

## Editorial: paradigm shifts

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This issue includes the 14 papers presented at the 2018 Forum, “Towards a prosperous yet sustainable Australia — what now for the Lucky Country?”, a submitted paper by Ann Moyal<sup>1</sup> on the reception of Charles Darwin’s *The Origin of Species* among scientists in nineteenth-century Australia, six Ph. D. dissertation abstracts, and an obituary on the late Distinguished Fellow, Noel Hush (1924–2019), by Don Hector.

Darwin’s argument that the emergence of new species from old occurs through the mechanism of natural selection — evolution — was an archetypal paradigm shift, to use Thomas Kuhn’s (1962) term: a paradigm shift is a fundamental change in the basic concepts of a scientific discipline. But paradigms are not easily shifted: “A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.” according to Max Planck (1858–1947).<sup>2</sup> And the evidence of the reac-

tions amongst the establishment scientists in Australia suggests that Max Planck’s observation was correct. The scientists’ birth and death dates are included in Moyal’s paper to emphasise Planck’s point.

For a paradigm shift to occur there must be an existing paradigm. A paradigm is a way of thinking or seeing, not so much a way of doing. This rules out such new technologies as sound recording and television and radar with no antecedents, and also such revolutionary technologies as double-entry bookkeeping in 1494 (single entry), steam engines (horse power), photography (painting), and the telegraph (semaphore etc.). The following list for the most part does not include new technology.

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### Examples of other possible paradigm shifts

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| 628–1202 | the formulation of zero as the tenth symbol in the Hindu-Arabic decimal numerical system with positional notation, promoted in Europe by Fibonacci, replacing Roman numerals (although perhaps this is new technology)                    |
| 1543     | from Ptolemaic to Copernican cosmology  |
| 1610     | using the new technology of the “telescope,” Galileo observed the moons of Jupiter which disproved the belief in the immutability of the heavens of Aristotelian cosmology, and also led to the adoption of Copernicus’ heliocentric view |

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<sup>1</sup> Ann Moyal was a veteran historian of science and inaugural winner of the RSNSW History and Philosophy of Science Medal in 2014. Les A. Murray, the late poet, dedicated his poem, “The Tube,” to Ann, as I found in my copy of Murray (1993), after his recent death. Ann died on 21 July 2019, aged 93.

<sup>2</sup> “Eine neue wissenschaftliche Wahrheit pflegt sich nicht in der Weise durchzusetzen, daß ihre Gegner überzeugt werden und sich als belehrt erklären, sondern vielmehr dadurch, daß ihre Gegner allmählich aussterben und daß die heranwachsende Generation von vornherein mit der Wahrheit vertraut gemacht ist,” in Planck (1949).

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**Examples of other possible paradigm shifts**

- 1686 Newton's three laws of motion (and his earlier theory of gravity) built on work by Galileo and Kepler, against Aristotle's notions
- 1783 Lavoisier's theory of chemical reactions and combustion in place of the phlogiston theory
- 1826 the discovery of non-Euclidean hyperbolic geometry by Gauss and Taurinus
- 1859 Darwin's theory of the evolution of species through natural selection
- 1866 our own William Stanley Jevons<sup>3</sup> (and, independently, Carl Menger and Léon Walras) derived neoclassical value theory in which individuals maximising utility is the way of understanding market behaviour: the marginalist revolution of microeconomics (against Mill's and Marx's classical approach)
- 1905 quantum mechanics replaced classical mechanics at microscopic scales (Planck and Einstein)
- 1876–1905 the transition from luminiferous æther pervasive in space to electromagnetic radiation in spacetime (Einstein)
- 1919 from Newtonian gravity to Einsteinian general relativity
- 1929 the expanding universe, the Hubble-Lemaître Law<sup>4</sup>

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<sup>3</sup> See Castles (2016) and Marks (2016).

<sup>4</sup> See Burton (2018).

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**Examples of other possible paradigm shifts**

- 1935 John Maynard Keynes argued against Say's Law (which implied that under-employment and under-investment were virtually impossible) and derived effective demand, and counter-cyclical fiscal policy (macro-economics)
- 1953 the discovery by Crick and Watson of the double-helix structure of DNA<sup>5</sup> — they used simulations<sup>6</sup> of physical models (their “stereochemical experiments”) — against Pauling's triple helix
- 1964 the discovery by Penzias and Wilson of cosmic microwave background radiation (the residual of the Big Bang) led to the demise of the steady state theory (Hoyle, Gold, and Bondi)<sup>7</sup> and the triumph of Lemaître's and Gamow's Big Bang theory in cosmology
- 1964 the proposed existence of Gell-Mann's quarks, and the Standard Model of particle physics<sup>8</sup>
- 1965 the acceptance of Wegener's continental drift as plate tectonics in geodynamics
- 1998 the accelerating universe, Brian Schmidt DistFRSN: the expansion is speeding up, not slowing down

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<sup>5</sup> They celebrated their discovery in *The Eagle*, my local in Cambridge.

<sup>6</sup> As they were well aware, simulation can derive sufficiency, but not in general necessity: was theirs the *only* possible structure?

<sup>7</sup> I remember Thomas Gold and Herman Bondi with Harry Messel on the televised International Science School in the 1960s; I met Thomas Gold at the Santa Fe Institute decades later, and reminisced

<sup>8</sup> Although this took some years and many experiments. At the Santa Fe Institute in March 1993 Murray Gell-Mann (1929–24 May 2019) was not amused at a lunch-time quip of mine.

In the future, the eventual reconciliation of quantum mechanics with general relativity (and gravity) may well need a paradigm shift, when it is devised.<sup>9</sup>

You might agree or disagree with this selection, not meant to be exhaustive.<sup>10</sup> Two earlier developments might also stand as paradigm shifts: the inventions of writing systems and particularly the invention of the alphabet (using symbols to record the sounds, phonemes, of words, rather than the whole word or phrase), but their details and impacts are lost in prehistory. And anyway we might look on the alphabet as a new technology.

A good topic for dinner conversation (at least in some circles) is what developments of today will be remembered as paradigm shifts after the dust settles: complexity theory? computational biology? “wet” (biological) quantum phenomena? quantum computing? But I digress.

The Forum includes two papers dealing with AI (Artificial Intelligence), a topic which is generating much discussion. A recent McKinsey Global Institute publication includes at least one article of interest in applying AI for social good (Chu et al. 2018). See Mitchell (2018) for another view. John Quiggin (2019) updates his Forum talk.

A note: the Forum committee invites the Forum participants to address the Forum, and for the most part they convert their addresses into papers for the *Journal*. As invited papers, these are not sent out for review, but are accepted without further scrutiny. Nor am I involved in the selection of the speakers. This might sometimes result

in papers from the Forum being published which, as editor, I would not myself have included in the *Journal*, for various reasons.

In recent news, we have observed the “shadow” of a black hole,<sup>11</sup> and we have continued to monitor gravity waves from the LIGO/Virgo observatories. There is now an app, Gravitational Wave Events,<sup>12</sup> that will notify you when a new observation is confirmed, using its GW chirp on your smart phone. And recent DNA analysis has shown that grapes used by the Romans 2,000 years ago are strongly related to today’s pinot noir and syrah varieties, meaning that the same lines must have been carefully tended and propagated through the Dark Ages to now. In monasteries?

Two other recent events are the sesquicentenary of the presentation by Mendeleev (1834–1907) on 6 March 1869 of his periodic table of the elements (which correctly predicted several new elements), and the demise on 20 May 2019 of the old definition of the kilogram, defined by the mass of a man-made artefact, the Grand Kilo, in Paris, which has been superseded by a definition based on Planck’s constant via a Kibble balance.<sup>13</sup> Is our moving from physical artefacts to define our units of mass, distance, and time etc. (now complete, with the demise of the rôle of the Grand Kilo) also a paradigm shift?

When the back issues of the *Journal* were scanned and placed in the on-line repository at the Biodiversity Heritage Library, one was overlooked: Volume 115, parts 3 & 4 (Parts 325 & 326). I have recently added this issue

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<sup>9</sup> See Powell (2015) for a clear discussion of the issues.

<sup>10</sup> What of Mendelian genetics? What of Bayesian probability? What of Freud’s insights into psychology? Other psychological schools?

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<sup>11</sup> See <https://www.vox.com/2019/4/10/18302343/first-picture-black-hole-evt-photo-event-horizon>

<sup>12</sup> See <https://itunes.apple.com/us/app/gravitational-wave-events/id1441897107>

<sup>13</sup> See Hibbert (2017).

to our Contents web page. Our collection from 1867 is now complete.

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Balmain, 9 June 2019.

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