

more manual skills. The ability to cut blocks which print accurately together has now been devalued by the advent of the machine.

Escher has stimulated some pure mathematics and Huson, Delgado and Dress (Bielefeld) have developed a symbolism which enables patterns of two kinds of tiles to be classified and generated. Their programme includes a kind of Escher machine which shows all the consequences of adjusting the perimeter between two tiles.

Escher's last print (of serpents entwined in interlocked rings) explored the consequences of an average coordination number greater than six. It is also a technical masterpiece of block cutting and printing. Escher was being prompted, by Coxeter, Penrose and others, to look at more general geometries. Penrose's

tilings which force nonperiodicity came too late, as did the flood of curved surfaces, such as the periodic minimal surfaces, now in spate, thanks to the advances in computer graphics.

Even crystallographers have much to learn. This book contains very many colour reproductions of the periodic drawings and analyses the 1941–42 notebooks which show Escher's development in this direction. Taking Doris Schattschneider's beautiful volume with earlier books, especially that by Bruno Ernst, documentation of Escher's life, intellectual development and corpus must now be almost complete. It makes a distinctive island in art history. □

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The end of innocence

John W. Birks

Global Air Pollution: Problems for the 1990s By Howard Bridgman. Pinter: 1990. Pp. 261. Hbk £30, \$49; pbk £12.95, \$25.

The Changing Atmosphere: A Global Challenge. By John Firor. Yale University Press: 1990. Pp. 145. \$19.95, £12.95.

CHANGES taking place in the atmosphere today as a result of fossil fuel combustion, chemical manufacturing, agricultural practices and deforestation have already had well documented detrimental effects on many of the ecosystems we depend on, but the effects experienced so far are small in comparison to those projected for the future. These two timely books treat acid rain, global warming, stratospheric ozone depletion, photochemical smog, and other global environmental problems mediated by the atmosphere in highly complementary ways.

Global Air Pollution is written in the style of a textbook suitable for advanced courses in applied climatology, environmental science or geography. It does not have sufficient chemical detail for a course in atmospheric chemistry, but would serve as an excellent supplement to other texts. It is replete with figures, tables and an extensive bibliography. The book treats all aspects of air quality problems — tropospheric and stratospheric, gas phase and condensed phase, health-related and climate-related — in an even-handed way. Earlier texts in this field have tended to emphasize predominately air pollution (troposphere, smog, aerosols) or aeronomy (stratosphere and above, ozone depletion, gas phase only), representative of two communities of scientists that

interact too infrequently. Topics of biogeochemical cycling, atmosphere-biosphere interactions and global warming, all included in this book, have either not been treated or have been given only cursory attention in earlier texts. I was particularly pleased to find a chapter devoted to nuclear winter and was anxious to see how a scientist not involved in the debate would summarize the findings. I found the treatment of the subject to be up to date, fair, and to come out about where I do in my assessment of the most probable climatic impacts and associated uncertainties of a major nuclear war.

The Changing Atmosphere is written for the nonspecialist, and its 125 pages of text can be read in one or two sittings. Even for the atmospheric scientist, however, this is a very interesting book, partly because it provides novel ways of describing concepts such as steady states, numerical modelling, and radiochemical dating to the nonscientist, but more importantly, because it discusses possible solutions to our dilemma. Many atmospheric scientists, including myself, are much better at describing the problems of the atmosphere in detail than at proposing reasonable solutions. But John Firor has been thinking about environmental problems in the broader context of history, energy, economics, politics, conservation, population control and even the subjugation of women. He asserts: "Acid rain, ozone depletion, and climate heating — the three most highly publicized aspects of the rapidly changing composition of the atmosphere — are more than just related. A single, larger problem underlies them. They are all three the result of the impact of human activities on the earth, which now equals and even exceeds the influence of large-scale natural forces." Firor points out that our species is not different from any other species in its modification of the environment: trees drop leaves, foxes dig burrows, beavers cut trees, algae

turn lakes into bogs. But these species have been held in check by disease, accidents, predators and a limited food supply. Humans differ in that they have been able to shake off some of these constraints, but paradoxically, the waste products of our success threaten the destruction of other species and ancient ecosystems on which our health and progress depend.

Firor describes two possible paths that humanity may follow. We may continue along the path of subjugation of the Earth, as decreed by God in the book of Genesis, in which case we must be "ready to embark on global management of the soil, the air, the oceans, and those species we decide should survive." But as he aptly points out: "For a people who are not yet able to describe fully the workings of a tree or the chemistry of an ocean or to put available food in the hands of those who need it, it would be perilous to undertake the design and maintenance of a complete life-support system for everyone." The alternative path of development he recommends is one in which we lessen our impact on the atmosphere enough to allow both ecosystems and human civilization to adapt to the changes. He warns that we cannot rely on a technological solution; there is no cheap source of energy just around the corner. Instead, he provides a recipe of increased energy efficiency for both industrialized and developing countries, protection of forests, and stabilization and possibly reduction in the human population. Firor does not have all the answers, but his analysis identifies the roots of the problems and provides us with a starting point.

Bridgman reaches some of the same conclusions in the final chapter of *Global Air Pollution*, which also deals with strategies for avoiding irreversible climate change. Needs for control over the world population, energy conservation and efficiency, sustainable development and lessening the gap between the rich and the poor are emphasized. This is the first text on atmospheric chemistry I have seen that considers the links between atmospheric chemistry and topics such as population, world hunger, gross national products, the World Bank, and genetic diversity of rain forests. Bravo! □

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