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WARMING TO YOU –  
FALLING FOR ME

Chapters  
13-16

*Draft for  
Comment  
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A DIALOG



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# Dedication and Acknowledgements



*Cover Painting by Peter Griffen:*  
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# Introduction



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

Jane hasn't 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? What will Jane really know when they get "there"?

Being busy with jobs (Jane's a part-time drama teacher; Bruce is 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 and back again- just like steps on a chessboard.

This 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 restaurant- wherever and whenever they can find a few minutes. Just talk.

The task is 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.

Most of the several thousand hyper-linked references are to Wikipedia. Why Wikipedia? Bruce explains his passion for the medium of the encyclopedia, which saved him from a fate as a farmhand. And it has a history- Alexandria's library, Diderot's Encyclopedie, Britannica, Richards... a window through which a light softly breaks....

## Chapter 13

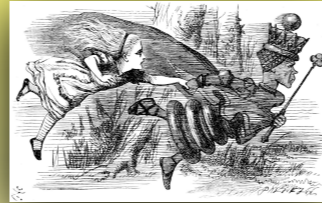
# MAKING A GOOD IMPRESSION

In which Jane and Bruce go deeper into Abstraction, only to find that Art and Science are in much the same boat.

**Édouard Manet** (1832–1883):  
***Boating*** (1874)



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**. That's **empathy** for you!



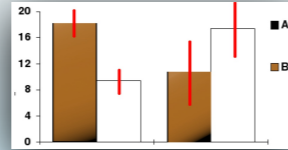
I guess that empathy is a kind of ***tacit understanding*** – and that's pretty important in the overall scheme of knowledge. But what **I'm aiming for at the moment is an *explicit* kind of understanding** – one that we can lay out like a road map **in this world of uninformed opinions, wild emotions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

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

Because it relies on *reason*?

Not guaranteed, but it's reasonably reliable.

And are there any cases of people haven't come back?



Exactly – or at least to a known level of confidence. 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 process.

Hmmm... you're certainly catching on to this empirical approach. That pejorative academic is usually applied to people who *haven't come back* – people who seem 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 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?

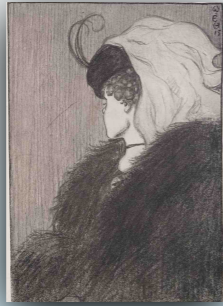
Well – I think that if one starts at *Stage One* and moves through each successive stage then there's no problem of getting back to concrete reality. A problem can occur...

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, Jane. **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 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.

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!**

**That line of defence has been used before, Bruce.** I'm talking about the behaviour, not the person.

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



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 OK. 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?**

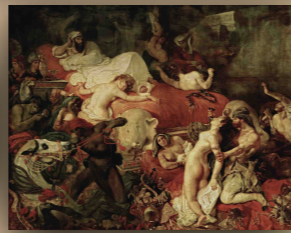
We are what we repeatedly do, Jane.

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.*

Yes, Jane, I agree – this *mind-brain-spirit thing* is a bit of a **conundrum**. 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*?



You're right, Bruce 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** of the early nineteenth century were, visually, obsessed with **literal** depictions of people and scenery. They were only exceeded in their realism by the so-called **Pre-Raphaelites** like **Rossetti** and **Millais** and **neo-Romantics** like **Aivazovsky** who wanted to return to the abundant detail, intense colours, and complex compositions of **fifteenth century Italian and Flemish art.**



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*.



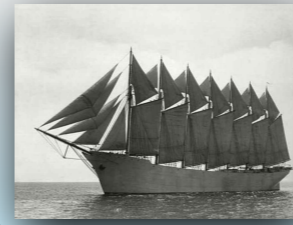
From what I've seen, those Pre-Raphaelite and neo-Romantic guys were the **fifty-megapixel Hasselblad cameras** of the nineteenth century. Their paintings were more real than *real* – they certainly would have been useful for depicting my *Stage Two*.

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

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

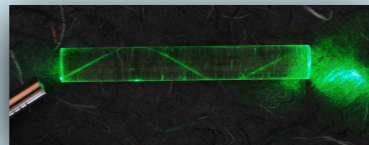
Gee – thanks, Bruce – I didn't know that. **But I think that we got distracted from abstraction.**

Thanks again – 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.**



Hmm... I didn't appreciate that – **it's a good example of what we call the sailing ship effect.**

Well, it's a phenomenon that happens more often than we might imagine. In the area of innovation, 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 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 – 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.



Sorry, Jane – **please carry on.**

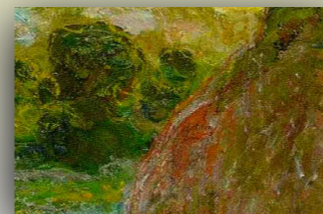
Point taken, Bruce. To continue – **the Impressionist painters, most notably Manet, Monet, Renoir, Pissaro and Cezanne** used relatively small, thin – yet visible – brush strokes, as well as open composition and an emphasis on accurate depiction of light in its changing qualities on common, ordinary 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 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.**

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* in art the same as *abstract*?**

You certainly have sucked me through the looking-glass, Bruce. From my *dim* 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!**

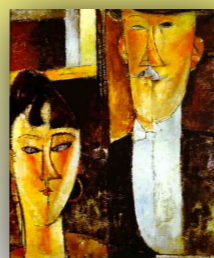
That resonance, Bruce, is a feeling of a shared truth with the artist.

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

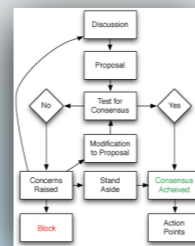


When you say that *their art strikes a resonance with the viewer* – that seems like code for *appealing to the emotions*. In science, we only deal with abstraction in a kind of progressive way where the steps can be linked by logic – call it *reasoning* if you like.

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



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.



Indeed – and I'm prepared to put up with this slavish devotion to reason to get to the heart of the matter.

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

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 *The Scream*, which was painted in the early 1890s, was an inspiration for many expressionist artists who followed, including van Gogh and Modigliani, to name a couple.



So the Impressionists took off in one direction of abstraction – what about the Expressionists?

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.**



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

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.

$$\begin{array}{ll}
 \nabla \cdot \vec{B} = 0 & \frac{\partial B_i}{\partial x_i} = 0 \\
 \nabla \times \vec{E} + \frac{1}{c} \frac{\partial \vec{B}}{\partial t} = 0 & \frac{\partial}{\partial x_i} \epsilon_{ijk} E_j + \frac{1}{c} \frac{\partial B_k}{\partial t} = 0 \\
 \nabla \cdot \vec{E} = 4\pi\rho & \frac{\partial}{\partial x_k} E_k = 4\pi\rho \\
 \nabla \times \vec{B} - \frac{1}{c} \frac{\partial \vec{E}}{\partial t} = \frac{4\pi}{c} \vec{j} & \frac{\partial}{\partial x_i} \epsilon_{ijk} B_j - \frac{1}{c} \frac{\partial E_k}{\partial t} = \frac{4\pi}{c} j_k \\
 \vec{B} = \nabla \times \vec{A} & B_j = \frac{\partial}{\partial x_m} A_\epsilon \epsilon_{mnsj} \\
 \vec{E} = -\nabla\phi - \frac{1}{c} \frac{\partial \vec{A}}{\partial t} & E_k = -\frac{\partial}{\partial x_k} \phi - \frac{1}{c} \frac{\partial A_k}{\partial t}
 \end{array}$$

I guess you're right, Bruce. Artists create works which they claim has 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.

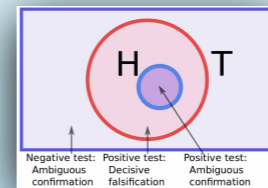
You can be so sweet, Bruce. But I think that there's more to it than that. I think that **it goes back to bad experiences with science at school – particularly with women of my age and older.** Because we didn't *get it* immediately in our school science lessons, **it was assumed that it simply wasn't 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.**

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.** 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 than just good, clear explanations.**

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 in the scary forest.**



It's pretty hard to deny that, Jane. And it's hard to appreciate other points of view when you're surrounded by **confirmation** of your own. Please go on.



**Golly!** I don't know whether I'm up to playing the role of **Sigmund Freud**. 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?**



Maybe *Ockham* is the woodcutter who saves us?



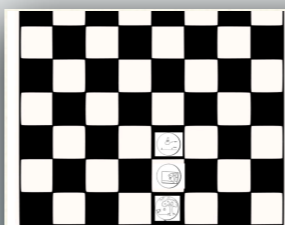
That's a rather grim description, Jane – but we scientists try to leave a trail of the *white stones of empiricism* rather than the *breadcrumbs of personal opinion*.

That seems to be the essence of it, Bruce.

Perhaps the moral of the tale is not to be tempted by that candy-house of subjectivism. 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 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?

Yes! Please do!

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



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!

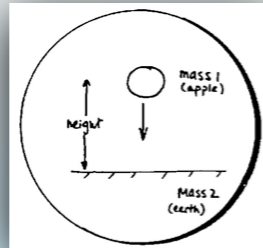




Not quite, Jane. **Stage Four** is characterised by a complete loss of **irrelevant detail**, although broad similarities to reality remain. In our example, **the falling apple becomes a circle** – suggesting that as it is **extensive** it must have mass. The earth is represented by a simple **line**, 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!**

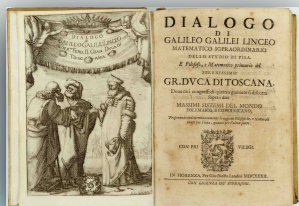
So what would be the words to go with the pictures?



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 have we gained by losing the apple-like appearance of the apple and the earth-like appearance of the earth?

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.



Nice question, Jane. Well – **that circle could represent any mass** – apple, orange, stone, or even **Galileo's mythical cannonballs** dropped from the **Leaning Tower of Pisa** – 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, Jane – **at Stage Seven.**

I'm trembling with anticipation. I think that I've got a handle on *Stage Four* now – **it's not a big mental stretch.** So there's a sign in front of *Stage Five* saying ***the public should enter at own risk – here there be beasties!***

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.**

**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 do it.** 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.*



## *Chapter 24*

# A CLASH OF SYMBOLS

In which Bruce and Jane explore the dimensions of abstraction in science and art.



It's a never-ending journey, Bruce – but I know what you mean. We left off our last little chat with the Impressionists and Expressionists in full flight. They had slain the dragons of Romanticism and Realism, but you could still actually see screaming faces, haystacks and water lilies 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 is the one most often used.



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.

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 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.**



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



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

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

And makes that little ripple...

The water slows down, swirls around and takes your coffee-grounds down the plug-hole.

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.

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...

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



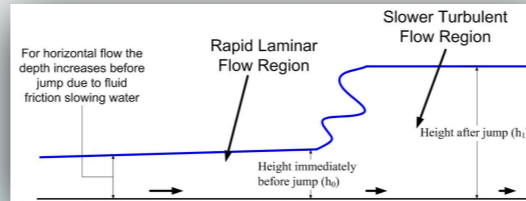
Well – you know when you turn on the tap above the sink and the water pours smoothly onto the base of the sink – and then spreads out...

Exactly. And what happens next, Jane?

So?

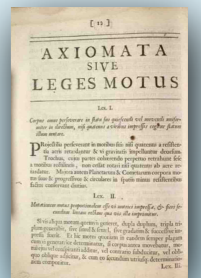
So! That is one of the most profound phenomena in physics, Jane.

You're kidding me? Okay – you're serious. **What's so profound?**



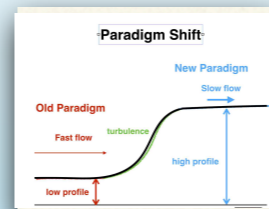
Well – at the level of physics, it's called a '**hydraulic jump**'. The water just can't transition from fast-and-low to slow-and-high **without going through**

**that turbulence** where some of the **kinetic energy** – the energy of movement – is turned into random movement. A property called **momentum** remains the same, because that never changes anywhere in the universe. This really at the heart of Isaac Newton's **laws of motion**.



**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** 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.



**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, Lenin, my mother...**



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.



No, Bruce – **that wasn't until much later** – mainly in the 1930s in his **Surrealist** period – **long after he returned to painting with more discernable forms** – as gruesome as they may have looked.

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?**



**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...

**Oh!**

Picasso and [Braque](#) 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](#) 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 first big bombs of the revolution, Picasso 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](#) – **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 –



Well – something that Kandinsky said – he was a **great theorist** 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 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?**

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.*



**And the *point* being?**

**Maybe we aren't as far apart as I imagined.** 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?** 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!

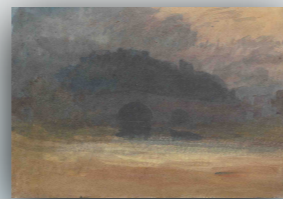


I did say *part* of the attraction. Just watch people in an art gallery – as far as I can see, most of them are playing *where's Wally?* – you know – like *can't you see the something-or-other in the picture?* That's okay – I'm just pointing out that part of our use of abstraction is to obscure elements 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 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 – qualia, it's sometimes called – the orange-ness of an orange, the bleak-ness 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?

Can't help but agree, Bruce. I think that [Cezanne](#) 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.'*



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*.



Yes – very nicely. James [Gleick](#) used even fewer words when he described ***the genius composers who succeeded Mozart, with their increasingly direct pipelines to the emotions.*** 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](#) 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*?**

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Well, if we leave aside a lot of **indigenous Australian art** with obvious representations of people, animals and places, **we have a range of paintings - for example the Papunya Tula 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.



**Wow! Please go on!**

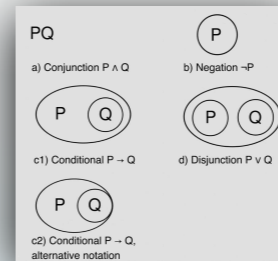
When viewed in monochrome, **other symbols can look similar, such as the circles within circles**, sometimes depicted on their own, sparsely or in clustered groups. When this symbol is used, and depending on the Aboriginal tribe you belong to, **it can vary in meaning from campfire, tree, hill, digging 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.

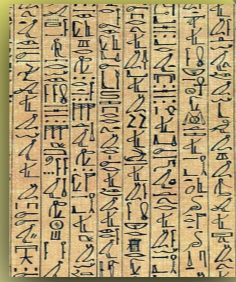
Why do you doubt it, Bruce? The claim of coherence has been made many times before by people far more expert than I am.

Well – to start with: when I hear that a certain picture gives instructions on how to get from A to B, 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.



I think that we're on the same wavelength here, Jane. The key issue is the use of symbols. Charles Sanders Peirce the American philosopher whose life spanned the time of the emergence of abstract art, defined the symbol 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?

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](#), 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.

Hmmm....

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.**

Dare I call that *pretty exact process* an *empirically-based knowledge system*, Bruce – even a *science*?

But what, Bruce?

Maybe with a couple of thousand years' more work on it, it would have greater coherence.

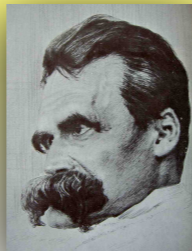
Thanks for that, Jane. **It seems like Aboriginal art is more akin to mathematics than photography.** We'll come to maths later. I guess that surviving – no – **flourishing – in a country like Australia for untold thousands of years required a pretty exact process for living.** You couldn't just pop down to the local deli if you ran out of kangaroo tails.

*Touche*, Jane. I feel humbled. But...

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.**



I wouldn't call it comfortable – but in this situation I would take comfort from [Nietzsche](#).

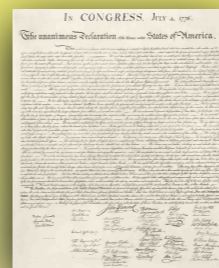


*Touche*, again, Jane. But back to my point – are you comfortable with the intellectual aspects of my attempt to explain scientific explanation?

Arguably, but there's more to him than that.

Yikes! *Nietzsche*! I didn't know he was on the board. Wasn't he the guy who inspired [Hitler](#)?

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](#)



Lead on, Jane – I'm a pawn in your hands.

*"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, Bruce.

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....?**

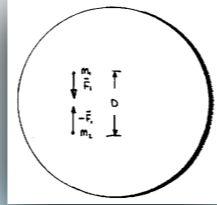


**...do the fandango Bruce!**



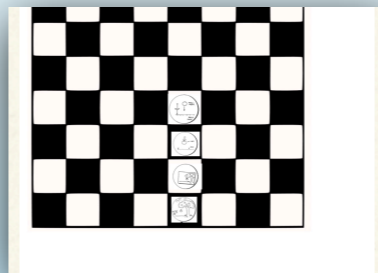
Very witty, Jane – indeed, not the Catholic masses – or even the Catholic Pope. **The next step was very closely associated with that *bête noir* of Pope Urban VIII – Galileo.**

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?



Indeed – Galileo led the Pope a merry dance, as this step replaced the circles with *arrows* – *vectors* we call them.

It was more than just the point of the arrow – or vector – it was also its *length* and *direction*. With Galileo, the emphasis shifted from this palpable thing called mass to the more abstract thing called force and an even more abstract thing called acceleration. Are you with me, Jane?



Always, Bruce. To me, it sounds more like Obe-Wan Kenobe 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 and the Roman Inquisition, believed that God's Earth was fixed and the Sun, Moon and stars revolved around us.

Then the fault, dear Bruce, was not in the stars, but in ourselves?



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. The 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.

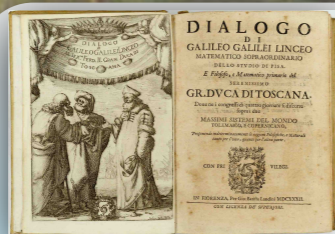
Quite possibly, Jane – but *belief* was the big issue with Pope Urban VIII.

**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 – if you will, but not necessarily the *true reality*.

Urban VIII 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 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.



Really Jane! I think that a month's *vacation* is a bit different from *nine years of house arrest*.

I take your point, Bruce – Aung San Suu Kyi could attest to that.

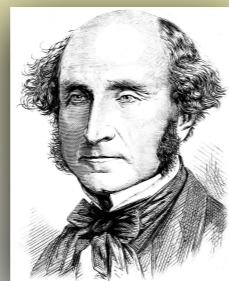


Interesting comparison, Jane. Both were up against totalitarian systems that would have preferred to have simply killed them to get them out of the way, but knowing that martyrdom might have had worse outcomes for their regimes. So they held on to their beliefs despite the system.



We keep coming back to *belief*. You do have trouble with that word, Bruce.

That's the Utilitarian 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.



I certainly do struggle with it, Jane. 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*.

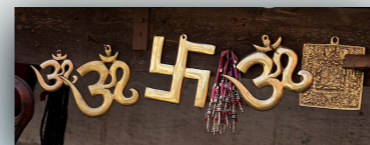
There certainly are connections. I'd buy into Nietzsche's *no gain without pain*, but didn't his views inspire the twentieth century wave of totalitarians like Hitler?

Unfortunately, yes, Bruce, although Hitler probably never actually read Nietzsche – he just cherry-picked his ideas about super-races. Nietzsche wasn't an anti-Semite.

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.



Then reflecting on all of this and symbolic abstraction – that little bent cross symbol called the swastika is enough to evoke the terrors and errors of a whole mode of thinking.



And their *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  
(And yet it moves)*

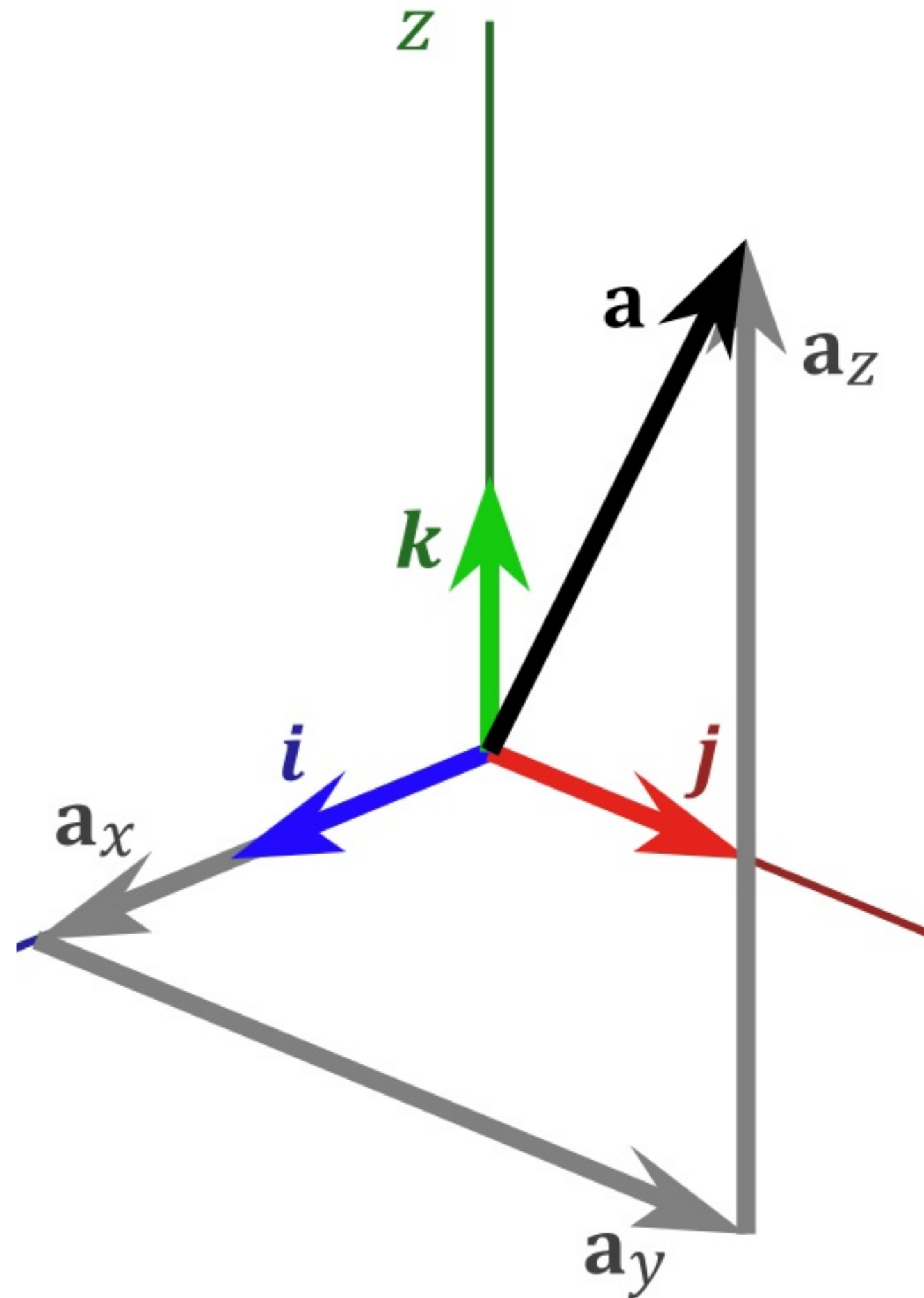
*(By the Author)*

## End Scene 14



## UN-CHARTED WATERS

In which the language in the discussion between Jane and Bruce becomes quite graphic.



Nope. Looking back, 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](#). I wouldn't see it as a flattering portrait if it were me, **but it clearly captured some essential aspect of her.** I'd personally call it [neo-expressionist](#).



So Picasso never took the final step into *abstraction*, Jane?

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's 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 to me!

That would be [Hieronimus Bosch](#), Bruce.

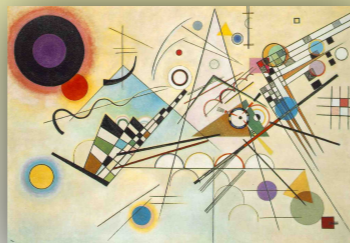




But if Kandinsky was *abstract*, what was he abstracting from? I can see that he was un-hinged totally from **figurative art**, but what were his references – you know – if his images were *symbolic*, what were the symbols representing?



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-



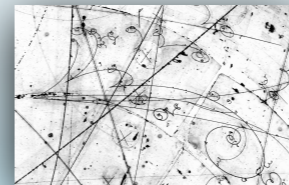
I guess that that is your prism, Bruce.

Liberate me, Bruce!

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*.

Good question, Jane – but I thought you were the resident *art-savant*.

Well, when I look at his stuff, he seems to be referring to the mathematics and physics that was to come in the twentieth century.



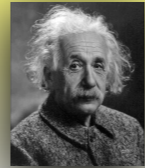
But not my *prison*, Jane.

The early twentieth century was a very exciting time for physics – the old, *deterministic* perspective of the nineteenth century was blown away by Einstein in 1905.

Yeah – I've heard of him.

I'm sure.

Relativity! E equals em-see squared!  
Everybody has heard of it – **but practically no-one understands it** – including me.



value
energy   mass   speed of light
$E = mc^2$
J   kg   299,792,458 m/s
units
$c^2 = 89,875,517,873,681,600 \text{ m}^2/\text{s}^2$

Ahh! **We're back on the track of understanding?**

Did we ever leave it, Bruce?

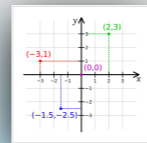
I think that my mind is leaving my body, Bruce. **Help!**



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.

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 world.

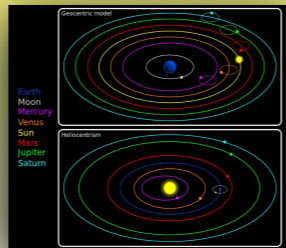
Err?

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!

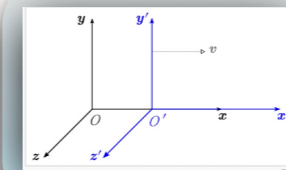
Last seen in deep contemplation in a villa outside Florence, with a cranky, bankrupt Pope trying to jam the Italian printing presses.

The historical parts aren't hard to grasp and the heliocentric viewpoint isn't too difficult and the clash with authority is understandable. It's the details of the physics that escape me.



Then let's go back to **Galileo** for a moment, and see if we can get a reference point.

You've been doing your homework, Jane.



OK. It was all about frames of reference.

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 you're 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!

Darn!

Oh!  
Bruce...!

Of course – so I squeeze up close to you so that we can *share the same point of view*.

But – although I'm *beside* you, it's all *beside the point* – or *beside the point of view*.

It was beautiful, Bruce – particularly after three [pina coladas](#) – but keep to the point.

Not quite, Jane – I'd say that Galileo probably reinforced **Modernism** in a round-about way – **if he didn't actually invent it**.

Here's a little example of what Galileo was talking about: You know what it's like – **we're holding hands, watching the sunset...**



...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**.

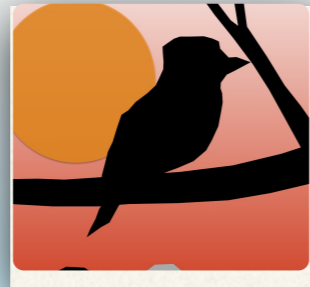
And that's lovely.

Not really, Jane. **In this not-so-hypothetical situation** – you know – remember when we were on holidays last summer...?

Of course! **That deduction shouldn't get you nine years of house arrest** – it should get you another *pina colada*!

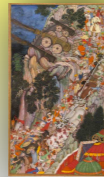
The point is that you knew that I wasn't **imagining things** – even after three *pina coladas*. You knew that if you moved to where I was standing, with your head on my shoulder – **then you would see the same thing as I was seeing.**

Genius, Bruce!  
So what?



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!***

It wasn't rocket science.

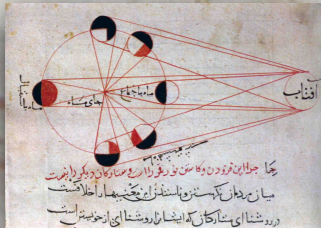


Well – **that act of sideways movement based on your reasoning, or intuition – translated *your frame of reference into mine*.** And more – as the sun was setting, you stood on tiptoes to see what I had seen half-a-minute *before*. So it was a translation in *both space and time*. **You and I shared a point of view because of your reasoning capabilities.**

Bloody typical – **science being funded by the military-industrial complex.**

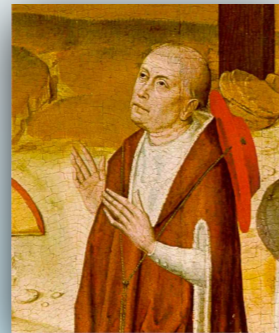
No – but rocket science is built on this idea. In fact, it was **Rene Descartes** – Galileo's successor in the pageant of modern science – **who used these ideas to work out the trajectory of cannon balls accurately for the French military,** and Isaac Newton contemplated cannon balls being shot so far that they continued to fall around the earth – that is, in orbit – the basis of rocket science.

A little space-time translation, Bruce?



But I digress – or at least I'm running ahead of the main story. I need to backtrack a little.

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** 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.

Darn! Then 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?

...and talking of axes  
– chop off her head!

I thought that you  
were the one  
using Alice as a  
guide.



Axes! Ockham's Razor!  
Cannons! Violence all  
around!

Why on earth would you  
climb up to the crow's  
nest with a cannon ball?

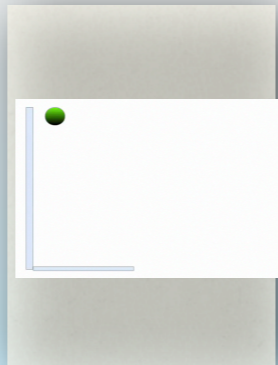
What? *Because it  
was there?*



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.**

Uh?

Oh – the Duchess, of course. Hmm... I wonder whether  
Lewis Carroll – at least as the mathematician Lutwidge  
Dodgson – **was thinking of this when he was writing.**



**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.

For the same reason that you'd climb up the Tower  
of Pisa with one – or even two cannon balls.

Test tubes in the head?  
That's an interesting kind  
of literary device!



infinite, random and  
anonymous, I presume.  
be – or not to be  
that is thegrrdnm zsplkt.

No, Jane – 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**.

No – not quite test-tubes, Jane – more like a *pencils-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 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. 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 – one of them would**



Meanwhile... back on the ship's deck  
with *our* thought experiment...

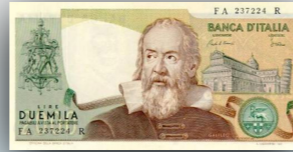


...it certainly sounds much safer than *actually* climbing a mast with a cannon ball.

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.

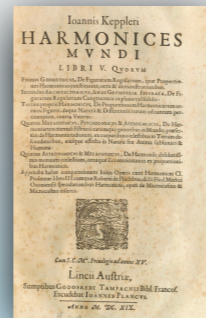
So these geometrical frames are your axes – not the axes as suggested to Alice by the Duchess?

How conciliatory of old Galileo.



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.

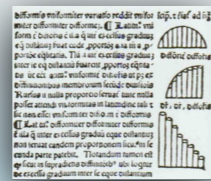
Right on, Jane! So both frames of reference are **equally valid** – they're just different points of view of the same thing. With some geometry, one can be transformed into the other – **no fundamental post-modern differences**.



By Kepler, she's got it! 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 different points of view.

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](#), anticipated him and Descartes by almost three hundred years.

So how come Brother Oresme didn't cop it like Galileo did?



They were more *pragmatic* than *idealistic*?

*For the most part?* Where did he slip with his science?

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](#). **Secondly**, the Pope, [Gregory XI](#), had a lot of other things on his mind at that time, with the possible break-up of the [Papal States](#) 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](#) 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.**



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.

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 he thought that having one God moving everything around was simpler than everything moving around

Indeed, Bruce – particularly using your definition of *explanation of relating something you don't know to something you do know*. That's historic relativism for you. You *do* have a streak of post-modernism in you after all!

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?**



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.

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.**

**Well I think that we can just put the uncertainty down to a lack of data and leave it there.**

It seems that Oresme made a couple of pretty profound contributions to our line of thinking..

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 your later heroes?

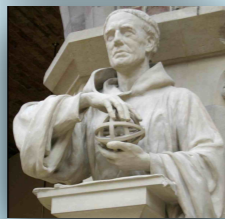


Amazing that it seems – yes – even more amazing that this was almost a century before [Gutenberg](#) invented the printing press. We still have many of Oresme's writings and there is some evidence that Galileo read him too. Not only Oresme, but his colleague [Jean Buradin](#) and the [Oxford Calculators](#). 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.

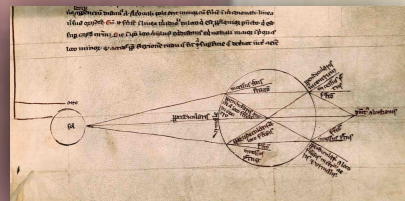
So – what *precisely* did they contribute?

Like the number of angels that could fit on [the end of a pin](#), Bruce?

Many things, Jane, 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.



Yes, Jane – that kind of thing seemed to be all the go with the early **Scholastics**. *Scholasticism* was not so much a *philosophy* or a *theology* as a *method of learning*, as it placed a strong emphasis on **dialectical reasoning** 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**, with the English Bishop Robert **Grosseteste** and his student **Roger Bacon**, 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, Bruce?

So all of this stuff was known three hundred years before Galileo and Descartes. How come the hiatus?

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.



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*?

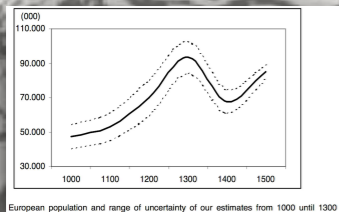
**Climate change!** Now there's some words that I haven't heard for a while. Do you mean that we are going to talk about climate change after all?

Darn! Well, carry on, anyway.

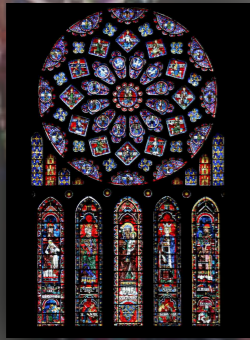
Not yet Jane. Asimov's Foundation Series' 'psychohistory' was science fiction. But it seems like we can identify a number of causative factors in the demise of scientific thought in the fourteenth century. Paradoxically, the main factor seems to have been *climate change*.

Not yet, Jane – at least not in any detail.

It seems that – at least in Europe – there was a **slightly warmer period from about AD 900- 1350**, called the Medieval Warm Period which was followed – **to about AD 1850** – by a longer cool period called the Little Ice Age. 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 was devastating – almost halving the population. 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!**

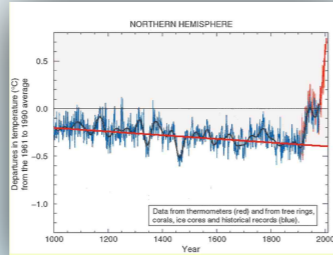


Well, while we're having this mini-excursion into the main topic, **what caused these changes and how big were they anyway?**

**That's not much, surely!**

**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.**

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.**



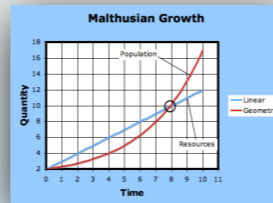
The average changes seemed to be *less than half of one degree...*

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 and where they might be grown.

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?

And what's wrong with that, Bruce? Surely it makes the process of learning more interesting?

So that's the *narrative arc* of modern scientific understanding, Bruce?



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 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.

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.

There's a lot of debate 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**. There's a lot of different things we *could* aim to do, **but making scientific sense is my aim**.

Something like that, Jane.







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 *Square Six*?**

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, Jane, ***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. As well, if we look closely at the history of science, **we find that it did not present a unified picture of nature,** but was an unstable field of different, often locally successful, but **just as often incompatible programs.** For example, Newton was a fervent **alchemist.**



**Four?** I don't hear of these new movies offering 4-D – **just 3-D to make them look real – like your *Stage 1*.**

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...**

Well – **the *fourth* dimension is *time*.** Those movies *are* actually 4-D – some take several hours – **with bags of action!**

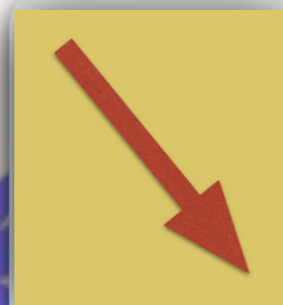
**Scary!** I can kind of grasp how the falling cannon ball looks like it's moving in one dimension – ie – *down*, rather than along – **a bit like when the kids drop a pencil out of the car** – it just looks the same as if they dropped it off the kitchen table – **it hits the ground underneath the car's 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?**

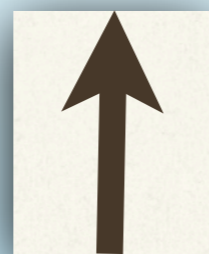
Or *x*-, *y* – and *z* – directions as we call them. **We treat time – or *t* – the same.** Imagine drawing a picture of where that cannon ball – or even the legendary Newtonian apple – is after a period of time. We draw a 2-D graph, **one dimension of which is *time*.**

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.**

So we are now surrounded by arrows like a Chinese Kung-Fu movie?



Move over, *Kandinsky!*  
Here we come!



It's a long way from an apple falling in your lap. **Verrry abstract!**

I guess that's what [Jackson Pollock](#) might have said to **Kandinsky**. But how does that play out with Galileo?



**That's a good line, Bruce.** What comes next?

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?

Not necessarily, Jane. This is where we take the next step to abstraction.

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.**

But not as abstract as it's going to get, Jane!

Alas! **At this stage we have to leave good ole' Galileo** – there was no doubt that he had made his point to the Pope.

Well, Galileo seemed to have been **stuck with the medium of geometry and arithmetic.** It was up to **Descartes to take the next step....**

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 and all that.** Where did the cannon ball come in?

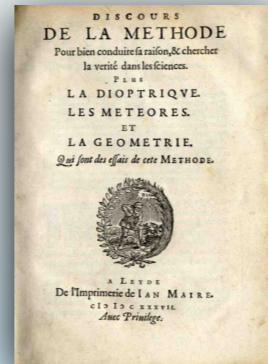
**So how come he didn't get into trouble with the Pope like Galileo?**

**Ok – so what did he do to advance the progress of abstraction?**

**More detail, please, Bruce.**



Yes, Jane, the very same Rene Descartes.

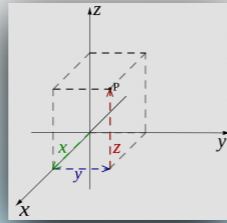


I guess that while you were tangling with his *cogitos* and *ergos*, **I was wrestling with his *sums* – or at least, his contributions to science and maths.** He was a pretty talented lad – he wrote about a lot of things, but most importantly for us today, **he set up science on its modern empirical foundations.** Galileo certainly practiced it, but it was up to **Descartes to write down the rules of engagement in his Discourse on Method.**

By practicing what he was preaching, perhaps – **a bit of empiricism to go with his rationalism** – 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.

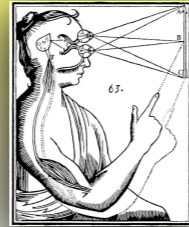
**In summary, he joined the dots and gave them a name.**

....And he gave them the cute names of  $x$ ,  $y$  and  $z$ .



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...

Like mind, body and spirit?



The very same ones. Each of them could be described separately from the others.

Sounds like Asperger's Syndrome to me – the guy seems to have had a dissociated personality – compartmentalizing everything in mental silos.

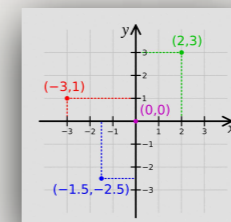
I guess so. He seems to have been consistent in separating these things from each other.

We are what we repeatedly do, Bruce. I rest my case about *Rene*.

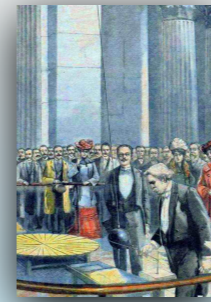
Sounds a bit harsh to me, Jane. But to some extent you're right. **Descartes wanted to put aside emotions and beliefs and focus exclusively on the world of the senses.**

It *is* if the habit becomes a compulsion.

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.**



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*.

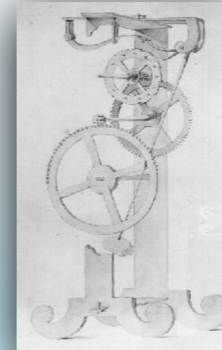


Maybe the pendulum has swung too far, Jane – there wasn't much respect for reason back in those days – **pioneers tend to overdo things a little.** We can stop now if it's all too much for you.

**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** invented the stopwatch – around 1700.

So how did they make accurate measurements of time?

Let's do the time-warp again!



Galileo did it by *slowing time down*.

Hmmm... I think that it was *flattened*, rather than *warped*. Galileo rolled small metal balls down a long board that he set on a slope – the shallower the slope, the slower the ball would roll. He used his subjective sense of time with bells, then made a timer using a water-clock – actually he used mercury – flowing out of a bucket with a tap into a cup – equal volumes of mercury 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?*

**But a ball rolling down a slope isn't the same as a ball falling straight down...**

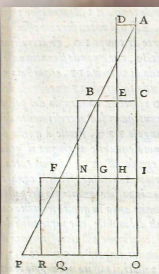
Apparently so. He was into *thought experiments*, but he also checked things out in reality. **That was Galileo's big contribution – *testing ideas*.**

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?**

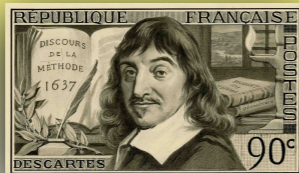


I'm inclined to agree with you, Jane – but **the greater the inclination, the closer it comes to reality.** That's part of the deal with what we call experiments – particularly **controlled experiments, where messy reality is simplified.** In this case Galileo set up a number of different experiments, which, together, covered most of the main issues.

No wonder the Pope had him locked up! Such language!



So – enter Descartes, left stage?

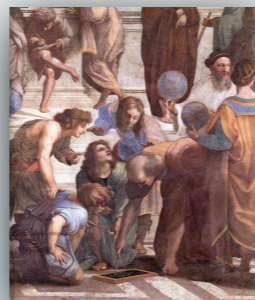


His body was going sideways while his mind was going forward, I presume?

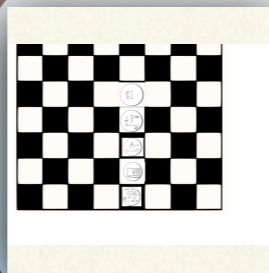


Galileo's scientific descriptions were limited by the state of the mathematics that was available at the time. He was able to make comments like:

*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 heights.*



Indeed – **that was the problem – language.** Galileo was able to describe his findings in **two ways** – one was using the **geometry** set down by [Euclid](#) 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' language** – as it is called – from Babylonian times.



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.



Steady, Bruce!

Let's give it a go!

...and three times three equals nine metres after three seconds...

Ahh! **The symbols!** They are an abbreviation of the words and literal pictures.

You're really 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...**

Sorry, Jane. There's no way around this, **but it is not hard to grasp...**

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...**



Yep – that's what we call **squaring** – although the actual rate of fall is a bit different than that. **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 Viète** – who introduced symbols in a **systematic** way – like  $x$ ,  $y$ ,  $z$  and  $t$  as well as little numbers near the top of those symbols to denote squaring, cubing and so on.



A marriage made in heaven! **But why didn't someone tell me this back in grade eight?**

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've drawn 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?**

Exactly. **That's algebra!** 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.

One of Life's mysteries, Jane. **That's why I got interested in this whole area of explanation in the first place.**

$$\begin{array}{ccccccc} 2 & 1 & 2 & & & & \\ \downarrow & \downarrow & \downarrow & & & & \\ 3x^2 & - & 2xy & + & c & & \\ \hline 3 & 4 & 3 & 4 & 5 & & \end{array}$$

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 woe*

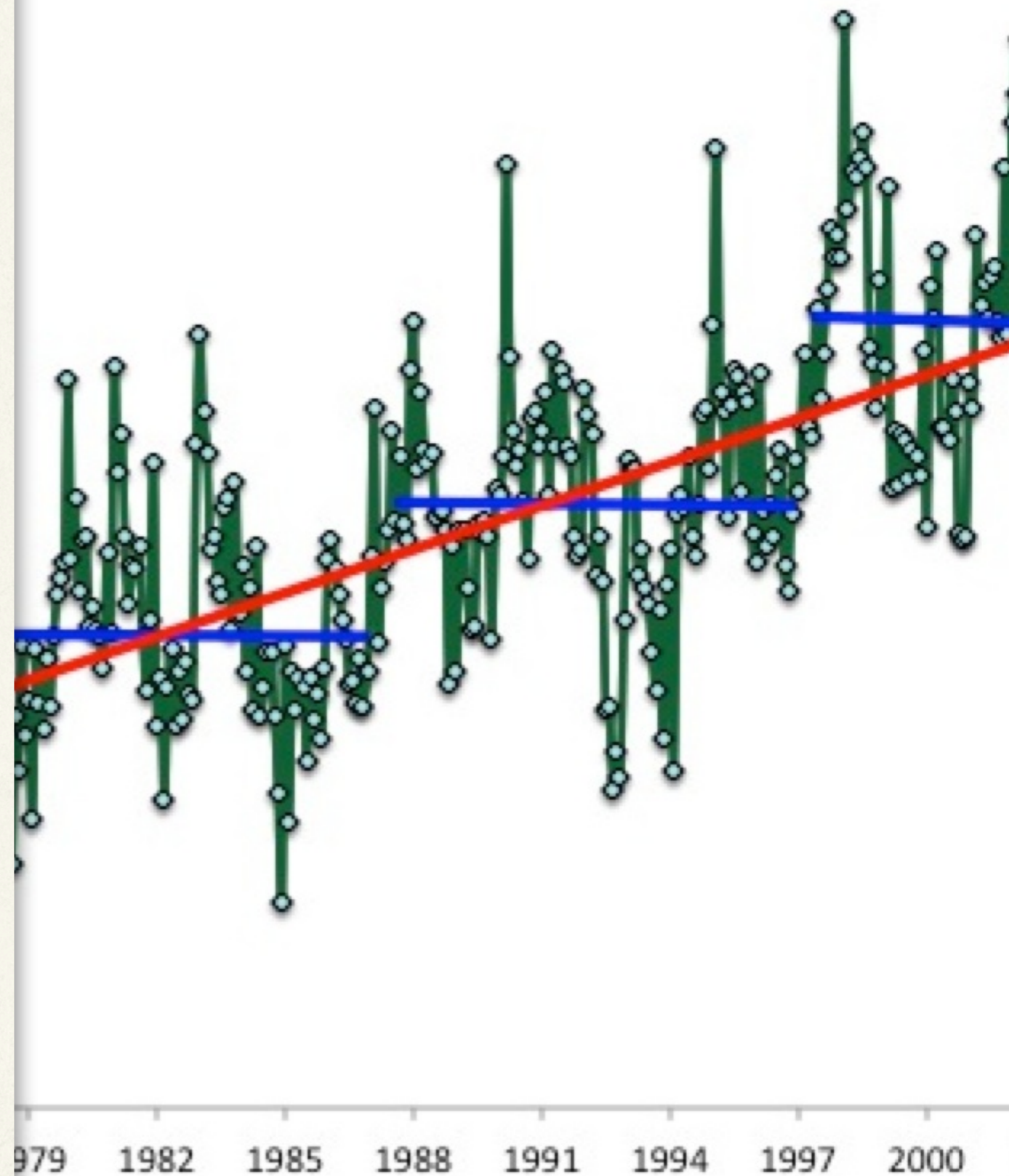


## Chapter 16

# JOINING THE DOTS

A brief interlude, in which Jane quizzes Bruce about how meaning can be extracted from a scattering of dots.

## "Skeptics" and Realists View Global Warm



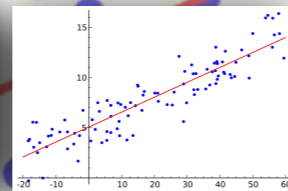
Something puzzles me about graphs, Bruce – you start with a bunch of spears – vectors you call them, then you draw a line from tip-to-tip, then say that a simple algebraic expression can represent that line...

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 or cannonball 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 in your dream* – a lot of them following an assumption that Nature's laws are simple. Why? Because it works better than any other assumption.

Works better at what?

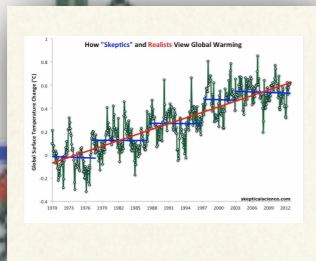
*Explanation of the past, control of the present and prediction for the future, I guess.*

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?

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**.

So much toil, so much trouble! But how do they come up with these *simple rules*, Bruce.

I can hardly wait, Bruce.

*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 praise.*



It certainly could. But that doesn't mean that the scientists are *wrong* – it just means that the *two-out-of-ten probability event* 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.



What scientists are seeking are simple rules that are **universal**. In a way, algebra is simpler in that it is compact and has only a handful of rules. I guess the problem is that along with its abstractness comes abstruseness – as only a few people seem to understand how algebra works, they are treated with suspicion like a coven of witches.

Ah! That's where the likes of Newton and the *eighth stage* come in!