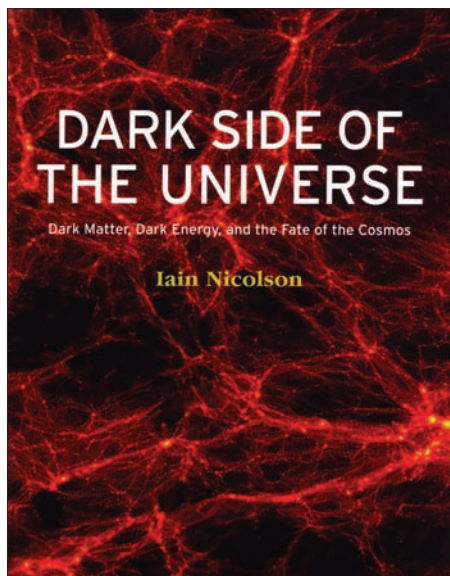


BOOKSHELF



Dark Side of the Universe. Dark Matter, Dark Energy, and the Fate of the Cosmos by Iain Nicolson, Canopus. Hardback ISBN 0954984633, £19.95.

If you are a particle physicist interested in cosmology, this book is for you. It makes a broad, clear and precise overview of our current understanding of dark matter and dark energy – the invisible actors governing the fate of the universe.

It is a challenge to try to make these apparently obscure concepts familiar to any motivated reader without a scientific background. But the author, Iain Nicolson, has been entirely successful in his enterprise. With a pleasant balance between text and colourful illustrations, he guides the reader through a fascinating, invisible and mysterious world that manifests its presence by shaping galaxies and the universe itself.

The book starts with an introduction to key concepts in astrophysics and the development of classical cosmology. It then describes the observational evidence for dark matter in galaxies and clusters of galaxies, showing that massive extremely dim celestial bodies cannot account for the missing mass. Particle physics is not neglected, with a description of our understanding of ordinary “baryonic” matter and the quest for detecting exotic weakly interacting massive particles (WIMPs). An entire chapter is also devoted to the idea that modified Newtonian dynamics (MOND) could be an alternative to the existence of dark matter. The second half of the book is devoted to cosmological

Summer Bookshelf

Summer for physicists is the season of conferences as well as (or instead of!) well-earned holidays, perhaps providing more time for reading about topics away from mainstream particle physics. In this Bookshelf, some of our regular contributors review a selection of less technical books for dipping into on the beach or on long plane journeys.

observations and arguments that suggest the existence of dark energy – an even more mysterious ingredient of the universe. The pieces assemble through these chapters to reveal a universe that is flattened out by inflation and that is essentially made of cold dark matter, with dark energy acting as a cosmological constant.

This new cosmology is generally accepted as the standard model and gives the full measure of the dark side of the universe. The visible matter studied by astronomers so far appears to be just the tip of the iceberg (less than 1%) and even baryonic matter studied so far by physicists is only about 5% of the mass–energy content of the universe. The remaining 95% is unknown territory, which the book invites us to explore using all techniques available. This will be the major challenge for physics in the 21st century. Marc Türlér, *INTEGRAL Science Data Centre and Geneva Observatory*.

Why Beauty Is Truth: a History of Symmetry by Ian Stewart, Basic Books. Hardback ISBN 9780465082360, £15.99.

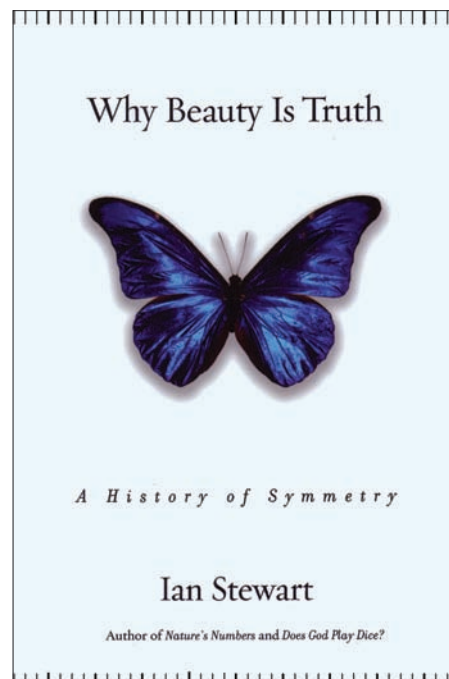
When I was at university studying physics, I used to think that symmetry was one of the most obscure topics that we were asked to digest. Indeed, symmetry is one of those concepts that at first appear clear and straightforward, but become increasingly distant and tricky when you really try to understand all of the implications.

In this book, Ian Stewart attempts to shed light on a fundamental question: why, at all, do we need to think of the universe in terms of symmetry? He guides us along an interesting historical path where all the names that you encountered in your studies – from Riemannian manifolds to hamiltonians and Lie groups – transform into real, “normal” people. He takes you to

a Babylonian school and then to a square in Paris where Galois is duelling – and dying – for love. The reading is enjoyable until you arrive at the physical description of our universe. Then, inevitably, it becomes harder to follow the multiple connections between physics and mathematics; again inevitably, the tough mathematical and physical concepts that lie behind our current knowledge of the laws of nature, are only “approached” in the final chapters and not really explored. So, no miracle then.

This is the second book by Stewart that I have reviewed and I was expecting a lighter approach to mathematical things, similar to the one that I had appreciated in *Letters to a young mathematician* (*CERN Courier* July/August 2006 p52). It turns out, however, that it is a hard task even for Stewart to explain symmetry in simple terms. I am relieved! Still, I really appreciated it and look forward to his next effort to make accessible the very abstract and distant ideas that science routinely uses.

Antonella del Rosso, *CERN*.



The Human Touch – Our Part in the Creation of the Universe by Michael Frayn, Faber and Faber. Hardback ISBN 9780571232178, £20.

British author and dramatist Michael Frayn is extremely bright and so multifariously talented that it must be difficult for him

to know in which direction to channel his prodigious energies. Frayn is best known for his translations of Russian classics, an impressive series of novels (including *Spies*) and some memorable plays – notably the classic comedy *Noises Off*. In 1998, he took a new direction with *Copenhagen*, a highly successful piece of theatre that imagines what happened when quantum pioneers Niels Bohr and Werner Heisenberg – each privy to different sets of nuclear secrets – met during the Second World War.

Remote and inaccessible, quantum science is the Cinderella of modern culture. Frayn, however, showed that – fleshed out with characters – it can make successful theatre. Emboldened by the success of *Copenhagen*, other authors have followed suit, while Frayn has ventured into much deeper scientific waters with his latest book.

In *The Human Touch*, he struggles to disentangle the actual universe from our perception of it. Words and language are what Frayn is good at, and there is some excellent analysis of the syntax in which such a conscious picture is based. On the other hand, he also acknowledges that the description ultimately must become mathematical (quoting Feynman's remark that no amount of intellectual preparation can make deaf ears experience the music of others), but the book has no mathematics. "A non-scientist (like myself) is a fool to

trespass in this great palace of thought," admits Frayn as he meanders on.

The essence is the "unresolvable paradox" of having to reconcile the 14 billion years of the existence of the universe with the fleeting timespan of human consciousness. Frayn's conclusion is that "the world has no form or substance without you and me to provide them; and you and I have no form or substance without the world to provide them in its turn". An example of this: "When scientists talk about objects that exist in space-time... it seems for a moment as if this makes them somehow independent of human experience."

Frayn acknowledges that Jonathan Bennett, his Cambridge philosophy teacher, sees the book's viewpoint as "anthropocentrism run amok". Anthropocentrism flourished when quantum mechanics revealed the bizarre role of the observer in the outcome of things, but became less important as quantum mechanics progressed to the bowels of the human intellectual digestive system.

The extensive footnotes display how Frayn has read far and wide, but not in any scientific depth. When he does tinker with real science, it is clumsy – as when he talks of "the discovery that imaginary numbers were a good model for the paradoxical behaviour of particles in quantum conditions" – and there is a puzzling description of the meaning of negative numbers. It is a rambling book with an index encompassing Democritus, Hitler, Newton, Ralph Waldo Emerson, Noam Chomsky, sexual arousal, Father Christmas, St Matthew, and oboes.

All books have errors. Here, the concept of the "arrow of time" was introduced by Eddington in 1927, not posthumously in 1958; the concept of zero, attributed to the Greeks, was imported from the Orient (the Arabic *zifr* is commemorated in our "cipher"); our understanding of the development of galaxies is somehow attributed to Victor Weisskopf; and the vital role of symmetry breaking in modern theory is confined to a mention of its role in the weak interactions of radioactive decay. Maybe this was something that Frayn felt he had to get off his chest. Having done so, he should return as quickly as possible to what he excels in: to entertain us and win more awards.

Gordon Fraser, *Divonne-les-Bains*.

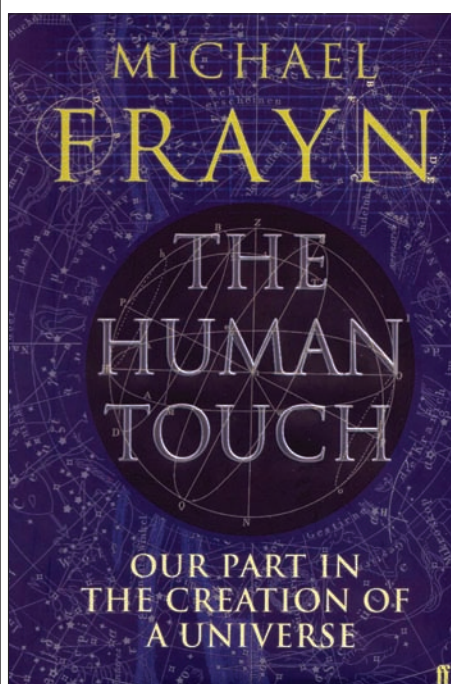


BANG! The Complete History of the Universe by Brian May, Patrick Moore and Chris Lintott, Carlton Books. Hardback ISBN 9781844425525, £20.

For 50 years, Patrick Moore has hosted the BBC's *Sky at Night* television programme. In this book, he has teamed-up with his current co-host, young astrophysicist Chris Lintott, and one-time astronomy PhD student Brian May, who also happens to be the lead guitarist with rock band Queen. The primary audience appears, at first sight, to be the general public. Indeed, most casual readers will be drawn to the hundreds of beautiful images of planets, stars and galaxies that form about half of the 180-odd pages and will be content with the fairly simple accompanying captions.

But with its subtitle *The Complete History of the Universe*, *BANG!* claims to be more than an attractive addition to the average coffee table. Chapters are arranged chronologically, beginning with "Genesis" (10^{-43} to 10^{-32} seconds A.B. – After Bang!) and progressing through the evolution of stars and planets, to life on Earth and ending some 18.7 billion years later with the "End of the Universe".

However, it appears that one of the chapters has been lost in editing: the time period 10^{-32} seconds to 300 000 years A.B. is missing, which will not win over too many particle physicists. The authors also fail to capture the imagination of the readers in the early chapters because it glosses over some of the basic mysteries of the universe such as the absence of antimatter ("due to reasons we do not yet understand").



The prose is often rather complex, and the beautiful images and simple captions, in fact, do little to help.

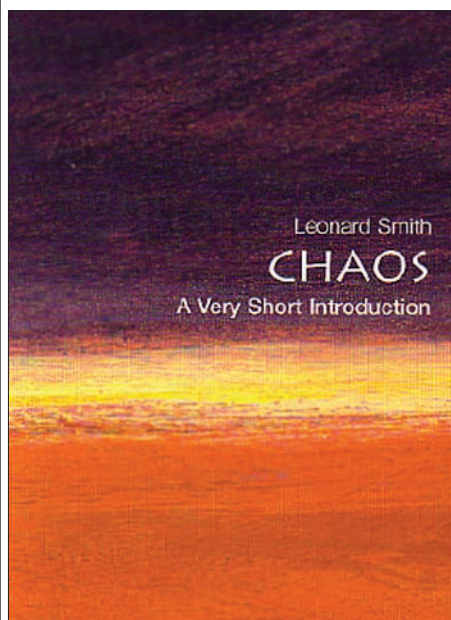
The later chapters are more rewarding. For example, the chapter on star and planet formation includes an excellent description of the development of our solar system and what might have happened if things had been slightly different – such as Jupiter crashing into the Sun and wiping out the intermediate planets. The book ends with a 15-page guide to practical astronomy for beginners – something that I found particularly valuable – and biographies of astronomers/physicists of the past hundred years or so.

Many people will buy this book simply because of the celebrity authors and the pretty pictures, but despite the misgivings mentioned above, *BANG!* has a lot to offer more serious readers.

Dave Barney, CERN.

Chaos: A Very Short Introduction

by Leonard Smith, OUP. Paperback
ISBN 9780192853783, £6.99.



The mission statement of OUP's Very Short Introductions series says they "are for anyone wanting a stimulating and accessible way in to a new subject". The volume titled *Chaos* deals with the mathematical and physical concepts behind those phenomena where small differences in the present state may have huge consequences in a future state.

I tried hard. Leonard Smith says that the

180-page booklet contains "no equations more complicated than $X=2$ ". This is perhaps the book's biggest weakness. I would have preferred some formalisms, and definitely a site from which one could download some models to run in simple spreadsheets. That would have helped.

Until I reached page 40, the text was amusing if not always very clear. After that, I think any interested layman with no mathematics background would certainly be lost. I kept going until page 60, at which point I became frustrated: the need to implement and observe working models of the book's examples soon became overwhelming. How many readers will have the skill and patience to write such models? And would that not defeat the idea of the concept of "a very short introduction"?

I do not doubt the author's competence in the field; mine is nil. The book gave me a set of more precise notions about what chaos is and what its governing aspects are; that alone was worth the considerable effort. Moreover, it is well-illustrated throughout and the glossary is good. But the book is an effort to read. Smith himself points out that it is difficult to define "a biology of non-elephants". Chaos comes in all the diversity of non-linear systems, and that makes the task of writing an introduction all but impossible. The result: many of the explanations are "chewy", making it difficult to recommend this little book to friends.
Robert Caillau, Prévessin, France.

The problems of physics by AJ Leggett,
OUP. Paperback ISBN 9780199211241,
£19.99.

Oxford University Press is now re-issuing some of its most-celebrated classics in the series Oxford Classic Texts. In *The problems of physics*, first published in 1987, Anthony Leggett presents an overview of the frontiers of physics at the time, aimed at the general reader. This includes chapters on cosmology and high-energy physics and also on condensed-matter physics, which is where he writes briefly on superfluidity, the subject of his Nobel prize in 2003. In high-energy physics, he covers the Higgs mechanism and provides, according to a reviewer, "one of the clearest [descriptions] I have come across". Unfortunately, the book is published exactly as it was in 1987, with no attempt to say what has changed in the past 20 years.

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The Newtonian Legacy by NJ Evans,
www.hep.phys.soton.ac.uk/~evans/NL.

There are many free novels available online, but this is probably the only one by a particle theorist. In this e-book, Nick Evans explains modern particle physics for a lay-readership as the background to a murder mystery. WPC Thatcher, a police officer who had previously studied physics, is leading the investigation into the death of a researcher at a physics institute. Her enquiring mind leads her also to ask questions about the Standard Model and beyond.

Reviews on Evans' web page show that his project is succeeding. Meanwhile, for readers of *CERN Courier*, the author has found a lost chapter – "Higgsless Dreams". Read on!

WPC Thatcher lay in the darkness, a disconnected consciousness in limbo. Stray worries competed for spare processing time as she tried to sleep, unaware of the room around her or the bed she lay upon. That is until her partner, sprawled next to her, gave out a loud isolated snore breaking the illusion.

Sometimes Mike's grunts would irritate her, but tonight they seemed tolerable or even endearing. Perhaps this was the result of pheromonal warfare between the sexes, she reflected – they had made love earlier.

She was awake after a run to the kitchen to get a warmed bottle of milk for her daughter who had balled for it at 3 a.m. She'd have managed five hours sleep by then – not enough, but sufficient to make a return to oblivion near impossible. She wasn't sure if she'd been awake hours or just minutes since then. Actually she was in that murky state of consciousness where she wasn't entirely sure she wasn't asleep.

The state of their bank balance was clammering for attention. It was near the end of the month and she had meant to check online. She'd worked really hard to ensure a £200 a month pay rise in the previous spring, but it didn't seem to make any difference to the bottom line a week before pay day. She could look in the morning, so why was she worrying about it now?

Think of something else then. Kissing Mike, his weight on top of her. Drowsy pleasure, the first hints of warmth between her thighs... well that wasn't going to get her to sleep!

Try again – work... she was investigating a strange death. A physicist at the local institute, called the Phi, had been found

dead in the grounds – it seemed to be connected to a chemical laboratory he was running at his home. Her degree, which had been in physics, although she could barely dredge up anything specific now, made her the best qualified of the police team to talk to the man's academic colleagues.

The Phi Institute was a centre for the study of theoretical particle physics. The staff seemed to spend their time dreaming up new theories of the most fundamental building blocks of nature – electrons and quarks and so forth, from which all materials are made. They took their ideas and then mathematically calculated the consequences for big experiments that collide particles together at enormous energies. They all seemed to have been waiting for years for an experiment called the Large Hadron Collider to switch on – this machine, in Geneva, Switzerland, will collide protons, creating fireballs with 10 times more energy than ever achieved before. The big hope apparently was to use this energy to create new particles through the famous Einstein $E=mc^2$ relation, which means mass is just a form of energy.

Now, she wondered, could she remember the thread of this? The main focus was trying to understand the weak nuclear force – a force involved in radioactive decay. The particles of matter have charge under this force, just as electrons carry electric charge. These charges interact through fields that permeate space, communicating the presence of one charge to another and controlling their attraction or repulsion. There are such fields for the weak force just as for electromagnetism.

Somehow those fields are like particles, she remembered. Ah yes! That's quantum theory – the energy in the fields turns out to be divided into lumps. If you interact with the field you might get given a lump of energy or two, but never half a lump. Those lumps of energy behave like particles – the lumps of an electric field are called photons (the same things that make up light, since light is an excitation of electric and magnetic fields).

Now the problem with the weak force lumps (the W bosons was it?) was that they were very massive, unlike photons that are massless. $E=mc^2$ again tells us they have some intrinsic energy associated with that mass that photons don't have. So you can't just simply adapt electromagnetic theory and get the weak force.

Enter the theorists – they all seem to

believe in this new particle called the Higgs boson. Their explanation was that all of space, even the vacuum between planets, is filled with vast numbers of these new Higgs particles. The Higgs particles have weak force charge so the W bosons keep interacting with them. It's like filling space with treacle; the Higgs particles impede the progress of the W bosons. The energy of that interaction is the W boson mass.

The only problem is that they've never made a Higgs particle. So, concluded the WPC, pleased with herself, that's what they're all looking for.

Is that really the only explanation, she wondered? There must be a theorist who's dreamt up another possibility, surely? Perhaps not? She should look on the internet – maybe she could learn something that would put the Phi staff off story!

Maybe she should really go to sleep? She rolled onto her side. She'd bought a sweater on Sunday – that might have pushed them overdrawn... for goodness sake... It's no good, she concluded, she was going to have to get up and check their bank balance.

Mike didn't move as she shifted to a sitting position and found her slippers. He had earned "midnight-milk-monster" duties for tomorrow she resolved. She padded out of the room across the landing and down the stairs. The first hints of dawn were creeping through the windows and, combined with the light they left on in the hall below, made her path clear.

She paused in the hall to examine her reflection in the large mirror hung on the wall. Her short blonde hair was crushed and askew and she had big black smudges under her eyes. The long, faded, white T-shirt with teddy bears across the front, which was all she was wearing, seemed overly twee. She'd used to look cute in it, hadn't she? Was she looking old or just feeling it? Still, who wants to be a cute policewoman? Some instinctive part of her subconscious still whispered against this rational conclusion.

The computer painted her in a blue glow from the desktop background when she moved the mouse. She summoned up a browser and clicked away to their account summary – it was as bad as she'd feared, though not quite overdrawn. Mike had been in town shopping last Wednesday, judging by the wracked-up debits. Funny, she thought, but he'd probably said and she'd forgotten.

Back to bed? Instead she Googled the

word “higgsless”. There were lots of hits – interesting... she clicked on one at random summoning the abstract of a scientific paper onto the screen. Kaluza Klein... moose... quiver... unitarity... Well, that was pretty unreadable, not to mention bizarre.

Suddenly some part of her brain had caught up with prior events and she found herself frowning. One of those payments from their account had been to Pink Moon – that was a lingerie shop in town. Another had been a chocolate shop. Her heartbeat raced a little and the blood drained from her face. Was Mike cheating on her? She tried to scan back through her life seeking other signs – it was just work and her daughter though. That didn’t seem very reassuring. Don’t panic, you’re being silly – he probably bought them for me, she thought. Not that it was her birthday anytime soon, nor Valentine’s. How about their wedding anniversary? He never remembered that and anyway it was five weeks away. God, she’d been doing so many late nights he could have been anywhere. Maybe she even deserved it then. The word “neglect” came to mind.

Cling to the wedding anniversary idea for a moment – she’d noticed only recently that their every weekend between now and then was booked up with children’s parties, visiting relatives and so forth. And she had made a big fuss about Mike forgetting last year. So she was accusing him of infidelity just because he was more organized than her. She was going to have to find the time to buy him something good now. The panic had ebbed away, well almost.

She clicked on a few more links to distract herself. Finally she got a PowerPoint show that made a little sense. It had been written by some mid-west US professor as part of his research group’s presentation to the Department of Energy for renewed funding. Interestingly, when they needed money these professors appeared to become a lot more comprehensible. She could imagine the panic as they tried desperately to make their talks accessible but not patronizing. Actually, she really could read this one, so the prof. had probably opted for patronizing in his own view!

Apparently the most urgent need for the Higgs was to solve a problem in the theory of scattering two W bosons. Without the Higgs, theory would predict that the probability of two Ws scattering was greater than one (What? If you flip a coin half the

time it will come up heads and half the time it will come up tails but it always adds up to one. Oh, that’s the problem!). If you include the Higgs then all is well.

The same job can be achieved by the inclusion of new heavier copies of the W particles, the presentation continued. It only works for a little bit though, if you give the Ws too much energy you get the same problem again. So then you add in yet more W particles to solve the problem again, and so on indefinitely.

None of this removes the need to explain where the W masses come from though. There seemed to be two ideas – firstly you could eventually resort to a Higgs (or many of them) to generate all these W masses. What you gain from the tower of Ws is that the Higgs mass could be much larger than it would be otherwise, so you might not find it at the LHC.

The second possibility was a bit more bizarre. Apparently you could choose to never end the tower of new Ws – every time you go to a higher energy you just keep finding a new W. If this happened it would mean you’d found an extra dimension of space! Weird.

There was a picture of a spatial direction (not up–down, sideways, or forward and back, but a new direction) which was a tiny circle. If you head off in this new direction you end up back where you started (this seemed to be an acceptable thing to happen, to this professor at least). This direction was going to be so short (smaller round than an atom is across) that in everyday life we’re oblivious to it.

Next there were pictures of the weak force field going round this circle. However it wiggled it always had to come back to the same value after going round the circle.



That means only very special weak force field configurations are allowed. Depending on how much they wiggle they have a certain amount of energy – that energy determines the mass of the associated W particles. You could always add an extra wiggle before you get back to the start so that’s why there is an infinite tower of more and more massive Ws.

Well that was kind of interesting. The mid-west professor had lost patience with his attempts at pedagogy at that point though and the following pages were a mass of equations that meant nothing to the WPC.

The slide’s use as a distraction was over and she was still stressing about Pink Moon. If Mike had bought her a present he’d have to have hidden it somewhere in the house. That wasn’t so easy for him because she did the washing and cleaning so she got to poke her nose most places. Modern equality culture required her to mentally qualify this thought with the point that they had tried an equal sharing of all duties but she’d just not been up to the physicality of cutting the hedge and painting over the stairs. They shared the cooking so the kitchen was out. Likewise the car. Well, she thought, that pretty much leaves the tool cupboard in the garage.

She was just left with the moral dilemma then. If she went to look it would be effectively accusing Mike and spying, wouldn’t it? She could just wait and see what happens on their anniversary. She wasn’t going to be able to think about much else in the meantime though.

She rolled the mouse to show her the final page of the physics presentation. Higgsless models were possible in principle but the extra Ws had to be rather heavy to explain why we hadn’t yet found them, and no completely satisfactory theory yet existed. These physicists always seemed to be waiting to find out the answer. She didn’t have their patience.

The WPC switched off the computer screen and walked out into the kitchen. She unlocked and opened the door into the garage. The fluorescent tube buzzed loudly when she switched it on – she hoped Mike was fast asleep. The car was on the drive so it was easy to reach and open the store cupboard. She realized she wasn’t breathing. Please God.

Garden tools hung neatly from hooks on the back wall of the cupboard. Stacked black plastic flower pots covered the shelf top. A large garden waste bag was on the floor, its top neatly turned over to hide its contents. She reached down to open the bag – her hand was shaking. Inside was a carefully placed Pink Moon bag.

The WPC crept back into bed next to her husband, mentally chastising herself. As she lay down Mike rolled over and blearily asked, “What are you doing? Did you go in the garage?”

“Can’t sleep, just mooching,”

“I thought you’d lost something important.”

“Nothing’s that crucial... except you.” They curled together and fell asleep.