and Singer), or is LTD—at least in cerebellum—unique (as implied by Ito)?

An especially attractive feature of this volume is the inclusion of chapters in which cellular and molecular mechanisms of "synaptic plasticity" are discussed within the context of interesting animal models of behavior. Rose, in detailing his studies on the biochemical changes found in the chick brain, presents an intimidating array of possible changes (from phosphorylation to immediate early gene induction) that could be related to the chick's learning behavior. The data from these studies do not define cause–effect relationships but do give the reader a sense of the direction in which much of this work is moving. Fittingly, the final chapter (by Thompson *et al.*) provides an excellent overview of electrophysiological and morphological data that bear on the learning and memory "circuits" underlying some complex behaviors—especially behaviors that may rely on LTP- or LTD-like mechanisms—and helps pull together many of the issues described earlier in the volume in terms of their relevance to complex behaviors.

Clearly, it is this tie between the cellular-molecular and the behavioral, this search for the "engram," that has attracted many of us to the field of synaptic plasticity. Given this interest, the current volume is a partial success and a useful complement to other recent works dealing with various aspects of neuroplasticity.

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Early Crustal Evolution

The Geology of Multi-Ring Impact Basins. The Moon and Other Planets. PAUL D. SPUDIS. Cambridge University Press, New York, 1993. xiv, 263 pp., illus. $59.95 or £37.50. Cambridge Planetary Science Series, 8.

The term "multi-ring impact basin" evokes an interesting but exotic phenomenon, important perhaps to planetologists, and approachable only by spacecraft or large telescopes. The phenomenon is indeed interesting. But multi-ring impact basins are broadly significant, and surprisingly accessible. They have had an enormous influence on the geology of many planets and satellites, possibly including the Earth, and the best-studied ones on the moon can be seen in great detail even with 7-power binoculars.

Impact craters are the most common landform in the solar system. Those over 300 kilometers wide are often termed basins. These are not simply oversize versions of Copernicus; with increasing diameter, their structure becomes more complex, culminating in the enormous rings of the Orientale basin. Recognized on the moon by Ralph Baldwin several decades ago, multi-ring impact basins have now been found on Mercury, Venus, Mars, several satellites, and perhaps the Earth, although this is controversial. To a surprising degree, the study of planetary geology is the study of multi-ring basins.

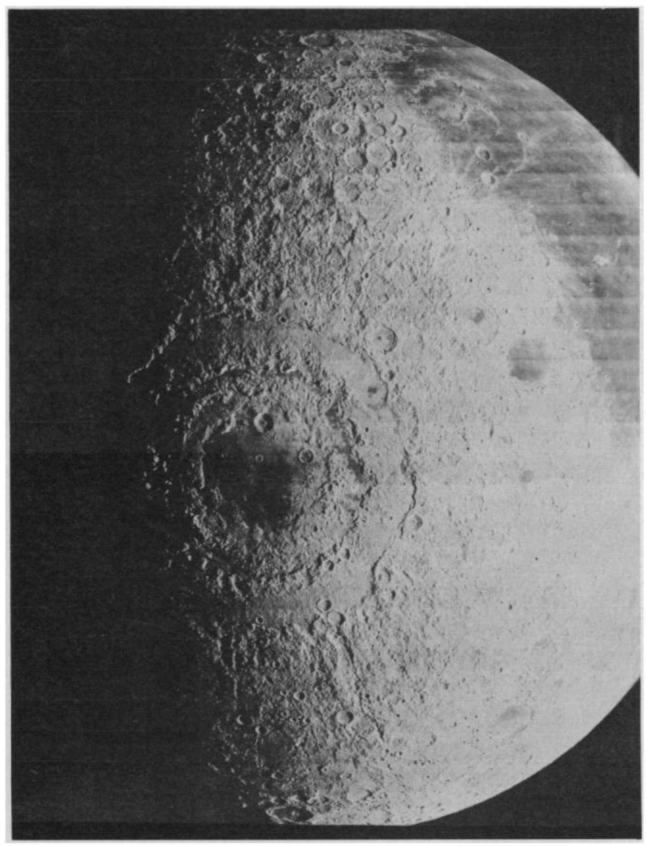
The rings of these basins resemble the concentric ripples generated by a pebble dropped into a pond; in fact this homey analogy has been invoked to explain how basins hundreds of kilometers wide formed. The analogy is probably too good to be true, and competing theories have been proposed. In *The Geology of Multi-Ring Impact Basins* Paul Spudis, one of the protagonists in the controversy, presents results of some two decades of research on the topic.

Spudis breaks the problem of basin formation into two parts: excavation of the initial basin and formation of the rings. Excavation processes have been interpreted either as scaled-up versions of small impacts (proportional growth) or as a fundamentally different phenomenon (nonproportional growth). Formation of the rings has been ascribed to three different mechanisms, which are not necessarily mutually exclusive. The "pebble-in-a-pond" analogy interprets the rings as essentially frozen waves formed by impact fluidization of the crust of the target body. Another interpretation is that the rings are concentric blocks of crust that slumped inward, in the same process that produced the internal terraces of Copernicus and similar craters. A third interpretation is that layering in the crust of the target body caused formation of giant nested craters.

Spudis presents examples of multi-ring basins from several planets and satellites, but his basic approach is lunar, with individual chapters describing the near-side basins of the moon: Orientale, Nectaris, Crisium, Serenitatis, and Imbrium. Surprisingly, the Orientale basin is not considered representative of lunar basins; although as the youngest lunar basin it is well preserved and exposed, it was formed after the lunar crust had been consolidated, and internal processes were minimal compared to those occurring, for example, in the Imbrium basin.

Spudis's approach shows clearly the value of focused research, that is, studies aimed at a particular problem. He relates evidence from photogeology, orbital remote sensing, Apollo and Luna landing site geology, returned sample petrology, and Earth-based reflectance spectroscopy. Collectively, these discussions amount to an excellent and concise treatise on lunar geology, with the only thing missing being a detailed treatment of the mare basalts. The descriptions of the four Apollo and three Luna landing sites will be invaluable to those who, like this reviewer, have been unable to keep up with two decades of post-Apollo lunar research. (The astronauts should find it interesting to see how their magnificent work has been applied.)

How were the multi-ring basins formed? Using the Imbrium basin as an example, Spudis presents an eclectic "synthesis," illustrated by detailed line drawings. If Spudis is correct, the formation of this basin—triggered by the 20-kilometer-



East half of the 930-kilometer-wide Orientale basin on the moon's western limb; earthward face to the right, north at top. [Lunar Orbiter 4 photograph 187M, National Aeronautics and Space Administration] per-second impact of a 70-kilometer-diameter body—was a majestic catastrophe lasting more than six hours. The event was complex, with the rings forming by all three of the mechanisms previously described. The main rim was produced by inward slumping, the next inner rings by structure-controlled slumping, and the innermost rings (now largely concealed under mare basalt) by acoustic fluidization (wave formation). Structural readjustment and basalt eruptions continued for tens or hundreds of millions of years.

Spudis concludes with examples of multi-ring basins from other planets and the Earth. The treatment of the 19 terrestrial examples is minimal. One of the most accessible (and debatable), the Sudbury Structure of central Ontario, is illustrated only by an interpretive sketch map, although Landsat and radar imagery has been available for years. Although the text ascribes this structure's elliptical shape to the Grenville orogeny, this is demonstrably incorrect, since, as the map shows, the Grenville Front is well south of Sudbury.

This book must be read carefully and critically. But it should be read by everyone with a serious interest in planetary geology and the early crustal evolution of the Earth.

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Vignettes: Dependencies

To the hothead, being "kept" is exploitation; to the docile, symbiosis. It's partly in how you look at it. Individuals that could not have survived "in the wild" can live out their lives under protection. (Ants grow great flocks of aphids by protecting them, then "milk" them for their sugar. Exploitation or symbiosis?) Humans themselves, compared with other primates, show the typical signs of domestication in their reduced jaws, claws, neck muscles, and hair—women even more than men. We partially domesticated ourselves first. In any case, many other species thrived under human care, and the humans rearranged their lives to care for the plants and animals that now came to depend on them.

Elizabeth Wayland Barber, in *Women's Work: The First 20,000 Years. Women, Cloth, and Society in Early Times* (Norton)

At the level of cultural evolution, parasites are attracted mostly by wealth and fame. Rock singers attract groupies, wealthy widows attract shady characters, rulers attract sycophants, celebrities of all kinds attract hangers-on. A person surrounded by parasites may need to spend a great deal of his or her energy to avoid being taken advantage of, instead of enjoying life. It is no wonder that so many religions and philosophies make the point that the accumulation of worldly goods fails to bring contentment.

—*Mihaly Csikszentmihalyi*, in *The Evolving Self: A Psychology for the Third Millennium* (HarperCollins)

Cosmic Chemistry

Dust and Chemistry in Astronomy. T. J. MILLAR and D. A. WILLIAMS, Eds. Institute of Physics, Philadelphia, 1993. xii, 335 pp., illus. $149 or £79. Graduate Series in Astronomy. From a meeting, Manchester, U.K., Jan. 1992.

About half of the mass of the interstellar medium in our region of the Milky Way contains hydrogen in molecular form. Molecular clouds are the sites where stars form and spend their early lives. Piecing together the physical conditions within the dark, cold interiors of clouds is a daunting task that requires observation of these molecules. To date some 70 species of interstellar molecules (many highly reactive and unstable under terrestrial laboratory conditions) have been identified; thus molecular clouds are of great interest to laboratory and theoretical chemists as well as to astronomers and physicists. This book outlines relevant observations, theories, and laboratory techniques designed to increase our understanding of the relation between interstellar dust and astrochemistry.

Molecular hydrogen can be formed only by reactions taking place on the surfaces of grains. Until recently it was suspected that grain-surface reactions might be dominant only for H_2, but observations have shown that other species (such as NH) also seem to require formation on grains. The nature of surface chemistry at low temperatures, under the influence of energetic particles (cosmic rays) and ultraviolet radiation, is the major theme of the book.

Various contributions to the book explore other interactions of dust and gas in space. Interstellar molecules deep within dusty molecular clouds manifest themselves through infrared absorption bands of their ices coated onto grains, seen in the spectra of stars embedded within the cloud. More diffuse molecular clouds show no ices but have enough dust to prevent the dissociation of H_2 by the stellar radiation field. The formation of stars within the clouds disturbs the gas, which is normally as cold as 10 K but can be heated to hundreds of Kelvins or more by the radiation of the embedded young stars or by the shocks produced by their outflows. In the general diffuse interstellar medium, where the hydrogen is atomic or even ionized, several infrared emission bands of aromatic hydrocarbons are produced, but the sizes and structures of the molecules cannot be clearly determined from the observations. Various forms of carbon, both hydrogenated and elemental (including interstellar diamond, found in meteorites) are adequately covered in the book. The relevant astronomical observations and their implications are clearly reviewed, as are the results of laboratory studies of ices of cosmically abundant molecules irradiated by both photons and energetic particles.

The contributions to this book are written at about the right level for those who want a brief introduction to various aspects of astrochemistry. Little familiarity with the nature of the interstellar medium is assumed. The main focus of the volume is the relations between grains and chemistry, and the reader might not realize that there are many purely gas-phase chemical models that are successful. The nature of the grains themselves is not given much discussion here but is covered in another volume in the same series by D. C. B. Whittet.

I recommend this book to those who want to catch up with the latest findings about chemical reactions occurring under conditions difficult or impossible to simulate here on Earth.

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