

The new age of ignorance

We take our young children to science museums, then as they get older we stop. In spite of threats like global warming and avian flu, most adults have very little understanding of how the world works. So, 50 years on from CP Snow's famous 'Two Cultures' essay, is the old divide between arts and sciences deeper than ever? Here we ask a celebrity panel to answer some basic scientific questions, while overleaf, you can test your own knowledge



TIM ADAMS
It is an immutable law of nature that acute embarrassment can make a few short seconds last pretty much for ever. The longest two minutes of my life occurred in the company of James Watson, one half of the famous double act who discovered the double helix. I was interviewing Watson, then in his late seventies, at his lab in Cold Spring Harbor on Long Island. At one point, I referred blithely to the 'perfect simplicity' of his and Francis Crick's findings about the code of life.

Watson is a mischievous, famously prickly man and that phrase seemed to get under his skin. He raised an eyebrow. He sat back. He thought he would have some fun. Seeing as it was all so perfectly simple, he suggested, maybe I could briefly run through my understanding of DNA base pairing, say, or chromosome mapping.

What followed – a tangled, stuttering stream of consciousness reflecting distant O-level biology and recent half-understanding of Watson's brilliant books, punctuated with words like 'replication' and 'mutation' and meaning nothing much – gave new resonance to the notion of floundering.

Watson, resisting the temptation to laugh, correct or comment, simply moved on, having categorically established our respective levels of evolution. I can still cringe now at the brief pause that concluded my ill-judged aside on the significance of the genome.

Given that science informs so much of our culture, and so many of us have such patchy knowledge, it is surprising that such embarrassments are not routine. It's half a century since CP Snow put forward the idea of the 'Two Cultures', the intractable divide between the sciences and the humanities, first in an article in the *New Statesman*, then in a lecture series at Cambridge and finally in a book. Back then, Snow, who was both a novelist and a physicist, used to employ a test at dinner parties to demonstrate his argument.

'A good many times,' he suggested, 'I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice, I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold; it was also negative. Yet I was asking something which is the scientific equivalent of: have you ever read a work of Shakespeare's?'

Fifty years on, and exponential scientific advance later, it seems unlikely that the response of dinner guests would be much different. I was reminded of Snow's test when reading the new book by Natalie Angier, science editor of the *New York Times*. Angier's book is called *The Canon*, and subtitled 'A Whirligig Tour of the Beautiful Basics of Science'. It is not a long book and it contains, as the title suggests, a breathless Baedeker of the fundamental scientific knowledge Angier believes is the minimum requirement of an educated person.

In many places, I found myself cringing all over again. I've read a fair amount of

popular science, tried to follow the technical arguments that underpin debates about global warming, say, or bird flu, listened religiously to Melvyn Bragg's *In Our Time*, but still I discovered large black holes in my elementary understanding of how our world works. Angier divides her book into basic disciplines – biology, chemistry, geology, physics and so on – and each chapter offers an animated essay on the current established thinking.

The result is the kind of science book you wish someone had placed in front of you at school – full of aphorisms that help everything fall into place. For geology: 'This is what our world is about: there is heat inside and it wants to get out.' For physics: 'Almost everything we've come to understand about the universe we have learned by studying light.' Along the way there are all sorts of facts that stick: 'You would have to fly on a commercial aircraft every day for 18,000 years before your chances of being in a crash exceeded 50 per cent', for example; or, if you imagined the history of our planet as a single 75-year human life span: 'The first ape did not arrive until May or June of the final year... and Neil Armstrong muddled up the Moon at 20 seconds to midnight.'

Angier also gives as clear an insight as I have read of CP Snow's culture-dividing Second Law of Thermodynamics, the law of entropy, the one that states that in any system inefficiency is inevitable and eventually overwhelming. 'Entropy,' Angier writes, 'is like a taxi passing you on a rainy night with its NOT IN SERVICE lights ablaze, or a chair in a museum with a rope draped from arm to arm, or a teenager.'

Entropy, unusable energy, leads to the law that states that everything in time must wear out, become chaotic, die. 'The darkest readings of the Second Law suggest that even the universe has a morphine drip in its vein,' Angier suggests, 'a slow smothering of all spangle, all spiral, all possibility.' No wonder CP Snow thought we should know about it.

For all of its infectious analogies and charged curiosity, the most telling fact about Angier's book is that it seems to have been written out of sheer desperation. It

THE PANEL

We asked three writers, three scientists and two broadcasters to answer six questions and their answers appear to confirm the divide.



JOHN O'FARRELL WRITER
Author, broadcaster and comedy scriptwriter.



IAIN STEWART GEOLOGIST
Stewart presents a new TV series, *Earth: The Biography*, this autumn



WILL SELF WRITER
Novelist, short-story writer, critic and broadcaster.



SUSAN GREENFIELD SCIENTIST
Author of several popular science books about the brain.



KIRSTY WARK BROADCASTER
Political journalist and presenter of BBC2's *Newsnight*.



MARINA WARNER WRITER
Novelist, critic and cultural historian, in particular of female myths.



ROBERT WINSTON SCIENTIST
Human fertility expert and science TV presenter.



DAISY GOODWIN TV PRESENTER
TV producer and presenter, editor of several poetry anthologies.

is something of a cry from the wilderness; impassioned, overwrought in places. It is written in the voice of someone who has spent her whole award-winning career evangelising about this amazing stuff and is facing up to the fact that most people have not even begun to 'get' any of it.

Angier's tipping point, the reason she came to write the book, was a decision made by her sister. When the second of her two children turned 13 the sister decided that it was time to let their membership lapse in two familiar family haunts: the science museum and the zoo.

They were, the implication went, ready to put away childish things, ready to go to the theatre and the art gallery, places where there was none of this 'mad pinball ping-pong from one hands-on science exhibit to the next, pounding on knobs to make artificial earthquakes'. They had grown out of science.

Angier believes this idea – that science is something for kids – still pervades much of our thinking, and characterises the presentation of science in culture. Part of it is the notion that argues science is just a bunch of facts with no overarching coherence. Just as bad are the media, which insist on ghettoising science and serving it up as clichés: scientists as boffins, with permanent bad-hair days; science as controversy, always set up for polarised clashes with religion.

'Science is rather a state of mind,' Angier argues and, as such, it should inform everything. 'It is a way of viewing the world, of facing reality square on but taking nothing for granted.' It would be hard to argue that this state of mind was advancing across the globe. We no longer make and mend, so we no longer know how anything works.

One of Angier's interviewees, Andrew Knoll, a professor of natural history at Harvard's earth and planetary sciences department, suggests that 'the average American adult today knows less about biology than the average 10-year-old living in the Amazon, or the average American of 200 years ago'. I spoke to Angier to find out why she thought that this might be the case. To some extent, she sug-

gested, that was a political question. 'Here in the US we have had the last seven years of this administration which has made everything about the two-cultures divide worse.' But it is not just that. 'Newspapers are getting rid of all their science pages; they are jettisoning all their science staff. The feeling is people don't want to read it.'

The implications of this, and the resultant general scientific illiteracy, she believes, are possibly catastrophic. Forty-two per cent of Americans in a recent survey said they believed that humans had been on Earth since the beginning of time. 'A geophysicist friend suggests we are at a critical crossroads just like the start of the Renaissance,' Angier says, 'where you couldn't just leave reading and writing to the kings and priests anymore. Ordinary people have to keep up. In the world we live in, the new economy, you have to become scientifically literate or you will fall quickly from view.'

It is, apparently, not just America that does not want to hear this news. Foreign rights to Angier's book have been snapped up in auctions by publishers across Asia and Eastern Europe, 'countries that see themselves as the economic future', but she has not, for example, sold her book in the UK, a place, we might remember, where 20 per cent of people still believe that the Sun revolves around Earth. 'I tend to see that as a tiny little sign that some of these more aggressive competitive nations are more aware of what the future looks like,' Angier suggests.

She believes this persistent apathy in matters of science in America and Britain comes in part from a lack of interest in what the future might hold. 'In the 1960s, we had the space race, we had

these world fairs and the whole idea of the future was very exciting. Science was something they wanted to be involved in.' You could hope that the apocalyptic panic that attends climate change, the front pages of floodwaters rising, might have a similar effect. 'Whatever you think of him, Al Gore has been great for science,' she says.

Angier's initiation into the 'beautiful basics' was brought about by a professor at the University of Michigan, who taught a 'phys-

ics of music' class. The walls between the two cultures came tumbling down every week. 'There were kids from the engineering and physics departments and then there were kids from the music departments. I was just in there on my own. But the way he brought us together was an extraordinary thing,' she recalls. 'Both groups were kind of ecstatic; this guy would get standing ovations at the end of every lecture. So I guess I saw that bridging that gap might be something to

strive for in life in terms of engaging people.' This kind of engagement, a sense of a bigger picture in science, its poetry and mystery, is no doubt all too rare. In a 2005 survey of British teenagers at school conducted by the exam board OCR, more than half said they thought science classes were 'boring', 'confusing' and 'difficult'. Just 7 per cent believed that scientists were 'cool' and when asked to pick out a famous scientist from a list including Isaac Newton and Albert Einstein, a fair few chose Christopher Columbus.

Some of this Angier believes has to do with the way science is taught – 'I go through these science books for kids and they are so dull compared to the novels that children read... I think that you have to make it an epic journey, a narrative with heroes and villains, molecules engaging in this struggle for life.' A lot of it, however, is cultural, she believes. Numbers of students still studying science at 18 are falling in Britain and America, perhaps because we are becoming generally less motivated to address difficulty.

As a culture, we allow ourselves too many excuses. 'Western parents are quite comfortable saying their children have a predilection for art or for writing or whatever, and allow them just to pursue that. In the Asian education system, if you are not good at something, it's because you are lazy and you just have to work harder at it. Just because things are hard does not mean they are not worth doing.'

That idea of difficulty, I suggest, cannot really be helped in the States in particular, when all of the presidential candidates of one party stand up in televised debate and say they believe in 'intelligent design' and suggest that the world could well have been created by a bearded God a few thousand years ago. Angier laughs, somewhat bleakly.

'I see all that as a macho kind of posturing. It's like, I can believe the impossible: look, I can lift a tree! It is a Republican initiation ritual, like having a hook pulled through your cheek and not flinching.' But no, she concedes, it doesn't help much.

Some people would suggest that Natalie Angier's enlightenment utopia, in which everyone might one day agree on the fundamentals of the universe, the beautiful basics, is a false ideal; the mass has always believed in mumbo-jumbo. One of these people is John Brockman. Brockman has probably done more than anyone to break down CP Snow's cultural divide. He is the PT Barnum of popular science, a great huckster of ideas. In the Sixties, he hung out with John Cage and Andy Warhol, got an MBA and then made his first fortune selling psychedelia to corporations, turning on marketing executives with 'multikinetick happenings' and showing them how their profits could levitate.

These days, he acts as literary agent for many of the world's greatest minds, including Richard Dawkins, Daniel Dennett and Steven Pinker, and achieves for some of them the kind of publish-



Q. Roughly how old is the earth?

JOHN O'FARRELL
I'll have a guess. About 100 million years?

WILL SELF
I'm completely winging this. A couple of billion years? No? Give me right on that. Mark me up.

IAIN STEWART
This I am sure of: 4.5 billion – no, actually 4.6 billion years.

DAISY GOODWIN
Pass. This is embarrassing.

MARINA WARNER
That I don't know. (I did actually just hear Melvyn Bragg's programme this week about very ancient worlds.) I'm not very good at figures.

ROBERT WINSTON
Well, the universe is 13 billion or 14 billion and the earth is between 4 and 5 billion years old.

KIRSTY WARK
More than 5 billion years.

SUSAN GREENFIELD
Oh blimey. Well I know that human beings have been going for about a million and a half years, so... I'm just grasping here. Something like 60 billion years or something like that, but that's a grasp. I'm not a physical scientist and it shows. I'm probably not scientifically literate.

ANSWER: 4.5 billion years.



WILL SELF
In my house, very little, because I never get round to changing the bulbs. You complete a circuit?

IAIN STEWART
This is taking me right back to school physics. It's the kind of question I always pray a nine-year-old won't ask me. I think the switch closes a loop for the circuit.

KIRSTY WARK
It gets brighter. There's a current... that connects between two protons.

MARINA WARNER
The energy is conducted along the wire to the filament.

JOHN O'FARRELL
I'm running out of steam here. I really don't know.

SUSAN GREENFIELD
There's a flow of electrons called a current, and it's that flow which is the energy and generates heat and light.

ROBERT WINSTON
Well you fall in love, don't you? Isn't that what it is? No, Okay, when you turn on the switch you make a circuit.

DAISY GOODWIN
You connect a circuit.

ANSWER The switch controls the flow of electricity through a circuit – a complete, unbroken loop through which electric charges can move. When the light switch is on, these electric charges can move in an endless loop. This loop begins at a power station where the charges pick up electric energy. They then flow through wires to the light switch, then to the light bulb where they deliver their electric energy, and finally back to the power company to obtain more energy.

Q. Is a clone the same as a twin?

WILL SELF
No.

IAIN STEWART
Yes, er, I think... oh God, it's probably not. But I think it has to be, doesn't it?

JOHN O'FARRELL
No. How could it be the same? That's not how cloning works, is it?

SUSAN GREENFIELD
Yes. An identical twin.

DAISY GOODWIN
As an identical twin? That's quite interesting. No, Well, I'm not sure about that. I'd say no. But maybe yes. I'm baffled.

KIRSTY WARK
No. But there's two different kinds of twin. You have to give me a point for that!

ROBERT WINSTON
Well, not necessarily. It's not genetically the same actually, no. You see, it depends on the kind of twin. Do you mean an identical twin? Identical twins are different in all sorts of ways. It's different epigenetics and there's different mitochondrial DNA, so it's a different organism. Actually, what we're beginning to understand is that the epigenetic aspects of cloning are fundamentally very important. And twins are rather more dissimilar than people imagine, too. For example, they have different fingerprints from each other, so there are quite interesting and subtle differences.

MARINA WARNER
Yes it is. Well, identical twins are clones, not non-identical twins.

ANSWER: Yes, up to a point (see Robert Winston's answer).



Twins: Big Brother contestants Amanda, left, and Sam Marchant.

ing advances that it takes great mathematicians to compute. It is Brockman who invented the publishing market for quarks and quantum theory and black holes in the 1990s, and it is he who is behind the current boom in atheism. The universe may be infinite, but Brockman takes 15 per cent of it.

He also runs a kind of global online Royal Society called Edge. Edge promotes what he calls the Third Culture, a marriage of physics and philosophy, astronomy and art. The name itself derives from a phrase of CP Snow's outlining his personal hope for the future. Brockman, when launching his Third Culture in 1991, had significant ambition for the project, much of which has been realised. 'The Third Culture consists of those scientists and other thinkers in the empirical world who, through their work and expository writing, are taking the place of the traditional intellectual in rendering visible the deeper meanings of our lives, redefining who and what we are,' he suggested, grandly.

Though Brockman borrowed Snow's phrase, he did not employ it in the same way. Snow had hoped for a kind of detente between the rival mindsets; Brockman perceived a third way. 'Literary intellectuals are not communicating with scientists,' he suggested. 'Scientists are communicating directly with the general public. Traditional intellectual media played a vertical game; journalists wrote up and professors wrote down. Today, Third Culture thinkers tend to avoid the middleman and endeavour to express their deepest thoughts in a manner accessible to the intelligent reading public.'

Brockman's cross-fertilising club, the most rarefied of chatrooms, has its premises on his website www.edge.org. Eavesdropping is fun. Ian McEwan, one of the few novelists who has contributed to Edge's ongoing debates, suggests that

Q. What is the Second Law of Thermodynamics?

WILL SELF

It's either the conservation or the dissipation of energy, isn't it? It's everything tending towards entropy, isn't it?

IAIN STEWART

It's about the conservation of motion, I think, but I'm not sure. Different field from mine, you know.

JOHN O'FARRELL

Let me think. Is it to do with heat conductors? Metal is an effective heat conductor and wood is not. I remember that from metalwork classes.

MARINA WARNER

Is it that mass cannot be... that no energy

can be lost? The first law is conversion. Is the second law that there is no loss... that energy must go somewhere?

SUSAN GREENFIELD

That everything degenerates to entropy.

ROBERT WINSTON

I've always refused to answer that question on a matter of principle, simply because of C P Snow, and you can report that. But it is in one of my children's books.

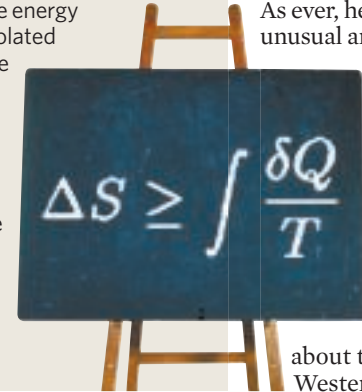
DAISY GOODWIN

Don't know. I'm scientifically illiterate.

KIRSTY WARK

No idea.

ANSWER: It is the Law of Increased Entropy. It states that in any system the quality of energy deteriorates gradually over time. 'Entropy' is defined as a measure of unusable energy within a closed or isolated system (the universe for example). As usable energy decreases and unusable energy increases, 'entropy' increases. As usable energy is irretrievably lost, disorganisation, randomness and chaos increase.



the project is not so far removed from the 'old Enlightenment dream of a unified body of knowledge, when biologists and economists draw on each other's concepts and molecular biologists stray into the poorly defended territory of chemists and physicists'.

Brockman is at the hub of this conversation. When I phone him, he is waiting for a call from maverick geneticist Craig Venter about an invention that will 'put new operating mechanisms into genes' and radically change our idea of life; earlier, he has been speaking to George Smoot, the Nobel-winning astrophysicist who first identified the background radiation of the Big Bang and thereby invented cosmology.

From where he is sitting, the Two Cultures no longer applies, the Third Culture has long-since prevailed.

'Basically, in terms of whatever war

has been going on, I think it has finished,' he says. 'I don't characterise it by saying we've won. I think everybody has won. We are living in a profound science culture and the big events that are affecting people's lives are scientific ones.'

What about Natalie Angier's anxiety that these ideas have not trickled down, that, if anything, scientific thought seems to be on the retreat?

'Since when have the masses of people had any ideas anyway?' Brockman asks. 'It is always a certain percentage of people who do the thinking for everybody else. What is changing,' he argues, contrary to Angier's perception, 'is that the media people, who used to have no thoughts of science, now sit up. Science makes the news.'

I wonder why there are still so few literary contributors to Edge, which has remained a predominantly scientific and

philosophical forum. Is there not some evidence there that the divide persists?

Brockman explains how Edge evolved out of a group called the Reality Club that held actual meetings with scientists, artists, architects, musicians. Ten of the leading novelists in America were invited to participate. Not one accepted.

'We are talking about Vonnegut, Updike, Mailer, John Irving,' Brockman says. 'Ian McEwan is one of the first writers to jump feet-first into the world of science and embraced it wholeheartedly. But we still have never had a novelist come to one of these events. Neither have we had a major business person. Maybe getting up in front of a group of Nobel-winning scientists to talk might be intimidating for these people. Maybe they are too busy.'

Brockman's optimism is infectious, and, at his elite level, the battle may have been won, but further down the food

chain, the forces of reason are still compromised by the culture.

When I had recovered a little of my composure with James Watson, back in Cold Spring Harbor, I asked him how he thought the climate of scientific research had changed since he made his fateful discovery of the structure of life in 1953. As ever, he came at the question from an unusual angle. He doubted, he said, that in today's world, he and Francis Crick would ever have had their Eureka moment.

'I recently went to my staircase at Clare College, Cambridge and there were women there!' he said, with an enormous measure of retrospective sexual frustration. 'There have been a lot of convincing studies recently about the loss of productivity in the Western male. It may be that entertainment culture now is so engaging that it keeps people satisfied. We didn't have that. Science was much more fun than listening to the radio. When you are 16 or 17 and in that inherently semi-lonely period when you are deciding whether to be an intellectual, many now don't bother.'

Watson raised an eyebrow, fixed me again with a look. 'What you have instead are characters out of Nick Hornby's very funny books, who channel their intellect in pop culture. The hopeless male.'

As James Watson knows perhaps more clearly than anyone alive, biology works in mysterious ways.

HAVING TOO MUCH FUN

Making science 'fun' is not the answer, says Tim Adams. Read his blog at:

► observer.co.uk/commentisfree