University of New England, Biddeford, Maine: Core Connections Lecture, 3 March 2010

Changing The Way The World Works

By Walt Patterson

Does anyone here but me remember *The Book of Knowledge*? Twelve volumes, dark green covers with gold embossed lettering, about so big? My friend John Schaw had a set on the bookshelf in his bedroom in Ottawa. It was summertime, 1944. We were lying on his bedroom floor, reading comic books and scribbling on drawing pads. The comic book I was reading might have featured forgotten superheroes, adventurers in space. On my drawing pad I doodled a circle, then drew an ellipse around it. 'That's Mars', I said, showing John the drawing. He shook his head. 'Nope', he said. 'That's Saturn.' 'What do you mean?' I demanded, affronted. 'You've drawn a ring around it,' he said. 'The only planet with a ring around it is Saturn'.

'What are you talking about?' I showed him the comic book. 'There's a whole bunch of planets with rings around them.' John sneered, as only a small boy can sneer. 'That's a COMIC BOOK. Here, I'll show you.' He pulled one of the green-covered volumes of *The Book of Knowledge* off the shelf, opened it on the floor and pointed to the pictures on the page. 'There - see?' I peered at the black-and-white photo with its caption - Saturn, the ringed planet, the only planet with rings. 'That's real, that is,' said John. 'They took that picture with a telescope.'

I was dumfounded. Looking back more than 60 years later, I think that was the moment that I became aware of the difference between imagination and reality. You can imagine whatever your mind can conceive. But around you is a world you can see, hear, feel, taste and smell; and so can your fellow humans. I have no idea what you are seeing when you see the colour red. But we can both look at a rose, and - if we both speak English - we can agree that we will both call the visual sensation we each get 'red'. This outer world we all share has a particular reality, different from the worlds we can individually imagine. Anyone with eyesight can look through a telescope and see Saturn with its rings. We can each imagine other planets with rings; but - so far at least - no one can show the rest of us any ringed planet except Saturn. The reality we can show each other is a special kind of reality. We are each part of it; but it is more, much more, than any one of us.

I fell upon *The Book of Knowledge* and revelled in its vivid, eclectic variety. When I began to prepare this presentation I googled 'Book of Knowledge' and checked out AbeBooks online; full sets of the original from the 1930s and 1940s are now being sold for four-figure sums. *The Book of Knowledge* was one of the key influences that set me on the path of science, the fascinating activity in which we humans collectively explore, describe and try to organize what we might call our shared reality, the reality we can show each other.

My first science was astronomy - not practical, just theoretical, reading the *Book of Knowledge,* studying the photos of planets and comets and telescopes. The endpapers of the *Book of Knowledge* showed distances from the earth to other heavenly bodies, represented - this is the 1940s, remember

- by trains making the journeys. That was probably my first experience of a key aspect of science - comparisons using numbers, what I learned to call measurement. We pick something we can show each other, say a hand or a foot, and call it 'one'. Then we count how many 'hands' high the horse is, or how many 'feet' from one fencepost to the next, and so on. Instead of using vague comparison words such as 'taller' and 'shorter', we can rank horses in numerical order of height, and agree, perhaps, prices accordingly. Measurement is a key feature of sharing reality. It allows much more detail and much more precision than we can manage with words alone.

Astronomy was okay; but my interest in science took a dramatic leap forward, from theoretical to practical, when I got my first chemistry set. Most of you won't remember chemistry sets. Test tubes, litmus paper, little bottles and vials of crystals and liquids, exotic names like chromium chloride and potassium permanganate and carbon disulphide - thinking back I'm flabbergasted at some of the stuff they included for kids, chemicals we now know to be toxic, carcinogenic, mutagenic, banned from sale even to adults. I bought a bottle of liquid mercury at the local drugstore. I loved poking a puddle of it with my finger. Yike. In a basement darkroom I made colours, smells, fizzes and minor explosions, sometimes all together - great fun. But all the while I kept hearing about an even more exciting science - physics. Somehow I found several books about physics on the shelves of my friends' parents. I borrowed and read them, way out of my depth but fascinated, by atoms and electrons and neutrons and even stranger things, relativity and quanta, and heroic names like Curie and Einstein and Rutherford.

By that time physics was on the front pages - nuclear physics, the science that had created the atom bomb. I knew the names, Hiroshima and Nagasaki, but I had absolutely no comprehension of what had happened, hundreds of thousands of people killed by just two bombs. All I sensed, for instance from reading *Popular Science* magazine about the atom bomb tests at Bikini in 1946, was the seething excitement about this extraordinary subject of nuclear physics. I could hardly wait to study physics, real physics, at school, instead of just general science.

When anyone asked me why my favourite school subject was science, I had a ready reply. 'In science tests, you know when you've got the right answer.' I was contrasting science with, say, English or history, when your mark depended so much on what the teacher thought of your effort. Looking back, I'm embarrassed to realize that I had not the faintest idea of how science really works - that in good science your answer is always - <u>always</u> - provisional. Reading the physics books, out of my depth, I simply accepted the fact that different books explained the same things differently. At the time I didn't notice that one book might have been published in, say, 1913, another in 1922 and another in 1934, as modern physics churned through its hectic evolution and one provisional explanation was overthrown by another, only to be overthrown in its turn by yet another.

Decades later, I now know that astronomy, chemistry and physics are aspects of our shared external reality, as we attempt to understand and agree a satisfactory way to describe it. So are the many other manifestations of science in which we are all immersed. This shared external reality appears to have a continuity and a coherence. The science that we humans pursue as a collective activity, using observation, reason, numbers and logic, helps us to create a *story* for ourselves - a story about how the world works and where we fit into it, a story we can share, develop, amend, improve and anticipate, as we await what happens next. But the shared external reality of science is only part of the story.

Why, for instance, did I decide to study nuclear physics? Reason had nothing to do with it. Yes, it was intellectually stimulating. But it was also an elite pursuit, open only to the few, conferring exclusive status even on undergraduates. You were at a party, and she would ask 'What are you studying?' and you'd reply 'Nuclear physics' and she'd be really impressed. Throughout the entire body of science the very first question you ask is 'What shall I study?' In science, what you choose to study and why is not usually a rational choice. Indeed, these days, if you choose to study science at all, rather than, say, business administration, your choice does not look rational to most people. The story of how the world works is woven from shared external reality and individual imaginations, interacting and evolving.

In my case, I stumbled into a trap I didn't recognize for decades. In the 1960s, long after I took my postgraduate degree, I read a classic book by the American psychologist George Miller, called *Experience and Behaviour*. It pointed out explicitly a detail I'd been vaguely aware of but never really recognized. Most people - so I'm told - think in pictures. I don't. I'm one of the perhaps fifteen per cent of us who think in sound, particularly the sound of words. When I sit at a keyboard writing, I hear what I'm writing; I don't see it. My eyes are practically switched off. For a writer that's fine. But I only realized a few years ago a crucial corollary. Studying nuclear physics, trying to share the reality unfolding for my fellow physicists, I was confronted ever more intensively with mathematical symbols, on paper and blackboards - concentrated pictorial, visual metaphors for ever more subtle concepts and relationships. Although I didn't at the time know why, I found myself floundering, unable to think in these pictures. I could hear familiar equations such as 'E=mc squared'. But the written symbols of vector algebra, tensor calculus, relativity and quantum mechanics grew ever more inaccessible to me. My personal channel for sharing external reality did not correspond adequately to the channels used by my physicist colleagues. Although I'd been accepted to study for a PhD in nuclear physics at the University of Edinburgh I decided against it. Instead I began teaching physics, chemistry and mathematics in London, and trying to find out if I could write.

In 1968 my English wife Cleone and I found ourselves caught up in the ferment of concern boiling up from the west coast of the US and Canada, about a novel concept called 'the environment'. We read Paul Ehrlich, Barry Commoner and other commentators, about population and resources, about air and water pollution, waste, wildlife, wilderness and conservation, and about a science called 'ecology' that was suddenly front-page news. The following year three poets, one of them the future British Poet Laureate Ted Hughes, launched a magazine called *Your Environment*. When I learned that they intended to publish an article on radioactive waste, I offered to write it for them. At the time I knew almost nothing about nuclear waste, nuclear engineering or nuclear power; but I spoke the language. I was also deeply uneasy about the idea, then common, that only experts could make decisions about such abstruse technical subjects. After I did some months of serious homework the magazine published my first-ever bylined piece, entitled 'Odorless, Tasteless and Dangerous'. The article is now on my website archive Walt Patterson On Energy, www.waltpatterson.org. When I reread it not long ago I was stunned to see myself referring in 1970, forty years ago, to fossil-fuel power plants causing 'disturbance of the carbon dioxide balance in the biosphere'. About some problems, we've known far too long and done far too little.

The poets soon lost interest in the magazine. I became editor, until it finally folded two years later. By then, however, I'd attended the landmark United Nations Conference on the Human Environment, in Stockholm, and joined the staff of the new UK wing of Friends of the Earth, with

my wife Cleone's encouragement and support. For a year or so I remained a general 'environmentalist', a clumsy word still only vaguely understood. Then, in the autumn of 1973, 'energy' became front-page news around the world. It was not the 'energy' that I and my fellow physicists recognize, that scientists measure and analyze. For me as a physicist 'energy' was, and is, a profoundly important physical concept, a unifying principle that underpins what scientists understand about the workings of nature and the universe. For politicians and the media, however, 'energy' was a convenient shorthand for petroleum, coal, natural gas and electricity, lumped together as if they were all equivalent and interchangeable, an amorphous commodity called 'energy'.

In October 1973, with war in the Middle East, the Organization of Petroleum Exporting Countries, OPEC, quadrupled the world price of petroleum, shaking the global economy. Some western countries including the US also ran short of natural gas. In the United Kingdom, labour unrest in the coal mines eventually led the government to impose a 'three-day week' on industry, as blackouts loomed. This so-called 'energy crisis' eventually abated; but it made everyone except scientists think 'energy' means fuels and electricity. Global society is still in the grip of this debilitating misconception. I'll have more to say about that.

As the 'energy crisis' unfolded, I found myself, rather to my surprise, becoming an 'energy campaigner'. I have been one ever since. At the time, I was far too busy to stop and think what an 'energy campaigner' might be or do, because I was doing it. I was caught up in major controversies about offshore oil and nuclear power, challenging the plans of the UK government and the electricity industry, doing frantic homework into technology, ecology, economics and politics, learning on the job. I was finding out in real time and high definition how the world works: how major decisions get made, by whom and why, what drives the evolving story.

At the time, Friends of the Earth was a tiny cluster of citizen troublemakers with almost no money and absolutely no political power. All we had was a handful of intelligent, capable people who did not like what was being done by those who did have the money and the power. But not liking what the powerful were doing was only the starting point. Simple protest was not enough. Only by making our case strong enough to convince others - students, journalists, broadcasters, members of the public, some politicians - could we apply sufficient social and political pressure to those in authority, those making the decisions, and challenge them to think again. That meant that we ourselves had to understand what the authorities intended to do and why. We had to explain, to ourselves and others, the technology, the economics, the environmental impact, the social and political implications of any official proposal we decided to challenge. We then had to explain, in detail, why it was not a good idea. In essence, we troublemakers had to make our story better - more credible, more coherent, more persuasive - than that of our opponents in government and business.

We campaigned, for instance, against killing whales; against wasteful packaging; against trade in endangered species; against confiscating land to build offshore oil platforms; and against new nuclear power stations. For each campaign we developed our own version of the story, the version we wanted to happen, the version we wanted the rest of society to accept and endorse. Our story had to be scientifically accurate. But our story also had to appeal directly to groups of other people with different agendas, on an appropriate emotional level. We researched and prepared wide-ranging material, explanatory, educational and polemic by turns. We published academic reports with references; learned papers for scientific journals; serious articles for serious newspapers; popular articles for popular newspapers; posters for bulletin boards; and slogans and badges for supporters.

We did street theatre to attract attention, sometimes funny, sometimes sombre. We made as many television and radio appearances as we could. But everything we did in a campaign had to be based, as far as we were able, on solid factual substance, on the kind of reality that anyone interested could cross-check and confirm. We did not squander effort on heroic but futile gestures. We launched a campaign only when we ourselves found the case convincing. We campaigned to win; and often enough we did.

My energy campaigning for Friends of the Earth was dominated by a succession of controversies about nuclear power, testing our campaigning skills to the limit. To demystify nuclear power and make campaigning easier, I wrote a book about it, a Penguin book just called *Nuclear Power*, first published in 1976. The final edition came out in 1986, a week before they blew up Chernobyl. The book eventually sold about 130 000 copies in English, and appeared in five other languages. It's now available as a free PDF download on my website archive, and is still downloaded more than 300 times a month. Even though it's now nearly 25 years old, far too much of it is still relevant in the alleged 'nuclear renaissance' that nuclear promoters, politicians and media now proclaim. As the home page on my website archive says, we have been here before.

Through the 1970s and 1980s I was caught up in so many nuclear controversies that I could hardly keep track - in the UK, the US, Germany, Italy, Norway, Sweden, Switzerland, Spain, Austria, Canada, Australia, New Zealand, Japan, Hong Kong and, at length, the Soviet Union, with the explosion of Chernobyl. The stories were more or less the same every time. The story told by the nuclear promoters was about a future of cheap, reliable, safe nuclear electricity; but some of us told a different story, about a shared reality already on the historical record, a factual international public record from the 1950s to the 1980s, of costly, unreliable and - once in a while - terrifyingly dangerous nuclear power technology, against an ominous background of nuclear weapons.

By the end of the 1980s I thought our story had prevailed. Electricity companies clearly believed it. Nuclear plant orders had slowed to a trickle; in most places they had stopped entirely. I was bored with the sound of my own voice, reiterating arguments that had hardly changed since the early 1970s. I was eager to move on to more rewarding work, and I did - on the newly exciting topic of electricity itself. To my astonishment, after more than two decades as an international troublemaker, I was invited to become a fellow of the oldest independent policy research institute in the world, the Royal Institute of International Affairs, known as Chatham House, in London. Chatham House plays host to world leaders, presidents and prime ministers, chief executives of multinationals and other major players from all over the world. It holds meetings and conferences and publishes studies about critical policy issues of every kind - the key stories that shape global society. When I joined the staff, electricity was becoming just such an issue, one that I've been working on at Chatham House ever since.

Those of us in the rich part of the world take electricity for granted. You probably can't remember the last time you turned on a light. We also, most of us, still take for granted the traditional electricity story, which is now more than a century old. It goes like this: very large power plants a long way off generate electricity, and send it out to users over vast networks of wires. If you use electricity - and in the rich parts of the world we all do - you assume that someone else will keep your lights on. All you do is throw the light-switch and pay the electricity bill. It's a good story, as long as it works - and for most of the past century it worked fine, at least for us lucky ones.

Unfortunately, however, some two billion of us - a third of humanity - still don't have electric light; and traditional electricity is not going to reach them, ever. Indeed, as populations increase, traditional electricity may even be losing ground. Meanwhile, in rich countries, as old dirty power stations reach the end of their lives and 50-year-old wires under city streets deteriorate, even those of us lucky enough to live here are having more and more trouble keeping the lights on. The old traditional electricity story no longer works, not well enough for this twenty-first century.

Fortunately, an exciting new electricity story is now emerging, very different from the old one. You've probably heard bits of it already - about 'smart grids', micropower, making your own house a power plant and so on. I've been immersed in this new story for almost twenty years. I've already written two books about it, and I'm working on a third. The first book was called *Transforming Electricity*, and the second *Keeping The Lights On*. That one has just come out in paperback. They're not for specialists; they're written for general readers, for people who use electricity without thinking about it. For me, however, thinking about electricity has convinced me not only that the traditional electricity story no longer suffices, but that we need to revise our whole story about energy in human society.

Start with this word 'energy'. What do you think it means? Does it mean oil? coal? natural gas? Does it mean electricity? They are not the same. They are not interchangeable. But calling them all 'energy' makes too many people, especially politicians, think they *are* the same - that one can substitute for another. We talk about 'energy supply', when we really mean 'oil supply' - not the same as 'gas supply' or 'electricity supply'. The very way we talk about energy, the story we tell ourselves, is fundamentally wrong. As a result we are managing energy wrong.

Why do we need these supplies? That is the key detail we so often ignore. We need fuels and electricity to *run stuff*. What matters is the *stuff* - lamps, motors, electronics, appliances, industrial plant, vehicles and especially buildings. This stuff, this user-technology, provides what we want - comfort, illumination, motive power, refrigeration, mobility, information and communication. The *technology* is what matters. Oil by itself is almost useless. Natural gas by itself is downright dangerous. Electricity as we use it does not even exist by itself. It's a process in technology. Fuels are only useful *because of technology*. Moreover, the better the technology the less fuel it needs to deliver the services. You'll hear that called 'energy efficiency'. I call it 'energy performance'.

Governments have been telling us for decades that we have to reduce our use of energy. I am a physicist, and a pedant; and I'm telling you that governments are wrong, wrong, wrong. I know what the word 'energy' really means. It's the unifying principle of the entire universe, as our science understands it. We can use as much *energy* as we want. That's how the universe works. But we have to reduce our use of *fuel*. The distinction is not just pedantic. It is crucial. Using fuel is why we worry about what politicians call 'energy security', but ought to call 'fuel security'. Using fuel is the main reason why we are upsetting the climate. That's why electricity is the key to a sustainable energy future. Electricity will help us to reduce our use of fuel.

Fuel is a substance. Coal, oil or natural gas comes out of a hole in the ground at a particular place. If you want to use it somewhere else you have to carry it there, often now over many thousands of kilometers. Electricity is not a substance. It is a process. If you have the right technology you can generate electricity anywhere, in any quantity from minute to vast. In particular you can generate it close to where you want to use it, in a versatile variety of ways.

Human society uses two different kinds of electricity. One we generate using the stored energy in fuel, such as coal, oil, natural gas or uranium. The other we generate using technology to convert natural energy flows into electricity. This electricity, including hydro, wind, photovoltaic, solar thermal, wave, tidal and geothermal, *does not use fuel*. It is produced and delivered not by combustion or any other reaction but by the functioning of physical assets, what we call 'infrastructure'. Most people call this kind of electricity 'renewable', a term I dislike because it's meaningless. I call this electricity 'infrastructure electricity'. Once the turbines or panels or other installations are in place and functioning, whenever the natural energy flow is available the infrastructure converts it into electricity, for us to use however we wish.

Do you see how this story might develop? To me the implication is obvious. Using fuel the way we do threatens the security of our energy services and the climate of the only planet we have. Of all the ways we use fuel, generating electricity is the easiest to change. To get better, more reliable, more universally available and sustainable electricity services, we should be intending, and planning, to move as rapidly as possible away from fuel-based electricity to infrastructure electricity, for every feasible application, all over the world.

My current project for Chatham House and the University of Sussex Energy Group is called 'Managing Energy: for climate and security'. Changing the way we manage energy will change the way the world works. My old friend Amory Lovins gives a striking example of the possibilities. It goes like this: we know three ways to make limestone into building material. We can cut the limestone into blocks; we can roast the limestone using fuel in a furnace at 1200 Celsius to make cement; or we can *feed the limestone to a chicken*. Weight for weight, eggshell is one of the strongest materials we know. But we don't know how the chicken does it. What's more, the chicken does it not at a high temperature but at a chicken's body temperature, close to our own. As we change the way we manage energy, I'd like to think we can move beyond the brute force of extreme high temperatures, especially combustion temperatures from fuel, to make human energy systems and processes converge toward those we see in living nature.

I'm trying to take radical ideas such as this and develop them into an alternative vision of energy in society, a coherent, persuasive story I can tell. But that's only the first step. The vision I'm looking for will be pointless if it exists only in my own imagination. It will be worthwhile only if it also resonates in other imaginations, including yours - only if it becomes a part of our shared reality, our common story about our world.

Looking at our world in 2010 we can see all too many problems. Getting energy right will not solve them all. But if we don't get energy right the other problems may become insoluble. We can and must change the way the world works. We can start immediately, by changing the way we think about it. It will be challenging, exciting and exhausting: but if we do it right it will also be *fun*. Let's do it.

Walt Patterson is associate fellow in the Energy, Environment and Development Programme at Chatham House, London, and visiting fellow in the Sussex Energy Group, University of Sussex. His latest book is Keeping The Lights On: Towards Sustainable Electricity *(Chatham House/Earthscan 2007, paperback 2009).*