group) the graviton is unified with lower spin fields and gauge invariance is unified with internal symmetry. Supergravity theories are finite through two-loop approximation, which is not the case with ordinary quantum gravity in interaction with matter.

Since only canonical quantization serves as a sure starting point to the path integral formulation and development of Feynman rules for calculation, Deser presents a Hamiltonian formulation of simple supergravity. He discusses the initial value problem and takes the "square root of gravity." Energy is defined in terms of Cauchy data on an initial hypersurface, provided space is asymptotically flat. Following Dirac, one takes the square root of the gravitational energy constraints that are quadratic in the canonical momenta. Deser shows in this way that no tachyons or negative energies can appear in supergravity. Taking the classical limit, he shows that the Einstein equations have only positive energy solutions. If a cosmological constant were included, the global group would be the deSitter group rather than the Poincaré group. Since asymptotic flatness is necessary in order to define the energy, a cosmological constant is thus incompatible with the positive energy theorem. Throughout the book there are many tantalizing statements about the cosmological constant. These are important to particle physics, since particle symmetry breaking or unbreaking necessarily produces a huge vacuum energy density or cosmological constant.

J. Scherk considers supersymmetry in space-time containing extra dimensions of the Bose type. On reducing the number of space-time dimensions to four, these simple supergravity theories become extended supergravity theories.

The reviews so far discussed contain an admirably detailed and clear exposition of the current situation in quantum gravity, supersymmetry, and supergravity. This complete presentation is likely to suggest, as have similar presentations in the past, new pathways in ordinary quantum field theory. Even more suggestive are proposals by S. W. Hawking, G. 't Hooft, and Scherk of ways in which to alter gravity so that it might be fully renormalizable. Hawking uses Euclidean path integrals in order to emphasize topological properties that are essential in getting around the limitations of Feynman diagram perturbations about flat space. He takes the attitude that "quantum theory and indeed the whole of physics is really defined in the Euclidean region and that it is simply a consequence of our perception that we interpret it in the Lorentzian regime." He sums over metrics of very complicated topology in order to see space-time as having "foam like" structure on the Planck length scale. Hawking's lecture also contains an interesting account of black-hole thermodynamics showing that the attractive and long-range nature of gravity permits a microcanonical, but not a canonical, ensemble to be defined: because black holes have negative specific heat, they can be in a box in stable equilibrium with thermal radiation if the total energy is fixed but not if the temperature is fixed.

New physics at the Planck length is also suggested by 't Hooft. At this scale, quantum gauge transformations make the metric tensor scale-dependent. A lattice gauge theory introduced into quantum electrodynamics and quantum chromodynamics formally to simplify calculations is to be taken realistically in quantum gravity.

Because alternative short-distance modifications of the Einstein theory lead to tachyons or ghosts, Scherk suggests the quantized spinning string model for renormalization. This suggestion originates in dual models for elementary particles.

Precisely because of its wealth of technical detail and the problems it exposes, the book is a tribute to how far we have already come in unifying gravitation with the quantum field theory of gauge fields, fermions, and scalar particles, the bread and butter of particle physics. In the conceptual area that mattered to him, the spirit of Einstein triumphs again.

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Oxygen Biochemistry

Biochemical and Clinical Aspects of Oxygen. Proceedings of a symposium, Fort Collins, Colo., Sept. 1978. WINSLOW S. CAUGHEY, Ed. Academic Press, New York, 1979. xx, 866 pp., illus. $45.

Oxygen plays a fundamental role in the biochemistry of all higher organisms. It is a mixed blessing for the biomolecular machinery of the cell, however; while aerobes have very effectively taken advantage of O_2 as the ultimate electron acceptor in the respiratory chain, they also pay a price for its presence in that they need special safeguards against its indiscriminate action. Both aspects of oxygen biochemistry are well represented in this volume of symposium proceedings. The contents delineate the frontier of current research with contributions ranging from a description of the quantum chemistry of oxygen to a discussion of the role of O_2 in the radiation treatment of tumors. Biochemical studies with an emphasis on physical techniques account for the majority of the papers. The prospective reader should not expect an even, systematic coverage of the important issues but must be prepared to work his or her way through masses of often fascinating yet incidental detail in search of the essential features. Discussions following each paper often help to establish proper perspectives.

The major part of the book is devoted to the molecular machinery and reactions involved in the cell's utilization of oxygen. Heme proteins clearly dominate the scene with 28 contributions out of 51. Other O_2-binding proteins are briefly but competently reviewed, in particular those containing flavin (papers by Massey and by Hemmerich and Wessiak are most noteworthy) or non-heme metal active centers.

The O_2 carriers hemoglobin and myoglobin have been studied more extensively than any other proteins, and they continue to be the focus of new experimental and theoretical endeavors. Iron porphyrin, the prosthetic group of all heme proteins, is a spectroscopist's delight, as is illustrated by excellent contributions on infrared stretching frequencies (Caughey *et al.*), single crystal absorption spectra (Churg *et al.*), and electron paramagnetic resonance and nuclear magnetic resonance studies (Gupta *et al.*). Information gained through these techniques raises new questions about molecular structure and function. Quantum chemical calculations (Goddard and Olafson) provide useful guidelines but need further refinement before they can reproduce the experimental data.

The more complex heme enzymes are represented by papers on peroxidase, cytochrome P450, cytochrome oxidase, and others. Considerable progress has been made in the characterization of membrane-bound proteins such as the mammalian P450's and cytochrome oxidase. Still, much less is known about heme enzymes than about the O_2 carriers; in the absence of structural information the studies focus on the rich chemistry of these proteins, readily monitored by spectroscopic means. Chemical analogs with specified heme ligands have been synthesized to mimic the

spectral properties of given enzymes (Groves and McClusky; Chang; Traylor *et al.*). Interpretations that relied on analogies with known heme proteins can now be verified by these model studies. Spectral similarity, of course, does not guarantee similar reactivity; in fact, it is clear that the reactivity of the heme group in an enzyme is governed by the dynamic structure of the protein. A detailed elaboration of these ideas is yet to come.

Roughly a quarter of the proceedings is concerned with the detrimental forms of oxygen, that is, singlet oxygen, superoxide, peroxide, and hydroxyl radical. Their effects on lipids and on the lens of the eye are described, and the enzymes that inactivate the reactive O_2 derivatives are discussed, in particular superoxide dismutase, peroxidase, and catalase. Other papers treat the bactericidal effect of leukocyte-generated activated oxygen species and the toxicity of elevated O_2 pressure. Related topics ranging from clinical studies to experiments at the molecular level are briefly touched upon.

Many of the papers capture the excitement of current research; all are informative, and together they provide an overview of the state of the art in this burgeoning field.

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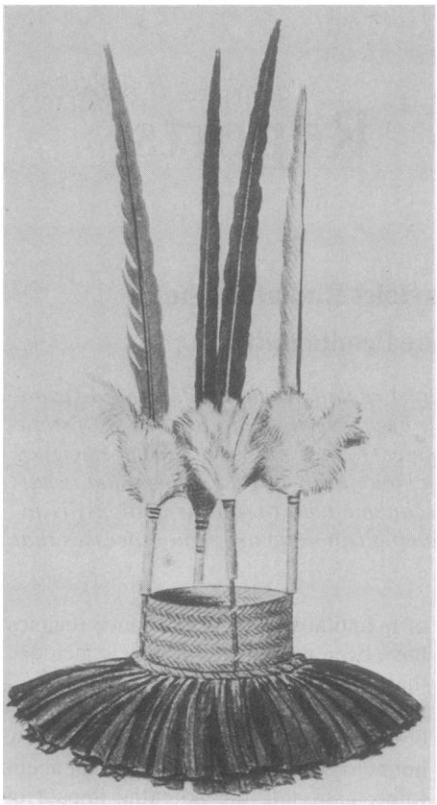
Pre-Columbian Societies

Ancient Panama. Chiefs in Search of Power. MARY W. HELMS. University of Texas Press, Austin, 1979. xvi, 228 pp., illus. $16.95. Texas Pan American Series.

The concern of this book is with the cultural evolution of ranked societies and their sociopolitical systems in pre-Columbian Panama and with the economic and intellectual values associated with the political life of the area. Its principal subjects are power relationships that depended on education of individuals, the maintenance of power, and far-flung trade. Helms draws her basic material from the Spanish chroniclers and ethnohistoric sources and utilizes comparisons with chiefdoms from the San Blas Cuna and peoples of northern Colombia and to some extent Polynesia.

When the Spanish Conquest began, the dominant form of social organization



Headdress of a Cuna *kantule* (chief). The tall feathers are (*left to right*) red, blue, and yellow. [From S. H. Wassén, "Original Documents from the Cuna Indians of San Blas Panama," *Etnologiska Studier*, No. 6, 1938, plate 1, by permission of the Göteborgs Etnografiska Museum; from *Ancient Panama*]

in Panama was the clan with patrilineal succession. Settlements ("pueblos") were composed of kinship groups each under a chief. If many people were involved, the "pueblos" were called "provinces." These were rank societies. Generally chiefly power was hereditary, falling to the eldest son, but there were occasions when the lack of male lineage drew the oldest daughter or the son of the second daughter because of his demonstrable ancestry. There was also a provincial chief or "cacique mayor," whose domain was marked by water (river, stream, or ocean) boundaries.

The resources of a province were limited according to its geographical position, and trade, local, regional, and long-distance, was necessary whether for subsistence items, raw materials, or luxury goods. Alliances for trade and war between provinces developed as means of controlling resources and of maintaining leadership as well as the social setting. Even when in power, the high chiefs were immersed in politics to assure or better their position and to push aside or use as tributing vassals less ranking rulers. To this it might be added that almost constant warfare was waged between rival alliances composed of non-related groups on account of the pressure for slaves, who sometimes were sold but whose principal role was for religious sacrifice. One does not mind killing a stranger but family is a different matter.

All of Panama shared an ideology that had its roots in northern Colombia, the seat of an elite group of teacher-scholars who excelled in esoteric knowledge. Colombia was likewise one of the most important centers of gold working in the Americas. Helms suggests that the recognition of the Colombian authorities formed one of the major elite "resources." Certain young chieftains journeyed to locations in Colombia to be schooled in cosmography and versed in sacred symbols, lore, ritual, and a special language, thus acquiring knowledge that was necessary for the acquisition of a mystical character to enhance political standing. At the same time, these distant voyages provided a commodity exchange network, making it possible to obtain prestige articles, particularly of gold, which gave the esoteric knowledge material expression and also contributed politically to the maintenance and expansion of chiefly power.

As Helms makes clear, gold artifacts were restricted to the sociopolitical elite. However, her premise that all Panamanian gold objects were imports from the south is debatable. Archeologically, gold-working tools and defective pieces that would have been unsuitable for trade are known from Veraguas, and in Costa Rica, which has the same pre-Columbian sociopolitical and ethnological background as Panama, one clay mold has been excavated and at least three unique styles of figures can be identified, offering evidence of this art in lower Central America.

From the point of view of plant geography, Helms's inclusion of citrus fruits in a list of foodstuffs enjoyed by pre-Columbian Panamanians (p. 11) bears mentioning. Citrus did not exist in the Americas until brought by Europeans during Conquest times. This error does not detract, however, from Helms's stimulating and careful account of the power struggle among the chieftains of ancient Panama.

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