhou Enlai in 1971 when the Chinese politician was asked what the consequences of the French Revolution were. Although he may have been referring to the French riots of 1968, the famously silky reply was, "It's too early to tell."

The Imager, whose eye is bright,
Whose beard with age is hoar,
Is gone and now the Wedding-Guest
Turned from the bridegroom's door.

He went like one that hath been stunned,
And is of sense forlorn:
A sadder and a wiser man,
He rose the morrow morn.

But let's not be despondent. Like that bright-eyed mariner, we will proceed optimistically. I would like to finish with a quick story from an old friend and what happened during his final radiology exams. He was shown a spinal radiograph that demonstrated a fracture. "What would you do next?" He replied that he would perform a CT study, which he was duly given. This confirmed the fracture. "Now young man, you are told that the patient has neurological symptoms. Is there any other test you could do?" He suggested an MRI, which unfortunately confirmed that the bone had pushed against the spinal cord. "Very good. Now what would you say to the neurosurgeon?" He thought for a moment and replied, "I think I would say …. well, that's me off home then."

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.

Thank you all very much for your very kind attention.

Further Reading

Samuel Taylor Coleridge. *The Rime of the Ancyent Marinere*. Poetry First Editions. London. Penguin. 1999.
Carl Sagan. *Cosmos*. London. Macmillan. 1981
Bill Bryson. *A Short History of Nearly Everything*. London. Transworld. 2005.
William Manchester. *A World Lit Only by Fire. The Medieval Mind and The Renaissance*. New York. Little Brown and Company. 1992.
John Farrell. *A Day Without Yesterday. Lemaitre, Einstein, and the Birth of Modern Cosmology.* New York. Basic Books. *2012.*
A.J. Cronin. *The Citadel*. London. Hodder & Stoughton. 1983
Aisha Khan. *Avicenna: Muslim Physician and Philosopher of the Eleventh Century*. New York. Rosen. 2006.
Seamus O'Mahony. *Can Medicine Be Cured?* London. Apollo. 2019
Douglas Adams. *The Hitch Hiker's Guide to the Galaxy*. London. Pan. 1982
Stephen Fry. *Stephen Fry's Great Leap Years -the Stories behind Inventions*. (Podcast series). Acast. 2018
Tom Chivers. *The AI Does not Hate You. Superintelligence, Rationality and The Race to Save The World*. London. Weidenfeld and Nicolson. 2019.

UMJ is an open access publication of the Ulster Medical Society (http://www.ums.ac.uk).
The Ulster Medical Society grants to all users on the basis of a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence the right to alter or build upon the work non-commercially, as long as the author is credited and the new creation is licensed under identical terms.