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PRESIDENT'S MESSAGE

Purpose and Intent

Lisa Durkin

When Intelligent Design was put on trial in Dover Pennsylvania we were all thrilled when it was exposed for what it is – religion in a lab coat. In the case of Kitzmiller vs Dover Area School District, Judge Jones had to determine the purpose and intent of the contested policy. The plaintiffs needed to prove that the Dover school board had a religious intention behind their policy, which not only encouraged teachers to teach intelligent design, but also demanded that they read a statement challenging the validity of evolution. The statement claimed that evolution is not a fact, is riddled with "gaps" and is not the only theory that explains our origins. What Judge Jones determined was that Intelligent Design is indeed a fancy term for creationism and the purpose of the new policy was to bring religion into the classroom via Intelligent Design.

The anti-evolution crowd found that their tactic to rename creationism with a scientific sounding term did not make it science and that teaching creationism by any other name is still illegal. What is yet to be determined is how challenging evolution, in the attempt to undermine its validity, will play out. The phony "gaps" mentioned in the contested Dover school board statement has become the centerpiece of the current creationist strategy. Creationists are preparing for a new battle and this time they have carefully sterilized their language. It still carries the same purpose and intent however. Creationists have synchronized their efforts with the media and "creationist" scientists, to sell their ideas in a smoke-and-mirror type subterfuge designed to bamboozle the public while maintaining their religious supporters. Creationists may not be able to legally teach Intelligent Design, but that has not stopped their attempts to undermine evolution theory in the public school classroom.

Local Activity

Meanwhile, New Mexico creationists have dragged out yet another bill trying to strengthen their position. The "gaps" of the Dover school board statement have evolved into "strengths and weaknesses" of evolutionary theory in a bill that supports the "academic freedom" of science teachers. Across the nation, such "academic freedom" bills are being launched in several states to encourage science teachers to examine the "strengths and weaknesses" of evolution. The intent is to eradicate the godless view that humans evolved from lower species instead of being created by God, as found in the literal account in Genesis. This is a theological debate, since not all Christians subscribe to a literal interpretation of the Bible. Politicians who produce and promote legislation that attempts to invalidate evolution through "strengths and weaknesses" language are asking that teachers not only promote a specific, anti-science, Christian viewpoint in science class, but they are also miring science teachers in a theologically contentious situation. The creationists' purpose is not to promote quality science, as they claim, but to eradicate "atheistic" evolution science, paving the way for God-driven miraculous human origin.

Creationists are in a pinch because they are desperate to make their latest tactic appear scientific, while keeping their religious constituency supportive. If the religious agenda behind the rash of new "academic freedom" bills

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were exposed, they could find themselves back in court. A judge could easily see that the purpose of "academic freedom" legislation is not to promote critical thinking in the science classroom, but rather the same old creationist religious agenda. The question is whether a judge would find this latest attempt illegal. While promoting religion in public school is against the separation clause, teaching bad science is not illegal. It is no surprise that this is the latest tactic taken by creationists. The Discovery Institute has been working overtime crafting a template for bills promoted across the country.

The latest creationist strategy has been timed and executed carefully so that it appears innocent to the uninformed, unwitting non-science community. The flurry of legislation was carefully timed with the production and release of a major motion picture "*Expelled: No Intelligence Allowed."* The "academic freedom" bills innocently state that teachers will be protected by the legislation so that they can teach the strengths and weaknesses of evolution, and students are protected so they can give critical responses in class. Who wouldn't want teachers to have the freedom to encourage students to use critical thinking in the classroom? Every "academic freedom" bill contains disclaimers which contend that the bill does not promote the teaching of religion in the science classroom, and Intelligent Design is never mentioned.

Jonathan Wells

No action taken by creationists underlined their new tactic better than Jonathan Wells' visit to Albuquerque in January. Wells is a creationist who studied under Reverend Moon, and found evolution so contrary and dangerous to his religious view that he made it his moral imperative to topple evolution theory. He went to college and obtained a doctorate in biology for the specific purpose of having greater clout in the argument. Wells is dedicated to his calling. It is no surprise that months before his visit, creationists, using the Discovery Institute template, persuaded a state legislator to introduce another "academic freedom" bill that was also carefully timed with the release of the *"Expelled"* film. It is as if a Discovery Institute memo was sent out to participating churches that stated: Step one; find a legislator who is sympathetic to your cause. Step two; give him or her a copy of *Expelled*. Step Three; once the Discovery Institute-inspired legislation has been launched, find a creation scientist to speak at the hearing. Step four; Jonathan Wells will come and speak the language of biology in an effort to drive support for the science behind the "academic freedom" legislation. For the next step I can imagine there will be an "All-Call to All Real Christians" to drum up support at the final hearing including a letter-writing campaign. Supporters may attend a viewing of *Expelled* one more time, to rally fervor.

I attended the Wells presentation with less fervor than many in attendance, who nodded in unison every time Wells made a stab at undercutting evolution science. He kept the presentation completely sanitized

of religion to underscore the serious "science" content that he was espousing. He repeatedly mentioned that biology colleagues were in the audience, but not one of them spoke up against his generous misuse of biological phenomena. Overall, Wells was compelling if one is biased toward his point of view. He gave excellent fuel for a fire that burns to expose and expel the evils of materialistic evolution science. It would have been interesting to survey the biologists in attendance to see who was swayed by his arguments. His target audience was those like the man who later walked to the parking lot with me. He works at Sandia Labs and thought the presentation was great. He was invited by a colleague and seemed assured that his way of thinking was validated. I see letter writing in his future and felt compelled to reason with him, but know from experience that once the zeal of creationism strikes a person, there is no going back.

A real biologist would not have been intimidated by the biological vocabulary, and have seen right through the smoke-and-mirror subterfuge. In fact, one biologist did ask the penetrating question: whether heritable characteristics that were not governed by DNA were mutable. Wells had to admit that they probably were, which would constitute evolution by another mechanism—which renders Wells' entire argument moot. A person would have to connect the dots to understand how damaging the question was. (The questioning biologist only nodded at Wells' response and allowed him to continue uncontested—but exposed.) Wells tried hard to avoid talking about religion, but most of the responses from the audience were from biblical literalists who wanted to know how Wells' message fit with their faith, or wanted clarification on rudimentary biological fundamentals. Wells was patient with the ignorant and highly uncomfortable with the pointed religious questions. I have to admit that I enjoyed watching him squirm. What is good news for those in the quality science camp is that the audience was only about 70 people. If even half were outside the biblical literalist arena, then only 35 people could have been swayed.

Conclusion

More than anything, I wanted to stand up and tell all of the biblical literalists, especially Wells, that their fight is divisive and doesn't suit the purpose of Christianity as a whole.What is worse, their proposed legislation would cause New Mexico students to slip further behind in their understanding of science. That is the fruit that Wells and the Discovery Institute would bear. Like it or not, evolution is a cornerstone of biology, and teaching it well will make people better informed to make wise decisions about themselves and the world we live in.

Will there be a day when America wakes up and realizes that these religious conflicts are counterproductive? Keep your ear to the ground for notification of our own efforts to thwart the New Mexico creationists yet again.

Jonathan Wells' Seminar on Science, Origins and Design

Wells' seminar at UNM Law School on January 20 was hosted by Tech Net, a creationist anti-science group which is currently lobbying the legislature to pass an anti-evolution bill. Wells' visit was timed to coincide with the bill. Since creationists can no longer supplant evolution with creationism, creation science, Intelligent Design, or any other religious notion of human origins, they have begun a new campaign whose primary purpose is to invalidate evolution with bogus "strengths and weaknesses." As long as the purported "strengths and weaknesses" remain sterile of religion there is a chance that they will be promoted in the public school classroom, or so the creationists hope. Never mind that they represent bad science because good science is never the intent no matter what the creationists claim.

The Wells presentation was supposed to represent the solid science behind creationist claims that evolution – or what they call Darwinism – is invalid, weak and riddled with errors. Jonathan Wells was a student of Reverend Moon and a member of the Unification Church. His moral imperative is to destroy acceptance of evolution theory. This was his motivation for obtaining a PhD in biology at UC, Berkeley. Wells is a Senior Fellow at the Discovery Institute and published "*Icons of Evolution*" in 2002.

The seminar was attended by perhaps 70 people. It was hard to tell who was a creationist and who was a biologist in the audience. I suspect the guy with J-E-S-U-S on his shirt was leaning toward the creationist end of the spectrum. Wells' presentation was about embryos and how they develop. His main contention was that DNA does not control embryonic development as evolution theory implies. His presentation was so deep in specific concepts in advanced embryology that only a person with an advanced biology degree would be qualified to comment. Many people in the audience asked questions and

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seemed assured that Wells was correct in his assertions that evolution theory is bad science. Their questions did not show any real understanding of the subject. The biologists that Wells claimed were present did not argue or belabor any of Wells ideas. It would have been interesting to take a survey when the presentation concluded as to how many biologists were in attendance and what they really thought about the presentation.

We were able to obtain Wells' PowerPoint slides from the presentation, so I asked a real biologist about them. Dr. Rebecca Reiss, a biology professor at New Mexico Tech, and a CESE board member, was kind enough to comment on what Wells had to say.

Our Q and A follows.

Q—Lisa Durkin & A—Dr. Rebecca Reiss

Q1. Jonathan Wells' main point for his talk was the contention that DNA does not control embryo development. What role does DNA play in embryo development? Is this as poorly understood and new to the world of biology as Wells proposes?

A. It is true that the DNA of a newly-fertilized embryo does not take control of development for the first few divisions; the mother's DNA is in control during very early development. The egg is packed full of nutrients (especially proteins) by the mother so development can proceed until the new nucleus can take over. The evidence for this is the existence of maternal effect mutations, which are changes in genes expressed during development of the egg, so their effect isn't noticed until after fertilization. Rest assured that DNA plays a major role in development, but early in development it's actually the DNA of the previous generation that is in control.

Q2. The chain of reasoning for Wells is that the "Darwinian" understanding of embryonic development demands that, "the instructions for how the egg develops into an adult are written in the linear sequence of bases along the DNA of the germ cells." How accurate is this assertion?

A. First, there is no separate "Darwinian" understanding of embryonic development. Second, the germ cell DNA does not control development until after fertilization, at which time it's no longer germ cell DNA, but is half of the inherited genome. Third, the environment plays a role that we don't completely understand; an example is fetal alcohol syndrome.

Q3. Jaques Monod is quoted by Wells as saying, "With. . . the understanding of the random physical basis of mutation that molecular biology has provided, the mechanism of Darwinism is at last securely founded, and man has to understand that he is a mere accident." Is this a common belief among biologists?

A. Molecular biology provides important evidence for evolution and development. Mutations may not be so random; we know there are regions of the genome that are more likely to be mutated (known as hotspots). When a scientist claims that something is random, we really mean that we haven't yet determined the pattern. The idea that life is just a happy accident is being challenged by chaos theory, which suggests that self-organization is a characteristic of matter, not just an accident. Stuart Kauffman's book *At Home in the Universe* provides a great summary of this discipline. In addition, there is new evidence that the environment can effect change in the DNA and that some of these changes are inherited.

Q4. Wells claims that differentiation of cells happens due to spatial differences in the early embryo which cannot come from DNA. He asks where the spatial differences come from. He contends that two heritable sources of spatial information are the centrosome and the cortex, both of which are not encoded by DNA sequences.

A. The centrosome and parts of the cortex are proteins, which are coded for by DNA. For proper development of the egg, these proteins are made by specialized cells (called nurse cells) in the mother and are transported into the developing egg. Prior to fertilization, the egg has one centrosome, but it needs two to divide. The second centrosome is supplied by the father and enters the egg with the paternal nucleus. This signal

triggers the spatial information necessary for development. The developing embryo is sensitive to environmental signals, which obviously are not coded in the DNA, but can affect the DNA.

Q5. The centrosome and cortex can be manipulated to completely change embryonic development. What bearing does this information have on the role that DNA plays in the development of an embryo? Is Wells correct to assume that it is these cellular structures that provide the blueprint for embryonic development, not DNA; and biologists have it all wrong due to the fact that they have been operating under evolution science assumptions?

A. The centrosome and cortex interact to set up cell division, which includes the division of the genetic material (mitosis). The plane in which the cell divides is determined by this interaction, which provides the spatial information for concentration gradients to form, which trigger further development. If you change the relative locations of the centrosome and cortex, embryonic development will be affected. The cortex and the centrosome are critical to development, and they are coded for by DNA.

Q6. If the cortical cilia are altered by microsurgery, the new cortical arrangement will be inherited by many generations. How is this possible without mutating the DNA of the cilia?

This example is from *Tetrahymena*, a single-celled protozoan that reproduces by dividing. One distinguishing feature of *Tetrahymena* is the rows of cilia that push food (bacteria) into the mouth. It is possible to microsurgically invert the cilia so they push food in the other direction. The claim that the inverted cilia remain after several generations is true, but the reason is simple; these protists simply divide, so there is no place for the inverted cilia to go but into the next generation. The inverted cilia are not inherited in the genetic sense, they just persist in subsequent generations. *Tetrahymena* do have a sexual mode of reproduction that is induced by starvation conditions and involves two cells joining and exchanging nuclei. There is no production of egg or sperm that must fuse to create the next generation because after the exchange the cells separate and the new nuclei take over the cell function. In both sexual and asexual development, the inverted cilia will become less frequent since they are diluted out by newly produced cilia, but they won't disappear.

Q7. Here is Wells' conclusion:

- The floor plan of the embryo is in the form of spatial information that precedes DNA differ entiation.
- Some of this spatial information is carried by the centrosome and cortex.
- There is evidence that both the centrosome and cortex are heritable independently of the DNA.
- **So DNA does not determine all the essential characteristics of living things. It is necessary but not sufficient for embryo development.**
- The idea that genetic programs control embryo development is not an inference from evidence, but a deduction from neo-Darwinian evolutionary theory.

Can you explain what is really going on here?

A. The spatial information is triggered by the entry of the sperm by fertilization. A centrosome may be supplied by the sperm and can define the plane that subsequent divisions take place. In turn, a concentration gradient of other gene products is established in response to the plane of cell division. The centrosomes are part of the cell division machinery and are made of protein, which is coded for by DNA. Centrosome and cortex proteins are made by cells during gamete production, so the proteins are supplied independently of the embryo's DNA. DNA cannot produce a new

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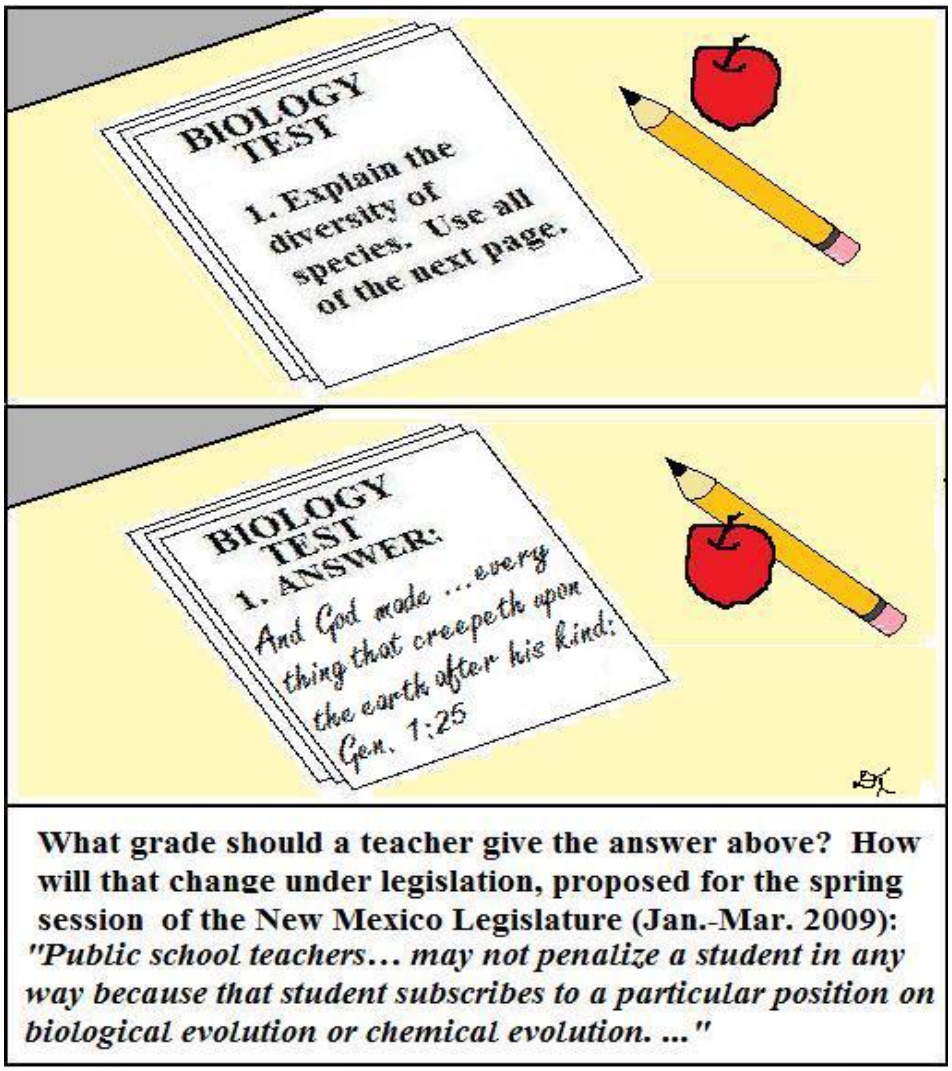
organism without having a cell surrounding it, so the environment plays a significant role in development. At least Wells admits here that DNA is necessary for development since one might assume from his title that the DNA has nothing to do with development. Wells conjures up this idea that there is some "Darwinian" conspiracy that ignores evidence. It is ironic that he ignores scientific evidence (such as the centrosome is made up of protein) when it doesn't fit his hypothesis.

Q8) One biologist (see p. 3)asked if the spatial information was mutable. Wells could not give a definitive answer to the question. If spatial information is mutable, then wouldn't that mean that the spatial information can evolve since it is heritable? Wouldn't that render Wells' argument useless?

In reality, the spatial information in the developing embryo is triggered by fertilization and involves differential gene expression. Of course these factors are mutable since they are gene products. But you are absolutely correct— these arguments are useless. They are also a distraction from bioethical issues raised by advances in the field of developmental molecular biology. While Wells and the Intelligent Design movement are finding conspiracies everywhere they look in science, we are learning how stem cells differentiate. These cells hold the key to rejection-free organs and to human cloning. But since ID/creationists don't accept the science that has gotten us this far, they must not be interested in the medical miracles (and nightmares) that will be facilitated by this new technology.

Toon by Thomas



What grade should a teacher give the answer above? How will that change under legislation, proposed for the spring session of the New Mexico Legislature (Jan.-Mar. 2009): ***"Public school teachers… may not penalize a student in any way because that student subscribes to a particular position on biological evolution or chemical evolution. ..."***

http://cesame-nm.org

The Meaning of Methane on Mars

Methane on Mars: Read all about it. First, online preliminary publication in *Science*, one of the world's top two scientific journals. Then a full dress NASA press conference and release, informing us that "Methane suggests Mars is not dead." Press coverage throughout the world, with at least two newspapers in Britain stating (quite incorrectly) that we now know there is life on Mars. By the time you read this, the print version of *Science*, a very sober document, will at last have appeared in the print version of *Science*. But didn't you read something about methane on Mars more than five years ago? Yes you did. The current work builds on what was done earlier, in very important and significant ways, but one does not have to be a cynic to wonder about the timing of the announcement, and whether it is meant to catch the eye of the new administration in Washington.

For reasons all too understandable, NASA presents its science as a series of firework displays. This is a most regrettable distortion, however inevitable in an age of instant celebrity and instant amnesia. As politicians like to say, it sends the wrong message. The reality of scientific activity is much more like the building of cathedrals, an incremental process spanning generations. Breakthroughs can indeed be dramatic, but science as a whole is patiently constructed from converging lines of evidence as surely as Chartres is constructed from converging vaulted arches.

The present advance brings us closer to an answer to questions that were raised before I was born, but I do not expect that they will be finally settled until long after I am dead. Is there life on Mars? A century ago, the answer seemed to be yes, and the Lowell Observatory at Flagstaff was originally built in large part to investigate more closely apparent visual clues ("canals") that we now know to be totally illusory. The first flyby of Mars, Mariner 4 in 1965, measured the density of the atmosphere from how much of a reflected radio signal was absorbed, and showed it to be less than 1% that of Earth. We now know the surface to be cold, dry, and strongly oxidizing, the result of the planet's relatively weak gravity, greater distance from the Sun, and the action of ultraviolet light dissociating water vapor into hydrogen, which escapes into space, and highly reactive fragments such as hydroxide radicals. It is difficult to see (although the versatility of life continues to surprise us) how any organisms can survive on such a surface, so if life ever existed on Mars, it could now survive only at depth. Such life forms would need to lie beneath the frozen surface, where the internal heat of the planet once again made liquid water stable, and would derive their energy from chemical reactions involving water, rock, and carbon dioxide. Ecosystems of this kind exist on Earth, and their ultimate metabolic product is methane.

Before 2003, there was no evidence for methane on Mars. Since then, three separate groups have reported its existence. The evidence depends on the infrared absorption bands of methane in the light reflected from the planet's surface, and comes from two separate sources. The most glamorous is the Mars Orbiter, part of the European Mars Express mission. The most reliable is patient data collection and analysis by earthbound telescopes.

The Orbiter spectrometer is a small and of necessity a relatively crude instrument. Moreover, it cannot really select any one area as it whizzes round the planet. But it does show that detectable amounts of water vapor are present in the Martian atmosphere, and also smaller amounts of methane, with a rough upper limit to the amounts of both. That's about all it can tell us. To tell more, we need high-resolution spectrometers, which can resolve separately the forest of closely spaced lines that make up the infrared absorption band.[1] There is no prospect of sending such an instrument to Mars, so we have to make do with earthbound observations.

The earthbound telescopes used for this work are attached to telescopes on Hawaii, high enough to be above much of the Earth's atmosphere. Even so, the absorption spectrum of methane in the Earth's atmosphere gives a much stronger signal than anything that could be hoped for from Mars, so the problem is to separate the two. Here, a variety of techniques were used. First of all, the Earth's own infrared absorption spectrum was measured by analysis of starlight. This was further checked against an elaborate computational model, taking account of the amount of methane in the Earth's atmosphere at different heights and temperatures. Finally, the observations on Mars were

[1]A note for spectroscopy fans: the band in question corresponds to the infrared active C-H stretching mode. The vapor phase spectrum acquires structure because of coupling between stretching and rotational modes. There is additional structure for methane, because spectroscopically it is a mixture of three separatekinds of molecule, depending on the relative orientation of the proton nuclear spins.

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carried out at times when the planet was moving away from us at 10 km/sec or more, causing a shift in the frequency of absorption bands of about one part in 30,000. Not much, but enough to help separate out the terrestrial and Martian signals. The observations we are discussing were carried out over a period of three Mars years (seven Earth years), and covered 90% of the planet's surface.

The results were unambiguous and unexpected. Yes, the earlier observations were right in telling us that there was methane in the Martian atmosphere, and we now know how much. What was unexpected was that this methane is unevenly distributed, in both space and time.

The methane appears to come from a source near the planet's equator, and to be spread out northwards and southwards by eddies in the atmosphere. In 2003, there was enough methane to constitute 6 ppb on average of the planet's atmosphere, but by 2006, there was only half as much. Clearly the methane is being liberated and destroyed on a relatively short timescale.

Methane is destroyed by ultraviolet light, and it had been expected that this would be the main means of removal. We know how efficient this process is, and how much ultraviolet light falls on Mars, so we can predict the half life for photochemical destruction. The answer turns out to be 320 years, too long by a factor of a hundred. However, we know that the surface of Mars is extremely strongly oxidizing, so it seems quite likely that reactions at the surface and, even more importantly, with windborne dust can account for this disappearance.

Since, as we have seen, the surface is strongly oxidizing, it follows that the methane is being produced at depth. The seasonal effect can then be explained by such things as softening and cracking of the subsurface ice which we know exists on Mars. So there is a reservoir of methane below the surface. Almost certainly, it is in the form of what is called "methane hydrate," a *clathrate* compound in which molecules of water pack round a molecule of methane to trap it within an ice-like overall structure. Such clathrates are believed to exist on Earth in massive amounts. They are stable at low temperature and high pressure, are thought to lie beneath the Arctic tundra, and have been detected in marine sediments. They are only stable over a limited range of depth, because at greater depths temperature increases. This is true on Mars, for the same reason as on Earth (outward diffusion of heat generated throughout the planet by radioactive decay), but to a smaller extent.

So we have a subterranean reservoir, leaking methane into the Martian atmosphere. We would expect this if there are organisms that work beneath the surface. But would we have expected them anyway? Are there any other possible sources of methane?

Where you get excess hydrogen, you get methane. So methane is common in the hydrogen-rich environment of the outer solar system. It makes up several parts per thousand of the dense atmospheres of Jupiter and Saturn, and is a major constituent of liquid hydrocarbon lakes on Titan. But we know, from observation of stars in the early stages of their lives, and from the relative rarity of noble gases such as neon in the atmospheres of Earth and Mars, that the inner solar system was effectively swept free of hydrogen and other gases in the first few million years of its life. (This, of course, is one of the main reasons for questioning the relevance of the Urey-Miller experiment to the history of life on Earth.) There must be some other source of reducing power.

Methane on Earth is very much more abundant than on Mars, and the large majority of it is clearly biological in origin. The biggest single source is bacterial action at and near the surface, in environments as varied as wetlands, and the digestive systems of termites and cows.[2] There are also significant contributions from sediments and oil reservoirs, and here again the ultimate source is biological activity. Most relevant to what could be happening on Mars, is the discovery at depth of whole ecosystems that get their energy from the reaction between hydrogen, generated either from radiolysis or from the reaction between water and strongly reducing rock, and carbon dioxide, to form methane. So is the presence of methane on Mars powerful evidence for the operation of similar processes, as the wording of the NASA press release clearly suggests?

Not necessarily.

Just over a year ago,[3] *Science* reported production of methane from the Lost City hydrothermal vent field, a relatively low temperature field discovered about 10 years ago in the North Atlantic, near the Mid-Atlantic Ridge. The carbon in this methane was devoid of ^{14}C, showing

[2] Is another good environmental reason for cutting down on meat eating? Yes.
[3] 1st February, 2008

that it came from the underlying rocks, not from carbon dioxide dissolved in seawater, and examination of the vent gases showed that the expected carbon dioxide had been very efficiently converted to methane. Iron-containing rocks that are rich in metal and very low in silica ("ultramafic," as they are termed) are dense, and therefore stable at high pressure. When raised up in submarine vents, they react with water to form hydrogen, by a process known as serpentinization, according to the simplified equation

$$6\ Mg_{1.5}Fe_{0.5}SiO_4\ (\text{olivine}) + 7\ H_2O \rightarrow 3\ Mg_3Si_2O_5(OH)_4\ (\text{serpentine}) + Fe_3O_4\ (\text{magnetite}) + H_2$$

and this hydrogen then reacts with carbon dioxide to make methane:

$$4\ H_2 + CO_2 \rightarrow CH_4 + 2\ H_2O$$

In the first of these reactions, the very basic SiO_4^{4-} group reacts with water to give polysilicate minerals with sheet-like structures, and magnetite, a "mixed valence" iron oxide, in which some of the Fe(II) has been oxidized to Fe(III), while water is partly reduced to hydrogen. The second reaction is self-explanatory. It is thermodynamically favored, but extremely slow in the absence of a catalyst. However, nickel-containing minerals, which will certainly be present in this+ kind of environment, speed up the reaction greatly. The reaction is related to the Fischer-Tropsch synthesis, used in Nazi Germany and in apartheid-blockaded South Africa to produce hydrocarbon fuels from coal. It will certainly have been taking place on the early Earth, as part of a whole suite of possible reactions at hydrothermal vents that, in my opinion at least, give a far more satisfactory explanation than Urey-Miller chemistry for the origin of the basic building blocks of life.

There has even been a detailed computational study[4] of the possible rate of this reaction on Mars. It was estimated that at a depth of 5 km, liquid water would be stable, and would react relatively quickly, on the geological timescale, with olivine-type minerals. A millimetre cube of mineral would completely dissolve, with production of methane, possibly within a century and almost certainly within a mere quarter of a million years. The origin of the carbon dioxide is not obvious, but we have this problem whether the methane is biologically generated, or not.

One of the most interesting thing to emerge from this last study was the inference that at one time there could have been enough methane on Mars to exert a considerable greenhouse effect, enough to melt ice near the surface, thus accounting for the observed gullies in the Martian landscape. So how can we find out which scenario is correct, straightforward mineral chemistry, or biological activity? In principle, this could be discovered by isotopic analysis (see January's *Beacon*). Carbon dioxide containing the rarer isotope ^{13}C is slightly less biologically reactive than ordinary $^{12}CO_2$, so that methane produced by bacteria is invariably depleted in the heavier isotope. So if we could compare the abundance of ^{13}C in Martian methane with that in Martian carbon dioxide, that might perhaps give us the answer. "Might," rather than "would," because under certain conditions the inorganic processes can themselves give rise to ^{13}C-depleted material. Low ^{13}C is, generally speaking, an isotopic signature for biogenic methane, but the signature can be forged. Nonetheless, the idea of placing some kind of isotopic analyzer on the next Mars mission is under active discussion. Two types of instrument are possible, a mass spectrometer that would directly sample the gas, and a spectrometer built purely to examine the methane C-H stretching region, and compare the intensities of the signals from $^{13}CH_4$ and $^{12}CH_4$. The difficulty, rather obviously, is the very small amount of methane available for examination. If the source could be pinpointed more accurately, that presumably would be a region of higher local concentration. Alternatively, some way might be developed of trapping the gas selectively for examination. The problem here, as in all isotopic analysis, is to avoid artifacts. The selection procedure would itself most probably select one isotopic form rather than another, and the uncertainty in instrument calibration might be comparable in size with the effect that we are trying to measure.

Finally, if indeed the methane is biogenic, what does that tell us about the question that really interests us, how easily can life emerge in the universe? Everything, or nothing. If there is life on Mars, we still have two possibilities. We know that meteorites from Mars, detached from its surface by impacts, occasionally find their way to Earth. We can be confident that the same process occasionally happens in reverse, although probably less often because of the relative strengths of the two planets' gravitational fields. We also

[4]GRL 32, L10203, 2005

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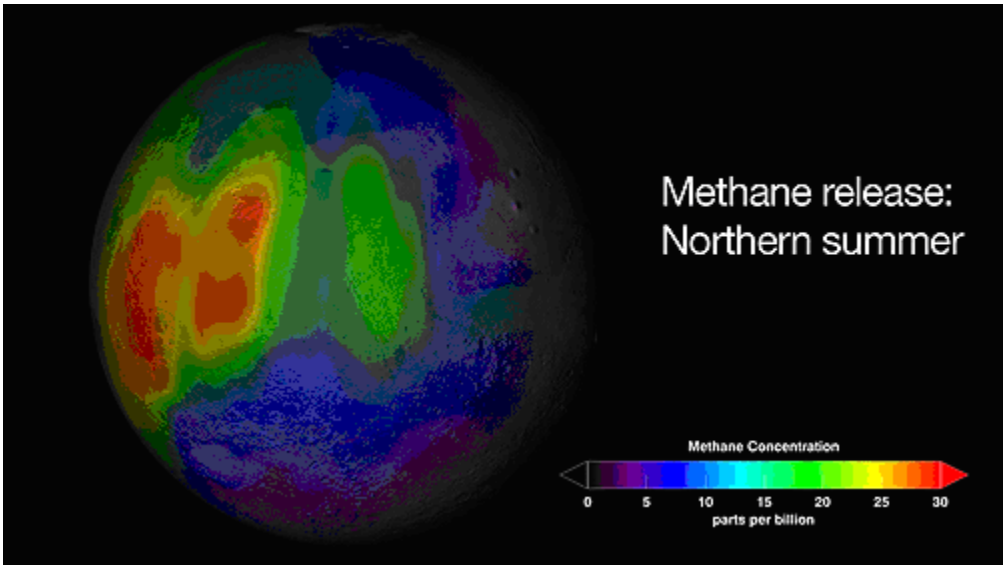
know that life on Earth is ubiquitous, with single celled organisms present in the most diverse and hostile environments, from pores in desert sandstone or Arctic ice, to rocks 2 km below the surface. So there is every possibility that a bacteria-laden rock fragment from Earth landed on the surface of Mars 2 billion or more years ago, when that planet still had liquid water and more of a protective atmosphere, spread and evolved, and survives deep underground in the one remaining favorable environment.

Or, indeed, the process could have happened at the opposite direction. Maybe we are all Martians.

The only way to settle this question would be to obtain samples of Martian organisms (I originally wrote "bacteria," but that rather begs the question) and compare them to us. If, give or take the well-understood effects of a few billion years of separate evolution, they share our biochemistry, use the same genetic code, and have similar translation machinery, then they are our cousins. If they arose completely separately, it is monstrously unlikely that they would have followed exactly the same pathway. So we could tell whether these Martian organisms share a common ancestor with us, or whether they arose independently. If the latter, that will give us the answer to one of the most interesting unsolved problems in the whole of science; is the emergence of life on a warm wet planet a monstrously unlikely event, or is it almost inevitable? Are we, or are we not, alone?

Dr. Paul Braterman



Methane release on Mars (NASA)

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