organisms, and their widespread use in biological research means there are more mycologists working today than ever before.

I would recommend this book particularly to those who know, or currently care, little about fungi. They will learn a lot in this easy read, and they can even try the anagrams at the back of the book. Here I learned that 'fantastic ugly mess' is an anagram of 'fungal systematics', which should upset the taxonomists. ■

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Elements of galactic evolution

The Chemical Evolution of the Galaxy
by Francesca Matteucci
Kluwer: 2001. 308 pp. £72, $106

Stuart Ross Taylor

Walter Baade, at Palomar during the Second World War, observed that the halo of the great spiral Andromeda galaxy was dominated by red, metal-depleted stars, whereas its disk contained mainly blue, metal-enriched stars. (Astronomers, to the exasperation of chemists, persist in using 'metals' to describe all the elements heavier than helium. But the term, along with 'metallicity', is too thoroughly entrenched to be replaced). Baade's observations enabled Olin Eggen, Donald Lynden-Bell and Allan Sandage to erect their classical model of galactic evolution, in which a spherical halo collapses to a disk. But it was Beatrice Tinsley who, in the course of her brief life, focused attention on the chemical evolution of galaxies, and stimulated the explosive growth in this field.

All of this was possible because of the elegant explanation of how chemical elements are synthesized — surely one of science's greater achievements — by Margaret and Geoffrey Burbidge, William Fowler, Fred Hoyle and Alastair Cameron. This, in turn, was based on an understanding of the relative abundances of the chemical elements, first established by Victor Goldschmidt from meteorite data.

Now the topic of galactic chemical evolution has become a major field of research. Francesca Matteucci's book is the second to address the subject, following on from the definitive 1997 text by Bernard Pagel, *Nucleosynthesis and Chemical Evolution of Galaxies* (Cambridge University Press). David Arnett's monumental work, *Supernovae and Nucleosynthesis* (Princeton University Press, 1996), is weighted more towards nucleosynthesis — the cosmic formation of atoms through nuclear reactions in the cores of stars and through supernova explosions. However, it deals specifically with the chemical evolution of galaxies in a final chapter.

Matteucci's book usefully complements these two, more advanced texts, concentrating on the Milky Way. She begins with an assessment of the observational evidence for chemical evolution, now so greatly enhanced by the development of high-resolution spectroscopy, and continues with a major section on stellar evolution and nucleosynthesis. As a planetary geochemist, I found her clear and precise treatment very useful. Matteucci concludes with a major discussion of the formation and evolution of the Milky Way, finishing with a brief assessment of the age of the Galaxy and some comparisons with other spiral galaxies.

As is typical in the astronomical literature, the text is replete with acronyms. Readers unfamiliar with the subject will be relieved to discover that, in the relatively peaceful field of astrophysics, IRA refers to 'instantaneous recycling approximation' and ICM to 'intracluster medium', not to their deadly alternatives. And they will discover that IMF, the 'initial mass function', has nothing to do with finance. These caveats aside, the book is an example of straightforward writing that might well be emulated by native writers in English. There is no index, but this surprising omission is mostly covered by a very detailed table of contents, so that it is easy to find one's way around.

The development of the field in the past two decades is impressive, Matteucci herself having made significant contributions. The earlier concepts have been replaced by a model of the Milky Way in which the Galaxy is divided into four distinct stellar populations, respectively the halo, bulge, thick disk and thin disk, which do not have simple relationships with one another. Thus we learn that the "evolution of the thin disk is completely disentangled from the evolution of the inner halo".

So galaxies have a much more complex history than previously imagined. Like terrestrial continents, they have undergone collisions and have grown by accretion of disparate material. Our Milky Way Galaxy appears to have evolved along at least two independent paths. One was the classical collapse from a spherical halo to a disk. And superimposed on this was accretion of gas and other galaxies, so that the present Galaxy contains components that formed in several distinct environments. As the accreting gas may be deficient in heavy elements, younger stars forming from this late-arriving material will not necessarily show the expected enrichment in metals that would be predicted to occur had the Galaxy evolved in isolation.

In an interesting assessment of the age of the Galaxy, Matteucci concludes that 13–15 billion years seems probable, with the age of the disk being in the range of 8–10 billion years. There is a useful discussion of nucleochronology — a technique for dating stages in stellar nucleosynthesis by examining the relative abundances of radioactive isotopes. Also discussed is the promise shown by measurements of thorium/europium ratios. It seems likely that these will yield ages for stars which are based on the radioactive decay of thorium-232, and will be totally independent of ages based on the Hubble expansion rate of the Universe — that is, once the formidable technical problems have been overcome and we have a "specific and correct model for the growth and chemical evolution of the solar neighbourhood".

Although Matteucci notes the interesting fact that the Sun is more metal rich than most similar stars in the solar neighbourhood, she does not comment on the observation of Guillermo Gonzalez that the planets so far discovered beyond the Solar System have formed around the more metal-rich stars. This also raises other interesting questions. As the metallicity of stars varies with location in the Galaxy, so the regions in which habitable planets may form may likewise be limited. The most favourable location (in which we find ourselves) is apparently the thin galactic disk, as discussed by Peter Ward and Don Brownlee in *Rare Earth* (Copernicus, 2000). ■

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