plausible than creation. Creation is a special case of saltation — the *saltus* is the large jump from nothing to fully formed modern life. When you think of what Darwin was fighting against, is it any wonder that he continually returned to the theme of slow, gradual, step-by-step change?

Punctuationists are in favour of a form of jumpy evolution, but it is leagues away from the saltationism that Darwin was fighting. The punctuationists' "real gaps" in the fossil record are gaps only if you confine your digging to one place. They are all too easily confused with the sort of gaps that only a divine architect could bridge. In Darwin's sense of the term, Eldredge and his colleagues must be gradualists — they would have to be creationists if they weren't. But they believe that the episodes of step-by-step, gradual evolutionary change are sporadic, separated in space and therefore hard to find in the fossils, and separated in time by long periods of stagnation. All that the punctuationists have really done is to *inject* periods of stagnation into an otherwise traditional Darwinian picture of gradual evolution with allopatric speciation. Whether they are right to do so is an empirical matter that palaeontologists continue to debate. The upshot of this factual debate, whichever way it goes in particular cases, will upset nobody, and certainly not "the four-decade long dominance of the Modern Synthesis". Darwin himself would have been equally happy either way, because evolutionary change is still gradual *during the times that it is actually happening*. The punctuationists deluded themselves that they were saying something revolutionary. And it was all due to a simple verbal misunderstanding: a confusion of two senses of the word "gradual".

There is a second controversy which does, in a sense, move outside the neo-Darwinian synthesis, narrowly interpreted. This is about whether a form of natural selection operates at the level of entire lineages, as well as at the level of individual reproduction stressed by Darwin and neo-Darwinism. Eldredge is particularly involved with this now and he makes some worthwhile points, especially about the "effect hypothesis", and about the unitary status of the species as a player in the evolutionary game. But he agrees that species-level selection can't explain the evolution of adaptations: eyes, ears, knee joints, spider webs, behaviour patterns, everything, in short, that many of us want a theory of evolution to explain. Species selection may happen, but it doesn't seem to *do* anything much. After reading this book, one is left with a feeling of "What was all the fuss about?", and a suspicion that Eldredge may be left with it too. □

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Unseen horizons: the future of astronomy

George Efstathiou

The Invisible Universe: Probing the Frontiers of Astrophysics. By George B. Field and Eric J. Chaisson. *Birkhäuser: 1985. Pp.195. SwFr. 58, $19.95.*

THE unveiling of the invisible Universe represents the most significant development in astronomy of the twentieth century. Since Galileo's time, astronomers have observed the sky with optical telescopes using visible light. Professors Field and Chaisson focus on the rest of the electromagnetic spectrum — the invisible radiation which holds the clue to many of the most spectacular phenomena in our Universe.

Their account is based loosely on a major report, *Astronomy and Astrophysics for the 1980s*, which was compiled for the United States Federal Government by a committee chaired by Professor Field. In the book Field and Chaisson provide a popular account of the advances we can expect from the next generation of satellites and telescopes. The choice of subject matter is wide-ranging — from Solar System astronomy to high-energy particle physics — and with the strikingly beautiful colour pictures cannot fail to excite the reader's imagination. The discussion is lucid, informed and supported by a useful glossary, although in places (for example the section on interstellar molecules) it does become quite technical and probably beyond the understanding of most lay readers. Throughout the book, the glittering array of new facilities provides the central theme but, curiously, the authors do not distinguish between those that are approved, such as the Space Telescope, and those that may never be built.

In some places, the discussion is too brief to be very helpful. For example, the Field committee concluded that an explanation for the vast amounts of energy produced by quasars is one of the most important of the current problems in astronomy, and so it was disappointing to find that only a few pages are devoted to the puzzle. Nevertheless, I enjoyed this book. Anybody who wants an authoritative account of future directions in astronomy would do well to read it, and it will be especially useful to undergraduates who are thinking of doing research. □

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Coming devices

C.R. Pidgeon

Free-Electron Lasers. By Thomas C. Marshall. *Macmillan, New York/Collier Macmillan, London: 1985. Pp.191. $24.95, £29.95.*

TWO years ago one could say that although many experiments had demonstrated the free-electron laser (FEL) as an amplifier of laser light, the gain threshold for actual laser oscillation in a mirrored optical cavity had only twice been surpassed. A renewed burst of activity since then has resulted in demonstrations of FEL oscillation in many countries, and at wavelengths all the way from the millimeter to the visible region of the spectrum. At the most recent meeting of the regular series of FEL conferences (Rome, 1984) it was predicted that in the near future ultraviolet, vacuum ultraviolet and soft X-radiation will be generated by FEL devices. As Thomas C. Marshall states in the present work, the FEL will be increasingly leaving the designer's laboratory and becoming available for research.

In a FEL amplifier one observes or infers the amplification of an external laser beam as it interacts with an undulating electron beam passing through the periodic magnetostatic structure of a "wiggler". By contrast, an FEL oscillator produces a laser beam without the need for an external laser. The spontaneous radiation generated by undulating electron bunches in the wiggler is reflected back and forth between a pair of end mirrors, generating enough stimulated emission in successive electron bunches to produce and sustain a laser beam.

Marshall has provided a worthwhile treatment of the operation and characteristics of the FEL, with a useful historical and conceptual review, and bibliography. Most aspects of the subject are covered, including both single-particle (or Compton) systems and collective-particle (or Raman) systems. The author has attempted — reasonably successfully, I think — to write for the larger scientific community something between "news" and a professional review paper. The book will also be useful to the FEL community itself as a less-specialized source of information in what has by now become quite a broad and fast-moving field, though the most detailed and up-to-date information must of course still be obtained from the proceedings of the yearly workshops held on FEL physics and devices. The only slight quibble I have, perhaps inevitable for a book of this length, is that in several places quite complex results are merely quoted, without derivation or even comment from other sources. □

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