fumed; the usual right-wing commentators fulminated; no one has since taken the Discovery Institute seriously.

All three books, despite their regrettable titles, handle the basic story very well and recount some extraordinary moments. An OxyContin-addicted school-board member ranted on record: "Two thousand years ago someone died on a cross. Won't anyone take a stand for him?" and then denied that creationism had ever been discussed at board meetings. The school-board president claimed in his deposition that he did not know where the money came from to purchase the *Pandas* books, and then was shown the cheque from the other board member to his own father. Expert witness Barbara Forrest graphically showed that the authors of early drafts of *Pandas* had changed some 150 uses of terms such as 'creation' and 'creationist' to 'intelligent design' and 'design proponents', despite a 1987 Supreme Court decision ruling that 'creation science' was not science.

Where does the 'science' of intelligent design come from? Biochemist Michael Behe of Lehigh University in Bethlehem, Pennsylvania, is virtually the only scientist prominent in the movement; he has published popular books (for a review of the latest see *Nature* **445,** 1055–1056; 2007) but no demonstrable peer-reviewed research on intelligent design. Behe's notions of 'irreducible complexity' and the status of intelligent design as science were shredded by attorney Eric Rothschild, who got him to admit that under his own definition, astrology would qualify as science.

Conspicuously absent from the trial was William Dembski, the other pillar of intelligent-design 'research', who holds advanced degrees in maths and theology but none in science, and believes that intelligent design is the Logos of the Gospel of John restated in the language of information theory. His notion of 'specified complexity', a probabilistic filter that allegedly allows one to tell whether an event is so impossible that it requires supernatural explanation, has never demonstrably received peer review, although its description in his popular books (such as *No Free Lunch*, Rowman & Littlefield, 2001) has come in for withering criticism from actual mathematicians. Plaintiffs' attorneys were eager to take him apart, but Dembski exited the proceedings in a suspicious eleventh-hour dispute about having his own lawyer represent him in deposition.

All three books are entertaining and informative reads; on balance the nod goes to Humes for his comprehensive account, although Slack is concise and readable. Another book on the trial, by local reporter Lauri Lebo, is due out next year. It promises even more lively details of this perfect storm of religious intolerance, First Amendment violation and the never-ending assault on American science education. ■

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A lone voice in the greenhouse

The Callendar Effect: The Life and Work of Guy Stewart Callendar (1898–1964), the Scientist who Established the Carbon Dioxide Theory of Climate Change
by James Rodger Fleming
American Meteorological Society: 2007.
176 pp. $34.95

Robert J. Charlson

With so much written on the subject of carbon dioxide as a cause of climate change, it seems to have a settled history. But the word 'established' in this book's subtitle moved me to ask who actually came up with this now well-accepted theory, and what the basis is for James Rodger Fleming's claim that the subject of his biography holds this honour.

There seems to be little doubt that in 1827 Jean Baptiste Joseph Fourier first articulated the idea that "light finds less resistance in penetrating the air, than in repassing into the air when converted to non-luminous heat". In the 1860s, John Tyndall showed that CO_2 and water vapour both absorb and emit infrared radiation. Then, in 1896, Svante Arrhenius performed the first calculations of the sensitivity of Earth's temperature to changes in atmospheric CO_2. He went on to calculate (incorrectly) that it would take some 3,000 years for a 50% increase of its atmospheric content at the prevailing rate of coal consumption. He further calculated, on the basis of the measured infrared transmission of the atmosphere by Samuel Langley, that a 50% increase of CO_2 would warm Earth's surface by 3.4 °C.

So how did author Fleming come to state that the CO_2 theory was established by Callendar? It seems that this credit should be given to Fourier, Tyndall and Arrhenius.

Callendar's seminal paper, 'The Artificial Production of Carbon Dioxide and its Influence on Temperature', was published in 1938, nearly half a century after these nineteenth-century works. During the intervening period, serious doubts had developed about the importance of changing atmospheric CO_2 as a factor in Earth's climate and a cause of ice ages. Competing theories — changes in Earth's orbital geometry or in solar output, the role of the oceans, the attenuation of sunlight by volcanic dust, and spectroscopic considerations such as water vapour and CO_2 absorbing infrared light in the same spectral regions — had seemingly brought the CO_2-climate field into a 'deep eclipse'.

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Guy Stewart Callendar revived the CO_2 theory of climate change.

Callendar's 1938 paper did not include a citation of Arrhenius's 1896 paper, although there are many parallels between the two. Callendar analysed just one set of data on atmospheric CO_2 content taken at Kew, near London, between 1898 and 1900. These data were taken near a source of CO_2 and were analytically very uncertain. From this analysis, he concluded that at around 1900 the free atmosphere over the North Atlantic region contained 274 ± 5 parts per million (p.p.m.) of CO_2. Then, after arguing that only a small fraction of the CO_2 from combustion of fossil fuels would dissolve in the ocean, he calculated from an estimated global production rate of CO_2 the amount that he thought would be there in 1936 (290 p.p.m.), 2000 (314–317), 2100 (346–358) and 2200 (373–396).

With a simple model of the absorption of infrared radiation, he worked out the amount of global warming to be expected from his predicted CO_2 levels, concluding that temperature would then have been increasing at a rate of about 0.03 °C per decade. Callendar's 1938 attribution of early twentieth-century warming to CO_2 increase might have been believable if global cooling had not ensued in the 1960s and 1970s.

His result was based on many assumptions and he used no contemporary CO_2 data on which to base his estimates. Nonetheless, his prediction was almost correct and, along with his 1958 paper — which included large amounts of CO_2 data (albeit of dubious quality) — his 1938 publication did rejuvenate the CO_2 theory of climate change. I doubt that this amounts to establishing the theory, but it came at a time when the fields of geochemistry and climate dynamics were ripe for stimulation, especially during the International Geophysical Year (1957–58). Shortly thereafter, Charles David Keeling presented accurate data, and the rest of the story is history.

Callendar's work on climate change is just part of the story Fleming tells about Callendar's life in this well written and especially well documented book. ■

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