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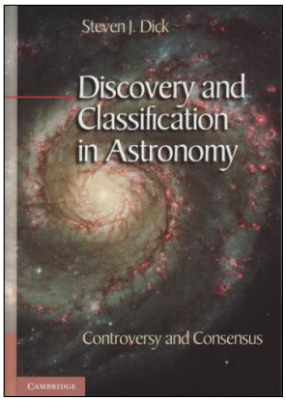
## ***Discovery and Classification in Astronomy*: *Controversy and Consensus*, by Steven J. Dick (New York, Cambridge University Press, 2013), pp. xviv + 458. ISBN 978-1-107-03361-0 (hard copy), 180 × 255 mm, US$45.00.**

Steve Dick, NASA's former Chief Historian, is well known for his books on astrobiology and the history of astronomy, and it is a great pleasure to see yet another book penned by him. But this one is a little different from his earlier tomes, in that it is about discovery and classification in astronomy.




As stated in the first of the front pages,

> Astronomical discovery involves more than detecting something previously unseen. The reclassification of Pluto as a dwarf planet in 2006, and the controversy it generated, shows that discovery is a complex and extended process – one comprising various stages of detection, interpretation, and understanding.

This book is composed of five Parts, titled "Entrée", "Narratives of Discovery", "Patterns of Discovery", "Drivers of Discovery" and "The Synthesis of Discovery". Each Part contains anywhere from one to four sections, that in total contain 36 short chapters.

Given the reference to the 'Pluto affair' in the first of the front pages it is fitting that Pluto's discovery as the Solar System's ninth planet in 1930, and its demotion to dwarf planet status in 2006, are the focus of the first and last chapters in Part I, "Entrée". Like, Steve Dick, I was there at the Prague General Assembly of the IAU and voted on Pluto's fate. Moreover, I was one of the rather sizable minority group that voted to retain Pluto as a planet, but when the outcome of these deliberations entered the public domain, all of us were tarred with the 'destruction of Pluto' brush and, like Steve, I too personally received abuse from members of the public and amateur astronomers. Everyone erroneously assumed that all (or almost all) of those at the Prague General Assembly wanted to demote Pluto.

Part I includes two other chapters, one about Pluto's satellite, Charon, and the other on the discovery of Kuiper Belt objects.

Part II also starts with the Solar System ("Moons, Rings, and Asteroids: Discovery in the Realm of the Planets") before examining stars and nebulae in our Galaxy ("In Herschel's Garden: Nebulous Discoveries in the Realm of the Stars", and "Dwarfs, Giants, and Planets (Again!): The Discovery of the Stars Themselves") and then "The Galaxies, Quasars, and Clusters: Discovery in the Realm of Galaxies").

In the various chapters in Parts I and II, Dick takes us on a 'Cooks' tour' of the Solar System, our Galaxy and the distant reaches of the Universe, and covers all of the key astronomical discoveries.

This astronomical focus is replaced in part in the remaining Parts of the book by philosophical themes. Thus, Part III has sections on "The Structure of Discovery", "The Varieties of Discovery" and "Discovery and Classification"; Part IV on "Technology and Theory as Drivers of Discovery"; and Part V on "Luxuriant Gardens and the Master Narrative" and "The Meaning of Discovery". Some of the chapters in these sections contain material that will be new to many historians of astronomy, and this is one of the great strengths of this book: the mixing of history of astronomy and philosophy of science. Thus.

> … we have noticed that … a discovery is not an event at a discrete moment in time … it has a structure, and this structure consists most often of detection, interpretation, and multiple stages of understanding … discovery is sometimes preceded by a "pre-discovery" phase, and (less surprisingly) is always followed by a "post-discovery" phase, both of which delimit the structure of discovery itself in both time and space. (page 177).

This is largely inspired by Thomas Kuhn's ideas, as best outlined in his well-known book, *The Structure of Scientific Revolutions*, and Steve Dick then proceeds to recount various examples drawn from the annals of astronomy.

Dick then discusses the microstructure of discovery:

> A study of the microstructure of each component would likely be even more revealing, uncovering particular forms of detection, interpretation, and understanding, as well as the problems associated with each, such as the problematic nature of observations ... Even more importantly, the conceptual elements we have emphasized so far inevitably had technological, social, and psychological components, revealing even more about the nature of discovery. (pages 190–191).

In discussing the social dimension of astronom-

ical discoveries, our old friend Pluto once again stars, followed by quasars and pulsars (and, by association, black holes). In the case of quasars, the papers by Waluska (2007) and Kellermann (2014) are particularly apposite.

In the seventh chapter, on "The Varieties of Discovery", Dick asks

> ... to what extent the telescopic discoveries differ from those made before the telescope, from discoveries of the few classes that can only be inferred indirectly by their effects, and from discoveries of new members of already established classes. (page 202).

One of the examples presented is the Great Comet of 1577 (C/1577 V1), and it is a happy coincidence that there is a paper in this very issue of *JAHH* documenting the indendent discovery of this noted comet by Abū'l Faẓl, the Prime Minister of the Mughal Emperor, Jalāl ud-Din Muḥammad Akbar (see Kapoor, 2015). In Dick's book there is then a discussion of super-novae and meteor showers, leading to

> … the following important conclusion: *casual sightings of astronomical objects with the naked eye, or telescopic observations that go unreported, unrecognized, or undistinguished as new classes of objects, constitute what we shall call a pre-discovery phase*. (page 211; his italics).

This takes us to instrument-aided indirect discovery, with cosmic rays, the solar wind and black holes presented as examples. As Dick notes, the ideas of John Michell and Pierre-Simon Laplace constitute the pre-discovery phase of black holes (Montgomery et al., 2009).

In the "Discovery of New Members of a Known Class", the detection of Mars' two moons and the rings around Jupiter, Uranus and Neptune are then cited as examples, and Pluto's discovery—as a planet—and later demotion, are also mentioned.

The last chapter in the section on "Varieties of Discovery" deals with ""Object" Discovery vs. "Phenomena" Discovery in Astronomy", on the basis that "… some of the landmark discoveries in astronomy have not been of objects, but of phenomena." (page 223). In this context, over the next 10 pages, Dick looks at three well-known phenomena: the expansion of the Universe (1920s); the accelerating Universe (1990s) and the discovery of extra-terrestrial radio emission (1930s) and later the 3° cosmic microwave background (1960s).

The final Section in Part III is about "Discovery and Classsification" and Dick points out that

> In contrast to the discovery of new laws, processes, or properties, one of the hallmarks of the discovery of localizable natural objects such as we have been discussing in this volume is an almost irresistible temptation to classify them. (page 233).

Not surprisingly, Dick begins by returning to the philosophy of science and looking at 'class' and 'classification' as used in the natural sciences, before turning to astronomy. First he focuses on the complicated issue of stellar spectroscopy, culminating in the MKK system and its subsequent MK refinements, before the focus shifts to galaxy classification, and then the place of 'class' in Solar System astronomy (with our old friend Pluto once again entering the fray). Finally, he constructs a hierarchical so-called Three Kingdom classification system for astronomy, extending from Kingdom to Family to Class, with possible extention to Type and even Subtype. This is developed fully in Appendix 2. Rounding out Part III are 6 pages on "Negotiation and Utility in Discovery and Classification", where negotiation, simplicity and utility are applied to stellar and galaxy classification.

Part IV is about "Technology and Theory as Drivers of Discovery" and begins by examining the role of optical telescopes and then the expansion of the electromagnetic spectrum to encompass radio astronomy and microwave, infrared, ultraviolet, X-ray and gamma ray astronomy. Then follow 10 pages on "Theory as Prediction and Expanation in Discovery", with Dick concluding that

> … while there may have been a general theoretical background behind many discoveries in the twentieth century, rarely did this background actually motivate discovery …
>
> The role of theory in the prediction of objects that actually led to their discovery is therefore very limited …
>
> [But] In the next stages of discovery – interpretation and understanding – theory indeed played an extremely important role. (pages 310–311).

The final Part (V) in *Discovery and Classification in Astronomy* is about "The Synthesis of Discovery". The first section, with the mysterious title "Luxuriant Gardens and the Master Narrative", begins by discussing cosmic evolution. Dick asks

> By what means, with what insights and motivations did astronomers "discover" the idea of cosmic evolution? Was it, in fact, through the synthesis of many of the discoveries addressed in this volume, or through some other more overarching principle? Does it in fact exhibit the extended structure typical of the classes it embodies, or some different structure? (page 317).

The question then emerges: is the endpoint of cosmic evolution planets, stars and galaxies (the physical Universe) or life, mind and intelli-

gence (the biological Universe)? Dick then looks at the ways in which the concept of cosmic evolution has entered the human consciousness in contemprary society, in part through the writing and television programs of the late Carl Sagan. I have no doubt that the late Sir Patrick Moore also played an important role in this regard. Consequently, the idea of cosmic evolution has been

> … interwoven into the fabric of society well beyond its scientific content … [although] The ultimate meaning of cosmic evolution is not yet apparent … (page 328).

The final chapter, on "The Meaning of Discovery", reviews the findings of the preceding 328 pages of this book by looking first at "The Natural History of Discovery" and finally at "Beyond Natural History: The Evolution of Discovery". We are warned that although the scheme presented in this book accommodates most astronomical discoveries,

> … we should take care not to shoehorn *all* discoveries into this structure … [as] *There are interesting exceptions* … [and] each of the components of discovery – detection, interpretation, and understanding – has its own *gray areas*. (pages 331–332; my italics).

Dick then discusses problems associated with the definiition of 'discovery' and sings the merits of collective discovery. Thus,

> … Galileo detected what we now know to be the rings of Saturn in 1610, Huygens interpreted them as such in 1655, and Maxwell showed how such an object could exist in theory in 1857 – a process encompassing more than two centuries. To say what is often said, that Galileo discovered the rings of Saturn, is to do violence to history, to conflate discovery beyond recognition, and to do a disservice to the beauty and complexity of science and discovery. The same may be said for other classes of astronomical objects. (page 336).

He then looks at the role played by developing technology in the occurrence and pace of discoveries, and produces Figure 11.1, a fascinating histogram that plots the number of discoveries against time for the past 450 years. This shows distinct decadal peaks that reflect Galileo's access to the telescope in 1610, William Herschel's use of large telescopes in the 1780s, and a "... mountain of discoveries in the twentieth century, three times greater than the sum of the previous 350 years." (page 338). The data used in compiling this diagram are assembled in a 23-page Appendix (number 2), at the end of the book.

Figure 11.1 automatically raises the thorny question of "Are we at the end of discovery or only the beginning, or somewhere in between?" (page 339). Different astronomers offer different answers, depending very much on how the term 'discovery' is defined. Only time will tell!

Ending the book are the two previously-mentioned appendices, 58 pages of Notes, a short "Select Bibliographical Essay", a glossary and a detailed Index.

I hope that the foregoing account imparts some of the flavour of this remarkable book. It is an intellectual banquet, but too large for most of us to consume in just one sitting. It is composed of different courses: first an introductory entrée, followed by a main course comprising historical narrative garnished with theory provided by the history of science, and then a dessert that looks at the the present and the future of astronomical discovery. It is masterfully written (as are all of Steve Dick's books), and is full of thought-provoking ideas and discussion. At just US$45.00 it is very well-priced, and should join the bookshelf of many astronomers—not just those committed to the history of astronomy.

### References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## CORRIGENDUM

Unfortunately there is an error in the caption of Figure 4 in the following research paper, that was published in the July/August issue of this journal:

Steinicke, W., 2015. William Herschel and the 'Garnet Stars': μ Cephei and more. *Journal of Astronomical History and Heritage*, 18(2), 199–217.

The new figure caption should read:

Figure 4: Herschel's 'large 20-ft' telescope, shown here at Datchet in its original form (after Dreyer, 1912: Volume 1, Plate B).