Friedman uses the new methods to give a thorough comparison of Newton's and Einstein's theories of space and time. He starts with a simple Newtonian theory of absolute space and, working Tinker-Toy style, adds and subtracts objects from it, progressing through various versions of Newtonian gravitation theory, classical electrodynamics, and special relativity and finally arriving at general relativity. Friedman carefully weighs the methodological criteria used to guide each step. Later in the book, this enables him to develop what he calls a picture of scientific method, based on the notion of theoretical unification.

In contrast with more traditional treatments, each theory is written in the same formalism, so that the exact differences between them become especially clear. We find a now traditional objection well justified: Einstein cannot claim that his theory is a true general theory of relativity just because its equations are generally covariant. For the equations of *all* the theories Friedman considers are presented in generally covariant forms. But Friedman does not allow this to settle the question. Following an approach best known from J. L. Anderson's 1967 *Principles of Relativity Physics*, he introduces the concept of "absolute objects." These are objects that act upon other objects of the theory without in turn being affected. Examples are the Minkowski metric of special relativity and the vector field defining absolute rest in some versions of Newtonian theory. Einstein's general theory of relativity is distinguished as being the only theory considered that is entirely free of these objects. It is essentially through this feature that the theory answers the epistemological objections that Einstein tells us guided him to his theory.

Unfortunately Friedman does not seem to have made any further serious attempts to understand the motivations that guided Einstein. Rather, in a way that is now all too familiar, he characterizes them as based on confusions compounded to the point of irresistibility (p. 209) and all but ignores Einstein's later reassessments and reformulations. If Einstein was really so fundamentally confused, then surely it is more than astonishing that he achieved all he did. I prefer to locate much of the confusion in *our* understanding of Einstein's motivations.

The remainder of the book deals with the questions of relationism and conventionalism in space-time theories. Friedman argues for a realist approach to space-time, rather than what he calls the Leibnizean relationist view, in which physical reality is accorded only to *occupied* points in space-time, that is to physical events. The argument is based on the methodological criteria, which began to emerge in earlier chapters, concerning whether we should ascribe physical reality to a given theoretical entity. Space-time passes the test because it has definite unifying power in Friedman's reconstructed development of space-time theories. In particular, Friedman concludes, adopting the realist attitude means that our space-time theories are better confirmed by the relevant evidence.

I was disappointed that Friedman should allow his arguments against relationism to focus on such general methodological issues, when developments in relativity theory have blurred the fundamental distinction upon which that view depends: the distinction between space-time the container and matter the contained. For, at least on a theoretical level, general relativity has fused space-time with the gravitational field and the energy-momentum that it carries. Friedman treats this thorny but crucial issue only briefly and in passing (pp. 222–223).

Following the work of Reichenbach and others, it has become widely accepted that the ascription of a geometry to space or a distant simultaneity relation to events in special relativity is conventional in large measure. In each case, the argument rests on the possibility of producing a range of theoretically distinct but empirically equivalent versions of the appropriate theories. To choose between them in any more than a conventional way, it is said, is to introduce an arbitrary, empirically superfluous structure into the theory. Here the intrinsic approach has a dazzling impact. From its point of view, as Friedman demonstrates, the situation is exactly reversed, and it is the conventionalists who are guilty of introducing arbitrary structures. For one can only produce these empirically equivalent formulations by introducing what are now seen to be empirically superfluous objects, such as a universal force field or one that generates an anisotropy of space.

Friedman's book is a timely addition to the literature on the philosophy of space and time. It is distinguished by the care and clarity of its exposition and will surely become compulsory reading for anyone seriously interested in keeping abreast of recent developments in the field.

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Hominids from Iraq

The Shanidar Neandertals. ERIK TRINKAUS. Academic Press, New York, 1983. xxvi, 502 pp., illus. $47.50.

Most of the scientific community now accepts the fact that the characteristics of modern human anatomy evolved from predecessors of distinctly less than modern appearance between 30 and 40 thousand years ago. The first of these predecessors to be recognized as such was found in the Neander Valley, the Neanderthal as it then was, in western Germany in the middle part of the last century. Many have subsequently used the term "Neanderthal" to stand for that grade in human evolution where modern brain size had been reached but before those reductions occurred that transformed Middle Pleistocene levels of skeletal robustness and muscularity into modern form.

What is not generally realized is that this view of Late Pleistocene human evolution has traditionally been rejected by the very specialists whose efforts have produced the evidence on which it is based. Consequently, analyses of major discoveries aided by modern techniques and perspectives, such as Trinkaus's report *The Shanidar Neandertals*, are of especially great interest.

Shanidar Cave in Iraqi Kurdistan near the borders with Iran and Turkey was excavated between 1951 and 1960. Seven adult and two infant human skeletons were found in varying degrees of completeness and in datable stratigraphic context. For the first time it was possible to use modern sedimentological, palynological, and radiometric techniques to assess the life and times of the inhabitants of a site of such age and importance. However, it is a mystery why it took a whole generation to produce a final description of the seven fragmentary human skeletons when time, money, and the best of skilled professionals were available from the beginning.

The delay was certainly not the fault of Trinkaus, who only took on the project in 1976. When he first got to the Iraq Museum in Baghdad, he found that one of the most important crania had not yet been unpacked since its excavation 16 years earlier. He got right to work, and, in an ambitious series of reports culminating in the book under review, he has produced the definitive description of the Neanderthal skeletons from Shanidar Cave. It is a careful and methodical, bone-by-bone descriptive account. Further, Trinkaus compares the Shanidar material with other Neanderthal and

modern fossils, using his own observations on them wherever possible—tedious reading for the non-specialist perhaps, but thoroughly admirable. The conclusions drawn from the analysis of pathologies and from the specifics of muscle origins, insertions, and morphological details are also admirable and thought-provoking.

Unfortunately the attempt to squeeze large-scale interpretations from tiny samples leads to less admirable results. There are pronouncements concerning stasis and change of postcranial, dental, and craniofacial aspects over 15,000 years or possible more at Shanidar, where one end of the span is anchored by only three individuals and the other by four relatively incomplete ones. Then there is the prolonged effort to deal with the significance of the supposed fact that the Neanderthal gestation period was 11 or 12 months rather than the normal human nine—a conclusion extrapolated from a grand total of two female pubic bones and five male ones distributed between Europe and the Middle East over a time span of perhaps 30,000 years.

Also, basically, the question of what is a Neanderthal is never thoroughly treated. Early in the book Trinkaus denotes the Neanderthals as regionally and temporally restricted archaic *Homo sapiens* sharing a set of features "that have been traditionally termed *classic Neandertal.*" What these features are and who established them as traditional designators—and on what basis—is not initially mentioned. This is partly rectified by emendations scattered throughout the text, but these are incomplete and do not make up for the lack of a competent treatment of the "Neanderthal problem."

The thorny issue of Neanderthal phylogenetic relations with previous and subsequent populations is relegated to confusion right at the beginning with the decision to call certain fossil groups "Early Neandertals" although they are not considered Neanderthals, whereas others that are in fact early are not so labeled because they *are* considered Neanderthals.

Although there are interpretative weaknesses and the publisher has saved space by cramming illustrations together, the basic presentation of the skeletal anatomy is exemplary, and this book joins the ranks of those classic monographs that now serve as the basis for our understanding of the course of human evolution.

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Photosynthesis

C_3, C_4. Mechanisms, and Cellular and Environmental Regulation, of Photosynthesis. GERRY EDWARDS and DAVID WALKER. University of California Press, Berkeley, 1983. x, 542 pp., illus. $65.

Photosynthesis is often portrayed as being made up of separate and distinct processes, labeled either light or dark reactions. Although photosynthesis involves the capture and conversion of radiant energy to produce useful chemical compounds, the dark reactions are not simply "turned on." Indeed, they are regulated by signals, other than the increased availability of ATP and NADPH, from the light reactions—*p*H and ion changes in the chloroplast and cytoplasmic compartments as well as modulation of the activities of enzymes involved in the reductive pentose phosphate (C_3) pathway and the dicarboxylic acid (C_4) pathway. A unique and important feature of the volume under review is a discussion of recent advances demonstrating how the dark reactions involving CO_2 fixation to sucrose and starch formation are metabolically regulated.

Over the last decade the authors of the book have each contributed significantly to the study of photosynthetic carbon assimilation. Rather than review contributions from the entire field, they have written from a personal point of view emphasizing their own observations.

Walker has used isolated and intact chloroplasts to investigate the mechanisms and regulation of carbon flow during C_3 photosynthesis. He considers first the essential features of the C_3 pathway and then aspects of its regulation and the relationship of the movement of metabolites between the chloroplast and the cellular environment. The delayed induction of the photosynthetic process, seen when going from dark to light, receives considerably more emphasis than is warranted. The delay occurs because substrates must be built up before the autocatalytic process (regeneration of the acceptor for CO_2) becomes efficient. Light activates some of the enzymes during the lag.

Walker interprets his experiments using a multitude of curves each lacking an accompanying measurement of intermediate pools, enzyme activities, or both. The intermediate pools in isolated chloroplasts are considerably lower than in chloroplasts of intact leaves, making any predictions of the cause of induction in leaves questionable.

Edwards has contributed significantly to the understanding of C_4 photosynthesis. A large number of the higher plants produce as the initial products of CO_2 fixation four-carbon dicarboxylic acids (oxaloacetate, malate, or aspartate). These products move from the mesophyll cells to specialized bundle sheath cells surrounding the vascular tissue. Decarboxylation occurs in the bundle sheath cells, and the CO_2 is refixed by the reductive pentose phosphate cycle. C_4 photosynthesis serves as an addendum to the C_3 cycle to concentrate CO_2 in the bundle sheath cells. The historical formulation and function of this pathway are discussed in the book, as are the compartmentation and regulation of enzymes, the transport of metabolites, and the physiological and environmental implications of the diversity of C_4 plants. Photosynthesis by succulent plants, called CAM (crassulacean acid metabolism), is discussed in light of C_3- and C_4-type metabolism.

The first part of the book attempts to provide a concise, elementary description of the photochemical apparatus and events that generate the assimilatory power (ATP and NADPH). Though the treatment of carbon assimilation is well organized and thorough, written to be understood by a graduate student, the discussion of the basic energy processes is oversimplified. It could give a reader the impression that the book is written for a popular audience, which is not the case.

C_3, C_4 presents a well-integrated description of the processes of photosynthesis and accompanying metabolism. It is the first book that clearly shows how the C_3 and C_4 pathways of carbon flow relate the processes of energy capture and conversion to the agronomic and environmental aspects of plant photosynthesis and production.

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