

**Warming to You-
A Dialog on Explanation and Understanding**

**By
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Synopsis

Jane wants Bruce to explain *climate change* to her- but Bruce isn't sure that she is prepared at all for the kind of explanation that she thinks she wants.

Jane is very talented – but she hasn't had a thought about science and maths for about 30 years. Her world has revolved around her passions of literature and art since primary school. Where can Bruce start? Where will he go? What will Jane really know when they get “there”?

Being busy with jobs (Jane's a part-time drama teacher; Bruce some kind of scientist-we never get to know) and two pre-schoolers, they agree to take the time to explore the issue bit-by-bit.

Bruce has a plan- he wrote an essay on explaining and understanding science some years ago – here's a chance to try it out – eight simple steps from the concrete to the abstract – then back again – just like steps on a chessboard.

So starts the dialog...

The book is purely dialog. No description at all. Pillow talk, talk in the car on the way to Bruce's parent's farm, talk in a Chinese restaurant – wherever and whenever they can find a few minutes. Just talk.

But it's nowhere near as easy as Bruce thought it would be- Jane comes from a position of ‘belief’ and has her own take on the world. She loves Bruce, but his relentless ‘empiricist probablist’ approach to life can be exasperating. And when she thinks that she has a handle on Bruce's explanations, she re-frames it as a Shakespearean sonnet and sometimes a poem of her own.

To Jane's feigned occasional annoyance, they never actually get to discuss climate change at all- the journey becomes more interesting than the possible destination. They tour the ideas of ancient Greece, the Renaissance, the Enlightenment, the evolution of art in the nineteenth century, Alice in Wonderland and much more – two bright and willful people agreeing to try to understand each other across the classical divides of art and science, faith and reason, childhood and adulthood – and man and woman.

This dialog is intended to be an e-book- its more than 700 references are hyperlinked- mostly to Wikipedia. Why Wikipedia? Bruce explains his passion for the medium that saved him from a fate as a farmhand. And it has a history- Alexander's library, Diderot's Encyclopedie, Britannica, Richards... a window through which a light softly breaks...

The e-book version is also copiously illustrated with ‘pop-over’ pictures and about a dozen animations. Several example pages are attached.

Note: The illustration on page 101 is essential to describe Bruce's 8-stage process.

Sample pages from e-book

...these acts – ‘seven ages’ – begin with **‘the infant – mewling and puking in the nurse’s arms’** and work through six further vivid verbal sketches, culminating in **‘second childishness and mere oblivion – sans teeth, sans eyes, sans taste, sans everything’**. Would that have helped?



They probably did, Jane. **Those ‘seven ages’ – or stages of Shakespeare’s – are part of our cultural DNA** – they help us think progressively. I think that they will come in handy later when we talk about life-cycle energy costs. But in this particular case of looking at explanation, **I was trying to focus on what happens when you have a fairly sane, sensible person – usually an adult, who says ‘please explain that to me’**, rather than someone at the mewling, puking and oblivion stages.

Okay – so Piaget’s four stages and Shakespeare’s seven stages didn’t fit – **what did you come up with?**

Eight.

Why eight?

It’s a very nice number.

That’s an unusually feeble reason, Bruce. I’m sure that there is more to it than just being ‘nice’.

Well, in fact there is. When I started analyzing the way that science textbooks and lecturers explained things, **I came up with six distinct stages ranging from ‘pictorial’ to ‘abstract’**. I then realized that there was a seventh stage that was a bit like Piaget’s earliest ‘concrete’ stage, but it seemed incomplete, because it didn’t account for the way *geniuses* look at the world. **So I made an eighth stage.**

So why is that ‘nice’?

How so?

His writing is so profound, but most of his characters behave like fools. They do all sorts of silly things and act impulsively. **How can we learn from fools?**

I kind of agree with you, Bruce – **there’s the foolish – and then there’s the fools.**

That sounds very Shakespearean, Jane. What do you mean?

Well, the Bard describes a lot of foolish behavior through his characters – most of whom are serious, upper – class citizens, **whose sense of reason is blinded by the extreme circumstances in which they find themselves.** As we all do. **They fall back on their base emotions – jealousy, rage, grief, besotted love and so on – and then do foolish things – often murder.**



But you make an odd distinction, Jane – aren’t people who behave foolishly, fools?

Not in Shakespeare. The **fool** is a special character – as well as providing comic relief after the serious characters had done something foolish, **they were permitted to speak frankly, while others minced their words.**



So they’re like scientists?

There’s more than a passing resemblance, Bruce.

So the fools are there to make sense of the foolish things that sensible people said?

Scene Zero

From the kitchen, Jane could see Bruce’s satisfied smile as he drove in to the carport.

“Stop smiling, Bruce, or you won’t fit through the door! What gives?”

“Just got our new [hybrid car](#)¹.”

“Hmm – looks nice. But why the big smile?”

“Well, Jane, we’ve got a car that is all that we’ll need for the next ten years – it has great fuel economy and really has a low fuel cost – in fact, about one-third of the cost of our old six-cylinder clunker according to [our motorist club](#)². It’s something we can be proud of – our bit towards saving the planet from [Climate Change](#)³.”

“That’s great, Bruce. Does that mean that we can take that holiday in Phuket without stretching our budget?”

“Err... That would be nice, Jane, but I don’t think we would be saving the planet if we did that.”

“Why not? Our [carbon footprint](#)⁴ to Phuket and back wouldn’t be that much. Wouldn’t it?”

“Sounds plausible, Jane, but I figure that it doesn’t work like that.”

“Why not? Please explain.”

“Well, there’s a short, simple answer, but the full explanation is quite lengthy.”

“Try the short answer first, Bruce. You know that I’ve got *acquired* [attention deficit disorder](#)⁵.”

“Yes – well – you do insist in listening to [talk-back radio](#).⁶ It’s a wonder that you haven’t acquired more than that.”

“The short answer, please, Bruce. It’s dealing with two pre-schoolers that’s done it to me. Without talk-back radio, I can’t keep informed.”

“So much information – so little understanding! – But we won’t go there. I’ll just give you the short answer: *Productivity*⁷ has got to be greater than *production*⁸ or we’re *buggered*. How’s that?”

“That’s bloody typical! So obscure that only an economics professor could understand it.”

“Well, you asked for an *answer*. An [answer](#)⁹ is not necessarily an *explanation*. That answer summarises it all, but I said that an explanation *could* be quite lengthy.”

“Isn’t there anything in-between? Like a concerned-playgroup-parent’s-conversation-length explanation? Or a dedicated-dog-walking-group-member’s explanation? Like a couple of minutes, not just a couple of fancy words?”

“Hmm... Can you boil down your master’s thesis on [Shakespeare’s sonnets](#)¹⁰ into five minutes for me?”

“But that’s different, Bruce.”

“Sure, [Shakespeare](#)¹¹ is different from physics, but I’m sure that the problem is the same.”

“Okay, Okay! Point taken. But I’m sure that I could give you the *gist* of it in five minutes. Can’t you do that with climate change?”

“Hmmm... dunno. We have a real problem here. It’s the problem faced by scientists every day, now and I think that it is actually a new problem – at least at a *public* level.”

“New? Teachers have been explaining science for centuries, surely?”

“To *students* – yes, but the *general public* is a somewhat different matter. The general public *used* to believe – or a least *accept* – the scientists’ occasional public statements – probably because most of those statements were about science with obvious economic or health or military benefits – or some totally amazing and way-out discovery that was useless and harmless. Every now and then the media would let a scientist ramble on in public and we – the general public – weren’t really any the wiser, but we *were* comforted because they seemed confident and in control. Now that the scientists are giving us bad news that we don’t like, we don’t want to accept their ten-second sound grabs of discoveries, outcomes, results and findings and we still haven’t got the talent to understand their lengthy explanations. It’s easy to boil down fear, greed, doubt and anxiety into a bumper-sticker-length statement. It’s pretty well impossible to do that to a believable scientific explanation. [Flight will always prevail over fight](#)¹² if we have the option.”

“So there’s a no-person’s land in understanding between one hundred words and one hundred pages?”

“Usually, even when you simplify the explanation of a significant theory sufficiently to make it understandable to anyone even an average high school science education, there is the danger that it will misrepresent the science sufficiently that unscrupulous people can make a plausible case that you are wrong. This is particularly true of descriptions of [complex systems](#)¹³ such as [climate](#)¹⁴.

“So is there any way to deal with this dilemma, Bruce? Can an explanation be both simple *and* true?”

“I think that *simple* and *true* are quite possible – but one person’s *simplicity* is often another person’s *difficulty*. So, what comprises a *satisfactory* explanation will depend on how easily you are satisfied or how much else you know about the subject¹⁵.”

“It seems that we are going to have difficulty getting beyond the notion of simplicity, Bruce. Are we going to get stuck at some [epistemological](#)¹⁶ first base?”

“Maybe even worse than that, Jane – *home base* comes before *first base*.”

“I thought that it came after third base – when you run home – it did when we played softball at school.”

“Yep – and baseball, too – it’s both where you start *and* finish.”

Mmmm.. Maybe there is some middle ground in explanation – but it does come with a few basic requirements...

“Oh! I thought I saw an asterisk.”

“Well... first it needs you to keep your [reasoning](#)¹⁷ abilities switched on. By that, I mean you’ve got to be prepared to examine the *logical* consistency of your various beliefs and the causal connections between them.”

“Are you saying that I’m *unreasonable*, Bruce?”

“No – not at all, Jane. More like *non-reasonable*, Jane, in a *scientific* sense. Your [reason](#)¹⁸ with regards to moral and aesthetic matters seems fine. I’m no literary or art expert and others have judged you there. But when you hear quick comments on matters related to science on the radio, or read the headlines in the mainstream media and they seem intuitively plausible and comforting, you take them in without reflection. They then stick in your intuition-bank, as we might call it – that part of memory that Pavlov used to demonstrate conditioned reflexes in [dogs](#)¹⁹. And when somebody says the trigger words, you blurt out the shock-jock slogan or headline. Where science is involved, you often don’t do a consistency-check between the latest statement and previous statements of these slogan-mongers.”

“You’re so sweet, Bruce. I’ve never been compared to Pavlov’s dog before. You know that I really care about these things, but my time is so fragmented that it’s a challenge to put two thoughts together. The kids yell and I’ve gotta run.”

“No offence meant, Jane – it’s just the difference between a [behavioural](#)²⁰ and a [cognitive](#)²¹ approach to these issues.” Of course you’ve gotta run when the kids yell. The media plays on that same basic reflex – just that they transfer that very sensible emotional reflex into the realm of public debate. If it’s not fear, then it’s greed – the prospect of gain without pain.”

“You’re starting to sound a bit preachy, now! Let’s stick to the subject. What are the other conditions for understanding?”

“Next – you’ve got to try to *remember* things. I know that it’s not fashionable to have a good memory – although I know that yours is pretty good when it comes to Shakespeare. That’s okay for the theatre and party tricks, but it seems that it’s considered rude to point out that a technical statement somebody makes today is at odds with a statement they made yesterday.”

“But there’s so much *stuff* out there. How can I remember all that *stuff*?”

“Well, there’s a lot of *stuff*, but not really as much new, relevant or important *stuff* as you might think. The first problem with memorizing is that all that *stuff* creates a mental state called ‘backward masking²²’ – the next new *stuff* comes so soon after the last new *stuff* that you don’t get to form a conscious memory of it. But it can go straight to your sub-conscious so it can be triggered later. Woof! Woof!”

“Are you sure that you’re not being *paranoid*²³, Bruce?”

“No – I’m not paranoid – they really *are* after me! Or, more correctly, they’re after *us*. *All* of us. These ideas were the feedstock of psychology PhDs in the ‘fifties and ‘sixties. It was just ‘interesting stuff’, then. When these students couldn’t get jobs as academic researchers, they went into marketing and advertising. Vance Packard first alerted the world to this in his book *The Hidden Persuaders* in 1957²⁴. I suspect that it did more to attract sharp minds into psychology schools than it did to sharpen up advertising regulators. More than half a century on, all of these techniques are bread-and-butter to every large corporation and political party – particularly those that employ or retain public relations and media management people – which is most of them. These people are now taught in the ‘Communications and Media’ schools – they don’t even call it ‘psychology’ any more. It’s like the link between *physics* and *engineering* – but in this case it’s *psychology* and *mind-engineering*. More than half the stuff that you read and hear in the public media is straight from these people even if it looks like edited news. On reflection, they’re not *after* all of us – they’ve already got *most* of us. They’re just mopping up the dissidents and intellectuals now. When did someone in the play-group utter anything more than a cliché or *meme*²⁵? And, according to the national statistics, your playgroup friends are amongst the most well-educated in the country.”

“You’re making it sound like *Nineteen Eighty Four*²⁶, Bruce. But let’s not get bogged down. So I need a pinch of reasoning and a good dose of memory. I got A’s and B’s at high school and uni. Even got a prize in third-year English Lit for the most original semester essay.”

“Well, you’ve got all that you need, then, Jane. Can you remember your times-tables from primary school and graphing from high school?”

“No need to be snide, Bruce. We learnt our multiplication tables by chanting first thing in the morning. I’m hard-wired with them now.”

“Just asking, Jane – but do you ever use them? Like – do you do a *guesstimate*²⁷ of the cost of groceries or apply them when a politician mouths off about billions of dollars wasted on some public project?”

“Hmmm.... Well, Okay. I *used* to do a quick check on value-for-money at the supermarket – you know how every brand is a different size and price – these days it’s all there on the price tag – ‘*unit pricing*’²⁸. No need to use my tables now. Thanks. And the pollies – you can’t believe *anything* they say, anyway, so why try to make sense of their extravagant statements. They are probably don’t understand them themselves.”

“I rest my case regarding media managers. What about *graphs*? Do the finance reports make any sense to you on the TV news?”

“That’s generally when I’m putting the kids to bed – okay – I know that we *both* share putting the kids down. Those reporters are so quick and slick that you haven’t got time to really take it in. Most of it is financial gobbledegook.”

“Maybe so, but do you get the gist of what a graph is? You know – how some quantity varies against another varying quantity. Like weight gained versus calories consumed...”

“Just don’t go there, Bruce! I guess if I had the time to sit and look at a graph, I know how to sort it out. Just getting the *time*...”

“Fair enough. You know that I’m pretty good at that kind of thing, but I wasn’t born programmed with graph-knowledge. Sure – I might have more than average basic abilities, but most of it comes from *practice*, like most other skills. It’s called “[visual literacy](#)”²⁹ – the same basic skill that enables you to interpret a modern [hyperlinked movie](#)³⁰ or [soapie](#)³¹ with its rapid change of scenes, parallel stories and twisted plots. We integrate them in our mind because they are *visual clichés* – abbreviations of things that we have seen at length before. Like the kids with their music lessons – it takes practice.”

“Anything else?” This started with your smiling because of our new hybrid car. I wasn’t expecting the [Spanish Inquisition](#)³².”

“[Nobody does!](#)³³ So that’s just *three* things that you need to understand all this stuff on climate change: *One* – elementary reason and logic; *Two* – some capacity to remember; *Three* – a ninth-grade ability at arithmetic and graphs and *Four*... There are four things that you need.....”

“Very droll. I know – fourth – you need a bit of *time*....”

“Exactly! Let’s try a series of five-minute *scenes*? Despite the years of media grabs, there’s a lot missing from the public discussion. Do you really want to understand, or just get by on plausible clichés?”

“Maybe it’ll come to that. The kids are having their afternoon nap, so I’ve probably got another five minutes before I’m interrupted by something or somebody. The clock’s ticking – now!”

“OK, darling, here’s the first five minute chunk. You can take it away and chew on it until we’ve got another five-minute window of opportunity.”...

*So oft have I invoked thee for my Muse,
And found such fair assistance in my verse
As every alien pen hath got my use
And under thee their poesy disperse.
Thine eyes, that taught the dumb on high to sing
And heavy ignorance aloft to fly,*

*Have added feathers to the learned's wing
And given grace a double majesty.
Yet be most proud of that which I compile,
Whose influence is thine, and born of thee:
In others' works thou dost but mend the style,
And arts with thy sweet graces graced be;
But thou art all my art, and dost advance
As high as learning, my rude ignorance³⁴.*

Scene One – Climate change – a matter of trust?

“Okay, Jane – the kids are watching a video and your [fair-trade](#)³⁵/soy/low-GI'd coffee is poured. Where do you want to start?”

“Well, Bruce, what I understand is that there are claims that the climate is changing very rapidly due to human activity and counterclaims that this is doubtful – and besides – the climate has always changed, so what's new? We've recently seen a long drought in Australia that broke with record floods – and then fires – and most other countries seem to have dramatic changes in weather as long as I can remember. So – *what do we mean by climate change* and how do we know that *we're* responsible? Privately, I'm prepared to believe that we're causing climate change on the basis that *you* believe it and I trust your judgment on this because you've been looking at this for a long time. But I'm *not* prepared to say *that* to my friends – I need my *own* response. What do I say?”

“I can see your dilemma, Jane. It doesn't seem to be [politically correct](#)³⁶ to refer to expertise in others – particularly one's partner. But first, Jane, let's pause and look at that word 'believe'. I don't *believe* in human-induced climate change, or [anthropogenic](#)³⁷ global warming – AGW as it's often called. In fact I'm not sure that I *believe* in much at all – other than I *believe* that I love you and the kids and I *believe* that trying to make a sustainable planet is worthwhile. *Belief*³⁸ is slippery notion, but I take it to mean *a basic or fundamental view that I am not prepared to surrender, that may – or may not – be based on any evidence*. I prefer to say that something – say AGW – 'seems to be very likely, based on the available evidence and more likely than other plausible explanations'. To me, if someone says that they *believe* something or *don't believe* something, then I wonder whether it is worthwhile continuing the discussion. 'Beliefs' are fixed positions that are immune from change by what we call [empirical evidence](#)³⁹. If someone believes in AGW, God or some guru or wise person, the best we can do is have a 'yes-yes' conversation. Disagreement is pointless.”

“That’s a bit strong, Bruce. I don’t think that everyone is saying that they’ll die in a ditch over everything that they say they *believe*. Religion and gurus aside, I think that most people use the word ‘believe’ when they mean ‘this is the present position that I’m taking on this particular matter’. *Why* they take that position is another matter. I said that I *trust* your judgment on this subject, so I’m prepared to accept your comments – so long as I can have some foundation of information to build on.”

“Hmm... the word ‘trust’ also hits my hot button. *What* are you trusting when you say you *trust* me?”

“I think we’re in danger of going backwards in this conversation. Climate change seems to be receding from view. *Trust* is *trust* – isn’t it?”

“Not quite. I doubt that we’ll make much progress unless we can make sure that we have agreement on a few of these words that we throw around so loosely.”

“You’ve got one minute on ‘trust’, Bruce, and then back to climate change. I know that kids’ video backwards – it’s got less than five minutes to run before the kids start bugging each other.”

“One minute. Okay – there’s a lot that can be said about [trust](#)⁴⁰, but for the moment, we are interested in ‘intentional trust’ and ‘competency trust’. If you say that you trust me to tell you the truth, then that’s ‘intentional trust’ – it’s a *moral* issue. If you say that you can’t trust me to remember your mother’s birthday, then that’s ‘competency trust’ – that’s a *technical* issue. When we say that we don’t trust politicians, then we’re probably talking about *both* kinds of trust. They sometimes shade the truth when they actually know something and often they don’t know what they’re talking about. Then they accuse each other of being ‘untrustworthy’. I think that it’s useless to trust someone’s intentions if they don’t know the relevant facts. They might ‘sincerely’ take us to hell.”

“Well, Bruce, *our* relationship is based on the *first* type – *intentional* trust, and on the matter of climate change, I trust your competency on that more than I do on birthdays. Four minutes left – how do I start explaining climate change to the playgroup?”

“Maybe if you use the issue of trust. We all know that a lot of scientists agree that the climate is changing due to carbon-dioxide and other pollutants generated by human activity. How many climate scientists? I’m not sure, but there are many thousands. And reliable [surveys](#)⁴¹ have found that 97-98% of them support the tenets of AGW outlined by the [Intergovernmental Panel on Climate Change](#)⁴². Climate change has been researched intensively since the early 1970s – more than 40 years. There is also plenty of evidence that the 97% of *supporters* are far more competent at climatology than the 3% of *doubters* – and I doubt that their moral intentions are any less. Are we going to trust that much competency – or are they very competent in sustaining a conspiracy over dozens of countries over that period of *time*⁴³? Or are we going to trust the less-competent 2-3% who disagree – along with some prominent people who are not competent climatologists?”

“Bruce – six hundred years ago probably 97% of people believed that the [Earth was flat](#)⁴⁴. The majority *can* be wrong.”

“Interesting point, Jane – and a point that is *wrong*.”

“Oh? Christopher Columbus? Queen Isabella of Spain? You know the story, Bruce.”

“One of the most enduring myths in history, Jane – practically nobody since the time of Aristotle has considered the Earth to be flat – at least nobody of public consequence. It’s a myth with a tenuous history, but one that is used frequently by climate-change doubters to try to undermine the scientific consensus.”

“So how did the idea get any traction, Bruce?”

“Just think about [Medieval](#)⁴⁵ and early-[Renaissance](#)⁴⁶ times. For most people, the Earth was, for all intents and purposes, flat. They never went more than a few kilometres from home. It didn’t matter and they probably didn’t care – the local hills and dales were the limit of their world. A few of them – princes and popes mainly – had a vested interest in saying that the Earth was flat because they couldn’t fit a [spherical-Earth model](#)⁴⁷ into the rest of their world-view – even though it had been around for thousands of years. Just look at the grief that [Galileo](#)⁴⁸ suffered 400 years ago at the hands of popes and princes. They had the power, so their word was rule. I’m sure a lot of people in those times said ‘the hills go up and down, but that doesn’t mean that the world isn’t basically flat’. These days, lots of people say ‘the weather goes up down’ but that doesn’t mean that the climate is changing’ – that’s the modern flat-Earth view.”

“So – leaving aside for the moment the [pillage and plunder](#)⁴⁹ that ensued from his adventures, did Columbus make any difference to the debate about the shape and nature of the Earth?”

“He probably did, Jane. Up Until then, most of the argument was based on fairly local experience – you didn’t have to go very far out to sea to notice the buildings and trees near the shore disappearing from sight – and some rather ingenious calculations of the Earth’s diameter had been made for over two thousand years. But it was [Columbus](#)⁵⁰, as the story goes, who was the ‘[scientist](#)⁵¹’ in this matter – the *empiricist* – he was the one who went out and [tested](#)⁵² the curved-Earth theory. He tested his idea over large distances – compared with the distances familiar to most people. Others followed and reported the same findings as Columbus – to the financial benefit of those same-said princes and popes.”

“Before you get onto your bike about monarchies and papacies, Bruce – could you make the connection to the present issue?”

“Most certainly, Jane. Climatologists have tested their ideas over long periods of time – greater than personal experience. The 97% of scientists today are all ‘Christopher Columbuses’ and [Vasco da Gama](#)’s⁵³, to extend the analogy. Empiricism rules – OK!”

“Okay, Bruce – I’ll buy that one – but what about Y2K then? As I recall, thousands of technical people believed that catastrophes were imminent if we didn’t check out every computer’s calendars before the turn of the Millennium.”

“Yes, the Y2K⁵⁴ is often raised as being comparable to climate change concern, because both involve the opinions of a lot of technical people. There are big differences – leaving aside allegations related to intentional trust and competency trust – a lot of people made a lot of money over Y2K. It was more about risk⁵⁵ – the potential or possibility of loss – and the time available to minimize the risk. Risk management⁵⁶ was a pretty new idea in the late-‘nineties and even mentioning the word ‘risk’ frightened people.”

“Now you’re throwing around words that sound much the same to me – *possible* and *probable* – but you’re making a lot of a fine distinction, aren’t you?”

“It’s an important distinction, Jane- one that the Doubters wish to blur. To say that something is *possible* is to say that it is *not impossible* – in that if it did actually happen, it would not defy the laws of physics, as we know them – and even if it did, we would be prepared to review our understanding of the laws of physics.”

“And probable, Bruce?”

“Rather difficult to define, Jane. A lot of definitions simply say that the *probability*⁵⁷ of an event happening is the *likelihood*⁵⁸ of it happening. That’s almost a *tautology*⁵⁹ – but the word *likely* is often used subjectively. We can make mathematical estimates of probability, but practically, we can only say that ‘in our experience, this kind of outcome has happened about so-many times in every hundred comparable events’.”

“So you don’t rule anything out entirely?”

“Nope.”

“Miracles can happen?”

“Possibly.”

“Groan! I think I’ve kind of got the hang of the difference. So where does that leave the Y2K schemozzle.”

“What they were trying to say was that there was a small – but *real* – *probability* that computer errors could lead to catastrophic results – like planes crashing or nuclear power plants malfunctioning. As I said, it was all done in a rush – a couple of years – and panic prevailed over rational risk assessment. It was *Chicken Little Syndrome*⁶⁰ meets *China Syndrome*⁶¹ – the likelihood was small but the consequences of failure *could* have been large. There were many allegations of failure of both intentional trust and competency trust – and there probably were plenty of instances of that – but I think that the biggest problem was the lack of time to make a better assessment. When somebody yells ‘fire’ in the theatre, we assume both intentional trust and competency trust – and run for the door.”

“So what’s the difference between that and climate change, Bruce?”

“As I said, Jane AGW has been looked at by thousands of very qualified scientists for over 40 years. They are saying that there is a problem, but we have a few decades to

fix it. There is a ‘fire’, but there’s no need to panic – we can move in an orderly way to the door, so to speak. But we’ve got to get moving. Y2K was a panic.”

“So, in summary – what’s my one-liner? I can hear the end-music on the kids’ video.”

“Who do you trust – thousands of scientists with forty years of heavily scrutinized research, or a handful of scientists backed by carbon companies? That’s why I say that I don’t ‘believe’ – I’m simply trusting the demonstrated competency of 97% over the 3%. They may be wrong – we’ve got to leave open that possibility – it’s **possibilities**⁶² compared with **probabilities**⁶³. Would you take our new hybrid to a backstreet mechanic? Where would you place your bets?”

*“We all that are engaged to this loss
Knew that we ventured on such dangerous seas
That if we wrought our life 'twas ten to one;
And yet we ventured, for the gain proposed
Choked the respect of likely peril fear'd⁶⁴;
And since we are o'erset, venture again.
Come, we will all put forth, body and goods.*

“Mummy – why didn’t the **Scarecrow**⁶⁵ have a **brain**⁶⁶?”

Scene Two – *What can I say about climate change?*

“It’s great that the kids like my mother, Bruce. It’s quite a little routine, now. Friday night stories – they love it. That gives us a few minutes to chat about climate change before going to sleep. I’d like to get some hard information from you, Bruce, but first, I want to know a bit more about scientists. They seem to be getting a bad rap these days that makes them sound like a bunch of conspiring crooks. I’m sure that it can’t be as bad as that, otherwise you wouldn’t hang around with them, but they seem to

present themselves as something special – I’d like to know *what’s so special about scientists that gives them a greater claim to believability*. They’re not a very loveable lot – they seem either shy or arrogant and often don’t speak in everyday English. How can we trust a bunch like that?”

“It’s hard to argue with that description, Jane. Where to start in defending them? Should I be defending them? Well – yes, because, ultimately, when you strip away their façade, you’ll find above-average trustworthiness – both intentional and competency trust.”

“Maybe – but they sure make it hard to get at. Why? Don’t they realize what game they’re in?”

“And what game is that, Jane?”

“The game of winning hearts and minds – or minds and hearts – getting people to *understand* your ideas and *believe* them. That’s what everybody else is doing – you’ve gotta *sell* your product – it’s a crowded market of ideas out there.”

“Most of them don’t think about science in those terms – they think that their product should sell itself, because it’s obvious.”

“Huh? What’s ‘obvious’ about science? When it comes to science, there seems to be only two sorts of people in the world – scientists, who all nod knowingly at each other when they talk, and the rest of us, who find science almost totally inaccessible. I don’t think that the 97% are wrong on that one. Tell me – what on earth do they think is so ‘obvious’ that they don’t need to bother to explain to us mere mortals?”

“The *truth*⁶⁷, my dear Jane, the *truth*. That’s what they think is obvious. In their view, they are telling the *unvarnished truth*. There is no place in science for deceit, so when they speak they assume that others will respect the fact that they are not hedging the truth. They aspire to one hundred percent intentional trust – even if their competence is less than perfect.”

*When my love swears that she is made of truth,
I do believe her though I know she lies,
That she might think me some untutored youth,
Unlearned in the world's false subtleties.
Thus vainly thinking that she thinks me young,
Although she knows my days are past the best,
Simply I credit her false-speaking tongue:
On both sides thus is simple truth suppressed:
But wherefore says she not she is unjust?
And wherefore say not I that I am old?
O! love's best habit is in seeming trust,
And age in love, loves not to have years told:
Therefore I lie with her, and she with me,
And in our faults by lies we flattered be.*

“Uh?”

“That’s [Shakespeare’s Sonnet 138](#)⁶⁸, Bruce.”

“Very nice, Jane. I wish that I could quote Shakespeare like that. I guess that’s your forte.”

“And I wish that I could quote science like you do. Maybe we’re not as far apart in our understanding as we first thought.”

“I don’t know. I haven’t a good ear for Shakespearean English. What was he on about, Jane?”

“Hmm... in a nutshell – *convenient lies will always prevail over inconvenient truths*⁶⁹.”

“That sounds familiar! But how so?”

“Basically, the relationship between these two lovers is one of mutual dishonesty. He’s much older than she is. He wants to appear younger, while she wants to think that she is with a more youthful lover.”

“Well – so long as they are consenting adults and nobody else gets harmed, I’d say that they are responsible for the outcomes of their mutual deceit.”

“Indeed, but there is more to the sonnet than that.”

“I bet there is – at least one master’s thesis – and probably a library full of them. I think that this is a beautiful and instructive digression.”

“And what’s the lesson in the digression, Bruce?”

“To me, the important difference between what I have heard of *Sonnet 138* and science is that so long as the couple wish to continue to kid each other, they’ll get along, notwithstanding their internal torments – but science is not *science*⁷⁰ unless ideas and thoughts are tested against the *external* world.”

“Whose world, Bruce?”

“Everyone’s, Jane.”

“*Everyone’s?*”

“Yep. No one’s excluded – so long as they follow the rules.”

“Rules, eh? So science is a game, after all!”

“Maybe – if you call *life* a game.”

“Wow! Heavy! Statements like that could vaporize our whole discussion. Can you bring it to bear on science and climate change in one easy step?”

“I wondered when you’d ask me, Jane. Sure – science has been described as ‘public knowledge’⁷¹. [John Ziman](#)⁷², an English-born physicist coined that description. Professor Ziman argued that the true goal of all scientific research is to contribute to the [consensus](#)⁷³ of universally accepted knowledge. Ziman was really a great communicator – he said that *all genuine scientific procedures of thought and argument are essentially the same as those of everyday life.*”

“I’m sure that Shakespeare would have said the same about his writing – but it’s nothing like science – as far as I can tell.”

“Shakespeare seems like a rather different approach to everyday thoughts and procedures than science – as far as I can tell.”

“Point taken, Bruce – but let’s try to stay on – or close to – the *scientific* track. I heard the words ‘true goal’ and ‘consensus of universally accepted knowledge’. *Truth* and *consensus* don’t necessarily go together – we talked about Christopher Columbus before. How do you wriggle out of that?”

“Well, as I said before, as far as we can tell from the [historical record](#)⁷⁴, most people who *thought* about the earth’s shape probably thought that it was a sphere. But most people didn’t think about it much at all and probably assumed that it was flattish, so I suppose that you are right – the majority weren’t round-earth advocates. I think that the key word here is actually ‘[knowledge](#)⁷⁵’.”

“I can hear a giant sucking sound of us disappearing into a semantic vortex. Get out of this one – and quickly – [Indiana Jones](#)⁷⁶.”

“Right on, Jane! Indiana Jones to the rescue. Now there’s someone I really admire – an intellectual *as well as* a man of action.”

“We’re getting closer to the edge of the vortex – quick!”

“Yep! Knowledge seems to come in two basic flavours – *words* and *action*. [Descriptive knowledge](#)⁷⁷ and [procedural knowledge](#)⁷⁸ if you want to be fancy.”

“I’d prefer *quick* to fancy with this one, Bruce. Our semantic canoe is starting to go ‘round and ‘round.’”

“Well, here’s Indiana Jones’s near an overhanging branch at the edge of the whirlpool: He’s a man of knowledge *and* a man of action – he *knows* what actions to take and importantly, *how* to take them – to him, *true* knowledge is procedural – it’s a [capacity to act](#)⁷⁹ – and that capacity is only believed to exist if it is *demonstrated* – no waffling, no overblown claims! He knows how to flick his whip around the overhanging branch and let the near-tangential forces push the boat towards the shore. Whhhhhipppp! QED!”

“Talk about [tangential](#)⁸⁰ mental forces! But wait! They aren’t on the shore, yet – they’re actually on a rock with swift currents between themselves and the shore. And there’s an alligator in the way, too!”

“Easy! He picks her up and nimbly treads on the slow-witted alligator. Presto! Dry land.”

“*They* might be on dry land but *you* aren’t yet. Where’s the connection to science in all this roudiness?”

“It’s like this, Jane: Indiana Jones went to whip-school, studied fluid dynamics and saurian biology. All before breakfast. But importantly, he is an [empiricist](#)⁸¹ – he only accepts those things that are tried and tested. He might experiment out in the realms of low-probability events, but he’d never have survived to make the movie sequels if his knowledge wasn’t grounded in the knowledge of the scientists that went before him.”

“Is it [ethical](#)⁸² to experiment with alligators like that?”

“Just as ethical as it is to experiment with alligator-hopping scientists. Read the small-print in the credits: ‘No animals were harmed...’

“Okay! I feel that we’ve been sucked into that vortex and out into an alternative universe.”

“The Empiricists strike back!”

“No – that was [another Harrison Ford movie](#)⁸³, Bruce. Meanwhile, back on Earth...”

“Well, the point is that *science is about what works* – with some conditions.”

“Oh – I wondered what that little asterisk was – ‘conditions apply’. What are the conditions, my love?”

“Hmmm... Let’s see. There’re five. *First*, empirical science –or empiricism – only relates to what we can perceive through our [five senses](#)⁸⁴. *Secondly*, there must be agreement – my [perceptions](#)⁸⁵ *might* be delusions – other people have got to agree that *their* perceptions, with regards to the subject at hand, are the same as mine. That’s the ‘public knowledge’ part. Next, any generalized statements – that is, ‘[theories](#)⁸⁶’ about my perceptions must be testable and [refutable](#)⁸⁷ – that last bit’s really important – it must be amenable to disproof. Then there’s the [Ockham’s Razor](#)⁸⁸ bit...”

“Oh! I’ve heard of that part –

*‘Is this a razor which I see before me,
The handle toward my hand? Come, let me clutch thee.
I have thee not, and yet I see thee still.
Art thou not, fatal vision, sensible
To feeling as to sight? or art thou but
A dagger of the mind, a false creation,
Proceeding from the heat-oppressed [brain](#)?⁸⁹’*

“Well, can *I* grasp Ockam’s Razor, Bruce?”

“Well, Macbeth wasn’t much of an empiricist – he was deluded, I know *that* much Shakespeare.”

“Well done, darling. Now cut to the chase. What’s Ockham on about?”

“*Entities must not be multiplied beyond necessity.*”

“Uh?”

“It’s the law of *succinctness* – it’s a principle that generally recommends selecting the competing hypothesis or theory that makes the fewest new assumptions, when the hypotheses are equal in other respects – for instance, if all the hypotheses can sufficiently explain the observed data. For example, a spherical earth makes for a more succinct explanation than a flat earth”

“Oh – the **KISS principle**⁹⁰. Why didn’t you say so before, Bruce?”

“Because KISS *might* fail the Ockham’s test – if it’s *too* brief to cover the whole principle. You can boil things down only *so* far. But, yes, it’s the KISS principle of science.”

“Sounds reasonable. Any other fine print for empiricism?”

“Only that we tacitly accept *reason* and *causality*. There’s no place for saying ‘**then a miracle occurs**⁹¹’. The chain of logic and reason can’t be broken.”

“Pretty cruel conditions. Not much room for romance, is there?”

“**Cruel – but fair**⁹². They apply to everyone. No exceptions.”

“What about a kiss goodnight?”

“An Ockham’s kiss?”

“You can multiply it beyond necessity if you like, Bruce. There are no conditions.

*But what at full I know, thou know'st no part,
I knowing all my peril, **thou no art**⁹³”
How oft when thou, my music, music play'st,
Upon that blessed wood whose motion sounds
With thy sweet fingers when thou gently sway'st
The wiry concord that mine ear confounds,
Do I envy those jacks that nimble leap,
To kiss the tender inward of thy hand,
Whilst my poor lips which should that harvest reap,
At the wood's boldness by thee blushing stand!
To be so tickled, they would change their state*

*And situation with those dancing chips,
O'er whom thy fingers walk with gentle gait,
Making dead wood more bless'd than living lips.
Since saucy jacks so happy are in this,
Give them thy fingers, me thy lips to kiss.*

.....

Scene Three – *Science and anti-science*

“Are you awake, Bruce?”

“Yeah – can’t you sleep, either?”

“I think that the heavy rain on our tin roof woke me and I’ve been lying here for a while. I was dreaming about climate change, and all those bearded young scientists and Ockham’s razor..... and ants, for some reason.”

“I’m sure Shakespeare had a lot to say about the subject.”

“To sleep, perchance to dream – ay, [there's the rub](#)⁹⁴.’ Poor ol’ Hamlet. It’s a pity that we can’t share dreams.”

“But we can share *visions* and *points of view*.”

“I was going to lie here and snuggle up to you and doze, Bruce, but it looks like we’re both wide awake. The kids are still in dreamland and the alarm won’t go off for another half an hour. I’m still avoiding talking much to other play-groupers about climate change stuff because I still don’t know anything about the subject that is more than a media-cliché.”

“I’m sorry if I seemed to have digressed. I thought that it was important for you to have some feeling for the scientific context of this issue. There’s a big gap between the media-cliches – as you call them – and the conversations that scientists are having. I’m not trying to humble you by setting scientists up as demi-gods, nor am I trying to turn you into a scientist. You’re already a goddess as far as I’m concerned.”

“You’re so sweet, Bruce. Unfortunately I can’t take my one-person fan club to play-group – some of those play-group parents are pretty opinionated – and their strongest

opinion is that they are entitled to their own strong opinions, although they sound like the strong opinions of the shock-jocks.”

“Isn’t democracy wonderful, Jane. Everybody is entitled to [their own opinions](#)⁹⁵. But are they entitled to their own *facts*?⁹⁶”

“I must say that facts are few and far between. Disconnected snippets as far as I can tell, Bruce. Claims like ‘in fact’ [the earth has been cooling since 1998](#)⁹⁷, like ‘in fact’ we breathe out high concentrations of CO₂, so how can a fraction of a percent of CO₂ in the atmosphere is going to change anything, like...”

“Yep, I’ve heard all of those ‘facts’ so many times. I’m not sure whether people that spout these ‘facts’ are amenable to sensible discussion anyway.”

“The curious thing is that they seem to be sensible and nice people, but with this ‘hot button’ on climate change. They’ll discuss the plot and production values of art-house movies, the literary worth of the latest best-seller, even the relative merits of the range of SUVs. It’s a mystery.”

“Perhaps that’s the clue. They’re sensible and nice people.”

“Uh?”

“That’s what so-called *sensible* and *nice* people do these days. Just think of it: When did you last have a coherent conversation with the play-group parents, or in the dog-walking group, or even at dinner at a restaurant with friends. By ‘coherent’, I mean where a statement made by one person is acknowledged and responded to in a way that actually builds on that statement. And when did you last hear someone talk on something for more than a few seconds before someone else chimes in? It seems to me that social conversation has developed a style that’s like an audio-kaleidoscope – lots of colourful fragments contained by mirrors that give the illusion of pattern and coherence.”

“Wow! All that at 5.43am! No need for coffee around you, Bruce.”

“Thanks for that compliment, Jane. That was a compliment – wasn’t it? But it’s very frustrating – it almost seems like a collective rejection of the virtues of reasoned discourse. I used to read about the [salons of the eighteenth century](#)⁹⁸ where modern science was created – I dream of their return.”

“Welcome to the [post-modern world](#)⁹⁹, Bruce.”

“I love it when you talk dirty, Jane. *Post-modernism* – I hear that word thrown around all the time – what’s that got to do with the price of carbon?”

“I had a hunch that you would think it a dirty word, seeing that post-modernists would probably view you as a [modernist](#)¹⁰⁰. In fact, that’s the gist of a response that I got at the play-group the other day – in the course of one of these kaleidoscope conversations – as you call them – I chimed in about the 97% of scientists thing that we talked about earlier.”

“And what was the pearl-of-wisdom response – or should I say ‘fragment-of-coloured-glass-opinion?’”

“It was something like ‘that sounds like an utterance from the discredited hegemonic modernists who have dominated the public conversation.’”

“Wow! That kind of language in front of children?”

“These fragments only come out when the kids are otherwise engaged. There are some pretty well-read parents there.”

“Does that mean I’m *past-it* or *post-it*, whatever *it* might be?”

“Not with me, darling, but there’s plenty of people who would claim that your way of looking at things is not ‘with-it’ anymore.”

“Oh? And what do these post-modernists claim to be more *with-it* than what I’m on about? I’m recognized as being at the cutting edge in my field.”

“It’s not necessarily what you’re doing, Bruce – it’s more the way that you look at it.”

“Go on – please. And what is *it*?”

“Well, *it* is *reality* – and post-modernism involves the belief that many, if not all, apparent realities are only social constructs, as they are subject to change inherent to the particular time and place.”

“What are these people smoking?”

“Probably the same stuff as you used to – but that’s not the point.”

“We’re at the ‘and the point being’ point?”

“If I don’t say something quickly to tie this together, the kids will be all over us and that will be it for days.”

“Press on, Jane.”

“Well, the other night you outlined what a scientist was about. If I’ve got it right, science is about a universally shared reality, with the objects in the universe moving about according to laws that are the same everywhere.”

“Spot on, Jane.”

“Thanks, Bruce. That’s considered a ‘modernist’ viewpoint.”

“Oh I am the very model of modern major viewpoint¹⁰¹.”

“Post-modernists are inherently suspicious of this *global cultural narrative*¹⁰² thing and prefer to think that reality is essentially a local construct. In summary ‘*appearance is reality*¹⁰³’.”

“Well – that goes a long way towards a useful interpretation of a few prominent politicians that I could name.”

“Steady, darling. No names, no pack-drill!”

“Okay, Jane – so as a consequence of this quaint perspective, they think that anyone who claims that apples will fall towards the earth at the same speed in Chile, China or Chiswick is acquiescing to a global cultural hegemony imposed through an insidious conspiracy of scientists and their political puppets?”

“Not quite.”

“Would they vote for me if I said that I would repeal the universal law of gravitation and allow for greater cognizance of local gravitational conditions?”

“I doubt it, darling. They would suspect that you were a neo-*deconstructuralist*¹⁰⁴ opportunist and you were simply offering *re-contextualization*¹⁰⁵ to get their vote. But they might vote for you made child-care tax-deductible.”

“Are they post-modernists or just *pragmatists*¹⁰⁶?”

“Their views on practical matters seem to be pretty short-range. Maybe there’s a connection between the two.”

“Ah! Now I’m beginning to see the light. Their interest in wider matters is inversely proportional to the prevailing interest rates – interest in interest! Soft thinking for hard times!”

“I think that this conversation is in danger of swallowing itself....”

...*But soft! What light through yonder window breaks? It is the sun....*¹⁰⁷”

“Mummy! Daddy! Why is it when you wet the bed first it is warm then it is cold?”¹⁰⁸”

“Over to you Bruce, you know all about thermodynamics.”

“Well, young man, let me draw you a picture.....”

.....

Scene Three-point-five: The knower and the narrative arc

“So- what was that ‘ant dream’ last night, Jane. You seemed to have been quite disturbed by it. Tell me – I’ve got a couple of minutes before I have to run for the bus.”

“Ugh! Weird! In my dream *I* was an anthill. Ants were streaming out of me in all directions, wandering around, as if *they* were in a dream. Then they would start coming back home to me- and the wandering became faster and straighter as they rushed towards me- carrying little bits of Lego, which they then assembled over me. It went on in waves- wandering out, rushing in, wandering out, rushing in ... agghhh!”

“Sounds a bit like the [labour of Sisyphus](#)¹⁰⁹ of cleaning up the kids’ playroom, Jane. But the *ants*- now that’s interesting...”

“*Interesting*- that’s your usual code for some theory or another that you’ve got. How about a bit of ‘my poor darling, you must be distressed by a dream like that’. Okay- what’s so *interesting*?”

“Well, my care and love for you almost goes without saying, Jane. My first thought was that you ate too much dark chocolate last night. But whatever the *cause* of your dream, it’s the dream itself that is most interesting. I wouldn’t dare to try to [psycho-analyse your dream](#)¹¹⁰, but on a literal level, it’s ‘interesting’ because it’s rather like the way that science works with Ockham’s razor.”

“Far out! That’s one giant step for ant-kind. Go on – we can’t leave it there.”

“Well, many people have looked at [ants](#)¹¹¹ and wondered how it is that the usually make straight trails from a food supply to the anthill...”

“That problem never kept me awake at night – although you think that it has visited me in my dreams?”

“No need to worry, because it’s been figured out- the ants have their own little Ockham’s razor rule – *follow the strongest scent*.”

“Very blokey! Squashed-ant cologne.”

“Well, actually it’s a [pheromone](#)¹¹².”

“I’ve heard of that, Bruce – even blokier.”

“Not really, in this case, Jane – it seems that all the [worker-ants](#)¹¹³ are sterile females – no comments, please! Anyway – the ants leave a trail of a particular pheromone that is short-lived, so the scent fades quickly with time. The strongest scent will be on the shortest trail.”

“And how does the trail get to be shorter – they could just wander round like Hansel and Gretel in the woods?”

“Mainly [trial and error](#)¹¹⁴- the first trail home will be the same one the successful forager went out on – and after it has signaled to its fellow ants that there’s food out there, they all follow the wandering trail. But some of them wander off a bit, and find that they are home first, so others follow *their* scent-trail, which is stronger than the initial scent trail. So it tends to get shorter and shorter as a simpler trail is developed. Presto! Ockham’s answer.”

“So all those scientists are just wandering around, prodding and poking and guessing until somebody cries out “eureka!” – and then all the boffins fall into line?”

“Not quite, Jane – there’s lots of forethought with most scientists – forming [hypotheses](#)¹¹⁵ and testing them – consciously looking for a simpler explanation. In the case of ants – I don’t think that they are hypothesis-testing – just reflexively following the strongest scent trail.”

“Nice, Bruce. Thanks. Is that what is meant by ‘anti-scientific’?”

“Moan. Phero-mone.”

*“Love's not Time's fool, though rosy lips and cheeks
Within his bending sickle's compass come;
Love alters not with his brief hours and weeks,
But bears it out even to the edge of doom.
If this be error and upon me proved,
I never writ, nor [no man ever loved](#)¹¹⁶”*

.....

Scene Four: By the shadows on the restaurant wall

“Having your *usual*, Jane?”

“*Our usuals*, Bruce – lemongrass beef, soy chicken with cashews, steamed vegetables and steamed rice for one. And a bottle of red wine. We’re not very adventurous, are we? Thursday evenings – dinner by candlelight at the Oriental...”

“Quality, service and value, Jane...and quiet enough to have a conversation. I wonder why so many restaurants and cafes care so little about acoustics – hard surfaces

everywhere and thumping music. They certainly encourage sound grabs rather than conversation.”

“Maybe that’s what people want, Bruce. It fits with their post-modern sensibilities.”

“Here we go again. Sounds like a cop-out to me. Maybe it just covers up the fact that they haven’t anything to say. Could you give an old-fashioned modernist defence of that statement?”

“[The medium is the message](#)¹¹⁷, Bruce. It’s the environment – the *ambience*, not the *specific* content. It’s like the jungle noises at dusk – everything’s a-twitter.”

“That was hardly modernist, but that’s about it – jungle noises – [full of sound and fury and signifying nothing](#)¹¹⁸.”

“You’re stealing *my* lines, Bruce. Maybe it’s just different strokes for different folks. You prefer a single magpie at dawn...”

“Maybe – but I’m also there at dusk – like [Minerva’s owl](#)¹¹⁹,”

“You’re a real hoot, Bruce! So you actually want to fly around with the dusky *po-mo* crowd?”

“Hardly. The *Owl of Minerva* spreads its wings at dusk: we only come to understand things in hindsight. *That’s the nature of explanation.*”

“...[you don't know what you've got 'til it's gone](#)...¹²⁰,”

“Something like that, Jane. But seriously – Joni Mitchell and Minerva’s owl aside, we’re trying to explain climate change in an intellectual climate that’s like a mad aviary – it’s parrots versus magpies.”

“That’s a colorful metaphor – at least half of it is. I don’t quite follow you, Bruce. More information, please”

“[Figure is that which always follows colour.](#)¹²¹,”

“So you want more steamed veges and rice, Bruce?”

“Yes, please – that too. But I was actually referring to something that Socrates said.”

“Then sock it to me, Socrates. What’s on your mind?”

“Simply – *how does one present an extended explanation based on the song of black-and-white reason in a parrot-like echo chamber of colorful, but meaningless tweets?*”

“You make it sound like a recent problem, Bruce. [Plato](#)¹²² railed against the [Sophists](#)¹²³ way back when...”

“...*that’s* the word I was searching for – *sophistry*. Cliches and rhetorical flim-flam.”

“I think that you are a bit hard on the oral cultures, Bruce. Besides, it was Plato and his followers with their *universals*¹²⁴ and *ideal forms*¹²⁵ that the post-modernists really object to.”

“Just as well Plato didn’t have a *Facebook*¹²⁶ page, Jane – the po-mos would have hacked it and crashed it, for sure. Tell me, Jane, what was – or is – the big angst between Plato and the po-mos?”

“Well – he was a bit of a *totalitarian*¹²⁷.”

“A *bit* of one?”

“Well, he – or Socrates – *proposed*¹²⁸ a city-state in which there is no private property, women and children are held in common, all is sacrificed to the common good and the place is ruled by an unelected elite bunch called the Philosopher Kings.”

“Hmm. The first part sounds pretty grim, but the last part sounds like the Czech Republic under *Vaclav Havel*¹²⁹ a few years ago. Maybe Plato was more of an *authoritarian*¹³⁰ than a totalitarian. In fact, as far as I can tell, he was just an intellectual who stood around copying down the ravings of another intellectual – Socrates. More of a *reporter* than an *intellectual*.”

“Rather more than *just*. A lot of people took his ‘ravings’ pretty seriously in *Athens*¹³¹ at that time. They didn’t seem to have the same views on the freedom of speech as we do – or Socrates did. But I think that you’re missing the main point, Bruce.”

“...and the main point being?”

“That Plato and Socrates were obsessed with definitions and ideals and a perfect social order that would be decided by just a few people. Socrates spoke out against tyranny, but he hung around with tyrants and seemed to want to cage people in his own narrow set of ideas.”

“Perhaps Socrates thought that genuine knowledge and professional competence was more likely to yield correct policies than a muddled majority opinion – like Christopher Columbus and the flat-earthers legend. So you think that trying to define things and use logic is tantamount to tyranny, Jane?”

“It might be – if you don’t agree with the basic premises. Maybe they had different views on what constitutes a good society. Socrates didn’t think much of democracy. He thought that with too much freedom, the people become drunk, and tyranny takes over.”

“I was just about to ask you whether we should finish the bottle. Do you want to risk tyranny?”

“You finish it, Bruce. I feel more tired than tyrannical.”

“But seriously, Jane, I think that there are two ideas of Plato and Socrates being conflated here – their ideas that underpin science and mathematics and their ideas about how society should be organized. As you know, my main interest has been on the first part – science and mathematics, so my reading focused on the [Socrates-to-Plato-to-Aristotle](#)¹³² development of the foundations of science – which is *real* stuff – not on their ideas about utopias – or dystopias. All sorts of people have had a go at ‘the perfect society’ – I read a few of them back in my undergraduate days – [Samuel Butler](#)¹³³, [Aldous Huxley](#)¹³⁴ ...”

“...and [George Orwell](#)¹³⁵. Yes, I know, dear – there’s lots of them. But don’t you see the connection between science and society?”

“That’s a big question to pose over lychees, Jane. It seems that you have some sort of answer in mind?”

“Yep. From that ol’ proto-modernist, [Karl Marx](#)¹³⁶: *‘the mode of production dictates the form each society will take’*.”

“Wow! That’s a [great leap backwards](#)¹³⁷!”

“Not at all. Just think of it. Our so-called ‘[Western World](#)¹³⁸’ is characterized by its almost slavish adherence to reason and logic and their off-spring – science. They are not separate from our society – they *define* it. Think of it – and think of the alternatives – the ‘old’ orient, tribal and traditional cultures...”

“Okay – I get it. But let’s take a great leap forwards – do the Po-Mo’s want us to make fire by rubbing sticks together – or do they think that cave-warming will inevitably lead to global-warming? They can’t have it both ways – you’ve got to have fire before you can have Facebook. And speaking of fires and caves – our little oriental tea-candle is flickering out – we’ve been here for hours. It must be time to relieve the baby-sitter. Maybe we can continue this discussion tomorrow. Let’s pay the bill and walk home.”

*“Out, out brief candle
Life’s but a walking shadow¹³⁹ ...”*

.....

Scene Five: *Movin’ right along: Are we there yet?*

“I’m impressed, Bruce. This car really *is* quiet and smooth. It makes country driving quite enjoyable. The kids have fallen asleep – as usual. At least they should be in a good mood when we reach your parents’ place.”

“Hibernating in a hybrid! Ah! [A bear in its natural habitat](#)...¹⁴⁰! Ah! [The open road](#)¹⁴¹!

“Quite a mix of [road movies](#)¹⁴², really, Bruce. But it’s more like [Monsignor Quixote](#)¹⁴³ here with you.”

“How so?”

“Like most of [Graham Greene’s](#)¹⁴⁴ novels, *Monsignor Quixote* was a dialog between [faith and reason](#)¹⁴⁵ – often in the context of a revolution.”

“Oh – who was faithful and who was reasonable?”

“Both of them.”

“Sounds schizophrenic to me.”

“Well, in that [common sense of the word](#)¹⁴⁶, it was. Monsignor Quixote had reason to doubt his faith, and Sancho, the old communist ex-mayor, was doubting his faith in reason.”

“Your summary is like a small sonnet, Jane. These discussions are certainly testing both our certainties. And the revolution?”

“Both within and without. And speaking of revolutions, Sancho-Bruce, isn’t that a new [wind farm](#)¹⁴⁷ on the hill over there on the left?”

“Indeed, my dear Quixote-Jane. Although some people see them as [ferocious giants](#)¹⁴⁸.”

“Personally, I think that those turbines look great out here – elegant – almost whimsical. What do you think of wind power, Bruce?”

“Do you want me to comment on the aesthetics of wind power or its contribution to energy supplies and climate change?”

“Both, actually. But first, there’s been a lot of fuss recently about the possible adverse health effects of [wind turbines](#)¹⁴⁹. There’s no point in exchanging coal for wind if all we’re doing is exchanging one set of problems for another.”

*‘They that have power to hurt, and will do none,
That do not do the thing they most do show,
Who, moving others, are themselves as stone,
Unmoved, cold, and to temptation slow;
They rightly do inherit heaven’s graces,
And husband nature’s riches from expense;
They are the lords and owners of their faces,
Others, but stewards of their excellence.
The summer’s flower is to the summer sweet,
Though to itself, it only live and die,
But if that flower with base infection meet,
The basest weed outbraves his dignity:
For sweetest things turn sourest by their deeds;
Lilies that fester, smell far worse [than weeds](#)¹⁵⁰.’*

“Agreed, Jane. But as we’ve discussed, making dramatic assertions is easy these days – *saying so doesn’t make it so.*”

“One of the playgroup parents said that he had heard an interview on the health effects of wind power – by – now who was it...?”

“*Nina Pierpont*¹⁵¹. Yeah – practically everybody’s heard of her by now, thanks to the power of the media. She claims that ultra-low frequency sounds from wind turbines affect human health. The big problem is that Pierpont’s publication wasn’t *peer-reviewed* – it was *self-published*¹⁵² and its so-called research was based on a very small sample of self-selected subjects with no control group for comparison.”

“Okay – so her research methods were a bit flakey – but how do her findings stack up?”

“There’s a vast amount of verified scientific literature on the subject now. For example, the Australian NHMRC were concerned enough to release a public statement in 2010, essentially rebutting *Pierpont*¹⁵³. Unlike Pierpont, they relied on peer-reviewed research from numerous sources. The nub of it was that the sound levels from wind turbines are actually quite low – much less than a car a 100 metres away and not much more than the background noises in the countryside at night.”

“So much for Pierpont – but what’s the big deal about *peer review*? Those words get thrown around all the time and often with a sneer.”

“Maybe – but we can’t sneer at peer review. It’s the best system that we can get, this side of heaven. Scholarly *peer review*¹⁵⁴ – also known as *refereeing* – is the process of subjecting an author’s scholarly work, research, or ideas to the scrutiny of others who are experts in the same field, before a paper describing this work is published in a journal.”

“Isn’t Pierpont an expert? I understand that she is a doctor with Harvard qualifications – that’s pretty impressive.”

“Indeed, *very* impressive. It has – and will continue to – impress lots of people. The key words are ‘experts in the same field’ – Pierpont is a *pediatrician* and she is commenting on areas that are well outside pediatrics – not to mention demonstrating the actual causes of those claimed symptoms.”

“But that doesn’t mean that the claims aren’t true.”

“Certainly, they may well be. But we come back to that vexing issue of *truth*¹⁵⁵. What do we mean by truth? When a bunch of people, whose state of mind and health is unknown and who have a preconception about an issue are then questioned by another person with a preconceived agenda, it raises lots of issues as to whether the findings have any wider validity.”

*“That I have frequent been with unknown minds,
And given to time your own dear-purchased right;*

*That I have hoisted sail to all the winds
Which should transport me farthest from your sight¹⁵⁶.”*

“That pretty well summarises it, Jane – Shakespeare on peer-review. Another problem is the way that the researcher can influence the findings by his or her interacting with the subject.”

“How so?”

“It’s a bit like [push-polling](#)¹⁵⁷. The questions are [loaded](#)¹⁵⁸ and are designed to lead the person being questioned in a certain direction of thinking. The classic question is ‘have you stopped beating your wife?’ More recently, the technique has been called ‘[framing](#)¹⁵⁹, ‘framing’ made popular by cognitive linguist [George Lakoff](#)’s¹⁶⁰ famous ‘don’t think of an elephant’.

“I see. It’s rather like those [John Grisham](#)¹⁶¹ court scenes, where the judge strikes out a question on the basis that the witness is being ‘lead’.”

“Exactly. Which points to the problem of everyday experience with these matters: Most people have seen a courtroom drama or two. These scenes are made interesting by the eloquence of the hero-cum-attorney – sometimes for the defence, sometimes for the prosecution. Although we often ‘know’ what the ‘just’ outcome should be from earlier information in the movie, it is the attorney’s eloquence at advocating – *sophistry*, if you like – that sways the jury to see the [evidence](#)¹⁶² in a particular light.”

“So what is the big difference, Bruce, between a court-case [jury](#)¹⁶³ – which is, essentially, twelve *social* peers – and a peer-review panel for a so-called scientific publication?”

“Hmm... That comparison has been made before, Jane. What passes for ‘evidence’ in law is often different from ‘evidence’ in science, although there seems to be an increasing convergence between the two.”

“How so?”

“Well, first, we need to separate out the parts of what we call ‘law’ and what we call ‘science’ that bear some comparison. With *law*, we are essentially looking at situations where a judgment is to be made about an alleged transgression of the law – or *rules or guidelines to conduct* that have been agreed to by society – for example, civil cases, where there is a dispute over a contract, or criminal cases where someone has been harmed or property has been stolen.”

“Hmm... okay – *The Merchant of Venice* was a contractual dispute – Antonio owed Shylock money as a loan guarantee and couldn’t pay it.”

“If I recall, Jane – that was the infamous ‘[pound of flesh but not a jot of blood](#)¹⁶⁴’ story. But I think it crossed over to a potentially criminal case, because any blood spilled would constitute a crime.”

“Well done, Bruce! – I can appreciate *that* difference, now – but what’s the law/science connection?”

“In the case of the *Merchant of Venice*, it seems that there was no real dispute about whether there was a contract default. However, it is an interesting case of what is called ‘black letter law’¹⁶⁵ interpretation of commercial contracts, where, unless an item is specifically *included*, it is deemed to be specifically *excluded* – the list of items is very literal, objective and complete.”

“Indeed – Shylock was entitled to flesh, but no mention of blood was made in the contract, so he definitely couldn’t have any. I get that, Bruce. I thought that it was just clever – but you see more to it?”

“To me, it highlights the central problem that besets both law and science – the notion of *certainty* regarding salient information that bears on being able to make a statement about the *cause*¹⁶⁶ of an event. In the case of law, *causality* is only part of the issue – after cause is established, issues of justice, fairness and mercy take over: the Sparrow may have killed *Cock Robin*¹⁶⁷, but should he be punished?”

*“The quality of mercy is not strain’d,
It droppeth as the gentle rain from heaven
Upon the place beneath...”¹⁶⁸”*

“Funny thing, Jane... the Sparrow ‘fesses-up as soon as the question is asked, the Fly verifies the event and then the rest of the critters are more concerned about their role in the funeral proceedings – no issues of punishment, justice, fairness or mercy.”

“Perhaps it goes to show the virtues of an early confession, Bruce.”

“Promise me life, and I’ll confess the truth...”¹⁶⁹”

“Yes, Jane – I’ve noticed more than a few public figures using that stunt to deflect attention from their transgressions by making a virtue of ‘fessing up. But we digress – although it does illustrate how easy it is to mask the core issues. *Our* core issue revolves around this thing called ‘evidence’ that leads to ‘proving’ the transgression, or more neutrally, the *event* – what was the *causal chain*?”

“So – science is more interested in *who* killed Cock Robin than the funeral proceedings?”

“Essentially – yes. For the most part justice is about *human values*¹⁷⁰ and science would like the information to which we apply our values to be as clear as possible so we are as confident as possible, given that information.”

“Confident is a pretty broad word – what does ‘confident’ look like, Bruce?”

“In *law*, confidence is expressed by several ‘*standards of proof*’¹⁷¹ – for *civil* cases, the standard is usually ‘the balance of probabilities’ and in criminal cases, it is about

‘beyond a reasonable doubt’, which is supposed to be a stronger, or more convincing proof, as the penalties are usually larger.”

“Hmm... sounds like hair-splitting to me, Bruce – but press on – what happens in science?”

“Remember, Jane, that when we first started these conversations, I said that I usually assessed things on the basis of ‘likelihood’¹⁷² – which really relates to *probability* – and in a way is similar to the ‘balance of probabilities’ in civil law. In simple, but strict mathematical terms, *likelihood* is about events that have happened and *probability* is about possible future events. So, legally, we should talk about the ‘balance of likelihoods’ rather than the ‘balance of probabilities’, but for our purposes, we can use them interchangeably.”

“I’m glad that we didn’t split the hair crossways as well. Keep pressing on, Bruce.”

“A very important difference is that in law, we have to make a decision – a decision that is going to be unpleasant for someone – and that unpleasantness can’t be entirely undone later, even if we change our minds – that decision is a *commitment*¹⁷³ – that’s why we hear that someone has been ‘committed’ – the judge is *bound* to a course of action.”

“And in *science*?”

“Well, we certainly make many decisions *based* on scientific findings – including imposing carbon taxes – but in science *itself*, essentially, there is no commitment – scientists will always say – or *imply* that they are saying – that the information or data that they have gathered – their evidence, if you like – ‘it is *likely* that A caused B’. They will then assign a probability to that statement – for example ‘a 0.99 probability’ or a ‘*confidence interval*¹⁷⁴ of 90%’ or ‘a *statistical significance* of 0.95¹⁷⁵’.”

“Whoa! My head’s swimming with numbers, Bruce – we agreed that numbers aren’t my forte – and certainly not while I’m driving!”

“Okay – fair enough. But if I can make one more important point on this matter, Jane – perhaps the most important point: When we are trying to explain something we are trying to describe the causal connections between events. For example, event A has always been observed to precede event B... But the point here is that scientists are *inherently* non-committal – you can make what you like of their findings or evidence – it’s up to you – you be the judge – or jury. One judge might want a higher level of statistical significance than another to convict the accused person. Scientists aren’t convicting anybody – although their statements might lead to someone being convicted.”

“Now we’re getting into my territory, Bruce – this sounds like CSI¹⁷⁶ stuff – forensic science.”

“Well – essentially – yes – although, with the emphasis on drama, CSI TV programs are probably closer to the original Roman use of the word *forensis* – both the person accused of the crime and the accuser would give speeches based on their sides of the

story. The individual with the best argument and delivery would determine the outcome of the case. The emphasis is on the sophistry – it's the *science* part is where CSI is weak.”

“Give ‘em a break, Bruce – it's TV drama, not a documentary.”

“Fair enough. But it's something I'm pretty sensitive about, having been an expert witness for quite a few court cases¹⁷⁷. A solid diet of this kind of fiction tends to influence people's understanding and expectations.”

“Maybe we'll come to that later, Bruce. I recall that you said previously that you had been an expert witness – that was before we met. I'd like to talk more about that, but before we drift too far, how would you sum up the basic difference between law and science?”

“Hmm... Summing up sounds a bit like a commitment – not my forte. But, if I had to...”

“You have to, Bruce – one sentence – we're almost at La Mancha – I mean – your parents' place. I don't want to be left hanging...”

“I wouldn't want you to hang for want of a sentence. To use John Ziman's words¹⁷⁸, it's the difference between *evidence* and *advocacy* – science doesn't *insist* on a judgment – law does.”

“Do you think that it's possible to convert people's views about science, Bruce.”

“I can always dream the [impossible dream](#)¹⁷⁹, Jane – but I know that it's an almost quixotic quest. But – hey! Who's doing all the converting these days? It's like the Spanish Inquisition out there...”

“Yes, given all the hope before [Copenhagen '09](#)¹⁸⁰, it's quite unexpected.”

“But nobody expects....”

“Yes, Bruce?”

*No more be grieved at that which thou hast done:
Roses have thorns, and silver fountains mud:
Clouds and eclipses stain both moon and sun,
And loathsome canker lives in sweetest bud.
All men make faults, and even I in this,
Authorizing thy trespass with compare,
Myself corrupting, salving thy amiss,
Excusing thy sins more than thy sins are;
For to thy sensual fault I bring in sense,
Thy adverse party is thy advocate,
And 'gainst myself a lawful plea commence:
Such civil war is in my love and hate,*

*That I an accessory needs must be,
To that sweet thief which sourly robs from me*¹⁸¹.

Scene Six: Talking turkey

“The kids just love being here on the farm, Bruce. We’re so lucky. Now that your dad’s got his new knees, he’s happy to walk with them to the creek and look for tadpoles. While they’re doing that, we can walk up to the top of the hill through the bush and chat as we go.”

“Let’s do it! Growing up on a farm seemed like a bit of a disadvantage at the time, but the more that I reflect on it, the more I think that *I* was the one with the advantages.”

“How so, Bruce? No friends to play with after school, miles to ride your bike to the school bus – in all kinds of weather, heaps of chores before you could go off and do your own thing after school, a Dad with polio disabilities...sounds like disadvantage to me. You did well to get a scholarship to finish high school in the city.”

“Yes – that’s what I thought at the time, but on reflection, I actually got to understand a lot of things – like the weather and the seasons and how things work. The chores were a bit of a drag, but I made chopping wood into a game of skill – and carrying buckets of grain and water for the poultry kept me fit and taught me that things don’t just happen as if by magic. If it weren’t for our visits to the farm, I’m sure that the kids wouldn’t have a clue where an egg comes from or even that water only runs down hill. I envied the town kids because I was alone a lot, but as a result I had time to be with my own thoughts. Sometimes I’d meet up with other kids on the weekend and we’d ride for miles – all very safe. All-in-all, I think that it gave me a good understanding of the physical world, its scope and its limitations. I tried to fit all the practical stuff that I experienced into my own funny little theories.”

“It’s hard to imagine growing up without TV, Bruce. As a kid, I used to revel in the costume dramas and then play dress-ups with the other girls in the street. We even built our own theatre and made up our own plays. It was lots of fun – no wonder I carried on with it. Perhaps I’ve never grown up.”

“Part of us *never* grows up – or at least I think that it *shouldn’t*, anyway. In fact, I think that it’s unhelpful to look at imaginative play ‘just kids’ stuff’. I suspect that many people have inadequate imaginations because their parents prevailed on them to

‘grow up’ too quickly and they prized precocious behaviour above normal juvenile behaviour – the ‘[Shirley Temple](#)¹⁸² syndrome’ – adult behavior in kids, I call it.”

“I thought that Shirley Temple was cute...”

“I rest my case, Jane. But, certainly, life wasn’t all frivolous – we had fun, but we had responsibilities – Dad would often chide me for not doing my chores, and approval was pretty rare. I guess it was pretty hard for Dad trying to keep a farm going with a gammy leg and a dreamy son. Kids remember the parental negatives more readily than the positives.”

“From what I’ve seen, Bruce, I think that he was – and is – quite proud of your achievements, just that he couldn’t show it. Typical bloke!

*As a decrepit father takes delight
To see his active child do deeds of youth,
So I, made lame by Fortune's dearest spite,
Take all my comfort of thy worth and truth;
For whether beauty, birth, or wealth, or wit,
Or any of these all, or all, or more,
Entitled in thy parts, do crowned sit,
I make my love engrafted to this store:
So then I am not lame, poor, nor despised,
Whilst that this shadow doth such substance give
That I in thy abundance am sufficed,
And by a part of all thy glory live.
Look what is best, that best I wish in thee:
This wish I have; then ten [times happy me!](#)¹⁸³”*

“I guess that’s a pretty good summary of my youth, Jane. TV reception was pretty poor – right up until they had a satellite dish installed just a few years ago – so I’d listen a lot to the ABC radio – it was an amazing window into the world of reasoned discussion – and good pronunciation of English.”

“I thought that you got that from boarding school?”

“No – it would have been too late then. I used to read all these big words in my encyclopedia that people never used in conversation out here. I had my own ideas on pronunciation and I’d feel a bit silly when I heard it pronounced correctly on the ABC. I think that they have relaxed their standards in recent years.

“‘*O tempora, o mores*’¹⁸⁴ ... But Bruce, you think that you took to science because of your experiences as a kid on the farm?”

“It’s pretty well impossible to unpack the motivations for any action, Jane, but I can say that when we started doing science at school, it made a lot of sense to me because of the many little experiences that I had around the farm – real experiences, not just reading about someone else’s experiences. As well, I thought that the rigorous

methods of experimentation that we used in the science classroom were very empowering.”

“You’ve mentioned some of your experiences before – generally over dinner with friends, where the conversation invariably segued to other topics and the point was lost. I recall that you thought that a certain experience with mirrors and turkeys was very formative. We’ve got the time now – can you spell that out – I’ll try to keep on track if you can.”

“Oh – yes! *The mirror and the turkey*. Well – Other than sunburn, I was first exposed to the possibilities of solar energy when I was about ten years old. One night, in my verandah bedroom, by the flickering light of a kerosene lamp, I strained to read about Archimedes “solar heat ray” incinerating the invading fleet at the siege of [Syracuse](#)¹⁸⁵. The illustration in my encyclopedia had Archimedes in a stately pose in Grecian garb, directing a single ground-mounted mirror at the [hapless ships](#)¹⁸⁶. At that age I was unaware of scientific disputes and implicitly trusted my encyclopedia – it was all that I had, which was infinitely more than my handful of classmates at our local two-room primary school.”

“So – you were a little Archimedes in the making! That explains a few things. But you weren’t trying to burn your model boat in the dam?”

“No – I tried to repeat Archimedes feat by taking my mother’s hand mirror and directing it at the blowflies that gathered in the cool shade of the verandah near my bedroom. But there was no [eureka! moment](#)¹⁸⁷ – and, although the [reflected](#)¹⁸⁸ bright oval of light clearly revealed the swarm of flies on the wall, it failed to burn them. And I found that when I shone the mirror onto my own face, it barely warmed it, but it did illuminate my curiosity.”

“Nice one, Bruce. So much for blowflies – I could have told you that – we were always taking Mum’s mirror outside so that we could put on make-up for our plays – Mum’s make-up, too. It got us into all kinds of trouble with her.

*Even so my sun one early morn did shine,
With all triumphant splendour [on my brow](#)¹⁸⁹;*

So where does the turkey come into the picture, Bruce?”

“Well – I figured that the problem was that the hand-mirror was too small and didn’t collect enough energy. So when Dad and Mum had gone to town one Saturday morning and left me home to do some chores, I decided to take the mirror off the top of the chest of drawers in their bedroom and try that – it was the best part of a metre square – I could hardly lift it.”

“And what were you expecting to do to the turkey with the mirror?”

“There wasn’t any hypothesis – in fact when I took the mirror outside I thought that I’d shine it at the shed, or a tree or something like that. I was just starting to fool around with it and one of our [free-range](#)¹⁹⁰ turkeys came strutting by – about five metres away. Okay turkey! You’re the invading Roman fleet! *Sigh Rah Kews* will be

saved! I think that I was hoping to set fire to its feathers – that didn't happen, but the turkey was in this intense rectangular spotlight for quite a while and as a result, was pretty well blinded by the light. It staggered off and in a bit of a panic I put the mirror back on the dresser and got on with my chores.”

“Needless to say, you didn't report your failed experiment to your Dad?”

“I didn't see it as a failure – I had succeeded in doing *something* – namely, *temporarily blinding a turkey*. When Dad got home he saw the dazed turkey staggering around the yard and asked me whether I knew anything about it – had the dogs mauled it, or something? I disclaimed any knowledge – what turkey Dad? Years later I fessed-up – Dad laughed and said that he had suspected as much, but didn't want to discourage me. Of course, at the time I thought that parents essentially disapproved of everything that kids did – but that's kids.”

“Poor turkey! But why didn't the turkey catch fire? That was a *big mirror*?”

“Good question. In summary, like most people, I didn't know the difference between [temperature](#)¹⁹¹ and [energy](#)¹⁹². The big mirror *reflected* lots of energy, but it didn't *concentrate* it to increase the temperature. It's the same misconception that many people have these days about solar energy. The mirror would have to be curved to do that. Archimedes would have had the same problem. But that wasn't the only experiment that I did with turkeys.”

“I can hear the groans from animal rights activists already.”

“For sure – but this all happened long ago when a lot of gruesome things were considered [fairly normal](#)¹⁹³.”

“Anything else that you'd like to 'fess up to, Bruce?”

“Hmm... well, my encyclopedia also has a great story about how the South American gauchos, or cowboys, used a thing called a [bolas](#)¹⁹⁴ instead of a lasso to capture cattle. It looked like fun, so I made one using three bootlaces about a-foot-and-a-half long and three one-inch nuts from the workshop tied to the ends.”

“So the turkey was a stand-in for cattle on the [Pampas](#)¹⁹⁵?”

“Kind of. I first tried it on a fence post. I'd swing it 'round and 'round my head – and then let go. The laces would make a terrifying whiffling sound going through the air and when one of them caught on the fence post the other two would quickly whip around the post tighter and tighter.”

“Oh no!”

“Oh yes! But I aimed at the turkey's legs, not its tempting long neck. Whirl! Whiffle! Whip! And over went the turkey, with its legs in a mess of bootlaces and one-inch nuts from the tractor-shed. It was such a tangle that I had to cut it off with my trusty pocket-knife. Darn! That was the end of my bolas! The turkey staggered to its feet and wobbled away. More questions from Dad and more denials that night.”

“So you were a ‘turkey-denier¹⁹⁶’, Bruce? The bolas sounds similar to the way we did spins in ice skating classes – the closer our arms got to our body, the faster we would spin¹⁹⁷ – and sometimes finish up on the ice tangled like your turkey. All very funny – but what was the point of these stories?”

“I guess that the farm always evokes these memories. But I guess I was giving you a feeling for the way physicists see the world. Or *saw* the world. Many of my contemporaries at uni came from similar backgrounds – even the ones from the city came from the outer suburbs where they could muck around and get a lot of experiences that later became the foundations for their understanding of physics and other science. The bolas story informs the whole ‘geocentric-heliocentric¹⁹⁸ universe’ issue in many ways – as we shall see. It’s hard to get that same level of gut-experience from a video-game console¹⁹⁹. More than that, the ‘mucking around’ was really the beginning of experimenting²⁰⁰ – taking ideas, making things and testing them through trial and error.”

“Not your average nerds?”

“No, not at all, Jane. These days we see images of weedy kids who stay up all night playing video games or computer hacking or whatever. We had to pinch-hit our ‘mucking around’ in between chores. We couldn’t help but be fit and healthy – there was real work to be done. The ‘mucking around’ served to extend our reality by applying our imagination. Ideas got tested – and, as anticipated, they often failed – or didn’t work as expected. We may not have told our parents everything, but these events were the stuff of our schoolyard conversations – generally with more than a bit of bragging. But we couldn’t get away with too much exaggeration, because if it sounded like fun, one of the other kids would try it and report back on what happened.”

“Peer review, eh?”

“Sure was. Respect came from having the most amazing stories that were verified by the other boys.”

“Boys?”

“Absolutely. As pre-teenagers, girls were another race and this kind of behavior served to make an exclusive bond between the boys. That’s just the way it was.”

“Hmm... that helps explain something.”

“Yeah – sorry about that. But I think that the girls came into their own in high school chemistry, with *their* background in helping Mum with the cooking. But, both boys and girls alike spent a lot of time in a wide variety of practical experiences, which eventually make for that ‘country wisdom’. It’s interesting that more farmers believe in climate change than their city counterparts²⁰¹.”

“That’s right – we started talking about climate change and segued off into Archimedes, mirrors, turkeys and gender-imbalance in peer review. Our stroll up the

hill and back seems to have disappeared in a flash. Any last comments before we get back to the house?”

“Talking about ‘flashes’ reminds me of another Archimedes connection – the ‘*eureka* moment’ – that flash of inspiration in the bath and its connection to forensic science that we were talking about in the car as we drove here.”

“There seems to be a few leaps in there, as well as flashes, Bruce.”

“Well, it’s like this. It all came about – the *eureka* thing – because King Hiero of Syracuse suspected that the goldsmith was diluting the gold for his new crown with silver. According to legend, Archimedes figured it out by noticing how the level of water rose in his bath. It’s actually a lot more complicated than that, but our point is that it was an early case of the use of science in law. History doesn’t record what happened to the offending goldsmith.”

“Was that story in your encyclopedia, too, Bruce?”

“It sure was.”

“And did the boys do peer-reviewed experiments to confirm it?”

“Well actually, it was a gender-balanced experiment. Water was always in short supply, so my sister and I shared the bath on Saturday nights. It was good, because with only one of us in the bath, there was hardly enough water to cover our legs. When the second person got in the bath, the water level rose up to our waists. We used to shout eureka when we found the soap.”

“Speaking of which, it looks as though the kids had a good time in the creek with Grandad – they’re covered in mud.

*Thy glass will show thee how thy beauties wear,
Thy dial how thy precious minutes waste;
The vacant leaves thy mind's imprint will bear,
And of this book, this learning mayst thou taste.
The wrinkles which thy glass will truly show
Of mouthed graves will give thee memory;
Thou by thy dial's shady stealth mayst know
Time's thievish progress to eternity.
Look what thy memory cannot contain,
Commit to these waste blanks, and thou shalt find
Those children nursed, delivered from thy brain,
To take a new acquaintance of thy mind.
These offices, so oft as thou wilt look,
Shall profit thee and much enrich thy book.²⁰²*

Scene Seven: *On the road again*

“That was a great weekend away from the city, Bruce. Your folks are amazing. The kids reveled in the slime and mud of the creek and had a lot of fun in the kitchen with your mother. She’s as inventive as a cook as your dad is around the farm.”

“Yep – [necessity is certainly the mother of invention](#)²⁰³. Mum’s garden is always a sight to behold. With chronic water shortages, and Dad invented – or probably re-invented – that clever reticulation system. It also made it easier for Mum to manage that large area. By the way – what’s your plans for that boot-load of veges?”

“They’ll probably go in the deep freeze so we can use them ‘as and when’. I don’t know what our ‘[food miles](#)²⁰⁴’ and ‘[carbon footprint](#)²⁰⁵’ – or whatever you call it Bruce – is going to look like, but those [organic veges](#)²⁰⁶ really *are* delicious.”

“Hmm...food miles and carbon footprints – that’s something we’ll have to discuss at some stage. In my opinion, there’s a lot of myths and misconceptions surrounding those two notions.”

“We could discuss them now, Bruce? We’re still a couple of hours away from home.”

“Nope. We’re not ready for that, yet, Jane.”

“Bruce – are you trying to *Scheherezade* me?”

“Now that’s a verb I haven’t heard before. I guess you can [turn proper nouns into verbs](#)²⁰⁷ – Simon and Garfunkel made a whole song of them:

*I been Norman Mailered, Maxwell Taylored.
I been John O'Hara'd, McNamara'd.
I been Rolling Stoned and Beatled till I'm blind.
I been Ayn Randed, nearly branded
Communist, 'cause I'm left-handed.
That's the hand I use, well, [never mind](#)²⁰⁸!*

... That was one of Dad's favourite vinyls – I used to play it a lot myself – I thought it was very funny. But back to 'the point' about *Scheherazade*... where does [Rimsky – Korsakov](#)²⁰⁹ fit into the picture?"

"Oh! That's where we were... and that segue neatly illustrated the point. Do you know the story behind Rimsky-Korsakov's symphony, Bruce?"

"Not really – over to you – that's more *your* thing, Jane."

"Well, it comes from the *Thousand and one Arabian Nights*²¹⁰ stories by [Sir Richard Burton](#)²¹¹ – well, translated by him anyway. As the story goes, King Shahrya, who had a grudge against women, would marry a new virgin every day and would send yesterday's wife to be beheaded. He had killed one thousand such women by the time he was introduced to Scheherazade, the [vizier](#)²¹²'s daughter. To avoid the same fate as the previous thousand wives, she would start to tell him a story each night, but would not conclude it until the next night, when she would start another story. She did this for one thousand nights, after which he decided that he was in love with her and made her his queen."

"Hmm... some grudge! *He* certainly knew how to set up an [incentive program](#)²¹³. So you think that I am stringing out this climate change story to avoid some unsatisfactory conclusion?"

"Could be. I think that the king became the archetype for [soap opera](#)²¹⁴-addicts."

"How so?"

"Soapies work with a *continuous open narrative*. Each episode ends with a promise that the storyline is to be continued in another episode. When one storyline ends there are several other story threads at differing stages of development. Soap opera episodes typically end on some sort of [cliffhanger](#)²¹⁵, just like Scheherazade's stories."

"Very post-modern of her, Jane. So she figured that an old-fashioned [narrative arc](#)²¹⁶ would have lead to the arc of a descending axe – or scimitar, as would be the case in those countries."

"Indeed, Bruce! I must say that we seem to have undergone some role reversal here – *I* want you to get to the point and *you* want me to hang off the edge."

"Well, I did say that *the complete explanation would be a lot longer*. You've set me a considerable challenge – *how to explain climate change to someone who doesn't have any technical or scientific background*. It may not even be possible. Maybe the best outcome I can hope for is that you will be satisfied that climate change is understood by people that you can trust – both for their competence and their intentions. Just like Scheherazade – it must have taken a while for her to get the king thinking in terms of morals of the tales rather than thinking about chopping off her head. I hope that I'm weaving a narrative thread rather than just a [tangled web](#)²¹⁷."

“I trust your *intentions*, Bruce – but at the rate we are going, I’m not sure that I can trust your ability to satisfy my request for an explanation. Can we draw any morals from this particular tale?”

“Let me try, Jane. So Scheherazade told a thousand and one stories before the king decided that he loved her? From my perspective, that’s a pretty impressive [data set](#)²¹⁸. Unless the stories were pretty poor, I would have thought that he would have [inferred](#)²¹⁹ something about the worthiness of Scheherazade before then.”

“Fair point. I think that he had some data other than the stories – by *that* time they had had three children together.”

“Is that possible in one thousand days? Let’s see – human [gestation period](#)²²⁰ is about nine months – say 270 days – times three – that’s...”

“Bruce! It’s only a story!”

“Possibly the thousand-and-second story that wasn’t told.”

“Anyway, I guess that they worked on the principle that they grew to love the person they married, not vice versa. In that case, love would be more of a process than an event – they didn’t ‘fall in love’ – they ‘grew in love’. Maybe I’ll grow to love climate change, even if I don’t fall for any particular explanation.

*But do thy worst to steal thyself away,
For term of life thou art assured mine;
And life no longer than thy love will stay,
For it depends upon that love of thine.
Then need I not to fear the worst of wrongs,
When in the least of them my life hath end.
I see a better state to me belongs
Than that which on thy humour doth depend:
Thou canst not vex me with inconstant mind,
Since that my life on thy revolt doth lie.
O what a happy title do I find,
Happy to have thy love, happy to die!
But what’s so blessed-fair [that fears no blot](#)²²¹?
Thou mayst be false, and yet I know it not.”*

“That’s a possible outcome, Jane – it’s not as philosophically pleasing to me as empirically-backed reasoning, but it might be the best that we can do. A kind of [coevolution](#)²²² of understandings. As we talk, I’m getting to know more about your [point of view](#)²²³ and hopefully, you of mine.”

“In our case, let’s hope for coevolution. There’s another possible interpretation of the Scheherazade-King Shahrya love story – [co-dependency](#)²²⁴.”

“What’s the difference, *Mrs Freud*?”

“Well, we might need to work this out together – I really only know about the co-dependency part.”

“Well *coevolution* can be thought of as the change of a biological object – a living thing – triggered by the change of a related object – usually another living thing. The classical example of coevolution is the colour and shape and nectar quality of some flowers that match the visual perception, beak shape and dietary requirements of some hummingbirds. Over time they have become increasingly closely matched so that the flowers can only be pollinated by the hummingbirds, and the birds are totally reliant on the flowers. They evolve together, live together, and possibly die if they are apart. So what’s co-dependency?”

“Hmm... co-dependency doesn’t seem to be as symmetrical as co-evolution. The co-dependent person usually compromises *their* own values and integrity to avoid rejection or the other party’s anger. *Co-deps* are extremely loyal and often remain in harmful situations way too long.”

“It doesn’t sound like as much fun as co-evolution, Jane. I appreciate that, unlike co-evolution we are talking about the establishment of a situation in one generation, rather than slowly over many generations, but I see that the important principle is mutual dependency in an ongoing relationship. For all we know, the passive flower might think that the hummingbird is the aggressor and *it* is the victim.”

“Hmm... I’m not sure how we drifted out to here in this conversation, Bruce, but when one party to the relationship is a medieval king and has a track record of murdering one-thousand wives and the other is a young woman, it’s hardly a symmetrical, or balanced, situation. Scheherazade was dicing with death. What I find curious is how you can look so dispassionately on such a situation.”

“Well, I was only abstracting it to its bare essentials, Jane. To me, the configuration of the ongoing relationship was the most important element.”

“I think that I’m having an *aha! moment*²²⁵, Bruce. I’ve just realized the big difference between the so-called *scientific mind* and the so-called *artistic mind*.”

“That’s great, Jane. Such events are rare for all of us. Do you care to share?”

“Glad to, darling. It goes back to Socrates and Plato and Aristotle and Archimedes and Galileo and.... well... the whole bloody lot of you! *You suck the humanity out of every situation that you look at!* Everything is reduced to abstract principles and numbers. What do you think of when I say:

*O thou invisible spirit of wine, if thou hast no name to be known by, let us call thee devil!*²²⁶”

“*Ethyl alcohol*²²⁷?”

“I rest my case.”

“I wish I had heard that quote the other morning after drinking shiraz with Dad – I had a devilish hangover. But seriously, Jane, scientists aren’t a bunch of bloodless zombies. It’s just that scientists are trained in the spirit of [Socrates](#)²²⁸ and [Francis Bacon](#)²²⁹ to extract the essential features of a situation that they see that are common to similar situations.”

“*Extracting the essence* – that’s it! A bowl of oranges is reduced to a thousand milligrams of vitamin C.”

“But, Jane, what was Shakespeare doing if not portraying universal verities? He used poetry and metaphors – *we scientists* use equations and numbers. To a scientist, there is as much beauty in those equations as you see in a sonnet.”

“I guess that I’ll never have that direct experience, Bruce. But it still doesn’t make King Shahrya a nice man.”

“You didn’t ask me whether I thought that he was a nice man. Clearly, he had behaved very badly, but I was commenting on his behavior towards Scheherazade. She started off thinking that he was *not* a nice man, but seemed to have changed her mind as time went on. That’s *appears* to be paradoxical, but, I understand, it’s not uncommon- it’s the [Stockholm Syndrome](#)²³⁰. Scientists are attracted to puzzles and apparent paradoxes in nature and life. We try to subdue our immediate reactions of horror or disgust and try to look at the enduring patterns. Having immersed ourselves in these abstractions and processed them, we try to bring ourselves back to the world of everyday – or shared – senses to make statements about these enduring patterns. This can’t be done unless we can subdue our passions while we are immersed – otherwise our statements will just be subjective and unreliable.”

“So after all this ducking and diving in and out of reality, do you come to the conclusion that King Shahrya was a [psychopath](#)²³¹ who led Scheherazade into a co-dependent relationship?”

“Well, given that the story says that he came to *love* Scheherazade, he couldn’t have been a psychopath – they aren’t supposed to emote like that. We haven’t really got enough evidence to psycho-analyse him to the point of making a medical opinion. All I can infer is that over time they formed a strong mutual attachment – the situation *evolved* – hence *co-evolution*. To me, the word *co-dependency* is emotionally laden and forces us to pre-judge the situation – like the [Queen of Hearts](#)²³² in Alice in Wonderland. It doesn’t allow for other possibilities – including a fair trial, forgiveness or redemption. Say – Shakespeare’s plays are full of murder and mayhem – aren’t any of these murderers and mayhem-ers redeemed?”

“Err – well – most of them – [Lear](#), [Hamlet](#), [Othello](#)²³³. But they didn’t murder one thousand women.”

“Is there a cut-off point? Ten? Twenty?”

“Really, Bruce.”

“So when you asked me whether I was trying to *Scheherazade* you, what did you mean?”

“I thought that I meant that you were stringing me along to avoid getting to the point. Maybe there’s more to it than that. Well – are you? Is there?”

“There usually is. Do you love me more or less for these discussions we are having?”

*“Where art thou Muse that thou forget'st so long,
To speak of that which gives thee all thy might?
Spend'st thou thy fury on some worthless song,
Darkening thy power to lend base subjects light?
Return forgetful Muse, and straight redeem,
In gentle numbers time so idly spent;
Sing to the ear that doth thy lays esteem
And gives thy pen both skill and argument.”*²³⁴

“Only nine hundred and ninety four to go, Jane!”

Scene Eight: *Watching the days pass by...*

“It’s fascinating to watch the kids at play, Bruce. They’re like little puppies – frolicking and yelling – totally involved in the moment. They’re divine! They’re a long way from discussions on climate change.”

“Not as far as one might think, Jane. I agree with you – they’re beautiful to watch – it’s as though we are looking at something that we have lost.”

“Yes – some people call it ‘[innocence](#)’²³⁵ – that stage before we start to reflect on our inner and outer world. That’s what the Bible is all about, as far as I can tell – the [Adam and Eve](#)²³⁶ and their ‘fall from grace’ – eating from the *tree of knowledge* – eviction from Eden and so on. ‘Lest ye become as little children, ye shall not enter into the [kingdom of heaven](#)’²³⁷. To me ‘going to heaven’ is about regaining that child-like state of looking at the world without reflection or judgment.”

“That’s a very [secular](#)²³⁸ perspective, Jane – a long way from your convent days. It’s very similar to the [Buddhist](#)²³⁹ view...”

“...from your commune days? What’s the connection?”

“Well, it started then, I guess. In summary, Buddhists see ‘enlightenment’ as the transcendence of suffering – and ‘suffering’ is essentially all those mental states that come from anxiety, fear, reflection and desire. You transcend by becoming *child-like* again – but not *childish*. Or like a dog that hasn’t been mistreated.”

“That’s odd, Bruce – I thought that ‘[enlightenment](#)’²⁴⁰ was what we got from our western education – you know – ‘[the age of enlightenment](#)’²⁴¹ and ‘age of reason’ stuff, that started soon after Shakespeare’s time.”

“Yes, I guess it does sound a bit contradictory, Jane – but as far as I can tell, the ‘Enlightenists’ were just taking the long way home, so to speak. They saw that the church was decadent and reason was a pretty useful tool. Perhaps they could get to heaven by the ‘critique of pure reason’²⁴², or maybe practical reason.”

“Or perhaps they Kant²⁴³. So what’s the connection, Bruce?”

“Good one, Jane. Well, I’ve struggled with this idea of learning and understanding – particularly in science – for a long time. I even presented a paper on the topic at a seminar one of the unis a few years ago. I took the approach that understanding was a developmental notion – an idea that goes way back to Socrates:

‘...for all enquiry and all learning is but recollection.’²⁴⁴,

“I got some ideas from Piaget’s²⁴⁵ developmental psychology and from the inimitable Edward de Bono²⁴⁶.”

“The ‘lateral thinking’ guy?”

“Yes – he used to be very popular – but my real interest wasn’t in his *lateral* thinking thing, but in the *linear* thinking thing that he was trying to overcome. It seemed to me that we hadn’t really sorted out what was *linear* thinking. This is where Piaget came in.”

“We did a bit of Piaget for teacher-training. He seems to have been somewhat superseded.”

“Maybe in detail, but the *essence* of his work hasn’t.”

“There’s that ‘e’-word again, Bruce! But I think I know what you mean. Piaget, as I recall, proposed that there were four stages of cognitive development – starting from birth, with children being purely practical and physical and in-the-moment with their five senses, then the development of motor skills, then to concrete thinking and finally the ability to think in a detached, abstract way. Gee! – that sounds like a slow fall from grace²⁴⁷ when you say it like that.”

“Indeed! Well, I figured that there were a couple of things missing from Piaget, when it came to understanding science – although he first trained as a research scientist. First, he was dealing with *children’s* development, so it left open the question as to *how to explain science to a non-scientist-adult* – who is supposed to be at Piaget’s ‘abstract reasoning’ stage, but clearly hasn’t acquired the abstract where-with-all of science – you know – the diagrams, the graphs, the equations and the like. And secondly, he didn’t have enough stages to cover the idea of explanation completely or comprehensively.”

“And after lunch, did you take on Einstein²⁴⁸? Why didn’t you try Shakespeare?”

“There’s that ‘S’-word again! What, pray thee, did Shakespeare have to say about stages of cognitive development.”

“Probably everything he said was about cognitive development, but in particular, I was thinking of *As You Like It*, when Jacques said:

*‘All the world’s a stage,
And all the men and women merely players,
They have their exits and entrances,
And one man in his time plays many parts,
His acts being seven ages....’*²⁴⁹

...these *acts* – ‘seven ages’ – begin with ‘*the infant – mewling and puking in the nurse’s arms*’ and work through six further vivid verbal sketches, culminating in ‘*second childishness and mere oblivion – sans teeth, sans eyes, sans taste, sans everything*’. Would that have helped?”

“They probably did, Jane. Those ‘seven ages’ – or *stages* of Shakespeare’s – are part of our cultural DNA – they help us think progressively. I think that they will come in handy later when we talk about life-cycle energy costs. But in this particular case of looking at explanation, I was trying to focus on what happens when you have a fairly sane, sensible person – usually an adult, who says ‘please *explain* that to me’, rather than someone at the mewling, puking and oblivion stages.”

“Okay – so Piaget’s *four* stages and Shakespeare’s *seven* stages didn’t fit – what did you come up with?”

“Eight.”

“Why *eight*?”

“It’s a very nice number.”

“That’s an unusually feeble reason, Bruce. I’m sure that there is more to it than just being ‘nice’.”

“Well, in fact, there is. When I started analyzing the way that science textbooks and lecturers explained things, I came up with six distinct stages ranging from ‘pictorial’ to ‘abstract’. I then realized that there was a seventh stage that was a bit like Piaget’s earliest ‘concrete’ stage, but it seemed incomplete, because it didn’t account for the way *geniuses* look at the world. So I made that an eighth stage. That seemed ‘nice’ because it was a kind of ‘[eight-fold path](#)²⁵⁰’, like the Buddhist path to enlightenment. Besides, Buddhism gave me some other insights into Piaget.”

“You’ve got me hooked, Bruce. You look like you’re bursting to tell me more. Lead on!”

“Hmmm... that’s a challenge. I’ll try to give a useful summary and if you’re still interested, I’ll see if I can dig out my original paper. The first thing to appreciate is that science, by definition, is *empirical*. That is, *all explanations, no matter how abstruse, must be amenable to being referred back to our five senses*. This, in my view, is what Socrates was on about with his ‘*learning is but recollection*’. He seemed to think that we were born with the basic knowledge – I agree that most of us are born

with our five senses, but it is mainly our early experiences with our senses that give us the foundation for understanding. As Einstein said:

*'Common sense is the collection of prejudices acquired by age eighteen'*²⁵¹.

*"Come on, then; I will swear to study so,
To know the thing I am forbid to know:
As thus, to study where I well may dine,
When I to feast expressly am forbid;
Or study where to meet some mistress fine,
When mistresses from common sense are hid;
Or, having sworn too hard a keeping oath,
Study to break it and not break my troth.
If study's gain be thus and this be so,
Study knows that which yet it doth not know:
Swear me to this, and I will ne'er say no."*²⁵²

"Shakespeare seems to be a bit of a paradox to me, Jane."

"How so?"

"His writing is so profound, but most of his characters behave like fools. They do all sorts of silly things and act impulsively. How can we learn from fools?"

"I kind of agree with you, Bruce – there's the *foolish* – and then there's the *fools*."

"That sounds very Shakespearean, Jane. What do you mean?"

"Well, the Bard describes a lot of foolish behavior through his characters – most of whom are serious, upper – class citizens, whose sense of reason is blinded by the extreme circumstances in which they find themselves. As we all do. They fall back on their base emotions – jealousy, rage, grief, besotted love and so on – and then do foolish things – often murder."

"But you make an odd distinction, Jane – aren't people who behave foolishly, *fools*?"

"Not in Shakespeare. The *fool*²⁵³ is a special character – as well as providing comic relief after the serious characters had done something foolish, they were permitted to speak *frankly*²⁵⁴, while others minced their words."

"Like scientists?"

"There's more than a passing resemblance, Bruce."

"So the fools are there to make sense of the foolish things that sensible people said?"

"Well said, Bruce! There was an inner-sense to their innocence."

"So why didn't Shakespeare say it straight out in the first place? Seems sensible."

“Well, as I said, Bruce, the fools were *frank*- they told it the way they saw it without *gilding the lily*²⁵⁵.”

“Uh?”

*“Therefore, to be possess'd with double pomp,
To guard a title that was rich before,
To gild refined gold, to paint the lily,
To throw a perfume on the violet,
To smooth the ice, or add another hue
Unto the rainbow, or with taper-light
To seek the beauteous eye of heaven to garnish,
Is wasteful and ridiculous excess”²⁵⁶.*

“Okay! That’s gilding the lily – squared! It’s a long way from *Ockham’s ants*.”

“Maybe the *sensual* is the way that some of us make sense of our senses, Bruce. We *feel* our way to the truth. We use our *common*-senses.”

“But, Jane, although we have these five senses in common, their common use doesn’t always lead to a *common* sense of what is so. I think that Einstein was referring to *intuition*^{257 258}, or *tacit*²⁵⁹ understanding when he is claimed to have said ‘prejudice’ – a sense that is rooted in our emotions rather than our reason.”

“I think that Albert had good reason for rooting for reason – given where he came from. He had a wider understanding of prejudice *as well*²⁶⁰.”

“Indeed, but we’ll leave that aside for the moment.....”

“I hear that giant sucking sound of humanity going south – again!”

“Really, Jane! If we get lathered up every time we come across a reference to a tyrant, we, too, will surely become their victims.”

“Okay. We’ll save that for later. Now *I’m* the one digressing. Please go on.”

“So we start with the notion of *feelings grounded in experience* and we also notice that we can talk about these experiences in *general terms* separately from the *experience itself*. That’s what we can call ‘*abstract*’²⁶¹. But these ‘general terms’ can bear more – or less – resemblance to reality – ranging from physical or verbal pictures and diagrams through to graphs and equations.”

“I get the gist of it – but I hope that I don’t have to learn equations to understand climate science.”

“It all depends on what will satisfy you in terms of ‘*understanding*’²⁶², Jane. If we take ‘understanding’ to mean that we feel ‘knowledgeable’ about the subject and that, in turn, by ‘knowledge’ we mean – as I said before – ‘the capacity to act’, then we might be satisfied by an understanding that doesn’t involve algebra. You might be

able to do lots of things – a lot of ‘acting’ – with knowledge that is not as abstract as algebra.”

“Thank goodness for that. I’ll go along with this idea that abstract-ing is a de-sensitising process, but I draw the line at algebra. Life’s too short!”

“Fair enough, Jane. That’s one of the reasons I had for writing this stuff about understanding science. Most people aren’t up to algebra and calculus and computer programs, but they *can* do better than just looking at things and trust their hunches – or intuition, as we’ve called it. Everybody can be ‘knowledgeable’ to some extent. Everybody can *act* a bit like a scientist.”

“But I don’t want to fake it, Bruce. I really want to understand something about this stuff.”

“This kind of *acting* isn’t faking it, Jane – I mean that at least you will behave like a scientist, to some extent. We can do a lot of acting and behaving scientifically without the heavy duty maths thing.”

“And everybody can act a bit like an *actor*, too.”

“Absolutely – or relatively, as the case may be. That ‘bit of a scientist’ means that the situation can be described at some *level of abstraction* in a consistent way and then related back to sensual experience.”

“That sounds nice.”

“Thanks – I thought that you’d like it. So you can see that you have a series of stages – or levels – of abstraction and the game is to work your way back to basic experience from that level. It *is* rather like a *game*²⁶³, in that each stage has an agreed set of elements and rules and the whole series of stages are linked by rules.”

“Your stages and acting are a bit different from the ones that I’m used to, Bruce. Sounds more like chess to me.”

“Yes, it’s a bit like that – in fact, that’s a rather good analogy...”

“I’m catching on fast, Bruce.”

“Indeed! You’re a much better chess player than I am, so you can think of progressing across the chess-board as going to greater levels of abstraction – a kind of process of *induction*²⁶⁴ where you infer more general statements about a situation from the particular information that you have gathered. Moving backwards is like *deduction*²⁶⁵ – because the more general, or abstract the statement, the wider the range of less-abstract situations can be described.”

“And how do you win in this game?”

“In this case ‘winning’ means getting back to home base of concrete experience without tripping over any flaws in your reasoning. Winning can also mean getting to the highest level of abstraction that you can.”

“Why is that winning?”

“Maybe that’s a value judgment, Jane, but higher means that one can perceive a greater degree of generality about a situation. It means that you can ‘act’ in a wider range of situations with the ‘knowledge’ that you have gained.”

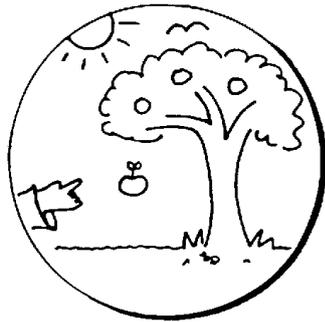
“Careful – you’re losing me! Could you provide an example?”

“Okay – let’s take [Isaac Newton’s](#)²⁶⁶ famous – or legendary - [apple incident](#)²⁶⁷.”

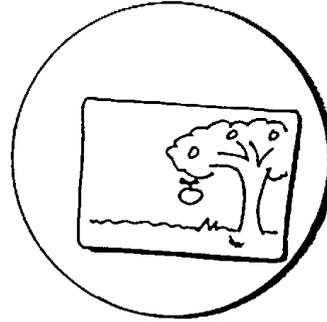
“The one where an apple fell on his head – I thought that was a myth like the flat earth myth?”

“Well – it’s somewhere between a [myth](#)²⁶⁸ and a [legend](#)²⁶⁹. Yes – that one, more or less. Story has it that he conceived of the algebraic equation in a flash of inspiration. But, to spread the ‘chessboard’ out, one could, at *square one* at one end of the abstraction scale, observe a lot of apples and then say ‘apples always fall to the ground when their stems break’, or at the other end, at *square eight*, say ‘ f equals G times $m(\text{one})$ times $m(\text{two})$ divided by r -squared’. The first case only applies to the class of objects called apples on trees, the latter applies to all objects – it’s the most general statement one can make – without going into Einstein’s [general theory of relativity](#)²⁷⁰. So – the person who can make the most general statement wins.”

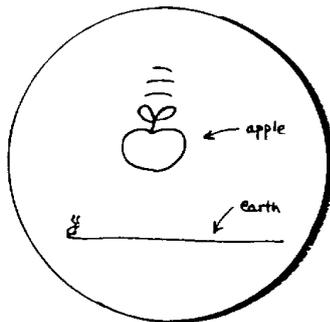
8 Levels of Explanation



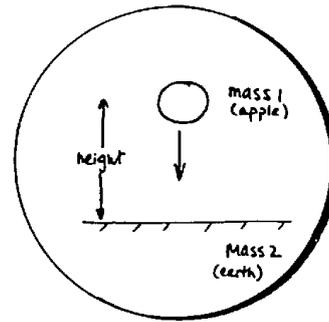
Zen



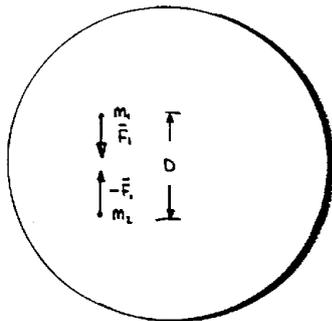
Polaroid



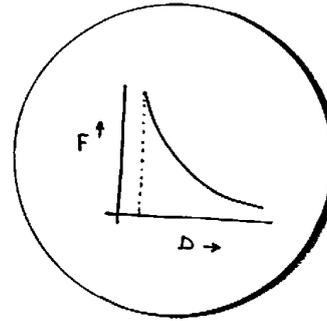
Cartoon



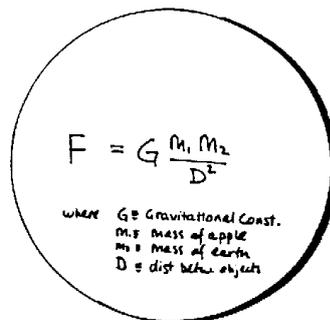
Public



Vector



Graph



Algebra



Newton

“What do they win?”

“*Satisfaction* – and maybe another research grant to come up with some more equations. For example, the [Navier-Stokes equations](#)²⁷¹, which are central to modeling weather and ocean currents, depend on the equation in [Newton’s second law of motion](#)²⁷².”

“Wow – very impressive, Bruce. But I think that we’re getting a bit ahead of ourselves. I’d like to understand your scheme in general terms – even if I can’t ever get to solve equations. Let’s get back to the beginning. So you’re saying that adults can also be in a perfectly concrete state of mind?”

“Well, let’s look quickly at that word ‘perfectly’. These eight stages are idealized – like the way Plato thought of essences or [ideal states or forms](#)²⁷³. In practice, things are less than perfect...”

*“As an imperfect actor on the stage,
Who with his fear is put [beside his part](#)...”²⁷⁴”*

“Indeed, Jane. As we discussed, the ideal first state or stage is where we understand things *wordlessly*. And by *understand*, we mean that we can *do* things – we have a *capacity to act* – that is, *successfully perform intended actions* – without reference to words or images. We *all* do this to some extent – we call it ‘skills’ or *tacit* knowledge. The difference being that with skills is that we have a very limited range of responses to a wide variety of situations. When one exists entirely, continuously and successfully in that state, one is – in the [Zen Buddhist](#)²⁷⁵ sense – *enlightened*.”

“Isn’t the notion of *understanding* is a bit of an [oxymoron](#)²⁷⁶ at this stage, Bruce? How can you explain something *wordlessly*?”

“That’s what all the fuss *is* about in Zen Buddhism, Jane – the enlightened master trying to convince students that by clearing their heads of that incessant inner chatter by meditating and performing certain exercises, they will understand everything that needs to be understood.

*Those who speak, do not know – those who know, [do not speak](#)*²⁷⁷.

“A lot of the descriptive part of Zen is in the form of [koans](#)²⁷⁸, which seem like nonsensical riddles to the uninitiated, but serve as a metaphor for principles of reality beyond the private opinion of one person – which is rather like John Ziman’s *Public Knowledge*²⁷⁹ and *Reliable Knowledge*²⁸⁰ approach to Western empiricism – I think that’s why Zen has been fairly popular with physicists for a long time. *Explaining at this stage goes no further than wordlessly pointing at the situation* and indicating to the student that they should [meditate](#)²⁸¹ on it until they *understand* it.”

“Like the psalm ‘*Be still, and know that I am God*’²⁸² ?”

“Yes, Jane – as far as I can tell, I think that they were getting at exactly the same thing. The only problem with Zen Buddhist enlightenment is that you can’t just stare at the sky and become a competent climatologist – although some people claim that

they can. It seems that the Zen approach is more viable for so-called traditional societies where things changed slowly enough for evolved wisdom to be used. For our immediate problem, the climate is changing too fast to rely on a couple of generations of [wisdom](#)²⁸³, but too slowly for one person's practical experience to be useful. We need the Navier-Stokes equation today."

"It looks as though the kids are about to come in for ice-blocks. We'll have to continue this discussion later, Bruce."

Understanding understanding

*What is it, to understand
The Nature of a flower
Or why
The sky is blue,
That all things change
And that
So many
People cry and
So few
Can stand against the wind?*

*We think, perhaps,
That to understand
We must explain
That there are parts,
And that they connect
By logic and reason,
With time and cause
Providing movement.*

*Thus separated,
Us from it,
The parts proliferate
Connections multiply
Thin threads of logic
Weave a tangled web
And reason creates
A past that severs
Time's circle.*

*Who is it who explains
Me to you
Or me to me?
Duality and words-
We take each other's experiences
As our own
As if my shoes,
Having trod so many paths
Would fit your feet.*

So-
To wish to understand
Is to wish,
And then to hope
That once separated,
All will become as one again
When we know.

No!
Understanding will not
Come this way like that
Only by leaving
Words and cause behind
By being here and now
Will we breathe out
And see
That it is so.

Love is all
We need to know²⁸⁴.

Scene Nine: *Falling for you*

“We’ve set the kids up finger-painting with Mum, so they should be busy with that for a while. They always have so much fun with her and some of their efforts are beautiful and interesting – they could be hung on the walls as abstract art.”

“I certainly agree with you, Jane. I like the way that your mother keeps the focus on the enjoyment aspect of it...”

“Hmm... I said *fun* – and you said *enjoyment* – like they were two different things?”

“I think so, Jane. Certainly they are both about *pleasure*, but to me, *fun*²⁸⁵ is essentially *visceral* and *enjoyment*²⁸⁶ is essentially *cerebral*.”

“That sounds very like *Descartes*²⁸⁷ *mind-body distinction*²⁸⁸ to me, Bruce. All that giggling and running around doesn’t *sound* very cerebral. I don’t think that Mum is trying to make the kids into little *Whistlers*²⁸⁹ or *Picassos*²⁹⁰.”

“I’m sure that she isn’t. But you might notice how their finger painting has changed over the past couple of years. When they first started, it seemed that all the *fun* was about the oozing of the paint through their fingers and the squishiness of applying it to the surface of the butcher’s paper. Your mother rewarded them by laughing and other sounds of approval when they directed their efforts towards the paper rather than each other’s faces. With time, they got more interested in colours – and she chimed in with the names of the colours – and now they are making all sorts of patterns – some of them blobs and some of them lines, to which she says ‘pretty’ or ‘beautiful’ or ‘gee –

that's amazing' and so on. And some of those blobs and lines are starting to look like people, animals and chairs and tables."

*"Make answer Muse: wilt thou not haply say,
'Truth needs no colour, with his colour fixed;
Beauty no pencil, beauty's truth to lay;
But best is best, if never intermixed'?"*²⁹¹ ...

"Very interesting, Bruce – but where is all this heading? We seem a long way from explaining *explaining* and even further away from explaining *climate change*"

"I guess it's *Piaget-at-work*, Jane – a gradual shift from the concrete to the abstract. As always, there's a mix of both. At the moment, their occasional thoughts are stimulated by their actions. With time – with any luck – it will be the other way around. As the Buddhists say:

*Right view yields right thought yields right action*²⁹²

"In my view, many people somehow seem mentally stuck at an early age and their thoughts are a crude rationalization of their uninformed feelings. They may be very skilled, but they don't deal very well with *new* situations that require abstract thinking to resolve."

"Wow! – I didn't think that finger-painting was so deep, Bruce. But, as interesting as all this is, it seems like a bit of a digression. I thought that we were going to look at the next stage of your eight-stage 'model' of understanding."

"We are, Jane – we are. Everything's connected:

*'To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand
And Eternity in an hour'*²⁹³ .

"How so, Bruce? If – as in your *stage one* – meditating-on, praying-about and pointing-at climate change don't convince me, what do we do next?"

"The next stage – or the *second level of explanation* is the huge quantum leap in mental activity as we leave the so-called *real* world of *direct and immediate experience* and enter the so-called world of *abstraction*. The second to seventh stages are really just increasing degrees of abstraction – that is, *things look less and less like the reality of everyday experience*."

"So if you called the first stage *Zen*, what do you call the second stage?"

"I wrote this paper on explanation and understanding before the era of digital photography – I called it the *Polaroid*²⁹⁴ stage."

“I guess that there are now a lot of young and enquiring minds who wouldn’t have a clue what a Polaroid photo is or was – just think of our own kids in a couple of years’ time.”

“But I hope that there will be young and enquiring minds who care about *epistemology* in a few years’ time, Jane. Polaroids were the nearest consumer technology that we had to instant photos until digital cameras became commercial around the turn of this [century](#)²⁹⁵. Let’s re-name this second stage the ‘*photo*’ stage, as everyone now can imagine looking at the image on the back-screen of their digital camera, enlarging it for details and even taking a series of photos in rapid succession or even a movie, that they can then freeze-frame their way through to look at details.”

“It’s something that we now seem to take for granted in our visually-saturated world, Bruce.”

“Like so many things that we take for granted, Jane – being able to make three-dimensional sense of a two-dimensional image is a pretty exciting thing. It’s the first step in visual abstraction. Perceptual [psychologists](#)²⁹⁶ and [physiologists](#)²⁹⁷ have been looking at this stuff for years.”

“Come to think of it, Bruce, it goes way back before the era of perceptual psychologists and physiologists.”

“Oh?”

“Well – Western art was, from the Renaissance up to the middle of the Nineteenth Century, underpinned by the logic of [perspective](#)²⁹⁸ in an attempt to reproduce an illusion of [visible reality](#)²⁹⁹. The advent of the camera changed all of that. At first the [Realists](#)³⁰⁰ used the fairly primitive black and white photos to help construct more realistic coloured paintings, but as photography [improved](#)³⁰¹, painters moved to [impressionism](#)³⁰² and other artistic forms that essentially went beyond photographic imagery.”

“Which, I suppose, accounts for the rather child-like appearance of [Medieval art](#)³⁰³. You’re the art expert here, Jane – although I know a bit about the history of *perspective*. I got interested in it doing technical drawing at high school. Not surprisingly, our teacher taught us all the techniques for creating realistic looking perspectives, but he didn’t mention that it was an eleventh-century Persian – actually an Iraqi – named [Alhazen](#)³⁰⁴ who worked out all the theory.”

“That good ‘ole *encyclopedia*, again, Bruce?”

“Indeed! And I recall that artists were assisted by optical devices long before the advent of the camera in the nineteenth century.”

“Oh! The [camera obscura](#)³⁰⁵ and the [Hockney-Falco thesis](#)³⁰⁶! We read about that in our art history unit.”

“Err... I’m not up on the thesis part of this, but I was pretty proud as a kid to have re-invented the *camera obscura*.”

“Is this another one of your turkey stories, Bruce?”

“Not quite – but it dates from about the same time. One of the walls in my sleep-out-bedroom was made of corrugated iron and had a few old nail-holes in it. The whole room became a *camera obscura* movie theatre for me, with pictures on the wall opposite the corrugated iron. I wondered why everything was upside-down until I read about it in my encyclopedia. Later on I read that the idea had been around since Aristotle, but it didn’t mention anything about the ... what’s-their-names’ thesis. What was that?”

“The Hockney-Falco thesis, Bruce. These guys thought that the great increases in technical accuracy of Renaissance art was due to the use of *cameras obscura* and other early optical devices.”

“Why not? The *art* isn’t the *technique* – is it?”

“*Art is that which transcends technique*³⁰⁷, Bruce.”

“Fair enough. But creating new techniques is an art, too.”

“So what does all this amount to, Bruce? As interesting as it is, how does it tie in with *explanation part two*?”

“Oh – just some insights into how challenging it really *is* to interpret – or make sense of – a flat image. By *make sense*, I mean *how we relate these static blobs and lines to an ongoing dynamic reality*. Unlike *holograms*³⁰⁸ and a range of images that require special glasses for viewing, ordinary flat images, by definition don’t provide any *real* depth perception – that requires each eye to see a different image – *stereoscopy*³⁰⁹, it’s called – we have to reconstruct and imagine reality from a series of learned cues.”

“So is stuff at this level any use to us for looking at climate change, Bruce?”

“Certainly. For example, examining the change in area of ice masses such as *glaciers*³¹⁰ and *Arctic ice*^{311 312} uses photos – but there’s a good example of the limitations of flat images – they don’t tell us the *volume* of the ice – only its area. We can’t get adequate depth information from photos alone – you need graphs and other things that we’ll come to later.”

“Looking forward, Bruce. But I heard somewhere that there was a lot of debate about melting ice.”

“Yes, it’s pretty complicated – and we’ll get around to that soon. But keeping focused on *explanations* – the wide range of *optical illusions*³¹³ that we see in psychology texts, kids’ encyclopedias and occasional annoying advertisements show how easy it is to fool our visual perception. The history of the development of so-called realistic art suggests that a person who hasn’t been coached in image interpretation from an early age will have difficulty making sense of these images. *It’s a huge mental leap*³¹⁴.”

“Fair enough – but where does that leave us?”

“It means that we actually accept a whole bunch of tacit and explicit rules when we look at an image. As a *Stage Two* explanation, we can imagine that we have captured an image of reality – a photo or realistic painting – and we then set about to examine what is in it – the particular bits – like a tree laden with apples, an apple falling, the ground, as well as, perhaps, the sky, a cat in the tree and a dog apparently barking at it. And we have posed the question ‘why does the apple fall to the ground?’”

“But how does this turn into an explanation?”

“Explanations at this stage hardly look like the explanations that you and I and lots of people would usually accept as such. Having frozen the scene-of-interest, we can see a lot of possible causes – including ‘ripe fruit always falls to the ground’, ‘the cat pushed it when the dog barked’, ‘the wind blew the apple off’, and so on. These explanations are almost **tautological**³¹⁵ – like ‘it falls because it’s in its apple-nature to fall’. You might notice that this is often how we explain things to small children – it might seem like a bit of a cop-out, but often it’s okay, because all they really want is reassurance that what they saw actually happened and they haven’t got the mental stuff – that we’re going to get to soon – to process it any further. Historically, many explanations in **Aristotle**³¹⁶’s time weren’t any more sophisticated.”

“So – we now have two squares on our chess-board, Bruce – the first is about *wordlessly pointing* and the second is *a picture that we’ve tried to make realistic* and that we have learned to look at and describe. So each square on the board provides us with a particular picture with various things in it that may – or may not – relate to each other or the thing of interest. *Our* form of explanation is a description of the way the things in that picture relate to each other?”

“I couldn’t have said it better, Jane. But a *full* explanation is a bit more than that.”

“This is where the chess-board comes in, Bruce?”

“Yep. Having examined the photo and come to some opinion about cause-and-effect relationships, we can then move *deductively* back to square one and have another look at the apple tree – we might wait and watch wordlessly for another apple to fall.”

What about a bit of **role-play**³¹⁷ here, Bruce – it might help to fix the idea with me.”

“Good idea, Jane. Okay – you almost have to imagine that you are a child to see it using only the first two squares – using more abstract squares than number two isn’t allowed. Imagine the young Isaac says: ‘Mummy – why did that apple fall to the ground?’ You assess his level of cognitive development and say ...”

“Good question, Isaac. Let’s watch the apple tree and see if another apple falls. Yep... there goes another one...”

“‘But why, Mummy’, he says...”

“Because that’s what apples do when they’re ripe, dear.”

“But why, Mummy?”

“Errr...let’s see. Well – see where the apple joins the branch?”

“I can’t see it very well from here.”

“I’ll take a picture with the zoom on the camera, Isaac. Now you can see on the picture that little brown stick at the top of the apple – called its stem. It’s got a little soft yellow spot where it joins the branch. When the apple is really ripe that gets really soft and breaks and the apple falls. Now let’s watch the tree again...”

“Look, Mummy, there’s goes another apple. It must be ripe. And the cat just fell out of the tree – it must be ripe, too.”

“No, Isaac, the cat wasn’t ripe – it slipped.”

*Mine eye hath played the painter and hath steeled,
Thy beauty's form in table of my heart;
My body is the frame wherein 'tis held,
And perspective that is best painter's art.
For through the painter must you see his skill,
To find where your true image pictured lies,
Which in my bosom's shop is hanging still,
That hath his windows glazed with thine eyes.
Now see what good turns eyes for eyes have done:
Mine eyes have drawn thy shape, and thine for me
Are windows to my breast, where-through the sun
Delights to peep, to gaze therein on thee;
Yet eyes this cunning want to grace their art,
They draw but what they see, *know not the heart.*³¹⁸*

Scene Ten: *Th...th...that's (not) all, folks!*³¹⁹

“The kids are watching the *Alice in Wonderland*³²⁰ video – for the fiftieth time I reckon – so we’ve got a bit of time for a cup of tea and continue *our* journey down the *Rabbit-Hole*³²¹ into the land of abstraction. Where do we go to next, Bruce?”

“Straight from rabbit-hole to *chess-board*³²², Jane. Say! We’re already there – along with the kids – in the land of cartoons.”

“*Curious and curiouiser*³²³, said Alice’. This pool of tears is certainly a long way from the dry land of climate change, Bruce.”

“Not as far as you might think, Jane. Climate science uses an enormous amount of imagery to interpret and display ideas. We’ll come to that in good time.”

“Lead on, *White Rabbit*³²⁴!”

“Hmmm.... Where to start? Well – we left reality and fell down the *Rabbit-Hole* when Alice wanted a book with pictures. In our case we said that we were moving across a *chess-board* – but never mind – just mixing up our metaphors. But we’ve found that *literal* pictures often seem to have too much spurious information in them for us to ‘understand’ what’s going on. What are we to do?”

“I get it, Bruce – Lewis Carroll’s fictional characters are *caricatures*³²⁵ of prominent Victorians – and so are *John Tenniel’s*³²⁶ drawings in the original Alice books. Certain details are omitted and some features are exaggerated to draw attention to that element.”

“Right on, Jane. Lead on.”

“I love art and illustration, Bruce – it’s an essential part of theatre. I’ve been interested in the history of illustrations ever since undergraduate days. In some ways, theatre is just a series of artistic poses – and vice versa. These days we do *storyboards*³²⁷ of the major scenes and poses of plays before we produce them. Many famous paintings are someone or something ‘striking a pose’. As such, storyboards are a fairly recent invention – usually attributed to Walt Disney in the late ’twenties.”

“I guess that what I’m trying to do at the moment – develop a bit of a *Mickey Mouse*³²⁸ storyboard on *explanation*.”

“Yes – let’s try to keep to the point, Bruce – I’m all ears – for you.”

“The challenge now is how we move across the board to the next stage – the *third stage* – if pictures are unnecessarily complicated, the question is: *what do we take out and what do we leave in?*”

“We leave in the *essential* features, Bruce.”

“Ohh! – that *e-word* again! And what is *essential* and what isn’t, Jane?”

“Nicely trapped, Bruce – a White Rabbit trap, I assume. I guess it depends upon what we want to give prominence – what is important to us.”

“How do we know what is important and what is irrelevant?”

“*Experience*, I guess?”

“Spoken like a true empiricist. An hypothesis followed by some observations.”

“I can use the *Force*³²⁹, now, Bruce. The *Dark Side*³³⁰ is calling.”

“So your intuition and sub-conscious experiences shape your senses so that you respond almost automatically to certain visual cues. What is your *first* cue, Jane?”

“Well – the first thing *I* notice is *colour*. And it seems like that’s the *last* thing that *you* notice. I bet if you closed your eyes you couldn’t tell me the colour of my shirt.”

“Maybe not, but I could tell you that you look *great in it*³³¹. But there’s a difference between what I notice first and what I *then* pay attention to – I think that most people notice colour first – our eyes – both males’ and females’ – are geared to see colour first. That’s what the *cones in our eyes are for*³³². That’s something that has been known for a long time – even if it wasn’t stated in such scientific terms. Remember Socrates and *Meno*³³³?”

“Tell me – again.”

“Socrates said: ‘*Figure* is the only thing which always follows colour’. He was using the relationship of colour to shape, or *figure*, as an example, while trying to get Meno to understand the basic nature of virtue.”

“That sounds a bit left-field?”

“Maybe, but Socrates labours the point in *Meno* and expounds it at length in his dialog with *Timaeus*³³⁴ to the extent that he seemed to have spent some time looking at the nature of perception. Of course, in those days they thought that vision came *out* of the eye, rather than *light going in*³³⁵, but that was a mere detail.”

“This all seems very esoteric – the point being?”

“Well – there are many points to light – *maybe a thousand*³³⁶ – but I’ll stop beating around the bush – essentially, when it comes to making visual images that we can understand – *visual perception*³³⁷ – we’ve only got three things that we can vary – *lightness, saturation and hue*. Things can range from light to dark, intense to dull or vary in colour. But after the first flash of colour, we settle down to look at details of *shape and size*. Ultimately – do you recognize Mickey Mouse from the colour of his pants or the shape of his ears? How can we tell that it’s Mickey – or is it a sabre-tooth tiger? We’ve got twenty times more vision receptors – *rods* – that only see black and white – than colour receptors – *cones*. So we have got a great built-in capacity to discriminate shapes.”

...so fill me in on cartoons and explanation, Bruce.”

“In this *third stage*, all – or most – ‘irrelevant’ detail is omitted from the picture. ‘Irrelevant’, of course, is a value judgment.”

“Hold it there, Bruce! Did I hear you mention ‘values’ in the context of scientific objectivity? You can’t sneak *that* past me!”

“All data is value-laden³³⁸ – or is subjective to some extent, in that, when we reduce everything that we perceive to a manageable data-set, then we leave things out. What we leave out is a matter of judgment – we might think that it is irrelevant or spurious and it might turn out that what we have omitted is very important. For example, Medieval and Renaissance astronomers³³⁹ rejected a lot of their measured observations because they implied orbits that weren’t circular. That *circularity* was laden with the values of Platonic and Christian perfection. It took Tycho Brahe³⁴⁰ to make measurements so consistent that their accuracy could not be denied – so Kepler³⁴¹ propounded that the orbits were, in fact, ellipses³⁴².”

“Talk about elliptical³⁴³! But back on *Planet Cartoon*, I must say, that when I think of that grand historic sweep of art, that many great artists – such as Da Vinci³⁴⁴, Michelangelo³⁴⁵, and Blake³⁴⁶ – just to mention a few – used a kind of cartoon-outlining extensively in their paintings. Many others -Titian³⁴⁷, Velasquez³⁴⁸, Joshua Reynolds³⁴⁹ and the ‘grand manner’³⁵⁰ portraitists used dark backgrounds or deep shadows, rather than outlines, to emphasise the features that they thought were important. Come to think of it – Reynolds was never content with a map of the face and a literal description of externals, but sought to fix on his canvas the permanent essentials of character in a large and dignified way. His effects of light and shade are always broad and simple, and he avoids a multiplicity of small lights that lead to pettiness of effect and distract attention from the being of the sitter³⁵¹. He was really more *Renaissance* than the Renaissance and he set the style for overblown nineteenth century romantic art.”

*To me, fair friend, you never can be old,
For as you were when first your eye I ey'd,
Such seems your beauty still. Three winters cold,
Have from the forests shook three summers' pride,
Three beauteous springs to yellow autumn turned,
In process of the seasons have I seen,
Three April perfumes in three hot Junes burned,
Since first I saw you fresh, which yet are green.
Ah! yet doth beauty like a dial-hand,
Steal from his figure, and no pace perceived;
So your sweet hue, which methinks still doth stand,
Hath motion, and mine eye may be deceived:
For fear of which, hear this thou age unbred:
Ere you were born was beauty's summer dead³⁵²*

“See – you knew it all already, Jane – I only had to remind you to remember.”

“Same world – just a different point of view, Bruce.”

“So there’s not really that much difference – in principle – between Tenniel’s *Mad-Hatter’s Tea Party*³⁵³ and Da Vinci’s *Last Supper*³⁵⁴.”

“Depends on how much you want to compromise your principles, Bruce.”

“We always compromise – or apply filters to the world when we look at it. In *systems theory*³⁵⁵ we call it *weltanschauung* – or *world view*³⁵⁶. You can look at the same situation in many different ways...”

“That’s a very post-modern admission, Bruce!”

“... Just that in science we try to declare our *biases*³⁵⁷ when we apply them, or ‘fess-up when someone else identifies them, Jane. Remember, I said that science is *reliable knowledge*³⁵⁸, not a *God’s-eye statement* of eternal truths³⁵⁹. It’s different in degree, but not in kind, from personal belief – it’s less strongly held and it’s *shared by many*. Safety in numbers. Just like ants.”

“Okay – I thought that I had you there. So *what* – when it comes to explanation – gets edited out of the picture?”

“Enough detail is left to determine that it *is*, say, an apple, a tree and the ground. Remember, at this *Third Stage* of explanation we are not *so* abstract as to lose all sight of things that look real. A bit of a precautionary measure – I guess. The leaves on the tree are not – we guess – a necessary detail, so they are omitted, so are the blemishes on the apple and the stones and grass on the ground. Cartoon movement is often distorted, and has jet-like trails or other repetitive marks behind objects of interest. Again, this is a leap in abstraction, as reality does not look like a series of cartoons. At least it doesn’t to me.”

“I’m not sure if the kids think that, although they seem to have a very different reaction to cartoons than to more *realistic-looking TV*³⁶⁰. It’s hard to make a comparison, but they seem more interested in repeat viewings of Walt Disney’s ‘fifties -version than *Tim Burton’s version of Alice*³⁶¹.”

“That’s a big subject that we might look at later, Jane. But it’s interesting to compare Burton’s and Disney’s *Alice’s* from the point of view of imagery – Disney took a fairly classical cartoon approach to his version, with mainly solid colours with very little shading or textures – so it simplified – or *abstracted* reality. On the other hand, Burton’s version is a kind of *surrealistic*³⁶² *post-apocalyptic*³⁶³ *hyperreality*³⁶⁴, with *computer generated imagery*³⁶⁵ often providing even *more* detail than one would notice if it were an ordinary film.”

“Umm... that *echoes*³⁶⁶ my *semiotics*³⁶⁷ exactly, Bruce. So where would you put Burton’s *Alice* in your scheme?”

“Maybe back at *Stage Two* – or even off in another dimension in our Wonderland/Looking Glass chess game. Suffice to say that I loved watching cartoons when I had the chance when I was a kid and it didn’t seem to harm *me*.”

“Hmmm... I agree that we should look at this issue later, Bruce. Meanwhile, back at the apple tree...”

“The point of this *Third Stage of explanation* – or the *second level of abstraction* – is to demonstrate that it could have been *any* apple on *any* tree or any day in *any* country etc – that is, a greater level of *generalisation*³⁶⁸ compared with a *particular* tree, apple, orchard and so on. Not only is nature frozen, as in the *Polaroid/photo – or Second Stage*, but it is also *simplified*. This level of abstraction suggests that *experiments* can be set up, as the *basic* phenomenon does not depend on the particular situation or location as observed.”

“So how might a *Stage Three* explanation look like in words?”

“A typical explanation at this stage might be ‘anything that looks like an apple – or maybe any fruit – will fall to a lower level, with ever increasing speed when it is released on Earth’. It is easy to see that having grasped this general concept, the teacher/ parent or any other explainer can then take the student back along the chess-board to the *polaroid/photo* stage to show that actual apples behave like this, and then show the student an apple on an apple tree, at the *Zen* stage, to convince the student.”

“Ahh! Now that we have three stages, I can start to see a *trend*³⁶⁹. We’ll keep removing features until all we have left is the essence of pure abstraction – just like the *Cheshire Cat’s*³⁷⁰ smile. So – which way do we go from here, Bruce?”

“That depends a good deal on where you want to get to. In that direction is *concrete reality* and in that direction is *pure abstraction*. Visit either you like – they’re both figments of our imagination.”

“Did you say *figments or pigments*³⁷¹? Never mind – I don’t want to *just* imagine things – I want to get an understanding of the real world and climate change.”

“I can’t help that Jane. I’m part of your imagination and you’re part of mine. We’re *all imagination*³⁷².”

“Speak for yourself, Bruce. How do you know I’m imagining things.”

“‘You must be,’ said the cat, ‘*or you wouldn’t have come here*.³⁷³”

“‘*For then my thoughts--from far where I abide--
Intend a zealous pilgrimage to thee,
And keep my drooping eyelids open wide,
Looking on darkness which the blind do see:
Save that my soul's imaginary sight
Presents thy shadow to my sightless view
Which, like a jewel hung in ghastly night,
Makes black night beautiful, and her old face new.*³⁷⁴”

“Would you like another cup of tea, Jane?”

Scene Eleven: *Still playing around with the context?*

“Well, Bruce, so far you’ve taken me down a rabbit hole and onto a chess board. This is all very fascinating, but I was wondering whether we are *actually* going anywhere with these discussions. I thought that our journey towards understanding climate change might go a bit faster than this, but we seem to be standing still and I’m a bit breathless and giddy from all this empiricism and abstraction stuff. I feel a bit like your dazed turkey and you are the mirror. Are we nearly there?”

“A few more days of being dazed, yet, I think. I’m sorry, Jane – I could speed things up, but I feel that it’s a journey where going *faster* won’t get us there *sooner*. And I really feel that we’re co-evolving on this journey...”

“...Wow! Do you know what you just said, Bruce?”

“What – the co-evolution issue? It made you see red the last time we discussed it.”

“No, no, darling! I’m up to speed now on co-evolution. You said *I feel that* – twice, in fact – you would usually say *I think*. Come to think of it...”

“...And you know what you just said?”

“Okay! Okay! It seems that we’re starting to *mirror each other’s point of view*³⁷⁵. That’s *empathy*³⁷⁶ for you!”

“I guess that empathy is a kind of *tacit* understanding – and that’s pretty important in the overall scheme of knowledge. But what I’m aiming for at the moment is an *explicit* kind of understanding – one that we can lay out like a road map in this world of uninformed opinions, wild emotions and unjustified attitudes.”

“It sounds like a road map *into* the wonderland of abstraction – but will it get us *back* home again?”

“Not guaranteed, but it’s reasonably reliable.”

“Because it relies on *reason*?”

“Exactly – or at least to a known *level of confidence*³⁷⁷. Besides, every time we take a step across the chessboard we are supposed to check whether we can get back to the previous square. It’s an *iterative*³⁷⁸ process.”

“And are there any cases of people haven’t come back?”

“Hmmm... you’re certainly catching on to this empirical approach. That pejorative *academic*³⁷⁹ is usually applied to people who ‘haven’t come back’ – people who seem to be stuck in a particular stage of abstraction and mode of speech that may well be correct or self-consistent, but doesn’t connect with everyday ideas and speech. That ‘connection’ comes from finding their way back to *Stage One* or *Two*, or at least to a stage where the other person in the conversation *also* feels comfortable.”

“Thanks – but do you have an answer to my question? Can we *really* get back?”

“Well – I think that if one starts at *Stage One* and moves through each successive stage then there’s no problem of getting back to concrete reality. A problem can occur...”

“Oh! Oh!”

“No need to panic – yet! As I was saying – a problem *can* occur when one *starts* at a later stage...”

“How can one start at a *later* stage? That sounds odd.”

“Not really. All this stuff is just something in our imagination – *ideas*, maybe – or on a piece of paper or on a screen. For example, I can draw a cartoon any way that I like, and then try to *ascribe*³⁸⁰ real or practical things from my doodlings that I wasn’t consciously intending or thinking of when I drew them. Later, we’ll talk about mathematics, where there is plenty of scope to become detached from reality – in fact, the challenge becomes to ascribe an everyday meaning to the maths that we have invented.”

“Sounds scary, Bruce”

“It also has benefits, so we have to look at the *risks in that light*³⁸¹. But – Jane – what’s so scary about this stuff? What’s really troubling you?”

“As I’ve said – or at least implied a number of times, Bruce – this so-called *empirical process*, in which you scientists revel, threatens to suck the life and humanity out of our mental experiences.”

“I know that you’ve said that, Jane, but I don’t agree with you on that. I am a scientist, like most scientists that I know, and *you* think that I’m okay. Hasn’t a scientist got eyes? Hasn’t a scientist got hands, organs, dimensions, senses, affections and passions? Aren’t we fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer, as a person of the arts? If you prick us, don’t we bleed? If you tickle us, don’t we laugh? If you poison us, *don’t we die?*³⁸²”

“That line of defence has been used before, Bruce. I’m talking about the *behavior*³⁸³, not the person.”

“*We are what we repeatedly do*³⁸⁴, Jane.”

“Well, I think – feel – believe – that we are *more* than that, Bruce. Much more.

*What's in the brain that ink may character
Which hath not figured to thee my true spirit?*³⁸⁵”

“Yes, Jane, I agree – this mind-brain-spirit thing is a bit of a [conundrum](#)³⁸⁶. But I believe that we’re in danger of slipping off the chess-board of explanation at the moment.”

“Oh – and you *believe* as well as *feel*?”

“Only in the *loose* sense of the word, Jane. My concern is that *you* feel uncomfortable with this notion of scientific abstraction. I’m no expert in the arts, but I know that the notion of abstraction is used frequently in literature and painting. I’d like us to explore that for a while before we move on – *if* we move on. To start with, tell me how the notion of abstraction plays out in painting.”

“You’re right, in that abstraction has been a central issue in the arts for quite a while – maybe a century-and-a-half. As I said before, the [Romantics](#)³⁸⁷ of the early nineteenth century were, visually, obsessed with [literal](#)³⁸⁸ depictions of people and scenery. They were only exceeded in their realism by the so-called [Pre-Raphaelites](#)³⁸⁹ like [Rossetti](#)³⁹⁰ and [Millais](#)³⁹¹ and [neo-Romantics](#)³⁹² like [Aivazovsky](#)³⁹³ who wanted to return to the abundant detail, intense colours, and complex compositions of [fifteenth century Italian and Flemish art](#)³⁹⁴. ”

“From what I’ve seen, those Pre-Raphaelite and neo-Romantic guys were the fifty-megapixel [Hasselblad cameras](#)³⁹⁵ of the nineteenth century. Their paintings were more real than *real* – they certainly would have been useful for depicting my *Stage Two*.”

“Indeed, Bruce, if I follow your metaphor correctly. I think that they were trying to out-do the photographers of that time, who had the advantage of light and shade, but not colour, as Socrates would have said.”

“Hmm... I didn’t appreciate that – it’s a good example of what we call the [sailing ship effect](#)³⁹⁶. ”

“Blow me away, Bruce! What have sailing ships got to do with art?”

“Well, it’s a phenomenon that happens more often than we might imagine. In the area of [innovation](#)³⁹⁷, quite often the old technology continues to be improved and reaches its highest stage of technical development *after* the new, competitive technology has been introduced. One prime example was the improvements in the performance of sailing ships after the introduction of [steam-ships](#)³⁹⁸ in the mid-nineteenth century – interestingly, around the same time as your Pre-Raphaelites were outdoing each other with microscopic detail in their paintings. Another example is the [electronic vacuum tube](#)³⁹⁹ – the smallest and most reliable ones ever produced were developed after the introduction of the transistor. More recently, the performance of the old telephone copper wires for internet digital data transmission has improved well beyond what was considered possible in the face of competition from [optical fibre](#)⁴⁰⁰. ”

“Gee – thanks, Bruce – I didn’t know that. But I think that we got distracted from abstraction.”

“Sorry, Jane – please carry on.”

“Well – like your sailing ship *versus* steamship stoush, there seemed to have been a reaction to this intensification of realism, with two separate streams emerging – the *Impressionists* and the *Expressionists*. To use your analogy again, they were the steamships that finally surpassed the sailing ships of Romantic Realism.”

“I don’t want to stop you in full-sail, Jane, but I find that the use of *-isms* and *-ists* to describe these art forms isn’t too far from my use of ‘stages’ to describe scientific explanation stages.”

“Point taken, Bruce. To continue – the *Impressionist*⁴⁰¹ painters, most notably *Manet*⁴⁰², *Monet*⁴⁰³, *Renoir*⁴⁰⁴, *Pissaro*⁴⁰⁵ and *Cezanne*⁴⁰⁶ used relatively small, thin – yet visible – brush strokes, as well as open composition and an emphasis on accurate depiction of light in its changing qualities on common, ordinary subject matter. It now seems commonplace, but other innovations were the inclusion of *movement* as a crucial element of human perception and experience, and unusual visual angles.”

“I didn’t know that, Jane. It certainly parallels the development of scientific thought – albeit several centuries later. So they moved away from *literal* reality – to *what?* To *where?* Is *un-real*⁴⁰⁷ in art the same as *abstract*^{408?}”

“You certainly have sucked me through the looking-glass, Bruce. From my *dim*⁴⁰⁹ recollections, abstract art is *unconcerned* with the *literal* depiction of things from the visible world. That lack of concern may be because the artist is brave and wants to show a *deeper* interpretation of the visible world, or maybe he or she is just a bit – or even quite – *mad* and their images are spontaneous expressions that haven’t any obvious connections to literal things. In either case, their art strikes a resonance in the viewer, who is left to make their own judgments and interpretations of the art and the artist. So the lack of reality might be *non-reality* – which is deliberate or sane, or *unreality*, which is spontaneous and perhaps non-sane, insane or just mad.”

“Wow! That wasn’t a dim view through the looking-glass, Jane. It certainly opens up more dimensions to abstraction than what science usually deals with. When you say that ‘their art strikes a resonance with the viewer’ – that seems like code for appealing to the emotions. In science, we only deal with abstraction in a kind of *progressive way*⁴¹⁰ where the steps can be linked by logic – call it *reasoning* if you like.”

“That resonance, Bruce, is a feeling of a shared truth with the artist.

*Past cure I am, now Reason is past care,
And frantic-mad with evermore unrest;
My thoughts and my discourse as madmen's are,
At random from the truth vainly expressed.*⁴¹¹”

“Jane – I’m beginning to appreciate that the ‘public knowledge’ *that is science isn’t the only kind of truth* – just that it’s more widely accessible and repeatable and therefore more *consensual*⁴¹².”

“That’s the nicest thing that I’ve heard for quite a while, Bruce.”

“I’m sorry that science doesn’t seem nice to you, Jane – but you *did* ask.”

“Indeed – and I’m prepared to put up with this slavish devotion to reason to get to the [heart of the matter](#)⁴¹³.”

“So the Impressionists took off in one direction of abstraction – what about the [Expressionists](#)⁴¹⁴?”

“Hmm... they made a more direct appeal to the emotions – ranging from love, fear, death, melancholia and anxiety to horror – probably with an emphasis on horror. [Edvard Munch’s](#)⁴¹⁵ *The Scream*, which was painted in the early 1890s, was an inspiration for many expressionist artists who followed, including [van Gogh](#)⁴¹⁶ and [Modigliani](#)⁴¹⁷, to name a couple.”

“Ohh! *The Scream*! Even *I* know *that* painting – scary stuff! Horror – without a lot of detail, monsters or blood!”

“Exactly – *Impressionism* is usually described as a reduction of visual detail while maintaining a complex purpose. So there was a move away from realistic *visual* artistic depictions to – depictions that weren’t visually literally realistic, but used images to evoke impressions and attitudes. Typically, *abstraction* is used in the arts to refer to art unconcerned with the literal depiction of things from the visible world. It can, however, refer to an object or image that has been *distilled* from the real world, or indeed, even another work of art. Abstract art *reshapes* the literal, natural world for expressive purposes. In the 20th century, the trend toward abstraction coincided with advances in science, technology and changes in urban life, eventually reflecting an interest in [psychoanalytic theory](#)⁴¹⁸.”

“Well, Jane, given your deep understanding of abstraction in art, I don’t know why you find *scientific* abstraction so scary. Artistic abstraction seems every bit as complex as science and you seem to have a pretty good grip on it – *and* enjoy it. Just think of science as having *another* dimension to abstraction. Our expressions in pictures, words or equations are meant to be distilled statements of the truth, that can ultimately be linked to pretty-well anyone’s everyday sensual experiences.”

“I guess you’re right, Bruce. Artists create works that they claim have meaning that isn’t immediately accessible to many intelligent non-artists, so I suppose I’m an intelligent non-scientist.”

“Exactly – or at least within the bounds of measurement-error.”

“You can be so sweet, Bruce. But I think that there’s more to it than that. I think that it goes back to bad experiences with science at school – particularly with women of my age and older. Because we didn’t ‘get it’ immediately in our school science lessons, it was assumed that it simply wasn’t in the *nature* of most girls to understand science. So we turned off and lived-down to the teacher’s expectations. We found other ways of expressing ourselves – and science then looked like a [very blokey cabal](#)⁴¹⁹.”

“It’s pretty hard to deny that, Jane. And it’s hard to appreciate other points of view when you’re surrounded by [confirmation](#)⁴²⁰ of your own. Please go on.”

“I’m glad that you appreciate my position, Bruce. Well – over the years, every time we were faced with science it just evoked the whole miserable childhood experience, so we avoided the confrontation as much as possible. So – years go by and it just becomes another minor trauma that has become the root of a habit of [avoidance](#)⁴²¹. So to me – and many others – including a lot of men – embracing science is essentially facing an unconscious fear – overcoming that fear is more likely to require [psychotherapy](#)⁴²² than just good, clear explanations.”

“Golly! I don’t know whether I’m up to playing the role of [Sigmund Freud](#)⁴²³. I just try to tell it how I see it and try to avoid the emotional stuff. That’s just me, I guess. Is it worth continuing – in my home-baked, non-psychoanalytic way?”

“Of course, Bruce. Please carry on. I think that I’m starting to get the hang of it. It’s just reality disappearing in steps and stages – but with a trail back to base – we’re a bit like [Hansel and Gretel](#)⁴²⁴ in the scary forest.”

“That’s a rather grim description, Jane – but we scientists try to leave a trail of the white-stones-of-empiricism rather than the breadcrumbs-of-personal-opinion.”

“Maybe Ockham is the woodcutter who saves us?”

“Perhaps the moral of the tale is not to be tempted by that candy-house of [subjectivism](#)⁴²⁵. I think that by now we are both getting a feeling for the nuances and dimensions of abstraction. Would you be happy with the idea that [abstraction](#)⁴²⁶ *is the process of reducing the information content of a concept, idea or an observable phenomenon – typically to retain only information which is relevant for a particular purpose?*”

“That seems to be the *essence* of it, Bruce.”

“Then shall we continue along the chess-board of abstraction?”

“Please do!”

“Well – we’ve now reached square – or Stage – *number Four*, that I have called the *Public* level, although I would welcome a better name. This level seems to be the highest level of general public explanation – beyond this level the enquirer usually becomes a student of the subject – accepting symbols and language that are generally not encountered in everyday life.”

“Here there be beasties!”

“Not quite, Jane. *Stage Four* is characterised by a *complete* loss of irrelevant detail, although broad similarities to reality remain. In our example, the falling apple becomes a circle – suggesting that as it is *extensive* it must have mass. The earth is represented by a simple line, and motion by an arrow indicating direction. The language used is generalised to words such as ‘mass’ and ‘velocity’, as these words

have scientific definitions – although they are also used more loosely in everyday conversation.”

“I’m still with you, Bruce. Proceed!”

“This is the highest level of abstraction that still has some physical similarity to the original physical picture of *Stage Two*, and it is not too difficult to convince most people that *Stage Four* is a reasonable representation of reality – that is, no elaborate code is required to interpret what is going on.”

“So what would be the words to go with the pictures?”

“Hmm.. an explanation at this level might be: ‘When a small mass is unconstrained at some distance from a larger mass, it will move toward the larger mass with a constant acceleration, and therefore an increasing velocity’. As well, numbers might also be used – and even simple calculations.”

“So what have we *gained* by losing the apple-like appearance of the apple and the earth-like appearance of the earth?”

“Nice question. Well – that circle could represent any mass – apple, orange, stone, or even Galileo’s mythical cannonballs dropped from the [Leaning Tower of Pisa](#)⁴²⁷ – anything, so long as it has a mass. Similarly, the earth could be any other mass that is very large compared with the apple-like mass.”

“Why the largeness proviso, Bruce?”

“We’ll come to that later – at *Stage Seven*.”

“I’m trembling with anticipation. I think that I’ve got a handle on *Stage Four* now. So there’s a sign in front of Stage Five saying ‘the public should enter at own risk – here there be beastsies!’”

“It seems so. In explaining any physical phenomenon, one does move beyond *Stage Four* at one’s own peril, as this seems to be the point where many attempts at explanations break down, probably because the abstract codes used are not those used in everyday life. So most people are unfamiliar with the game as it is played beyond *Stage Four*. It’s a pity, because we *all* have met these concepts at school, but they seem to be rejected or totally avoided in everyday conversation.”

“Most certainly in my conversations, Bruce. The so-called ‘experts’ might be as much to blame as the punters, Bruce. There’s nothing like having your own [language to separate you from the masses](#)⁴²⁸.”

“Do we really do that, Jane?”

“I’m sure that it’s not conscious and deliberate, Bruce – but I guess that it has the same effect as if it were. Don’t worry, we all do it – even kids. Which reminds me....

*Those children nursed, delivered from thy brain,
To take a new acquaintance of thy mind.
These offices, so oft as thou wilt look,
Shall profit thee and much enrich thy book.*⁴²⁹”

Scene Twelve: *A clash of symbols*

“Jane – I’d like to explore your real forte of language and how it this idea of abstraction plays out in *that* sphere. But before we do that, I’d like to know a bit more about art and abstraction. It seemed as though *that* journey wasn’t quite completed.”

“It’s a never-ending journey, Bruce – but I know what you mean. We left off our last little chat with the *Impressionists*⁴³⁰ and *Expressionists*⁴³¹ in full flight. They had slain the dragons of *Romanticism*⁴³² and *Realism*⁴³³, but you could still actually see *screaming faces*⁴³⁴, *haystacks*⁴³⁵ and *water lilies*⁴³⁶ in their paintings if you looked hard enough. By the turn of the century the prevailing style continued using vivid colours, thick application of paint, distinctive brush strokes, and real-life subject matter, but they were more inclined to emphasize geometric forms, to distort form for expressive effect, and to use unnatural or arbitrary colour. Various names have been given to this era, but *Post-Impressionism*⁴³⁷ is the one most often used.”

“It always seems a bit of a cop-out when a cultural period is named as ‘post-’ the previous period – like *Post-Modernism*⁴³⁸ Not that there is a shortage of words to use.”

“Agreed, Bruce. The other names were probably too localized to be acceptable to the art world in general, but would think that a century later we could agree on a better name. Anyway, the Post-Impressionists gave rise to *Cubism*⁴³⁹ around 1907, which, I think, is a very important transitional stage in the history of art, as it seems that art without any discernable connections to realistic images emerged at this time.”

“Verrry interesting, Jane. Transitions from one steady state of being into another are an endless source of fascination to physicists – we see them in fluid dynamics, quantum mechanics, magnetic materials – the list is endless. *Why* does the transition occur? *How* does it occur? The transition is often quite brief and turbulent and chaotic – and hard to observe in detail and explain in simple terms...”

“...talking about connections to realistic images, Bruce – do you think that you could give a simple example of your *transitions*? Can you take a few steps back along our chessboard.”

“Certainly, Jane. We can use a real *kitchen-sink* example – something that you see in the kitchen sink.”

“I won’t ask you how long ago you observed this, Bruce – but do go on.”

“Well – you know when you turn on the tap above the sink and the water pours smoothly onto the base of the sink – and then spreads out...”

“And makes that little ripple...”

“Exactly. And what happens next, Jane?”

“The water slows down, swirls around and takes the coffee grounds down the plughole.”

“Yes, that, too. So you’ve noticed that there is an area of flat, fast flow that becomes an area of slow flow that is deeper, with a boundary of turbulence between the two areas.”

“So?”

“So! That is one of the most profound phenomena in physics, Jane.”

“You’re kidding me? Okay – you’re serious. What’s so profound?”

“Well – at the level of physics, it’s called a ‘[hydraulic jump](#)’⁴⁴⁰. The water just can’t transition from fast-and-low to slow-and-high without going through that turbulence where some of the [kinetic energy](#)⁴⁴¹ – the energy of movement – is turned into random movement. A property called [momentum](#)⁴⁴² remains the same, because that never changes anywhere in the universe. This really at the heart of Isaac Newton’s [laws of motion](#)⁴⁴³.”

“So science does have a heart, after all? Well, that’s fascinating, Bruce – but, from what you said before, that’s only half the story. I think that you were going to connect the big picture of science to the small picture of the kitchen sink. What’s the connection?”

“It’s about [paradigm](#)⁴⁴⁴ shifts, Jane. *You can’t go from one paradigm to another without going through a revolution.* The revolution enables you to throw off the

excess intellectual baggage of the old paradigm so that the new paradigm can be widely adopted. [Thomas Kuhn](#)⁴⁴⁵ laid it all out for us in the ‘sixties.’”

“Omelettes are not made without breaking eggs.”

“Uh?”

“That’s a lesson from *near* the kitchen sink, Bruce – lots of people have said that – [Robespierre](#)⁴⁴⁶, [Lenin](#)⁴⁴⁷, my mother...”

“I get it now. So – these transitions in science are not only at the immediately observable level – the transition from one scientific paradigm to another has exercised the minds of many scientists for the past half-century. So much for science – how does this play out with abstract art and Cubism?”

“Well – first, let’s look at Cubism. In Cubist artworks, objects are broken up, analyzed, and re-assembled in an abstracted overall form—instead of depicting objects from one viewpoint, the artist often depicts the subject from a multitude of viewpoints to represent the subject in a greater context. Often the surfaces intersect at seemingly random angles, removing a coherent sense of depth. The background and object planes interpenetrate one another to create the shallow, ambiguous space – that’s one of Cubism’s distinct characteristics.”

“Certainly sounds turbulent and chaotic to me – just like in physics. If I’ve got it right, that was one of Picasso’s early stages – people with both eyes on the same side of their nose...”

“No, Bruce – that wasn’t until much later – mainly in the 1930s in his Neo-classicist-[Surrealist](#)⁴⁴⁸ period – long after he returned to painting with more discernable forms – as gruesome as they may have looked. Picasso and [Braque](#)⁴⁴⁹ kicked off the Cubist style, which – as usual – had a bunch of followers, but, I think, more importantly, their efforts served to unhinge Western Art from millennia of representational art. Given the work of the Cubists, it wasn’t such a large step for [Wassily Kandinsky](#)⁴⁵⁰ to abandon direct representation altogether and have shapes and colours of all kinds that can’t be readily connected to particular objects, people, fruit or landscapes. What we call ‘abstract’ art has flourished ever since.”

“Are you saying that Picasso – who is seen as *the* archetypical ‘abstract’ artist wasn’t, in fact, the first *abstract* artist?”

“That’s probably right, Bruce – having set off the big bombs of the revolution, he retreated, leaving others to fight the big fights. It’s actually hard to find a painting of his that hasn’t got at least some vestiges of recognizable representations of people or things. In the artistic sense, he was never fully abstract. Kandinsky is credited with that honour.”

“Hmm... I’m still trying to come to grips with the artist’s use of the word abstract and how we use it in science.”

“It seems pretty clear to me, Bruce – you put some squiggles on a page that don’t look like an apple falling from a tree and Kandinsky puts some squiggles on a canvas that don’t look at all like a [small world](#)⁴⁵¹ – they’re both [abstract](#) in the sense that they are something that is *apart* from what we usually call the real world.”

“Yes, that part is pretty obvious, but there seems to be more – and there seems to be a departure of meaning of *abstract* between art and science. Jane – beyond the visible aspect, what do you understand by *abstraction* in art?”

“Well – something that Kandinsky said – he was a [great theorist](#)⁴⁵² as well – he was primarily concerned with evoking a spiritual resonance between the viewer and the artist. That was the purpose of the image. In my view he was trying to get away from the Cubist’s clever and confusing camouflaging of reality and get straight to the point.”

“And the *point* being?”

“I think that The [Bard](#) anticipated Kandinsky by about 300 years:

*Mine eye hath played the painter and hath steeled,
Thy beauty's form in table of my heart;
My body is the frame wherein 'tis held,
And perspective that is best painter's art.
For through the painter must you see his skill,
To find where your true image pictured lies,
Which in my bosom's shop is hanging still,
That hath his windows glazed with thine eyes.
Now see what good turns eyes for eyes have done:
Mine eyes have drawn thy shape, and thine for me
Are windows to my breast, where-through the sun
Delights to peep, to gaze therein on thee;
Yet eyes this cunning want to grace their art,
They draw but what they see, [know not the heart](#)⁴⁵³.”*

“Maybe we aren’t as far apart as I imagined, Jane. It seems that a lot of the focus on ‘abstract’ has been about the extent to which a particular image is free from obvious – or even hidden – representational qualities. Part of the attraction of these images has been what I would call the ‘[where’s Wally](#)^{454?}’ effect.”

“Uh?”

“Well, somewhere in the painting is a representational image – the challenge is to find it. I think that a lot of Cubism is like that.”

“That’s not a very sophisticated viewpoint, Bruce – you surprise me!”

“I did say *part* of the attraction. Just watch people in an art gallery – as far as I can see, most of them are playing ‘where’s Wally?’ – you know – like ‘can’t you see the something-or-other in the picture?’. That’s okay – I’m just pointing out that part of

our use of abstraction is to obscure elements of reality for some purpose – including just being playful or maybe to make the viewer look more deeply.”

“Fair enough. What else do you see in artistic abstraction?”

“It goes back to Plato....”

“Here we go again!”

“We scientists prefer to quote original sources when we can. Plato may have said a lot of things that we disagree with, or are demonstrably wrong – but his notion of *essence* lingers. *Essence, abstract* – it’s about core and enduring features that make something what it *is* – the orange-ness of an orange, the bleakness of the Yorkshire moors, the anguish of madness – or what makes an apple – or any heavier-than-air object fall to earth – its *mass*.”

“Massi-ness as an essence?”

“Yep. Just that artists seem to concentrate on extracting essences that relate to the experience of *perceptions* – like the impressionists and cubists – or *emotions* – like the expressionists. *Scientists concentrate on extracting the essence of the experience of reason*. Ockham’s Razor is more of a distillation plant than a sharp object.”

“Can’t help but agree, Bruce. I think that [Cezanne](#)⁴⁵⁵ summarized it nicely:

*‘Shut your eyes, wait, think of nothing. Now open them.... one sees nothing but a great coloured undulation. What then? An irradiation and glory of colour. That is what a picture should give us, a warm harmony, an abyss in which the eye is lost, in secret germination, a coloured state of grace... lose consciousness. Descend with the painter into the dim tangled roots of things, and rise again from them in colours, be steeped in the light of them’*⁴⁵⁶.”

“Yes – very nicely. James [Gleick](#)⁴⁵⁷ used even fewer words when he described ‘*the genius composers who succeeded Mozart, with their increasingly direct pipelines to the emotions*⁴⁵⁸.’ Those *increasingly direct pipelines* seem to be the distilled essence of the artistic-ness of art.”

“You certainly seemed to have been doing your homework, Bruce! But – and this is a bit of an [epiphany](#)⁴⁵⁹ for me, too – what about *indigenous art* – particularly Australian Aboriginal art?”

“I think that I’m not up to that chapter, yet, Jane. What’s the connection and what’s the epiphany?”

“Well, if we leave aside, for the moment, a lot of [indigenous Australian art](#)⁴⁶⁰ with obvious representations of people, animals and places, we have a range of paintings that comprise dots, lines and circles and solid-colour regions that must be considered ‘abstract’ art in that they are intended to convey meaning – they are *not* just pretty patterns. Certain symbols within the Aboriginal modern art movement retain the same meaning across regions, although the meaning of the same symbols may change

within the context of the whole painting. When viewed in monochrome, other symbols can look similar, such as the circles within circles, sometimes depicted on their own, sparsely or in clustered groups. When this symbol is used and depending on the Aboriginal tribe you belong to, it can vary in meaning from campfire, tree, hill, digging hole, waterhole or spring. Use of the symbol can be clarified further by the use of colour, such as water being depicted in blue or black.”

“I think that I can guess where you’re coming from, Jane, but I’d rather hear your epiphany in your own words.”

“Well, this kind of indigenous art comprises abstract symbols that form a coherent story or message that can accurately and consistently conveyed to someone else who has – what we would call the expertise – *the initiated* – to read and decode these symbols. This seems pretty far-fetched to a lot of people – but it has been demonstrated often enough that these pictures contain *transferable knowledge*. My mini-epiphany is that this art is, in principle, the same as those ordered symbols that comprise scientific explanation at the so-called abstract stage.”

“I think that we’re on the same wavelength here, Jane. The key issue is the use of symbols. Charles Sanders [Pierce](#)⁴⁶¹, the American philosopher whose life spanned the time of the emergence of abstract art, defined the [symbol](#)⁴⁶² as *a sign that comes to be understood through social convention*. The meanings that we attach to certain symbols, therefore, are contextualized through our cultural influences. The kind of aboriginal art that you’re referring to certainly has a commonality with science in its use of symbols, but – without intending to demean aboriginal art – I think that there are significant differences. You really believe that all those dots, dashes, circles, and wiggly lines amount to a coherent narrative, Jane?”

“Why do you doubt it, Bruce? The claim of coherence has been made many times before by people far more expert than I am.”

“Well – to start with: when I hear that a certain picture gives instructions on how to get from A to B – probably from water-hole to water-hole – across all sorts of terrain, I wonder where that much information is in such a simple picture. It would take pages to write down all of the information claimed to be in no more than fifty different elements.”

“Well Bruce, my understanding is that they are symbols, and symbols are a shorthand for lots of things. Maybe a small squiggle – as you call it – is a shorthand reference to a story that fits together with other stories represented by the other wiggly lines, dots, dashes and circles. Besides, the positioning of these symbols creates further relationships between them that might be an even more complex – or extensive – code.”

“Hmmm.... Fair enough. I hadn’t thought of it that way before, Jane.

“So how were you thinking of it?”

“Well, to the extent that I had thought about it at all, I had assumed that the symbols had a linear coherence – rather like [Egyptian hieroglyphs](#)⁴⁶³, where, for example – and

to put it in English – a bird, an eagle and a door would spell “bed”, and perhaps the overall picture might be like a map.”

“Where did you learn that, Bruce?”

“From my encyclopedia, of course. That was in *Volume 14* – ‘Puzzles and Games’.”

“Thought so – fair enough deduction, I suppose, because that’s pretty well where I started from – a simple linear symbolism. In fact, it seems that with Aboriginal art we are looking at a multi-layered, non-linear system, where most of the information is in songs and stories. The picture is more like a collection of references, but the relative positioning of the elements is important as well. Remember that this system developed over tens of thousands of years – there were thousands of songs and poems that were never written down and the visual stuff was just a code for all the oral stuff that went with them. Unfortunately, a lot of the songs and poems have been lost, so our comprehension of all of this is fragmentary at best. Add to that the problem – for us – that some of the images, poems, songs and stories are sacred, so we can’t get at them even if they are still known.”

“Thanks for that, Jane. It seems like Aboriginal art is more akin to mathematics than photography. We’ll come to maths later. I guess that surviving – no – flourishing – in a country like Australia for untold thousands of years required a pretty exact process for living. You couldn’t just pop down to the local deli if you ran out of kangaroo tails.”

“Dare I call that ‘pretty exact process’ an ‘empirically-based knowledge system’, Bruce – even a ‘science’?”

“*Touche*, Jane. I feel humbled. But...”

“But what, Bruce?”

“Well, I was thinking, that seeing that you have a good grasp on Aboriginal symbolic abstraction, then you shouldn’t have too much difficulty with my little chessboard of scientific explanation.”

“Maybe with a couple of thousand years’ more work on it, it would have greater coherence.”

“*Touche*, again. But back to my point – are you comfortable with the intellectual aspects of my attempt to explain scientific explanation?”

“I wouldn’t call it comfortable – but in this situation I would take comfort from [Nietzsche](#)⁴⁶⁴.”

“Yikes! *Nietzsche*! I didn’t know he was on the board. Wasn’t he the guy who inspired Hitler?”

“Arguably, but there’s more to him than that.”

“Lead on, Jane – I’m a pawn in your hands.”

“Nietzsche thought that nothing worthwhile came from staying in your comfort zone. He thought that the *pursuit of happiness* was a British disease, that the Americans enshrined in their *Declaration of Independence*⁴⁶⁵.

“We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.”

Wrapping my head around this stuff of yours is a challenge for me – perhaps because I’ve never really thought of it before.”

“Didn’t you say that you were actually avoiding maths and science from an early age because of the discomfort that they gave you? Where was Nietzsche then, when you needed him?”

“My excuse was that I was a scrawny, pimply adolescent convent girl, more interested in plays than Pythagoras. I lost the plot on the linear narrative of science – undoubtedly due in part to uninspiring and uninformed teachers – and found other viable ways of interpreting my world.”

“I thought that those nuns would have given you the impression that life wasn’t meant to be easy, even if you weren’t up on your Nietzsche.”

“*Mea culpa*. I was a teenager.”

“Fair enough – so was I – just that I was a teenage nerd. To each their own. So – are you ready – if not comfortable – to proceed to *Stage Five*?”

“Yep. Please – lead me into *your* particular world of symbolic abstraction.”

“Well – let’s pick up the threads – last seen, the particular apple had morphed into a circle representing *all* masses...”

“...but not the Catholic mass.”

“Very witty, Jane – indeed, not the Catholic masses – or even the Catholic Pope. The next step was very closely associated with that *bête noir* of *Pope Urban VIII*⁴⁶⁶ – *Galileo*⁴⁶⁷.”

“...do the *fandango*⁴⁶⁸, Bruce!”

“Indeed – Galileo led the Pope a *merry dance*⁴⁶⁹, as this step replaced the circles with arrows – *vectors* we call them.”

“No wonder the Pope was outraged. Galileo must have been quite insufferable – getting into that slanging match and ridiculing the Pope. Anyway, what was the point of all this.”

“It was more than just the point of the arrow – or **vector**⁴⁷⁰ – it was also its *position*, *length* and *direction*. With Galileo, the emphasis shifted from this palpable thing called ‘mass’ to the more abstract thing called **force**⁴⁷¹ and an even more abstract thing called **acceleration**⁴⁷². Are you with me, Jane?”

“Always, Bruce. To me, it sounds more like **Obe-Wan Kenobe**⁴⁷³ versus Darth Vader. And now the force is with us and the light sabre has been replaced by a vector!”

“It’s an enduring theme, Jane. It will always be with us.”

“To continue, Bruce...”

“Yes. If we imagine a force, we can imagine larger and smaller forces, depending on the masses of the bodies involved. The apple has mass, so has the Earth, the Sun and the stars.”

“So Galileo thought that the Pope had faulty logic?”

“Yes – the Pope – backed up by the **Jesuits**⁴⁷⁴ and the **Roman Inquisition**⁴⁷⁵, believed that God’s Earth was fixed and the Sun, Moon and stars revolved around us.”

“So the fault, dear Bruce, was not in the stars, but in **ourselves**⁴⁷⁶?”

“To put it brutally – yes!”

“So an apple falling from a tree could turn our view of the universe upside down – they must have thought that Galileo was nuts.”

“Nuts, apples and arguably, even **cannonballs**⁴⁷⁷. The position, length and direction of the symbol of an arrow – or vector – contain a lot of information – far more than the picture of a circle.”

“If you believed in it and knew the code to the symbols – just like Aboriginal art.”

“Quite possibly, Jane – but *belief* was the big issue with Pope Urban VIII.”

“*Belief!* Here we go again!”

“Well, Galileo knew that his system was powerful in that it could explain and predict with Ockham-like simplicity, but he had to tread a fine line, as the Pope was in charge of the official ‘belief system’. So *GG* thought that it would be prudent to put his ideas forward as a useful way of looking at things – an **hypothesis**⁴⁷⁸ – if you will, but not necessarily “the true reality”.”

“Urban was not convinced by this line?”

“Not at all. The whole theory was too much of a threat to Papal authority. Besides, Galileo’s **Dialogue**⁴⁷⁹ lampooned too many recognizable characters-at-court, so they locked him up in a villa outside Florence for the last nine years of his life.”

“Gee – that would have been hard to take.”

“I think that a month’s vacation is a bit different from nine years of house arrest.”

“I take your point – [Aung San Suu Kyi](#)⁴⁸⁰ could attest to that.”

“Interesting comparison, Jane. Both were up against [totalitarian](#)⁴⁸¹ systems that would have preferred to have simply killed them to get them out of the way, but knowing that martyrdom might have had worse outcomes for their regimes. So they held on to their beliefs despite the system.”

“We keep coming back to *belief*. You *do* have trouble with that word, Bruce.”

“I certainly struggle with it. Could we say that both Galileo and Suu Kyi were both convinced by the evidence that there was a “better way” than what prevailed. They were – and are – fighting against this notion of ‘fixed belief’ – *their* belief is like *my* belief – *life for most will be less pleasant than it could be if one hangs on to commitments to systems that fly in the face of empirical evidence.*”

“That’s the [Utilitarian](#)⁴⁸² view that Nietzsche hated so much – the pursuit of happiness and the greatest good for the greatest number. I guess that it links to that democratic *public knowledge* of Ziman’s that we talked about before.”

“There certainly are connections. I’d buy into Nietzsche’s ‘no gain without pain’, but didn’t his views inspire the twentieth century wave of totalitarians like Hitler?”

“Unfortunately, yes, Bruce, although Hitler probably [never actually read Nietzsche](#)⁴⁸³ – he just cherry-picked his ideas about super-races. Nietzsche wasn’t an anti-Semite.”

“Then reflecting on all of this and symbolic abstraction – that little bent cross symbol called the [swastika](#)⁴⁸⁴ is enough to evoke the terrors and errors of a whole mode of thinking.”

“Certainly – but not a reflection through Alice’s mirror. The Fatherland was no Wonderland. I think that I get the point about vectors now, Bruce.”

“And the size and direction, Jane. Shattering thoughts.”

Adolf Slumbers

*And as he slumbers
He dreams
Of the Sleep of Reason
And of Galileo's charge of treason:
A world comprising perfect spheres
That lasted for two thousand years
Upset by glass ground as a lens
And pointed at the stars.*

*And how glass, ground underfoot
On Kristallnacht
Tore apart
That enlightened world
As Adolf's flags unfurled.*

*The light, that now
Seen through the prism
Of global Reich
And Corporatism
Blinds all who gawk
Or talk
Of glories past.
Or try to fix
The world in marble
Stone or bricks-
As if what's carved will last.*

*Dark dreams at dawn
Before a sun
That even brighter burns
Awakens Reason
From its sleep
*Eppur se muove*⁴⁸⁵
(And yet it moves)⁴⁸⁶*

Scene Thirteen: *All in the mind*

“So Picasso never took the final step into abstraction, Jane?”

“Nope. Looking back, at his Cubist period with Braque was quite brief – about 1907-12. After that, he went into his so-called neo-classical period and broke new ground with the way that he portrayed people, but they weren't what one could call purely abstract, as they were recognizable as people. Take, for example his *Dora Maar: The Weeping Woman*⁴⁸⁷. I wouldn't see it as a flattering portrait if it were me, but it clearly captured some *essential* aspect of her.”

“You now seem fairly comfortable with the notion of *essential*, Jane. Anyhow, Picasso pulled out of the race to total abstraction. How did it progress, then?”

“Wassily Kandinsky. He started out as an impressionist in the 1890s, but around 1912, he started producing paintings that were all squares, circles and squiggles – rather like some of those images that you see on the business reports on the TV news.”

“Ahh – you mean graphs?”

“I guess that’s what you call them. I rather like it when they take a long shot across the trading room and there are lots of screams and shouts as the traders yell crazy things. It looks just like a Kandinsky painting.”

“Looks more like a medieval scene of Hell.”

“That would be [Hieronymus Bosch](#)⁴⁸⁸.”

“Yes – that’s him – some of his paintings were in my encyclopedia. Scary stuff – enough to scare any non-believer back into the fold – a kind of *hyper-reality* – quite the opposite of Kandinsky, who was hyper-abstract.”

“But if Kandinsky was abstract, what was he abstracting *from*? I can see that he was un-hinged totally from [figurative art](#)⁴⁸⁹, but what were his references – you know – if his images were symbolic, what were the symbols representing?”

“Good question, Jane – but I thought you were the resident *art-savant*.”

“Well, I know about the story of progress from *literal* representation to so-called *artistic* abstraction, but I feel that there has been something lacking in my knowledge-set. Kandinsky was referring to something, but I don’t know what. I never went any further into it than placing his style in the art-evolution time-sequence.”

“Well, when I look at his stuff, he seems to be referring to the mathematics and physics of that period.”

“I guess that that is your prism, Bruce.”

“But not my *prison*.”

“Liberate me, Bruce.”

“The early twentieth century was a very exciting time for physics – the old, [deterministic](#)⁴⁹⁰ perspective of the nineteenth century was blown away by Einstein in 1905.”

“Yeah – I’ve heard of him.”

“I’m sure.”

“Relativity! *Ee equals em-see squared*! Everybody has heard of it – but practically no-one understands it – including me.”

“Ahh! We’re back on the track of understanding?”

“Did we ever leave it, Bruce?”

“I must say that we’ve skated around the chessboard a bit. The Mad Hatter would be proud of us, although I think that the Red Queen would disapprove. To me, *understanding is the process of comparing what we want to know with what we*

already know – we started with a shared, tangible world and started peeling away the veils – we became familiar with more general images and statements about things.”

“I think that my mind is leaving my body, Bruce. Help!”

“Well, to cut to the chase, Einstein was incomprehensible to many people because they didn’t have a grip on the ideas that preceded him. The paradoxes of relativity are only comprehensible as paradoxes if you understand what was accepted as scientifically valid before he said that it was wrong, or at least limited in its validity.”

“And what was that?”

“A simple *Cartesian-geometry*⁴⁹¹ world.”

“Err?”

“I rest my case. I know that you have spent your life avoiding this stuff, Jane – but are you prepared to face it now?”

“Having come this far, I’m prepared to face *anything*, Bruce. Yes! I’ll face my fear.”

“Then let’s go back to Galileo for a moment, and see if we can get a reference point.”

“Last seen in deep contemplation in a villa outside Florence, with a cranky, bankrupt Pope trying to jam the Italian printing presses.”

“You’ve been doing your homework, Jane.”

“The historical parts aren’t hard to grasp and the *heliocentric*⁴⁹² viewpoint isn’t too difficult and the clash with authority is understandable. It’s the details of the physics that escape me.”

“OK. It was all about *frames of reference*⁴⁹³.”

“Can you boil that down a little more, Bruce?”

“Frame of reference... hmmm... well – it’s a point-of-view-thing, essentially.”

“Go on, Bruce – this sounds familiar”

“Well, unless your standing on exactly the same point as someone else and moving at the same speed, then your sense of what is happening will be different.”

“So! Galileo was a post-modernist after all! Sprung!”

“Not quite, Jane – in fact Galileo probably reinforced Modernism in a round-about way – if he didn’t actually invent it.”

“Darn!”

“Here’s a little example of what Galileo was talking about: You know what it’s like – we’re holding hands, watching the sunset...”

“Oh! Bruce...!”

“...and I see a kookaburra in the tree in front of us, perfectly silhouetting the sun and I point it out to you. But you say that it’s not a *perfect* silhouette because the kooka is to one side of the sun from where you are standing.”

“Of course, so I squeeze up close to you so that we can share the same point of view.”

“And that’s lovely.”

“But – although I’m beside you, it’s all beside the point – or beside the point of view.”

“Not really, Jane. In this not-so-hypothetical situation – you know – remember when we were on holidays last summer...?”

“It was beautiful, Bruce – particularly after three *pina coladas*⁴⁹⁴ – but keep to the point.”

“The point is that you knew that I wasn’t imagining things – even after three *pina coladas*. You knew that if you moved to where I was standing, with your head on my shoulder – then you would see the same thing as I was seeing.”

“Of course. That deduction shouldn’t get you nine years of house arrest – it should get you another *pina colada*.”

“No argument here! What you did was translate your frame of reference into mine. You could see – or at least imagine – that my viewpoint was plausible, so you first imagined what was needed to be done to verify it – that is, move sideways and presto! *Solar-Kooka!*”

“Genius, Bruce! So what?”

“Well – that act of sideways movement based on your reasoning, or intuition – translated your frame of reference into mine. And more – as the sun was setting, you stood on tiptoes to see what I had seen half-a-minute before. So it was a translation in both space and time. You and I shared a point of view because of your reasoning capabilities.”

“It wasn’t rocket science.”

“No – but rocket science is built on this idea. In fact, it was [Rene Descartes](#)⁴⁹⁵ – Galileo’s successor in the pageant of modern science – who used these ideas to work out the trajectory of cannon balls for the French military, and Isaac Newton contemplated cannon balls being shot so far that they continued to fall around the earth – that is, in orbit – the basis of rocket science.”

“Bloody typical – science being funded by the [military-industrial complex](#)⁴⁹⁶.”

“But I digress – or at least I’m running ahead of the main story. I need to backtrack a little.”

“A little space-time translation, Bruce?”

“Well done, Jane. You’re catching on fast, relativistically speaking. What I wanted to add here was that Galileo, in his *Dialogue*, in a number of simple steps, shifted the point-of-view – or frame of reference – for looking at the Solar system, away from being Earth-centred to being Sun-centred – the *Heliocentric perspective*. And even further, that the Sun was only the centre of our little solar system and not necessarily the centre of the universe.”

“So – it was all relative – Post-modernism wins! Yeah!”

“No, Jane! Not yet, anyway – if ever. With a [Galilean transformation](#)⁴⁹⁷ any point of view can be understood from any other point of view. Different – yes, but they could be harmonized with a bit of rational geometry.”

“Are we getting closer to our path of explanation, Bruce?”

“Of course! The so-called Galilean Transformation used a diagram to show how one point of view could be mapped, or transformed into another.”

“How so?”

“I must say, that it’s easier to use pictures than words at this stage, but in words, Galileo would draw the picture of the situation and then construct axes around it.”

“...and talking of axes – [chop off her head](#)⁴⁹⁸!”

“Uh?”

“I thought that you were the one using Alice as a guide.”

“Oh – the [Duchess](#)⁴⁹⁹, of course. Hmm... I wonder whether Lewis Carroll – at least as the mathematician Lutwidge Dodgson – was thinking of this when he was writing.”

“Axes! Ockham’s Razor! Cannons! Violence all around!”

“Steady, Jane. The point was that by putting a frame around the picture, he could imagine more than one frame – and the frames could be made to coincide – that is, the *transformation*. Let’s take another of Galileo’s examples: a cannon ball dropped [from the mast of a moving ship](#)⁵⁰⁰.”

“Why on earth would you climb up to the crow’s nest with a cannon ball?”

“For the same reason that you’d climb up the Tower of Pisa with one – or even two cannon balls.”

“What? Because it was there?”

“No – actually, it is quite likely that Galileo never actually did these things, although he is considered to be the founder of modern empirical science – doing real experiments to test ideas. He was, also – arguably – the founder of the scientific *thought-experiment*⁵⁰¹.”

“Test tubes in the head? That’s an interesting kind of *literary device*⁵⁰².”

“No – not quite test-tubes, Jane – more like a pencil-and-paper. Galileo seems to have been the first scientist to use this in his writings, but it’s a form of argument that has been around a long time in philosophy – Plato and Socrates’ *man-in-a-cave*⁵⁰³ scenario is an example. Einstein used it much later – a *gedankenexperiment* he called it – to imagine someone riding along and looking around at or near the *speed of light*⁵⁰⁴. You don’t need to actually do the experiment – just make sure that all of the imagined components and actions don’t contradict what is already known – like a science fiction story without the fiction. A more recent example is an explanation of infinity and randomness by setting up an infinite number of *monkeys with typewriters*⁵⁰⁵ – one of them would eventually produce Shakespeare’s Hamlet.”

“Infinite, random and *anonymous*⁵⁰⁶, I *presume*⁵⁰⁷.”

To be – or not to be
*That is thegrrdnm zsplkt*⁵⁰⁸.”

“Meanwhile... back on the ship’s deck with *our* thought experiment...”

“...it certainly sounds much safer than *actually* climbing a mast with a cannon ball.”

“Even directly under the mast, which *would* be safe if Galileo was wrong. From that point of view, the cannon ball would be dropping straight down, even though the ship is moving along with the prevailing breeze.”

“I get it, Bruce – and if you were on the shore, watching this thought experiment with one of Galileo’s freshly-minted telescopes, then the cannon ball would appear to be moving *forward and down* against the headland behind the ship.”

“Right on, Jane! So both frames of reference are equally valid – they’re just different points of view of the same thing. With some geometry, one can be transformed into the other – no fundamental post-modern differences.”

“So these geometrical frames are your axes – not the axes as suggested to Alice by the Duchess?”

“By *Kepler*⁵⁰⁹, *she’s got it*⁵¹⁰! These ‘axes’ divide the scene into *along* and *sideways* and *up-and-down* – into one, two or three dimensions. And the trick of the transformation is that you can *harmonize*⁵¹¹ different points of view.”

“How conciliatory of old Galileo.”

“Well – you know us physicists – never let a bad argument get in the way of the facts – although Galileo was not conciliatory enough. It was alright when it was just cannon balls, but the Earth, the Moon, the Sun and the stars were just too much for the Pope. Adding mathematics to observations was letting the Devil into the discourse. Once He was in, what other untested beliefs might be brought down, and Papal authority with it?”

“So that’s how we got all of those square pictures – graphs, you call them – that fill the business pages? The Devil wears Armani!”

“Probably. Certainly Galileo didn’t invent axes, but it was his *innovation* – a French theologian, [Nicole Oresme](#)⁵¹², anticipated him and Descartes by almost three hundred years.”

“So how come Brother Oresme didn’t cop it like Galileo did?”

“Interesting question, Jane. I’m no historian, but from what I can gather there were a different set of circumstances. First, he seemed to have had a pretty enlightened patron in [King Charles V](#)⁵¹³. Secondly, the Pope, [Gregory XI](#)⁵¹⁴, had a lot of other things on his mind at that time, with the possible break-up of the [Papal States](#)⁵¹⁵ and was busy shifting back to Italy from France. And thirdly, it seems that he was smart enough to declare most of his most contentious ideas as *untested hypotheses*. The late [medieval scholars](#)⁵¹⁶ rarely experienced the coercive power of the church and would have regarded themselves as free – particularly in the natural sciences – to follow reason and observation wherever they led.”

“They were more pragmatic than idealistic?”

“It’s hard to tell. Maybe Oresme was a good scientist in the modern sense – he didn’t have the data to support his hypotheses, so he left it at that – at least for the most part.”

“For the most part? Where did he slip with his science?”

“On that pretty fundamental point that got Galileo into strife. He said: ‘everyone maintains, and I think myself, that the heavens do move and not the Earth.’”

“That’s not a small part, Bruce!”

“Maybe Oresme figured that getting – and *keeping* – his written words into circulation was more important than his personal reputation. That’s the marvelous thing about the written word – it has a life of its own beyond that of the author. He did, quite rightly, make the point that he had no way determining which was moving and which was stationary. However, he ultimately came down on the side of conventional thinking, rather than the side of Ockham. His attitude probably enabled him to keep writing.”

“Maybe he thought that having one God moving everything around was simpler than everything moving around independently.”

“You may be right, Jane. It’s easier to *explain* relative movements between objects than it is to explain something that happened six hundred years ago.”

“Indeed, Bruce – particularly using your definition of ‘explanation’ of *relating something you don’t know to something you do know*. That’s historic [relativism](#)⁵¹⁷ for you. You *do* have a streak of post-modernism in you after all!”

“Well I think that we can just put the uncertainty down to a lack of data and leave it there.”

“Okay- I won’t press you on that, Bruce. Let’s stick to the point – or the line – or the collection of lines you call a graph. What can we make of Oresme and beyond?”

“It seems that Oresme made a couple of pretty profound contributions to our line of thinking..”

“You mean by *contribution* that his ideas survived and were heeded by you later heroes?”

“Amazing that it seems – yes – even more amazing that this was almost a century before [Gutenberg](#)⁵¹⁸ invented the printing press. We still have many of Oresme’s writings and there is some evidence that Galileo read him too. Not only Oresme, but his colleague [Jean Buradin](#)⁵¹⁹ and the [Oxford Calculators](#)⁵²⁰. These concepts were developed fairly and squarely under the auspices of the Church, although Buradin was never ordained, so I guess they let him play his secular mind-games, as long as they didn’t question the fundamental tenets of theology. Theology and metaphysics were seen to be separate intellectual pursuits. It seems that Oresme and Buradin were very careful to not cross the line on these matters.”

“So – what *precisely* did they contribute?”

“Many things, ranging from theology to economics and including lots of maths and physics. Curiously, it seems that the origins of their abstract notions were directly related to their theology. There was a lot of discussion about the relative magnitude of various ethical concepts, which seemed to have segued into the magnitude of abstract notions like speed and acceleration.”

“Like the number of angels that could fit on [the end of a pin](#)⁵²¹, Bruce?”

“Yes, Jane – that kind of thing seemed to be all the go with the early [Scholastics](#)⁵²². Scholasticism was not so much a philosophy or a theology as a method of learning, as it placed a strong emphasis on [dialectical reasoning](#)⁵²³ to extend knowledge by inference and resolve contradictions. The Scholastics, starting about a century-and-a-half before Oresme and Buradin, and a generation before [Thomas Aquinas](#)⁵²⁴, with the English Bishop Robert [Grosseteste](#)⁵²⁵ and his student [Roger Bacon](#)⁵²⁶, were the first to understand Aristotle’s vision of the dual path of scientific reasoning: generalizing from particular observations into a universal law, and then back again from universal laws to prediction of particulars. Aristotle got a lot of it wrong, by modern standards, but at least he set up a systematic and progressively abstract system.”

“Just like your chessboard of explanation and understanding?”

“Exactly – or at least the general process of induction-and-deduction is the same. I just divided the process into bite-sized squares. Oresme found a way of making a visual representation of these ideas that were, essentially, *graphs*. The earlier ones were like our vectors, showing the size of these ideas at different points in time or space. Later ones were simple lines – he just joined the tops of the bars or vectors, implying that there were results intermediate to the ones that are illustrated by a limited number of vectors. So he used *Stage Five* and *Stage Six* visualisations.”

“So all of this stuff was known three hundred years before Galileo and Descartes. How come the hiatus?”

“Good question, Jane. There doesn’t seem to be a simple, single answer or explanation to that.”

“So there’s a history of science, but not a science of history?”

“Not yet Jane. [Asimov’s Foundation Series](#)⁵²⁷ was science fiction. But it seems like we can identify a number of causative factors. Paradoxically, the main factor seems to have been *climate change*.”

“Climate change! Now there’s some words that I haven’t heard for a while. Do you mean that we are going to talk about climate change after all?”

“Not yet, Jane – at least not in any detail.”

“Damn! Well, carry on, anyway.”

“It seems that – at least in Europe – there was a warm period from about AD 900-1350, called the [Medieval Warm Period](#)⁵²⁸ which was followed – to about AD 1850 – by a long period called the [Little Ice Age](#).⁵²⁹ The thinking is that the warmer period enabled greater food production and an almost doubling of the European population. Art, architecture, literature and philosophy flourished in these relatively good times. [The Black Death in 1348-50](#)⁵³⁰ was devastating – almost halving the population⁵³¹. It is thought that the spread of the Black Death was assisted by the crowding of the new cities. In the chaos ensuing the Black Death, attitudes became more conservative and simplistic, as they usually do during times of strife.”

“So all this climate change stuff has happened before – and before we started burning vast amounts of fossil fuels in the industrial era? You’ve got some explaining to do, Bruce!”

“Yeah – these two events have been seized on by climate-change-doubters as proof that the present climate change is not due to fossil fuels. There’s a lot that’s been written and talked about it, but in summary, there are two main points: first – as far as we can tell from the indirect evidence – the temperature change involved in each event was less than half of the present changes. Secondly, it is quite likely that the cooling effects were confined to Europe – with possible warming in the southern hemisphere at that time. It is quite likely that some of the cyclical changes in the sun’s

energy output were amplified by the Gulf Stream. But it was a much smaller effect than we are [seeing now](#)⁵³².”

“Well, while we’re having this mini-excursion into the main topic, what caused these changes and how big were they anyway?”

“The average changes seemed to be less than half of one degree...”

“That’s not much, surely!”

“I agree, Jane. That’s a problem that we have with this whole debate – the *average* changes seem to be tiny compared with the normal daily and seasonal changes and variations between one place and another. But we have plenty of evidence that *small changes* in average temperatures can cause *marked changes* in the behavior of living things over a few years – including [changing the growing season of crops](#)⁵³³ and where they might be grown.”

“So this halcyon period came to an end with a double-whammy – a plague followed by the Little Ice Age. One might wonder what the world would look like if those two events didn’t happen.”

“I don’t know whether the intellectual gymnastics of a few monks would have made much difference in the face of all the social inequality and [Malthusian](#)⁵³⁴ population pressure. It was like the “re-set” button was pushed on Europe. The population didn’t recover its pre-plague-level until the time of Galileo and Shakespeare.”

“Speaking of which – this has been a very instructive excursion into Medieval times, Bruce, but I’m starting to lose my way on our trip across the chessboard of explanation. Which square were we up to?”

“Sorry Jane. I guess that the excursion illustrates the point that our chessboard is intended to be both independent of the age of the enquirer – as Piaget had described it – and independent of history. Quite often the presentations of science have these three approaches combined.”

“And what’s wrong with that, Bruce? Surely it makes the process of learning more interesting?”

“There’s a lot of debate⁵³⁵ among education theorists about this, Jane. I’m all for teaching both the history *and* the conceptual chessboard – but history is *not* an overarching framework through which science inevitably [makes sense](#)⁵³⁶. There’s a lot of different things we *could* aim to do, but making *scientific sense* is *my* aim.”

“So that’s the *narrative arc* of modern scientific understanding, Bruce?”

“Something like that, Jane. We have, in our approach to scientific understanding, a *sequence of concepts*, with the sequence being defined as proceeding, cognitively, from the concrete to the abstract. To me, history is a bunch of more or less reliable observations, which we can put in a fairly reliable temporal order and from which we boldly infer causal connections. To me, any history, particularly the history of

scientific events and ideas, is all too muddled and convoluted and unreliable to be used as a foundation for everyday living – as interesting as it all is. Historical vignettes can't form a universal method, but instead, ought to intersperse our discourse on contemporary science methods on an occasional basis. Moreover, science, in those days, did not present a unified picture of nature but was an unstable field of different, often locally successful but just as often incompatible, programmes.”

“I guess that is what we've been doing here, Bruce. It's a rather different world from the theatre. Meanwhile... what did our friends from bygone times show us about *Stage Six*?”

“Okay, Jane – I need to practice what I'm preaching. Well- they showed how these abstract representations of size – or magnitude – could be used in many situations – just think of any movement being able to be divided into four dimensions...”

“Four? I don't hear of these new movies offering *4-D* – just *3-D* to make them look real – like your *Stage 1*.”

“Well – the *fourth* dimension is *time*. Those movies *are* actually 4-D – some take several hours – with bags of action.”

“Scary! I can kind of grasp how the falling cannon ball looks like it's moving in one dimension – ie – down, rather than along – a bit like when the kids drop a pencil out of the car – it just looks the same as if they dropped it off the kitchen table – it hits the ground underneath the car's window, as if we were standing still.”

“Exactly – give or take a bit of wind resistance.”

“I can imagine a pedestrian seeing it differently. But how do you treat time the same as up, along or sideways?”

“Or *x*-, *y* – and *z* – directions as we call them. We treat time – or *t* – the same. Imagine drawing a picture of where that cannon ball – or even the legendary Newtonian apple – is after a period of time. We draw a 2-D graph, one dimension of which is *time*.”

“And how do the arrows – or vectors – that we talked about before – come in?”

“It's like this: if the length of the vector represents the velocity – or speed – with it pointing towards the ground for direction, then we see that with time the vector/arrow grows longer. If we imagine a series of photos of this situation, we have arrows of increasing length. We can then line the photos up as we might edit a video film on the computer – the frames on the screen are each a picture at a different time and if we line them up we can see that the arrows are getting longer as the apple or cannon ball is getting faster as it plummets towards the ground.” (Picture here)

“So we are now surrounded by arrows like a Chinese Kung-Fu movie?”

“Not necessarily. This is where we take the next step to abstraction.”

“Move over, Kandinsky! Here we come!”

“I guess that what we get next looks a bit like a Kandinsky picture – we have some straight lines, or axes, and a curved line representing the increasing velocity or speed of the object with time. We get that smooth, curved line by joining the ends of the arrows.”

“It’s a long way from an apple falling in your lap. *Very* abstract!”

“But not as abstract as it’s going to get, Jane.”

“I guess that’s what [Jackson Pollock](#)⁵³⁷ might have said to Kandinsky. But how does that play out with Galileo?”

“Alas! At this stage we have to leave good ole’ Galileo – there was no doubt that he had made his point to the Pope.”

“That’s a good line, Bruce. What comes next?”

“Well, Galileo seemed to have been stuck with the medium of geometry and arithmetic. It was up to Descartes to take the next step....”

“The same Descartes who made cannon balls land more precisely on the nominated enemy – not just on the ground under the Leaning Tower of Pisa, or on the wooden deck of a ship?”

Yes, Jane, the very same Rene Descartes.”

We read some Descartes at uni – but there didn’t seem to be much geometry in what we were studying – it was all about mind-body duality and *cogito ergo sum*⁵³⁸ and all that. Where did the cannon ball come in?”

“I guess that while you were tangling with his *cogitos* and *ergos*, I was wrestling with his *sums* – or at least, his contributions to science and maths. He was a pretty talented lad – he wrote about a lot of things, but most importantly for us today, he set up science on its modern empirical foundations. Galileo certainly practiced it, but it was up to Descartes to write down the rules of engagement.”

“So how come he didn’t get into trouble with the Pope?”

“By practicing what he was preaching, perhaps – a bit of empiricism to go with his *rationalism*⁵³⁹ – he knew what had happened to Galileo, so he delayed publication to around 1640. But I suspect that by then the Church was fighting on too many fronts and was broke. The Enlightenment really took off after that.”

“Ok – so what did he do to advance the progress of abstraction?”

“In summary, he joined the dots and gave them a name.”

“More detail, please, Bruce.”

“At this stage, there are a number of things that get pulled together. First, He clarified the coordinate system – the up, along and sideways directions of space...”

“....And he gave them the cute names of *x*, *y* and *z*.”

“The very same ones. Each of them could be described separately from the others.”

“Like mind, body and spirit?”

“I guess so. He seems to have been consistent in separating these things from each other.”

“Sounds like [Asberger’s](#)⁵⁴⁰ to me – the guy seems to have had a [dissociated](#)⁵⁴¹ personality – compartmentalizing everything in mental silos⁵⁴².”

“Sounds a bit harsh to me, Jane. But to some extent you’re right. Descartes wanted to put aside emotions and beliefs and focus exclusively on the world of the senses.”

“[We are what we repeatedly do](#)⁵⁴³, Bruce. I rest my case about Rene.”

“Fair comment, Jane. But I think that a *habit of mind* – like reflexively using the scientific method – is not quite the same as a full-blown psychiatric disorder.”

“It is if the habit becomes a [compulsion](#)⁵⁴⁴. That’s the problem that I have with all this stuff, Bruce – it starts off with a ‘let’s pretend that sensory perceptions are objective and can be separated from emotions, which are subjective...’ and after a while science seems to lose sight of the fact that all of this is happening in the same body. It’s literally dehumanizing.”

“Maybe the pendulum has swung too far, Jane – there wasn’t much respect for reason back in those days – pioneers tend to overdo things a little. We can stop now if it’s all too much for you.”

“No way! I’ve come too far to turn back now – lead on! Apart from chopping mental and physical space into bits, what else did Descartes do?”

“As I said, he joined the dots. For example, I’m sure that you appreciate that our cannon ball goes faster the further it falls – or put another way, it goes further in each successive period of time.”

“Err.... A question here, Bruce – It’s OK for us to do this thought experiment – or even to *actually* do the experiment – but you’d need a stopwatch to measure the few seconds that it would take the cannon-ball to drop from the mast or tower. By my understanding, time-pieces that could work as stopwatches weren’t invented in Galileo’s lifetime – even in Descartes’ lifetime.”

“Good point, Jane. It was well into Newton’s era that [Samuel Watson](#)⁵⁴⁵ invented the stopwatch – around 1700.”

“So how did they make accurate measurements of time?”

“Galileo did it by slowing it down.”

“Let’s do the time-warp again⁵⁴⁶!”

“Hmmm... I think that it was flattened, rather than warped. Galileo rolled small metal balls⁵⁴⁷ down a long board that he set on a slope – the shallower the slope, the slower the ball would roll. He then made a timer using water flowing out of a bucket with a tap into a cup – equal volumes of water flowed out in equal periods of time. He showed that the speed of the ball increased by equal amounts in each period of time. Neat little experiment, eh?”

“A *real* experiment?”

“Apparently so. He was into thought experiments, but he also checked things out in reality. That was Galileo’s big contribution – *testing ideas*.”

“But a ball rolling down a slope isn’t the same as a ball falling straight down...”

“I’m inclined to agree with you, Jane. That’s part of the deal with what we call experiments⁵⁴⁸ – particularly *controlled* experiments, where messy reality is simplified. In this case Galileo set up a number of different experiments, which, together, covered most of the main issues.”

“So – Galileo had his metaphorical feet on the ground – and his head towering full of abstract ideas – but you say that it gets even more abstract than this – how so?”

“Galileo’s scientific descriptions were limited by the state of the mathematics that was available at the time. He was able to make comments like:

“The times of descent along planes of different length, slope and height bear one another a ratio which is equal to the product of the ratio of the lengths by the square of the inverse ratio of their heights⁵⁴⁹.”

“No wonder the Pope had him locked up! Such language!”

“Indeed – that was the problem – language. Galileo was able to describe his findings in two ways – one was using the geometry set down by Euclid⁵⁵⁰ almost two thousand years before – a cartoon level abstraction – and using written language – in his case, Latin. I must admit that unpacking a statement like that can be a challenge – in any language. Mathematicians had been using this ‘rhetorical’⁵⁵¹ language – as it is called – from Babylonian times.”

“So – enter Descartes, left stage?”

“Probably left and back – so he made a diagonal line to centre stage. Rather like a bishop on our chess-board – although I’m sure that he wouldn’t have liked the comparison.”

“His body was going sideways while his mind was going forward, I presume?”

“You’re catching on, Jane. Galileo had all the right ideas, but no compact way of expressing them. For example, he stated that the distance travelled by the cannonball was proportional to the square of the time....”

“Steady, Bruce.”

“Sorry, Jane. There’s no way around this, but it is not hard to grasp...”

“Give it a go!”

“Simply, if, say, the cannonball dropped one metre in the first second, then in two seconds it would drop two-squared – that’s two times two – that is, four metres...”

“...and three times three equals nine metres after three seconds...”

“That’s what we call *squaring*. Just that Galileo didn’t have a shorthand way of saying it. Actually, like most ideas, the development of fully symbolic algebra has a long history, but it was another Frenchman – François Viète⁵⁵² – who introduced symbols in a systematic way in the late 1500s – like x, y, z and t as well as little numbers near the top of those symbols to denote squaring, cubing and so on.”

“Ahh! The *symbols*! They are an abbreviation of the words and literal pictures.”

“Exactly. That’s *algebra*⁵⁵³! But Descartes went even further – *he married Galileo’s geometric descriptions to algebra*. These abbreviations were much easier to use than wordy descriptions or pictures with lines going every which-way.”

“Easier to use if you know how, Bruce. Why didn’t someone tell me this back in grade eight?”

“One of Life’s mysteries, Jane. That’s why I got interested in this whole area of explanation in the first place.”

“Never too late, I guess. But let’s see – you’ve somehow measured the speed of the cannon ball at different heights above the ground, then you draw a vector symbolising the speed at each point. You then make a graph with one axis being height above the ground and the other, the speed of the cannon ball, so you can line up all the vectors and join the tips or tails to form a line. Now where does the algebra come in, Bruce?”

“Well done, Jane. The algebra replaces all of those ‘rhetorical’ words to describe the line. And now that we have these little symbols, we can play around with them. We have a set of rules that dictate how we can play. Those rules, along with the symbols, are algebra.

*If the dull substance of my flesh were thought,
Injurious distance should not stop my way;
For then despite of space I would be brought,
From limits far remote, where thou dost stay.*

*No matter then although my foot did stand
Upon the farthest earth removed from thee;
For nimble thought can jump both sea and land
As soon as think the place where he would be.
But ah! thought kills me that I am not thought,
To leap large lengths of miles when thou art gone,
But that, so much of earth and water wrought,
I must attend time's leisure with my moan,
Receiving nought by elements so slow
But heavy tears, badges of either's woe⁵⁵⁴.*

“Something puzzles me about graphs, Bruce – you start with a bunch of spears – vectors you call them, then you draw a line from tip-to-tip, then say that a simple algebraic expression can represent that line...”

“Yep – just like that, Jane. What’s the puzzle?”

“Well – it’s a bit of a fairy story – reality isn’t like that. I bet that if you measured the time-of-fall of a ball using a watch, say, then drew it up and joined the tips, then it wouldn’t be a *smooth* line. To start with, how do you know what shape the line should be, and then, you can’t be perfectly accurate with your watch, so how do you justify drawing this line or that?”

“Very good questions, Jane – questions that go to the heart of a lot of the climate change argument.”

“Great! Do you mean that we are going to talk about climate change at last?”

“We can for a while, because we now have most of the explanatory equipment to do it – there’s a bit more to come, but as you’ve asked, we can look at some of it now.”

“So how do you justify *this* line rather than *that* line, Bruce?”

“Ultimately, we *can’t*, Jane. Our thinking on this goes back to Plato and Ockham. We draw the line through those points as some kind of *ideal* path that an *ideal* apple might follow in some *ideal* situation – one where there’s a perfect watch used perfectly and the wind doesn’t blow and the apple is very smooth and so on. Then we assume that Nature is simple and that the path of the apple wouldn’t just have little irregularities in it that we couldn’t account for.”

“That’s a heck of a lot of assumptions, Bruce.”

“Yes, but as I said, Jane, science is like those ants – a lot of them following an assumption that Nature’s laws are simple. Why? Because it works better than any other assumption, that’s all.”

“Works better at what?”

“*Explanation of the past, control of the present and prediction for the future*, I guess.”

“Is that all! And how does it do that?”

“It’s all to do with the relationship between the dots, the lines and the algebra. Simply, just using the line, we can extend it beyond the area on the graph where we have data-dots. We can extend it backwards or forwards. In the case of the legendary apple or cannon ball, we can extend it forwards to predict its speed at a certain time or distance if it fell from a greater height. If we extend it backwards, then it might suggest the state of affairs at an earlier time – say the likely average global temperature in the *eighteen-hundreds*. And if we extend that graph forwards, it might predict the global average temperature in, say, fifty years’ time.”

“But if the *past* and *present* are a scattering of dots, why shouldn’t the *future* be a similar scatter?”

“Indeed, Jane. That’s why scientists use the language of probability and statistics. In qualitative terms that might say that, for example, it is ‘highly likely’ that the global temperature will be two degrees higher in the a hundred years’ time, or they might say that there is a probability of 0.8.”

“So they might be wrong – the temperature could go down?”

“It certainly could. But that doesn’t mean that the scientists are ‘wrong’ – it just means that the ‘two-out-of-ten possibility’ happened. They’re just trying to provide a way of looking at things that is better than random or listening to people who have no justification at all for their prognostications.”

“Okay! But why do we need the algebra? I think that I could handle lines on graphs without having to go into the mysterious world of algebra.”

“What scientists are seeking are simple rules that are universal. In a way, algebra is simpler in that is compact and has only a handful of rules. I guess the problem is that along with its abstractness comes *abstruse*⁵⁵⁵-ness – as only a few people seem to understand how algebra works, they are treated with suspicion like a coven of witches.”

“So how do they come up with these ‘simple rules’, Bruce.”

“Ah! That’s where the likes of Newton and the *eighth stage* come in.”

“I can hardly wait, Bruce.”

*When in the chronicle of wasted time
I see descriptions of the fairest wights,
And beauty making beautiful old rhyme,
In praise of ladies dead and lovely knights,
Then, in the blazon of sweet beauty’s best,
Of hand, of foot, of lip, of eye, of brow,
I see their antique pen would have expressed
Even such a beauty as you master now.*

*So all their praises are but prophecies
Of this our time, all you prefiguring;
And for they looked but with divining eyes,
They had not skill enough your worth to sing:
For we, which now behold these present days,
Have eyes to wonder, but lack tongues to praise⁵⁵⁶.*

Scene Fourteen: *Slowly, slowly...*

“So Descartes completed the journey into scientific abstraction, Bruce? You say that he separated space into different directions and gave time a place as well. He then reduced Galileo’s fairly believable pictures of masts, towers and cannonballs to graphs and then further reduced these graphs to squiggles that are called ‘algebra’ – which doesn’t look in the least like anything real – more like our pre-schooler’s attempts at writing half-words – little twos and threes perched on the shoulders of x’s and y’s. You don’t get much more abstract than that – do you? To me it’s like saying that a circle in a Kandinsky painting represents the world and the chequerboard vanishing into it represents...”

“You’ve got the right idea, there, Jane. It’s all about ‘representation’. Those ‘squiggles’ as you call them *represent* things – at least to people who agree that, for the purpose of scientific discourse, they will use those squiggles as a short-hand to represent things – they are *symbols*⁵⁵⁷...”

“But the things that *they* represent aren’t *real*, Bruce. It’s like looking down the tunnel formed by two mirrors facing each other. It’s unreality stacked on unreality!”

“Perhaps that’s why Alice went *through* the looking glass, Jane – *to break through the infinite regression of illusion*. Certainly algebra can be used to represent graphs and graphs can be used to represent vectors, but the thrust of my approach to understanding is that this *chain of representation* eventually leads back to the physical reality of the child or Zen monk, or even *our* perceptions of things. People who have a good grasp of physics can look at the algebra and immediately see the physical reality that it represents without *consciously* going through the chain of symbols that we have been talking about. I guess that it looks nonsensical to you, Jane. I suspect that algebra caught you at a bad time at school and you took fright at the apparent non-sense of it.”

“You guess right, Bruce – fourteen isn’t a good time for most kids. In my case, I was pubescent. Before that, I had been happy in my make-believe world of dolls and play-acting. I could exercise my imagination and then return to my real-world where I was growing incrementally and everything seemed smooth and steady. God was in His heaven and all was right with the [world](#)⁵⁵⁸. Then my body started changing suddenly and differently. My thoughts were scattered and then my parents pulled me out of the convent because they had heard rumours of sexual misconduct somewhere. A very confusing mixture – puberty blues, ugly sex-talk and algebra! Not to mention that my class at my new school was months ahead of the convent in maths, so I missed some vital steps, I think. Something had to give – and it was algebra. I figured that I could live without those little squiggles – my new school had a good drama teacher and I soon found a place in the class play. No contest – Shakespeare 1, Descartes 0. Game over! I guess that I hid behind my theatricality a bit – drama queens aren’t expected to be maths-whizzes as well. So, by the next year, maths was an option and I opted out. No more [Mr Squiggle](#)⁵⁵⁹!”

“That’s a shame, [Miss Jane](#)⁵⁶⁰.”

“Very sharp, Bruce.”

“I always liked that TV program, Jane – Mr Squiggle could make sense out of a few lines – even upside down. In my case I guess that I took the [road less travelled](#)⁵⁶¹. My reality on a farm was pretty immediate and brutal – with sheep, roos, rabbits, frequent accidents, floods, droughts, death and destruction were everywhere – not to mention Dad giving me a pretty hard time. To preserve my sanity, I escaped into the other-world of my encyclopedias and the mysterious and fantastical world of science and maths. It was my very own world in my own head and nobody could go there without my permission – so that’s where I spent my spare time. As you said, we are what we repeatedly practice. You practiced your acting and reading plays and I practiced manipulating letters and numbers – algebra. No magic in those squiggles, Miss Jane – just practice and familiarity...Practice makes progress.”

“...Mr Squiggle – the man from the [Moon](#)⁵⁶². But I still get anxious when I see an open maths book.”

*But wherefore do not you a mightier way
Make war upon this bloody tyrant, Time?
And fortify your self in your decay
With means more blessed than my barren rhyme?
Now stand you on the top of happy hours,
And many maiden gardens, yet unset,
With virtuous wish would bear you living flowers,
Much liker than your painted counterfeit:
So should the lines of life that life repair,
Which this, Time's pencil, or my pupil pen,
Neither in inward worth nor outward fair,
Can make you live your self in eyes of men.
To give away yourself, keeps yourself still,
And you must live, drawn by [your own sweet skill](#)⁵⁶³*

“Ah! [Maths anxiety](#)⁵⁶⁴ – the curse of our times – and our times-tables!”

“You make it sound like a psychiatric disorder, Bruce. It’s just the way I *am*.”

“No – that would be [dyscalculia](#)⁵⁶⁵ – an *innate* inability to do maths – I doubt that you have that.”

“Oh – Dr Squiggle Freud! How come you’re an expert on *dys* – whatever you call it?”

“Certainly not an expert – just that I first came across this when I used to tutor a lot of school-kids. Before starting a tutorial, I would often chat with their parents, who would frequently say something like ‘Jack/ Jill is pretty hopeless at maths – *just like me – aren’t you – Jack/ Jill?*’ And they would then draw the poor kid closer in a desperate hug. What a dilemma! What was the kid to do – reject maths or their parents? I then read up a bit on the subject. You start with a pretty normal kid of average abilities and subject them to a classic [operant conditioning](#)⁵⁶⁶ situation – you know – giving a reward or punishment for some particular behavior – in this case acceptance or rejection – and presto! The kid responds by sweating every time they even think of maths.”

“But my parents didn’t do that to me...”

“But what happened at school? You said that the convent was miles behind your new school in maths, but what was the teaching style?”

“What do you mean – *style*? Nothing *stylish* about it – it was rigid discipline – it reminded me of learning the [catechism](#)⁵⁶⁷ and other religious stuff – all rote and no reason – and a harsh response for non-performance or ‘getting it wrong’.”

“[Indoctrination](#)⁵⁶⁸ is the common name for it. At least [Pavlov](#)⁵⁶⁹’s dog was given the positive reward of food – although what we call negative rewards, or punishment, can produce the desired result if non-performance can be paired with the punishment. But often the risk is that the subject ‘gives up’, as you did and then spends the rest of their life trying to avoid confronting the experience again.”

“All very morbid – it upsets me just to think of those early experiences. But let’s be positive – what did you do to overcome these reflexive attitudes in your students? I need to know!”

“Well – at the time I thought that I was just taking a sensible and decent approach to helping anxious kids. Later, when I started reading about this stuff, I found that my approach was pretty close to the methods used by [cognitive behavioral therapists](#)⁵⁷⁰ to reduce anxiety.”

“You’re a natural, Bruce! What was the recipe?”

“As I said, at the time I didn’t see it as a recipe – just my *way*. But the process is pretty straightforward – you chat for a while with the student to get them relaxed and then assess their current situation with regards to their understanding of the topic, find

a way for them to re-imagine the topic, then set out on a path for transforming their imagination into a method for understanding and solving problems. After that, its just consolidation of the new approach, generalizing it to a wider range of problems and then matching their skills to their conventional test methods.”

“Just like that? You make it sound easy and obvious. If it works so well, why don’t all teachers use it all the time?”

“I think that some try to – and succeed, but faced with a bunch of kids with varying abilities and many with dysfunctional conceptual frameworks, not to mention their personal anxieties and the demands for instant results by the community in general and parents in particular...”

“Bruce – you’ve just described me and maths and science at school – except for the parent bit – as you know, mine were hopeful, but not demanding. But there’s something missing in your recipe – how do you get an anxious kid started on a new path when they freeze up at the thought of the subject – *a la* Pavlov?”

“Sometimes it’s not easy – indeed, there were kids that I couldn’t get through to, but the trick that I used that worked most of the time was to get them talking about something that they liked – most people are enthusiastic about something...”

“I was enthusiastic about acting.... That’s a long way from maths and science. How would you have gone about tutoring me as a maths-and-science-phobic fourteen-year-old?”

“Hmm... well, maybe in a cut-down version of what we’ve been doing since we started this conversation.”

“Uh?”

“Well, haven’t we been pretty well following my ‘recipe’ – relating all these science ideas to things that you know and love – literature, theatre, art – and chess.”

“I guess so.

*But do thy worst to steal thyself away,
For term of life thou art assured mine;
And life no longer than thy love will stay,
For it depends upon that love of thine.
Then need I not to fear the worst of wrongs,
When in the least of them my life hath end.
I see a better state to me belongs
Than that which on thy humour doth depend:
Thou canst not vex me with inconstant mind,
Since that my life on thy revolt doth lie.
O what a happy title do I find,
Happy to have thy love, happy to die!
But what's so blessed-fair that fears no blot?
Thou mayst be false, and yet I know it not⁵⁷¹.*

...How do you propose to advance my understanding of algebra from here, Bruce?”

“Well, in principle, we could start from anywhere that you feel happy, but let’s use *chess*.”

“Yep, I’m happy when I’m playing chess against the computer, but what has that got to do with algebra and all those other squiggles – other than some computer nerd probably used a lot of maths to program the computer.”

“That’s [progressing](#)⁵⁷² a few steps ahead of where we are at the moment – in fact in the Land of Probability – we might visit there later if you like.”

“I think that shining light is on the other side of the my [Slough of Despond](#)⁵⁷³, Bruce. Let’s stick to chess for a moment.”

“Yes... I was thinking more about the chess-page in the newspaper more than the realistic-looking computer-based chess. From a distance, it looks like algebra – a mid-game picture, a few words and a lot of coded squiggles of [chess notation](#)⁵⁷⁴ that tell you how to get to ‘check’ in five moves. As you know, I’ve never been a keen chess player, but *you* are – I’ve always been impressed by the way that you can skim down those codes and say ‘I know a better way’ or ‘they’re wrong in line five’, and so on. It’s [aptitude](#)⁵⁷⁵, but it’s also practice.”

“I just looked at it as something that I did for enjoyment and relaxation – not a prelude to algebra. What’s the connection?”

“Well – those symbols for chess pieces and chess moves *are* a form of algebra – they don’t look like *real* chess pieces – so they’re abstract symbols. And, like algebra, there’s agreed rules for using these symbols. With familiarity and practice, you can look at the symbols and ‘understand’ the chess game that is going on in your mind. Chess is a [game](#)⁵⁷⁶ – and this kind of game has *rules and tools* that are much the same as algebra.”

“Well, I never really thought about it like that, Bruce. In fact, quite often I don’t even have a conscious picture of a chess-board in my head – the symbols take on a life of their own – I can tell if the moves are right and what the next row of symbols would look like. To me, it was more like my mother’s [knitting](#)⁵⁷⁷ books, with their symbols for stitches, than an algebra exercise.”

“Exactly, Jane. Chess, knitting, golf – as I said, you can start from anywhere and find your way to mathematics or science – if you want to look at the world that way. And that’s just the same way that a mathematician sees rows of symbols in a [mathematical ‘proof’](#)⁵⁷⁸. It’s all just symbols for rules and tools. The outcome – proving a theorem, winning in chess or knitting a sweater – is the result of deductive reasoning using those rules and tools.”

“You mentioned golf – how does golf fit in?”

“Hmm... well, it has rules and tools, but the deductive reasoning seems to fail one at critical moments.”

“Now I’ve heard every excuse! But we seemed to have strayed somewhat. We were talking about maths anxiety and operant conditioning and we finish up missing a half-metre putt. What’s the connection?”

“I think that they are different descriptions of similar behavior – the behavior of [learning](#)⁵⁷⁹. We usually think of learning in a positive way – as acquiring new, or modifying existing knowledge, behaviors, skills, values or preferences. And we think of this ‘acquiring’ as if it were a conscious decision.”

“You mean it isn’t? I made a sincere and conscious decision to try to learn algebra at high school – but it didn’t seem to work for me...”

“Yes, Jane – the *decision* was the conscious part. The part that you didn’t consciously decide was the on-going *activity* of pairing of unpleasant experiences with your effort to learn algebra. Before long, you had a textbook case of operant conditioning – as soon as you saw algebraic squiggles, it invoked all the unpleasant feelings of the classroom. So you eventually learned to avoid the situation that gave you unpleasant feelings.”

“That sounds plausible. But how does that connect to missing half-metre putts?”

“Ahh! The [yips](#)⁵⁸⁰! I don’t mean just missing a short putt because you misjudged the slope of the green, or you simply hadn’t practiced enough to get good hand-eye coordination. The yips is a sudden, unexplained, loss of previous skills – in this case the skill to make a fairly easy putt. There’s some argument as to what causes it, but the theory that fits with our present conversation is that a few coincidentally – missed putts can lead to an anxiety about failure: tension and then more failure. Soon, the situation of addressing a short putt invokes fear and tension and guaranteed failure. More than a few famous golfers have quit because they couldn’t overcome the yips.”

“Okay. You claim that maths anxiety can be overcome – how do you overcome the yips?”

“Success is never guaranteed. But the basis of the attempted ‘cure’ is the same – you’ve got to take the ‘road less travelled’.”

“You’ve been down this path before, Bruce. Where are we going this time?”

“Well, as I said, overcoming maths anxiety starts with calming the student, then creating a different path strewn with pleasant experiences and at the same time letting the well-travelled road of anxiety fade by not travelling over it and reinforcing the wheel-ruts.”

“Very poetic! And the yips?”

“There’s a range of options. One is to get a new [putter](#)⁵⁸¹.”

“Oh yeah? A bad workman always blames his tools. That just sounds like an excuse for getting a new toy to show the boys.”

“And sometimes it is, Jane. Quite often a new putter will help for a while, then the yips re-appear. It seems that is because – in many cases – *the new putter is not a sufficiently different path*. The putters that seem to work are the ones that are *radically* different – like ‘broom-handle putters’ or ‘belly putters’. But another approach is to cross the hands over, or take a ‘claw grip’.”

“So these work because the golfer feels okay and has to learn something quite new, leaving the old rutted yips-road aside?”

“Exactly, Jane.”

“Then thinking your way through it won’t work?”

“Well, as I said, sometimes you can, but often thinking about it will only reinforce it – whatever ‘it’ is – some kind of unconscious reflex to previous behavior patterns. There’s been a lot said and written recently about this question as to whether we can think our way out of our present mindset.”

“Mind-set. *Mind-set*. A mind that is *set* – a mind that is *made-up*. Funny – we hear these phrases so often and kind-of take them for granted – but when you reflect on them, they are quite horrifying. What are people *meaning* when they say these things? They’ve turned their left-brain off? They are beyond help? Good grief!”

*O! change thy thought, that I may change my mind:
Shall hate be fairer lodged than gentle love?
Be, as thy presence is, gracious and kind,
Or to thyself at least kind-hearted prove:
Make thee another self for love of me,
That beauty still may live in thine or thee.*⁵⁸²

“I think you’ve gone to the heart of it, Jane – can we ‘change our mind’?”

“Well, Bruce, why do you think that we reflexively first look for information that seems to support our present beliefs?”

“It’s often called [confirmation bias](#)⁵⁸³. But it seems to me that we are trying to understand confirmation bias as though it was a just an honest mistake in reasoning. I think that it can be better understood in terms of what we have just been discussing – *operant conditioning*.”

“Dr Squiggle Freud writes again! How so?”

“It seems that people show confirmation bias because they are weighing up the apparent personal costs of the options that are presented, rather than investigating them in a neutral, objective or scientific way. By *weighing up*, I don’t mean a conscious, cerebral evaluation – it’s unconscious – *intuitive* if you like. *They fear the possible pain of loss* – that’s *anxiety*. Their present mindset is working okay for them

– at least in the short-term – no pain. Adopting a new idea could bring pain through losing something. It’s what behavioral economist [Daniel Kahneman](#)⁵⁸⁴ calls [loss aversion](#)⁵⁸⁵ – we give a greater weighting to a loss than we do to a similar sized gain. He thinks that most of our reasoning is just rationalizing our feelings.”

“And if our feelings are based on our previous conditioning, we are not likely to change our views unless we can overcome our conditioning.”

“That’s the way I see it, Jane.”

“That’s a pretty gloomy view, Bruce. Is there any hope?”

“Gee, Jane! You’re in a better position than I am to answer that – you’re the one with the direct experience with religion. Isn’t that what religion is all about?”

“Whoa! A moment ago you were missing half-metre putts, now you’re driving your tee-shots into the deep rough! [Religion](#)⁵⁸⁶ is a whole bag of clubs, Bruce – morality, ethics, the meaning of life.... What club are you thinking of to get yourself back onto the fairway?”

“My [quintessential](#)⁵⁸⁷ five-iron, Jane – [Transcendence](#)⁵⁸⁸.”

“[Heaven](#)⁵⁸⁹s! With that shot I think that you’re even deeper in the rough, up against a tree.”

“More likely a [cross](#)⁵⁹⁰, really. Seven-iron, please! No, seriously – from my point of view religion has two purposes – one social and one personal. The social one uses a whole bunch of threats and rewards to maintain social cohesion. The personal purpose is to overcome – or transcend – [compulsively repetitive](#)⁵⁹¹ behavior.”

“You really *are* Dr Squiggle Freud!”

“Well Freud had a lot to say about the subject – but it seems to be fundamental to pretty well every religion that I’ve looked at. For example, there’s the [Samsara](#)⁵⁹² of [Hinduism](#)⁵⁹³ -the continuing cycle of birth, life, death and rebirth – with the hope of achieving [Moksha](#)⁵⁹⁴-the final extrication of the soul through good [karma](#)⁵⁹⁵. The idea of [Nirvana](#)⁵⁹⁶ in [Buddhism](#)⁵⁹⁷ is much the same, if you follow the [Noble Eightfold Path](#)⁵⁹⁸ you might transcend the suffering caused by ‘[desire](#)⁵⁹⁹’ – or stress, anxiety or dissatisfaction – whatever you might like to call it.”

“What about [Christianity](#)⁶⁰⁰, [Islam](#)⁶⁰¹ and [Judaism](#)⁶⁰²?”

“Much the same, basically, but it’s very hard to cut through the layers of authority and personification to see that *their* God is the perception of the universe by the *still mind*.”

“Oh? Like ‘[be still and know that I am God](#)⁶⁰³’”

“Exactly. And a lot of the activities like prayer were designed to be [meditation](#)⁶⁰⁴, rather than a request for an invisible bearded magician to perform some trick or

personal favour. Perhaps what distinguishes religions from each other are their different meditative practices. Some chant loudly, others keep quiet; some jump, whirl or sway, others sit still. Different strokes for different folks. All have worked, but not all the time for everybody.”

“Well – while we’re hacking around in the bushes and bunkers of your spiritual golf course, which club corresponds to [faith](#)⁶⁰⁵? Where does that *faith* fit in the bag?”

“Hmm... maybe it isn’t like a club – it’s more like what gets you to go out on the course, thinking that you’ll *not* do all or any of those things that make up the catalog of excuses as to why you didn’t do the course in par, or better. Maybe today I won’t slice, hook or gouge...”

“Or miss half-metre putts. But *thinking* – not *believing* or *hoping*?”

“Yep, it all comes back to the same-old-same-old – *faith versus reason*.”

“Well, how does it play out here, Bruce?”

“One way would be to consider [Pascal’s Wager](#)⁶⁰⁶, my sweet. It might also help to get us back on course with our quest for understanding and explanation.”

“Are you betting on a trick-shot, Bruce? You seem to be a fair way off the fairway.”

“Nope. [Blaise Pascal](#)⁶⁰⁷ was, like so many people, troubled by the ideas of belief and non-belief in God, so he devised a proposition for people who like to use logic and reason to sort things out. Bear in mind that he lived in that exciting era of the pre-[Enlightenment](#)⁶⁰⁸ – in Galileo’s and Descartes’ latter years and just before Newton got busy – it seemed that *all* ideas were up for grabs – at least outside Italy.”

“Play your shot, Bruce.”

“Well, simply, betting on God is a no-brainer – Pascal argued that it is simply unconscionable, by comparison, to bet against an eternal life of happiness for the possibility of gaining nothing. The wise decision is to wager that God exists, since ‘if you gain, you gain all; if you lose, you lose nothing’, meaning one can gain eternal life if God exists, but if not, one will be no worse off in death than if one had not believed. On the other hand, if you bet against God, win or lose, you either gain nothing or lose everything.”

“Sounds a lot better than a [Faustian Bargain](#)⁶⁰⁹.”

“You bet! The Faustian bargain is paying for a finite amount of pleasure with an infinite amount of pain. Contrary to Pascal’s bargain, where he is purchasing the infinite amount of pleasure with a finite amount of pain.”

“Sounds like [an offer too good to refuse](#)⁶¹⁰, Bruce – odds of infinity to zero! What’s the catch?”

“Hey! Who’s the skeptic now? I thought that I’d offered you the perfect deal for any wavering soul.”

“Bruce, I know you too well – you would have taken up the wager if it were that good.”

“Perhaps I did, Jane.”

“What!”

“Well, you’ve got to look a bit closer at the God that Pascal was offering. He talks about coming to God by ‘the abatement of your passions’ – that is, ‘stilling the mind’. Given his strong interest science and maths, I suspect that his notion of God was more like the mind freed of repetitive compulsions than an omniscient magician.”

“Okay! Let’s now assume that we’re back on the fairway. What’s the other connection with Pascal? We seemed to have strayed a long way from Galileo, Descartes and Newton, Bruce. I’m keen to hear the rest of their story.”

“Well, Pascal seemed to be particularly absorbed in the ideas of the infinitesimal and the infinite. They seemed to be pretty popular pastimes in the seventeenth century. The problem was, that even with the symbolic algebra that Descartes had developed, there was still no effective abstract tool for dealing with questions about the very large and the very small. Even as a mathematician, Pascal was using rhetoric to argue about the infinite.”

“What kind of questions, Bruce?”

“One of these questions had been around for thousands of years – it was called ‘[Zeno’s paradox](#)⁶¹¹’.”

“Nothing to do with the [Warrior Princess](#)⁶¹²?”

“Not really, Jane. It was also known as the ‘Achilles and the tortoise paradox’, which shows up again in [Aesop’s fables](#)⁶¹³ as the ‘[tortoise and the hare](#)⁶¹⁴’ story.”

“Oh yes! That’s in the books that I’ve been reading to the kids. But it seemed to be more of a *moral problem* than a *mathematical problem* – talented, but lazy people will always lose out to perseverance.”

“Hmm... I think that’s a bit of a con on the working class by the privileged elite – the [protestant work ethic](#)⁶¹⁵ for kids. More operant conditioning!”

“See – it wasn’t just the Catholics – the Protestants were in on it as well. But that’s enough revolutionary talk, Bruce – just how is the tortoise-and-the-hare story a paradox? I thought that the tortoise won the race fare and square.”

“Indeed, the tortoise got across the line ahead of the hare, or Achilles – depending on the story. But when you look hard at the situation, it appears that the tortoise is aided by a mathematical paradox more than Protestant perseverance – how *can* the hare

ever catch up? Every time it gets to where the tortoise was, the tortoise has moved on. He might get closer, but he never catches up, according to Zeno.”

“I know the feeling – there’s a variation called ‘the-mother-and-the-housework’.”

“That’s why it’s such an enduring problem. Everyone has their own version.”

“Okay – I can see the *apparent* paradox, Bruce, but we know from everyday experience that faster cars *do* pass slower cars, sprinters who are slow out of the blocks *sometimes* win the race, and so on. It’s just common sense.

*Ah! yet doth beauty like a dial-hand,
Steal from his figure, and no pace perceived;
So your sweet hue, which methinks still doth stand,
Hath motion, and mine eye may be deceived*⁶¹⁶.”

“Of course it’s common sense – but how do we *explain* it? You know – starting with a concrete image, going stepwise into increasingly abstract descriptions, finally showing that the maths works and then returning to base with the bunny out in front.”

“How so? Just as well it wasn’t a race between mathematicians – it would have been hare-raising.”

“Well, if it was a race between pre-Newtonian mathematicians, it would have stalled. Galileo talked about this problem, as did many philosophers. But the explanation, as such, operates on two levels – common sense and observation – the things that we see every day – and in the mathematics of *calculus*⁶¹⁷.”

“Aghh!”

“What, Jane?”

“Calculus!”

“Well?”

“Well! If you think that *algebra* was *terra incognita* for me, just think of the terror that calculus strikes in my heart.”

“Again, Jane – unfamiliarity breeds terror.”

“Some of my school drama friends were also doing applied maths – they said it was okay – just like a bunch of shake-and-bake recipes. But they said that the kids – mainly boys – who were doing calculus looked with disdain at applied maths. It seemed to be a secret world that they weren’t going to let the uninitiated into.”

“Yes – that’s a pity – I remember those days – the calculus kids were like a *cabal*⁶¹⁸ – secretly sharing the mysteries of the infinite and the infinitesimal. Actually, I just thought that it was an amazing world that you could visit in your mind, using your

own mental microscope and telescope, but could never visit in reality – you could only see the results of what happened on that world.”

“Yeah – we called that world *Nerd-land*, with its secret words and signs. It was like the [Freemasons](#)⁶¹⁹ – and just as blokey. It was more than a step or two away from *Bard-land*.

“Too bad. The problem with explaining calculus is that it is not a one-step process – like all of these explanations that we have explored, you have to be familiar with the previous steps to understand the next step. In this case, by my reckoning, we are seven steps away from reality.”

“You mean that we’re in [Seventh Heaven](#)⁶²⁰, Bruce?”

“That’s your sphere more than mine, Jane. Do you want to know about calculus?”

“At this stage I’d like to know *about* calculus, rather than *know* calculus. At this rate we’ll never get across the chessboard.”

“Well, calculus is mainly about rates.”

“No roads and rubbish? Counsel me.”

“Maybe – if you include the path not taken and the vanquishing of superstition. In the case of calculus, rates are a kind of abstraction on top of an abstraction. You’re familiar with rates at the human level – people are always saying that the climate is changing at a faster rate than ever, the kids are growing at a great rate and the rate of improvement of my golf is negative.”

“I wondered when golf would come in again – but let’s move on – at a faster rate. How did calculus come into the picture?”

“We need to step back a few squares to appreciate this next step. Historically, [Copernicus](#)⁶²¹ broke things open on the astronomical scale – claiming that the sun, not the earth, was at the centre of the universe. Amongst other things, Copernicus was a Catholic priest. His ideas were treated more as a convenient fiction for the purpose of calendar-calculations than a threat to the rigid Aristotelian cosmology of the mid-sixteenth century. Although he was steadfastly non-Catholic, Kepler was devoutly religious and also held on to a lot of Platonic and astrological mumbo-jumbo. Nonetheless he insisted that Copernicus’ theory of helio-centrism was correct. Moreover, he also insisted that the planets moved in ellipses, rather than circles. At about the same time, Galileo was promoting helio-centrism in Italy – to his personal cost – but curiously, held to the idea that the planetary orbits must be perfect circles. He pretty well ignored Kepler. Meanwhile, back on Earth, Galileo had established solid foundations for kinematics – the motion of objects. Later, Descartes perfected the algebra for describing these motions concisely.”

“Wow! A hundred years of science in less than a minute! So what was missing?”

“A few things – but mainly that they had a *description* of how things moved in the heavens and on Earth – celestial bodies moved in ellipses and Earthly bodies either moved in parabolas or straight lines. But they didn’t have a *consistent explanation* for these observations. *The supernatural kept on being invoked*. And then along came Isaac Newton.”

“But I understand that he was *also* deeply religious and a cranky nutter to boot. How on earth did he sort it out?”

“He certainly was a character. Maybe he believed that God wanted to keep things simple and therefore the universe didn’t have different rules for different places. Furthermore, he accepted the empirical evidence of the astronomers – if the planets were seen to move in ellipses, then so they did. The breakthrough was that he assumed that the force that acted between the sun and the planets was the same as the force that acted between the Earth and a cannonball or an apple and that this force diminished as the square of the distance between the objects.”

“You mean twice as far reduces it to a quarter, three times to one-ninth, and so on?”

“Exactly, Jane. He then showed mathematically that if that were the nature of the force, then the orbits would have to be ellipses. He then calculated the force that was necessary to keep the moon in orbit around the Earth and that force was what would be expected at that distance if it were the same force as between a cannonball and the Earth. Bingo! The [universal law of gravitation](#)⁶²²! His mathematics of *fluxions*⁶²³ – as he called calculus – had been used to unify the universe with one algebraic equation.”

“That was nice, Bruce. So – the belief in an omnipotent force called *God* was replaced by the belief in an omnipresent force called *gravity*? Is that what they call [scientific progress](#)⁶²⁴?”

“I think that it was a lot more than that, Jane. God may have still been in His heaven, but His self-appointed agents – the peddlers of fear and superstition in the churches and castles – had essentially lost their authority. Not only was the Earth *not* the centre of the universe, but also, the observations of *ordinary* people could contribute to a greater understanding of everything – and that understanding could be used to improve their lives. Bring on the [Age of Enlightenment](#)⁶²⁵!”

“Whoopee! Pawn takes both Bishop and King in five moves: Copernicus – Kepler – Galileo – Descartes – Newton – check!”

“So that’s it, Bruce? Having progressed, square-wise from the concrete to the abstract, all the little [rationalist](#)⁶²⁶ pawns can now scamper around the board at their own [free will](#)⁶²⁷?”

“I think that there were a few more moves than that, but the pawns certainly won. And we’re not quite there, yet, Jane.”

“And where is Love in all of this, Bruce?”

“I’m not sure, Jane, but I think that love can only exist in the absence of fear. The heart has reason that reason cannot know⁶²⁸.”

*“How can my muse want subject to invent,
While thou dost breathe, that pour'st into my verse
Thine own sweet argument, too excellent
For every vulgar paper to rehearse?
O! give thy self the thanks, if aught in me
Worthy perusal stand against thy sight;
For who's so dumb that cannot write to thee,
When thou thy self dost give invention light?
Be thou the tenth Muse, ten times more in worth
Than those old nine which rhymers invoke;
And he that calls on thee, let him bring forth
Eternal numbers to outlive long date.
If my slight muse do please these curious days,
The pain be mine, but thine shall be the praise⁶²⁹.”*

Scene Fifteen: *Fiat Lux*⁶³⁰!

“Bruce – we seem to have scuttled pawn-wise across the chessboard of explanation at a pretty fast pace. By my count, we’ve illuminated the first seven squares or stages – that means that we’ve made it across to the eighth – and last! But – surely – that seventh square of algebra seemed to be about as far as anyone could go on the path to abstraction – what could be more abstract than a jumble of numbers and squiggles? What *could* be next?”

“Yes, Jane – we’ve almost done it – although you’ve actually been part-pilgrim-pawn and part-knight – moving across our chessboard to greater generality, as well as along the path of greater abstraction...”

“More like a [knight-errant](#)⁶³¹ – on a [quest](#)⁶³² for the [Holy Grail](#)⁶³³ of *Understanding* – although I feel more like a [Guinevere](#)⁶³⁴ than a [Lancelot](#)⁶³⁵. What say you, my [Merlin](#)⁶³⁶?”

“One more step, Jane and you can have your wish – your petty pawn can be [promoted](#)⁶³⁷ – perhaps your Guinevere will become a [Red Queen](#)⁶³⁸!”

“Whoopee! I’ll be entitled to slip and slide around the board at will!”

“*Entitled?* You’ll be *able* to... like the queen that you really are.”

“Thank you, Bruce – you’re really kind – but I’m more like Alice than the Red Queen – going faster and faster – but I’m not sure that I’ve really gone anywhere yet. Why, I do believe we’ve been under this tree the whole time! [Everything’s just as it was!](#)⁶³⁹”

“Of course it is, Jane, what would you have it? What kind of tree do you think it is?”

“Oh! I [get it](#)⁶⁴⁰. But there’s something that I don’t get...”

“What’s that, Jane?”

“Well, you’ve described the plodding pawn’s perspective on explanation and understanding, but is this how your heroes really saw it?”

“What do you mean, Jane?”

“I mean, did Galileo or Newton or Descartes or Einstein or any of your [pantheon](#)⁶⁴¹ of proto-scientists *really* go stepwise through all of this – these seven steps – so that they could then take one more step? Did they *really* think like that?”

“Well – Newton summarised it as ‘seeing further by [standing on the shoulders of giants](#)⁶⁴²’. Each member of the pantheon – as you call them – couldn’t have made their particular contribution without the contributions of those who went before them.”

“Yeah, yeah! I’ve heard that before. Every celebrity and CEO and politician uses a version of it these days – like: ‘I would like to acknowledge all the little pygmies and [munchkins](#)⁶⁴³ who toiled tirelessly and anonymously to make this blockbuster movie/smash-hit song/humungous-quarterly-profit/landslide election victory – for which I alone will be rewarded and remembered.’ Well – that last part is said *sotto voce*⁶⁴⁴. Maybe they were just the glory-grabber on the top of the pygmy-pyramid or munchkin-mountain – or the [queen](#)⁶⁴⁵ on top of a [house of cards](#)⁶⁴⁶”

“...or the elephant on the back of the [turtles](#)⁶⁴⁷?”

“Yeah – that too – with [turtles all the way down](#)⁶⁴⁸.”

“What are you getting at, Jane? There’s something still worrying you?”

“Lots of things, Bruce. I’ll return to the foundation-turtle-problem later. My concern at the moment – if you’ll pardon my mixed metaphors – is turtle-thinking versus elephant-thinking.”

“You’re pardoned – I won’t [mock](#)⁶⁴⁹ your mixed metaphors. Stir away! Is this anything to do with our afore-mentioned hare-and-tortoise?”

“Maybe, Bruce. The poor old turtle/tortoise usually gets a mixed rap in the literature – apparently dull and slow, but persistent, learning from a long life of experience. Small steps, with at least three feet on the ground at all times. But he/she gets there, eventually, wherever *there* is.”

“No hare-brained theories from him! No leaping to conclusions – not even bunny-hopping hypotheses! No [Oscars](#)⁶⁵⁰ or [Nobels](#)⁶⁵¹. Noble, but not nimble. And [no leaps of faith](#)⁶⁵²!”

“Exactly, Bruce.”

“So what has the turtle taught us?”

“It’s about incremental thinking, Bruce.”

“More [thinking, fast and slow](#)⁶⁵³?”

“Quite possibly, Bruce. The way that you’ve described understanding and explanation is in terms of – what *you* consider to be – *small* steps from square to square. I think that they are *giant* steps, if they are steps at all.”

“Are we talking about what’s *in* each square, or the *step* between each square?”

“Both.”

“You mean, after all this time, you think that this model is wrong?”

“No, Bruce, not *wrong* – it all makes a kind of sense, in an [idealistic](#)⁶⁵⁴ way, but, historically, it all didn’t really unfold that way, and I wonder whether either ordinary people *or* geniuses think like this.”

“I suspect that I probably agree with you there. We need to look at this aspect in detail if we are to have any hope of coming to any agreement. How do you see it unfolding, Jane?”

“Suspect! Probably! Can’t you ever make a commitment, Bruce?”

“I tell you that I love you every day, Jane. And I love our kids. Everything else is provisional, to some degree. I said before that I am an empiricist-probablist⁶⁵⁵, if I’m any “-ist” at all.”

“I guess that I was warned. I love you, too, Bruce. But this isn’t about love, is it?”

“Well, love⁶⁵⁶ is an attachment⁶⁵⁷ that involves a commitment⁶⁵⁸, but not all commitments are what we call love. As you know, I do make commitments, issue by issue – after considering the available, relevant information. That’s what scientists do. We live or die by our assessment of probabilities.”

“You’re certainly attached to your science – looks like a weird kind of love to me. But – do you apply these same ‘-isty’ criteria to your choice of science as a way of dealing with the world? Maybe some alternative to science might turn out to be more satisfying.”

“Hmmm... an interesting example of Russell’s Paradox⁶⁵⁹, my Love.”

“Groan! A paradox! A paradox! A most intriguing paradox⁶⁶⁰! How did we get here?”

“You were asking whether I used scientific thinking to choose whether I used scientific thinking or some other kind of thinking. That’s a paradox of a particular kind – called Russell’s Paradox. If I was already using scientific thinking, I wouldn’t be choosing...”

“I kind of get it, Bruce. But paradoxes aside, how do you explain why you use your approach to dealing with the world, rather than some other approach? Not everybody thinks like a scientist – probably not even most scientists when they’re not writing their scientific papers – but they still seem to be able to survive – and even flourish.”

“Simple – it works for me.”

“What do you mean by *works*?”

“It enables me to do the things I want to do – *efficiently* – and it doesn’t fail me unexpectedly – it’s efficient partly because it’s reliable⁶⁶¹.”

“... and you’d like our kids to think this way, too?”

“I’d like them to be able to make up their own minds as to how they make up their own minds.”

“Russell’s Paradox strikes again!

*Cleopatra, know,
We will extenuate rather than enforce:
If you apply yourself to our intents,
Which towards you are most gentle, you shall find
A benefit in this change; but if you seek
To lay on me a cruelty, by taking*

*Antony's course, you shall bereave yourself
Of my good purposes, and put your children
To that destruction which I'll guard them from,
If thereon you rely. I'll take my leave*⁶⁶².

“Steady, Jane – all that I’m saying is that I don’t think that forcing kids into a particular **mindset**⁶⁶³ is the best way of preparing them for life in the twenty-first century.”

“So *your* way of thinking *isn't* a ‘particular mindset’? It seems like a **Claytons**⁶⁶⁴ mindset to me – the mindset you’re having when you’re not having a mindset. *Everyone* has a mindset!”

“Of course you’re right, Jane. We’ve all got a bunch of fixed responses to variable stimuli.”

“Uh?”

“What I’m saying is that nobody – indeed – no living thing – responds to what they perceive *ab initio*⁶⁶⁵ – just using the laws of physics and the mathematics of probability to figure out what to do. We’re the product of a billion years of evolution that has hard-wired a lot of basic reflexes into us. We can’t do much about our *biological* hard-wiring – our *animal-nature* even if we wanted to. But we *can* do something about our so-called *human-nature* – the *psychological* soft-wiring that we impose on our children – and on each other as adults for that matter.”

“Hard-wiring! Soft-wiring! You make us sound like robots! Okay – I know what you mean by hard-wiring, but *soft-wiring*?”

“Well, I could have said **operating system**⁶⁶⁶ or **firmware**⁶⁶⁷, or something like that, as a more consistent metaphor. What I am trying to say is that the way that we react to the world around us isn’t just a given. Evidence? – different people respond differently to the same situation – why? – because they derived different lessons from previous experiences that were similar to the present one. Our soft-wiring or firmware is our **operant conditioning**⁶⁶⁸.”

“But, Bruce – aren’t you saying that we are responding reflexively one way or the other – just different strokes for different folks?”

“Maybe. But I think that we can look at it this way – *mindset* is when a simple basic programming – or conditioning – covers a wide set of situations. Alternatively, rather than a *mindset*, one might have a *skill set*⁶⁶⁹ – a *wider* range of successful ways to respond to situations that are broadly similar, but not the same.”

“Hmmm... But aren’t these skills just conditioned reflexes, too?”

“Sure, but it plays out quite differently. To mix my metaphors, you can think of the ‘fixed mindset’ approach as having only one tool – say a large wrench – to try to fix a bike. There’s a few things you might be able to fix readily with it – like a loose

handle-bar or sprocket, but it's hard – but perhaps not impossible – to fix a lot of other things on the bike – like loose spokes, gears and brakes. So what do *you* do?"

"Take it to the bike shop! At least it will get fixed before the kids grow up and there will be no parts left over when it's fixed."

"Ouch! I think that you're deliberately missing the point, Jane."

"Okay. Pedal on with your metaphor, Bruce."

"There seems to be a range of possibilities – and maybe out-sourcing it to the bike shop is one of them – just shifting the responsibility of thinking to someone else – if you're prepared to pay the price. I was thinking that, metaphorically, one might deny that the bike needs fixing, or say that broken bikes simply can't be fixed, or find ingenious ways of using a large tool to do small jobs, or maybe make sure that bikes only have parts that can be fixed with a large wrench – it could be done, but the bike would be pretty clunky."

"And the alternative, in this bizarre metaphor?"

"A reasonably-sized tool-kit – a few shift-wrenches, screw drivers and two pairs of pliers – one pointy, the other, snub. And maybe a hammer."

"Just like the ones that you leave scattered around the house?"

"The very same ones, Jane. You are most observant."

"Sure – but as I said, a lot of people would say that about *their* way of thinking. What's different?"

"Indeed, Jane. It all depends on what they want to achieve, or what they expect. In my case, I want to achieve new things – and achieve *lots* of new things. Life is short!"

"But you just can't summon up successful ideas by the use of your plodding empiricism."

"Of course not. It's not *summoning* up ideas – that's the easy part – it's getting one's – or anyone's – ideas to *work* – that's the difference between *invention*⁶⁷⁰ and *innovation*⁶⁷¹."

"...And getting one's ideas widely accepted...?"

"That's called *entrepreneurship*⁶⁷², Jane."

"I thought that entrepreneurs were rascals who made zillions from mining and banking scams. Most members of your scientific pantheon were far from rich."

"That's true, but most of them were rascals who were selling ideas that weren't wholly their own invention. Plato promoted Socrates' ideas, Galileo promoted Copernicus' and Oresme's ideas, Descartes promoted Viete and Newton's originality

remains in dispute. To them, the important thing was that a wide range of people “bought” the ideas that they were promoting. Remember, they were building on the shoulders of the giant body of information that was the life’s work of many people. They turned that information into knowledge – *real knowledge*.”

“*Real* knowledge? What other kind is there?”

“Well – there’s knowledge that is just *words* and there’s knowledge that is *action* – *declarative knowledge*⁶⁷³ and *procedural knowledge*⁶⁷⁴. One might be able to recite – or declare – how to do something, or some particular facts, without necessarily being able to *do* anything with that information that you have recited. And until somebody *does* do something based on those words – then they’re just so many words – *real words*, but not what I’d call *real knowledge* – *real knowledge* is a verified capacity to act – to achieve something intentionally. It may involve words, but not necessarily.”

“So where does that leave me, Bruce – I have a capacity to act with words?”

“Hmm... I think that theatrical acting is a form of procedural knowledge – the words are accompanied by gestures and intonation that are more than simply, tonelessly reciting words.”

“I guess I *did* ask. But – knowledge *without* words? Sounds like an oxymoron!”

“I guess that most people’s first impulse is to see it that way, Jane – particularly when we live in such a word-intensive world where more people are employed to say things than to do things...”

“Indeed, Bruce,

“*All the world’s a stage*
*And all the men and women merely players*⁶⁷⁵ ...”

“Exactly – but we – all of us – often say: he *really knows* how to play football, or he *really knows* how to play the violin...”

“...or *she* really knows how to act...”

“... Yes – and – in many cases – without any of these players necessarily being able to *say* how they kick, fiddle or spruik. They often have the capacity to act, and not be able to give an *account* of how they do it. So they have *procedural* knowledge without *declarative* knowledge.”

“Rather like *Marcel Marceau*⁶⁷⁶, miming *Youth, Maturity, Old Age and Death*⁶⁷⁷, compared with some hack actor just strutting and fretting their way through Jacques’ monologue on the seven ages of man.”

“If that’s the way you like it, Jane – yes.”

“Well, doesn’t that all fly in the face of your chessboard-hopping antics, Bruce? I mean – *doing it* is what really counts, doesn’t it?”

“We need *both*, Jane, particularly if we are going to try to transmit what we know through space and time – the big idea of science is to transcend the limits of local, informal learning in apprenticeships by establishing a universally understood language.”

“But knowing *about* acting isn’t the same as being able to act, or knowing how to answer a quiz question isn’t the same as being able to make a cellphone.”

“I agree, Jane. But it’s the challenge that we always have with abstraction – first, we have to *know* something – in the sense that we can *do* something. Then we have to translate that thing that we know into some abstract form – from photos to algebraic squiggles. Then the receiver has to be able to comprehend those abstract symbols and lastly, transform those symbols back into their own actions. There are challenges all the way along that chain of events. The biggest criticism of our so-called education system is that the student is left at the second-to-last stage – they can say the words or reproduce the squiggles – *but they can’t do anything useful with the squiggles*. They haven’t been taken back along the chess board to their own senses and body.”

“And sometimes they just remain in *squiggle-land* – squiggling away. Always squiggle, squiggle, squiggle! [Another damned thick book](#)^{678!}”

“But that can be the beauty of the squiggles, Jane – we – or at least theoreticians – can extend the squiggles into realms that hadn’t been squiggled before – and then they might say: *what do these squiggles mean in the real world?* That gives science the power of [prediction](#)⁶⁷⁹. They can make their squiggles around the falling of apples and then predict the correct orbits of moons and planets.”

“Like our esteemed Mr Newton?”

“*Sir Isaac*, until you know him better.”

“Which brings me back to my question about the likes of *Sir Isaac*, *Professor Einstein et al* – did *they* inch their way across the chessboard as well? I think not!”

“I’m sure that you’re right, Jane. They were scientific [geniuses](#)⁶⁸⁰. They mainly inhabit the eighth square.”

“So – I’ve been conned?”

“Uh?”

“Well – I’m no genius – scientific or otherwise. I can never get to the eighth square. It’s all a big con – struggle with these squiggles and one day you’ll wake up as a new Newton. Not! You’ve gotta be born there!”

“Hmmm... interesting proposition, Jane. You might have just undermined all our efforts since the [Enlightenment](#)⁶⁸¹.”

“You mean that you’ve *actually* been holding out the ‘Promise of the Eighth Square’ as the reward for a life of squiggle-struggling and -wrestling? Talk about [snake-oil salesmen](#)⁶⁸²!”

“Not quite, Jane, although I’d agree that some people have gotten carried away with the Enlightenment proposition.”

“You’ve got some defending to do, Bruce – enlighten me.”

“Exactly, Jane. It seems as though two different propositions got muddled because of their common origins – the start of the so-called ‘Age of Enlightenment’, in the mid-Seventeenth century, was essentially a struggle against the ‘[Counter-Reformation](#)⁶⁸³’ – the revisionist religious absolutism that was implemented after the [Council of Trent](#)⁶⁸⁴ in the mid-Sixteenth century.”

“Heavy stuff, Bruce. Swift reaction, I must say!”

“Yeah – a bit of a slow burn to start with – and like all [complex systems](#)⁶⁸⁵, it’s probably impossible to pin down a beginning, or signal-event that started it, but my take is that Northern Europe became more interested in commerce than religion in Elizabethan times, and one thing led to another. Copernicus had set things in train with his heliocentric views, which led to a revision of the [Julian calendar](#)⁶⁸⁶ – paradoxically at the behest of the Council of Trent – as well as Galileo’s stuff – which was more appreciated *outside* Italy. Prosperity in Northern Europe led to increased invention of elaborate mechanisms and I think that helped provide a clearer – and more extended – metaphor for causality...”

“...that’s a new one – ‘extended metaphor for causality’. What’s that metaphor for?”

“Just think about those times, Jane – one-step causality has always been with us – push – and it moves, lever it and it will lift, hit it – and it breaks, and so on. But situations where it is clear that the effect of ‘C’ on ‘D’, say, came from ‘A’’s effect on ‘B’, which then affected ‘C’, then ‘D’ requires a *connected mechanism*, like a wind-up [clock](#)⁶⁸⁷ or trigger mechanism on a [flintlock musket](#)⁶⁸⁸. When you start to deal with this kind of technology, you mind can start to wander and wonder as to what other things might be causally connected, rather than being the work of some mysterious hand of fate. By the beginning of the seventeenth century these technologies were pretty widespread, so these extended mechanical principles became part of the language.”

*“When I do count the [clock](#)⁶⁸⁹ that tells the time,
And see the brave day sunk in hideous night;
When I behold the violet past prime,
And sable curls, all silvered o’er with white...”*

“Exactly, Jane. Your timing is perfect. So, after the Bard’s [alter ego](#)⁶⁹⁰, [Francis Bacon](#)⁶⁹¹ laid down the ground rules for empiricism in 1620, the way was clear for the Enlightenment to get into full swing.”

“So – where is this leading us, Bruce? It seems like a very tortuous path to enlightenment.”

“Well, as I said, Jane, it’s not straightforward – James Burke⁶⁹² gave a sample of this in his ‘seventies TV series “Connections”⁶⁹³ – you can trace a plausible thread through historic events which precede an event of interest, but history is not science.”

“But isn’t climate change as much history as science?”

“Agreed, Jane – anything about the past can’t be treated directly like an experiment – all we can do is try to narrow down the web of events to a consistent, plausible thread.”

“...so the *Enlightenment* thing?”

“Well – as I said, two ideas have been conflated – the *outcome* and the *process*.”

“Do you mean that I *can* reach the eighth square after all?”

“Possibly.”

“But not *probably*?”

“It’s not pre-determined, my darling.

“Great! Tell me more!”

“Well, first, my understanding of the outcome, or goal – although I think that the whole thing is a bit miscast, as an *outcome*, rather than a *process*. *Enlightenment*, in the European sense, seemed to have meant something like *sainthood*⁶⁹⁴ – and an automatic pass to heaven or paradise, as you had reached a state of virtue beyond reproach.”

“Mmm... my probability has gone to zero already.”

“Well, I think that you’re divine, Jane.”

“Thank you, Bruce, but I don’t know how much weight your recommendation holds – I think that there is a mutual non-recognition between you and St Peter.”

“Be that as it may... I think that it’s worth saying that Eastern belief systems have a similar *goal*⁶⁹⁵ – Buddhism and Hinduism calls it *Nirvana*⁶⁹⁶. Given the number of saints in the West and *Bodisattvas*⁶⁹⁷ in the East, I would agree that, other things being equal, we have dim prospects of reaching this level of enlightenment.”

“Dim prospects’ equals ‘low probability’?”

“You’re catching on, Jane. But this group of very excellent people seems to have served a greater purpose, related to the *process* part. *You couldn’t get to heaven*

without being good. Saints, Greek gods, Bodhisattvas – all models of possible perfection.”

“Well, I was told *that* often enough by the nuns at school. Mum and Dad were more mundane and promised lollies and dolls if I was good. The dolls bit seemed to work – at least sometimes.”

“And they forgave you when you were naughty?”

“Of course – after due penance, of course – like room-cleaning, dish-washing and so on.”

“And so it was, Jane – and still is – with the churches – behave yourself, work hard, be obedient to authority and you’ve got a chance of getting to heaven....”

“...a heaven that was something like the paintings in the Renaissance and Baroque⁶⁹⁸ churches...”

“...but much, much better – not to mention the eternal choirs, that were like the church choirs, but always in tune... and alternatively...”

“Oh, oh! – the fire and brimstone⁶⁹⁹ bit – I’d much prefer to go clean my room.”

“You’ve got the general idea – parental authority morphed into obedience to the church and its various agents – popes, priests, kings...”

“...so *you* think that it was all a big con, Bruce? And what did this have to do with *your* bright bunch of scientists?”

“I don’t think that it was a complete con...”

“Bruce! You mean *you’re* cutting them some slack?”

“A bit, Jane. In the absence of any other model, the old carrot-and-stick of heaven and hell enabled a fair degree of social cohesion. Just that as groups got bigger and formed towns and cities the carrots and sticks⁷⁰⁰ had to grow commensurately.”

“Okay – I get the general idea – at least the cardinal points. But while we’re at it – how did this idea play out in the East?”

“As I said, there was the possibility of Nirvana, which seemed more like a *state of being* than some astral real estate, like the visual cliché of the Western Heaven⁷⁰¹. Bodhisattvas were – or are – somewhat equivalent to saints, but still *mundane*. To achieve Nirvana, you generally had to first achieve Satori⁷⁰².”

“Sounds complicated – a two-step process...?”

“Even more detailed than that – Eight-fold Paths and all...”

“Being *good* isn’t enough?”

“Well, the [Ten Commandments](#)⁷⁰³ top the Eight-fold Path. Just that the Ten Commandments are mainly cast in the negative – telling you what to not do, rather than what actual actions you can usefully take...”

“Okay... speaking of paths, can we get back on track with this Western Enlightenment thing?”

“Yes, we’re now in a position to bring home the Bacon....”

“Groan!”

“I guess that it amounts to this: the Western Enlightenment, as a *process*, was essentially the development of the modern so-called ‘scientific way of thinking’ – there were plenty of players, but Bacon – and then [Spinoza](#)⁷⁰⁴ – were big players in setting up the ground rules of science – a kind of Ten Commandments and Eight-fold Path for others to follow.”

“And the [value proposition](#)⁷⁰⁵ being...?”

“*An Earth that is a bit like heaven* – or at least, somewhat less miserable – if the Enlightenment Way was followed. Its purpose was to reform society away from irrationality – specifically, away from superstition, dogmatism of all kinds, unfounded intolerance of all kinds and gross abuses of power by both the Catholic Church and by despotic kings.”

“That’s rather couched in the negative, Bruce. That’s what they *didn’t* want – what did they want instead?”

“Lots of things, Jane – democracy, racial and sexual equality, individual liberty of lifestyle, full freedom of thought, expression and the press, eradication of religious authority from the legislative process and education – and full separation of church and state.”

“Quite ambitious! But not really secular – they seemed to want the best of both worlds – or at least the best of the World and Heaven as well – so long as it wasn’t a Catholic heaven.”

“As I said, the origins of this idea are complex – and geo-politics seems to have been part of the early motivation – You can go back to [Henry VIII](#)⁷⁰⁶ and [Martin Luther](#)⁷⁰⁷ in the early-ish sixteenth century, who were essentially wresting power from Rome, rather than pursuing rationalist philosophies.”

“That’s a big leap, Bruce.”

“Yes- a leap of faith- sideways- I guess.”

“Groan! Again!”

“Sorry about that, Jane. It’s this perennial problem of dealing with [first causes](#)⁷⁰⁸, [final causes](#)⁷⁰⁹ and [cosmological arguments](#)⁷¹⁰ – we’re always trying to find what happened first, why we’re here and where we might be going. Probably futile – although physicists keep on coming back to it with [Big Bang Theories](#)⁷¹¹.”

“As a far as I know, Bruce, pretty well all those Enlightenment characters were still religious – mainly Christians. How did they – or you – reconcile *that* paradox?”

“Well, as I said, Jane, it was complex – there was no script for it. Most of them came had a religious upbringing, because the church was all-prevailing – *conditioning* as I’ve called it – and although they could come up with extended rational discourses on causality about mundane things, they couldn’t find an answer for the big questions – they had neither the intellectual tools nor the scientific instruments to do it. So they consigned [God to the gaps](#)⁷¹² – of which there were many in those days.”

“Or the God of *the beginnings and ends*... So they really set up a philosophical system that was modeled on the Judao-Christian system – believers, liturgy...”

“...I think that is imputing too much order to the events, Jane. Certainly Spinoza’s ideals continued to echo through that period, but he was near the beginning, not the end of that period that is called *The Enlightenment*. Spinoza was considered as an example of the *Radical Enlightenment*, while most others were subscribers to the *Moderate Enlightenment*, who believed that there were two sources of Truth – *reason* and *experience* – and experience included much of the *status quo*.”

“So they were *believers*, then! Not *empiricist probablists*?”

“They were pragmatists, as well, Jane – in the everyday sense of the word – they lived in [absolute monarchies](#)⁷¹³ and didn’t want to buy into trouble unnecessarily.”

“Secret squirrel societies?”

“No – not really, as far as one can tell – the nearest to a secret group were the [Freemasons](#)⁷¹⁴, whose members included some of the prominent scientific thinkers of that time, and held a view that God didn’t interfere with everyday life.”

“Which must have made them unpopular with the powers-that-were?”

“Anybody who contributes to the erosion of authority runs that risk. ‘Twas always thus, [and always thus will be](#)⁷¹⁵.”

“So the Enlightenment wasn’t a unified attempt to overthrow the existing order?”

“Not as far as I can tell. Sure, there were Societies, ranging from the Freemasons to the [Royal Society of London](#)⁷¹⁶ and its [French equivalents](#)⁷¹⁷, [salons](#)⁷¹⁸, [coffeehouses](#)⁷¹⁹, the [Republic of Letters](#)⁷²⁰ and other groups who were interested in finding things out and talking about them. [Grub Street](#)⁷²¹ writers served to popularize some of these ideas as well as promote literacy in general. It seemed like the effect was the same as it is today – accumulated knowledge – generated by intellectuals and experience – becoming widely accessible – leading to a general feeling of unbearable

contradiction between what is known and what is said by authority – [cognitive dissonance](#)⁷²² it's called.”

“Nobody expects the French Revolution!”

“I think that it was pretty widely expected, darling.”

“So that was the high point of Enlightenment thinking?”

“The Enlightenment thinkers certainly got a bad rap out of the French Revolution – unfairly by some accounts⁷²³. But, with the benefit of hindsight, the core ideas of the Enlightenment continued to take hold and are still with us today.”

“So we're all little *Enlighten-istas*, now?”

“Some more than others, from my observation.”

“And what, in this sense, makes for an ‘enlightened’ person, Bruce.”

“Simple, Jane – *a preference for traversing the squares of our explanatory chess-board, rather than relying on intuition and revelation as a guide to managing the material world.*”

“All that fuss for *that*?”

“I think that it is a pretty different *that* than the alternative.”

“Well, that seems to be somewhat short of sainthood.”

“As I said, Jane, there seems to be two – somewhat different – interpretations of enlightenment....”

“I get it – subscribing to chess-board hopping is rather like being a virtuous, religious person – it might keep you out of trouble, but it's a bit short of *transcendent*. So religions have their saints or what-have-you in the East – what have you got to offer, Bruce?”

“[Genius](#)⁷²⁴.”

“Genius? So that's your secular sainthood?”

“Yep. Why not?”

“Just – I hadn't thought of it like that. In fact, I hadn't thought too much about geniuses, other than to recognize that many of the people who highlight civilization with their contributions are far more talented than I could ever hope to be. Shakespeare, Milton, Bach, Mozart, Monet, Picasso – all geniuses of the arts, I guess.”

“Well, I add in my group – Galileo, Newton, Einstein, Feynman⁷²⁵ ... to name a few of my secular saints.”

“Feynman? I’ve heard of the others, of course – but who’s he?”

“Like their religious equivalents – it sometimes takes a while for secular saints to be recognized. Feynman is generally considered – or at least considered by physicists – to be the greatest genius of physics since Einstein.”

“Okay! But what do we mean by ‘the greatest genius’? We throw these words around – not just scientists, but literary people as well. What makes a *genius* – and what makes one greater than another?”

“Hmm... that’s a tricky question. I might ask the same question of the pious bunch as well. There’s lots of stories about geniuses, but I like the one about Feynman – describing⁷²⁶ his problem-solving “method” – he’d write the problem down, then clench his fists on the sides of his head, and then write down the answer.”

“You mean that he didn’t do a dance across the ‘chessboard of explanation’?”

“Not usually – it seems that he – like many other scientific geniuses – floated – dreamlike – *above* the chessboard. He had a profound feeling for all the squares or stages – from the sensual first square, through the various levels of abstracted reality all the way to the squiggly math. He’d only do the math to verify what he already “knew”. The math – or often his famous *diagrams*⁷²⁷ – were there to explain his knowledge to others – *non-geniuses*.”

“He was *in* it – but not *of* it, Bruce?”

“Or maybe *over* it but not *on* it, Jane. *Sleepwalkers*⁷²⁸, Jane. Even *they* don’t know *how* they know.”

“Either way, we are not made of *such stuff*⁷²⁹.”

“And what “stuff” are your celestial friends made of, Jane?”

“*Saints*⁷³⁰ seem to come in a number of flavours, Bruce – some are great exemplars of the way that God would wish us to behave, some are conveyors of *revelations*⁷³¹ and some work *miracles*⁷³². In all cases, as far as the Catholic church is concerned, they are *revealed* and *recognised* – not *created* by following the church. They’re *born*, not *bred*.”

“I guess that it’s the same with our mob – no amount of teaching will make a non-genius into a genius. It’s a bit of a con-job.”

“But we seem to be *defining by pointing*, Bruce – as Socrates used to say. How do they do what they do that is so different from the way that we do it?”

“You mean – what’s the *essence* of sainthood and genius?”

“Exactly.”

“First, I’d set aside the [savants](#)⁷³³ – people with an exceptionally deep, but very narrow abilities.”

“Like [Rain Man](#)⁷³⁴?”

“Yes – a lot are like that – [autistic](#)⁷³⁵ – but not all of them – a lot are brain damaged in some way. Most of them can do some trick or another – like arithmetic, calendar dates, memory feats, playing music and so on – but with no – or very little accompanying intellectual abilities. We’re talking about [intellectuals](#)⁷³⁶ – people who are extraordinarily inventive and can also express their reasoning and thinking abilities – in writing, music, science – things like that.”

“Aha!”

“What?”

“So there are two parts to this genius thing – *inventiveness* and *creativity*?”

“Yes – I’d say *inventiveness* and *innovativeness* – both the ability to imagine something novel – to have an original idea – *and* the ability to transform that idea into something that works. In this case, we’re talking about a *something* that is writing, music, science, maths etc.”

“But lots of people do that – and we don’t call them geniuses.”

“That’s *everyday talent*. I think that [Schopenhauer](#)⁷³⁷ summed up the difference:

Talent hits a target no one else can hit; Genius hits a target no one else can see.”

“That’s a bit [metaphysical](#)⁷³⁸ for you, Bruce!”

“You’re probably right, Jane. The fact is that we simply don’t have a good grip on the phenomenon of genius. We can point at it, but we can’t explain it very adequately – either behaviorally or at a neurological or biochemical level. Perhaps we need a genius to look at the subject. But the important thing here is that whatever quantum leap or paradigm shift the scientific intellectual genius performs, it is subject to the same rules of scrutiny by objective empiricism as the work of the plodding researcher – as much as we might admire them, in science, geniuses have no God-given authority or immunity from scrutiny.”

“I guess that is where saints and geniuses depart, Bruce. Saints become perfect or perform miracles by the grace of God. They transcend scrutiny.”

“A kind of diplomatic immunity?”

“You could put it that way, Bruce. I think that I’m beginning to see the light.

*When most I wink, then do mine eyes best see,
For all the day they view things unrespected;
But when I sleep, in dreams they look on thee,
And darkly bright, are bright in dark directed.
Then thou, whose shadow shadows doth make bright,
How would thy shadow's form form happy show
To the clear day with thy much clearer light,
When to unseeing eyes thy shade shines so!
How would, I say, mine eyes be blessed made
By looking on thee in the living day,
When in dead night thy fair imperfect shade
Through heavy sleep on sightless eyes doth stay!
All days are nights to see till I see thee,
And nights bright days when dreams do show thee me.*⁷³⁹

The Final Scene:

“So how would you summarise our journey, Jane?”

“Indeed – it has been a surprising journey, Bruce. A real head-trip – if that isn’t an oxymoron.”

“So – do you understand science now, Jane?”

“Who knows, Bruce? If you mean: can I *do* science now, the answer is *certainly not*. I doubt that I could ever do that – I’m wired differently. But if you mean: *do I understand how scientists understand science*, then I think that I’ve now got a *feeling* for it. All that heat and light just to distill the essence from our senses.”

“I’ve got a feeling that you’re probably right, Jane.”

Understanding understanding

What is it, to *understand*
The nature of a flower
Or why
The sky is blue,
That all things change
And that
So many
People cry and
So few
Can stand against the wind?

We think, perhaps,
That to understand
We must explain
That there are parts,
And that they connect
By logic and reason,
With time and cause
Providing movement.

Thus separated,
Us from it,
The parts proliferate
Connections multiply
Thin threads of logic
Weave a tangled web
And reason creates
A past that severs
Time's circle.

Who is it who explains
Me to you
Or me to me?
Duality and words –
We take each other's experiences
As our own –
As if my shoes,
Having trod so many paths
Would fit your feet.

So –
To wish to understand
Is to wish,
And then to hope
That once separated,
All will become as one again
When we know.

No!

Understanding will not
Come this way like that.
Only by leaving
Words and cause behind
By being here and now
Will we breathe out
And see
That it is so.

Love is all
We need to know. (By the Author)

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