gae. The algae have been isolated from a variety of environments around the world, including soil, fresh and sea water, and air at 1100 meters. The book emphasizes the utility of *Chlamydomonas* as systems for research on a broad range of biological questions. Few organisms have such versatility. More work has been done with *C. reinhardtii* than with other species, but *C. eugametos* and *C. moewusii* have also been extensively studied. The organisms provide nearly all the general features of plant cells and more. Two flagella (undulipodia) give the cell motility and are used for initial pairing of mating types. The manipulability of mating types and subsequent zygotes under laboratory conditions has made them classic systems for examining nuclear (Mendelian) and organellar (non-Mendelian, uniparental) inheritance. The magnitude of work already accomplished, the availability of a large variety of mutants, and the ease of generating additional mutations provide a strong foundation for the use of *Chlamydomonas* in studies of processes that would be more difficult with higher plants and animals.

The early part of the book reads like a detective story, with bits and pieces of information gathered to trace origins and lineages. From this Harris develops a standard for nomenclature of species and mutant strains. Approximately half the book is devoted to a detailed description of the major cellular structures and their functions. This review aptly illustrates the suitability of the algae for examining such processes as cell wall biosynthesis, the cell cycle, assembly of microtubules and flagella, motility and phototaxis, gametogenesis and mating, organellar and nuclear molecular genetics, photosynthesis and chloroplast development, and plant metabolism. Chapters concerned with these topics are liberally illustrated with electron micrographs and diagrams.

The last chapter provides experimental protocols. Most were contributed by the investigators who developed the procedures and are presented in sufficient detail that the novice will have no difficulty using them. Protocols for essentially every aspect of work on the organisms are provided, from those pertaining to the fundamental aspects of cell growth to the recently developed techniques for transformation. Even several laboratory exercises are included to introduce some intriguing aspects of *Chlamydomonas* to future investigators.

An index of known nuclear and chloroplast mutations (mostly of *C. reinhardtii*) is included near the end of the book. Interestingly, no mutant of the mitochondrial genome has yet been identified. For each mutation the genetic locus (if known), phenotype, source, and reference to the original description are given. Also included are the repositories from which these strains can be obtained. The major collection, of which Harris is curator, is located at Duke University. Unexpected components of the book are a list of Ph.D. theses of 184 graduate students who were trained by *Chlamydomonas* between 1913 and 1986 and a 123-page bibliography. After this much activity, the field is due a handbook.

The book is exceptionally free of errors. It is written in a clear and matter-of-fact style and is logically organized. In short, the book is a superb achievement. It should be on the shelf of every person who has an interest in *Chlamydomonas* as a research or teaching system and in every library used by students of biology.

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Quasi-Stellar Spectra

QSO Absorption Lines. Probing the Universe. J. CHRIS BLADES, DAVID A. TURNSHEK, and COLIN A. NORMAN, Eds. Published for the Space Telescope Science Institute by Cambridge University Press, New York, 1988. x, 348 pp., illus. $39.50. Space Telescope Science Institute Symposium Series, vol. 2. From a meeting, Baltimore, MD, May 1987.

QSOs, or "quasi-stellar objects," are distant galaxies whose centers contain black holes with masses up to 100 million times the mass of the Sun. Objects near the black hole—either gas clouds from the interstellar medium or shredded stars from the "host" galaxy—are drawn into the black hole by gravity. This accreting material must lose some angular momentum via viscous forces before dropping below the event horizon of the black hole. In this process, an enormous amount of energy is liberated, which either radiates away in the form of light or is retained by the gas as heat.

The supermassive black hole and accretion flow, called the QSO's "central engine," can far outshine the surrounding stars. The high luminosities of QSOs enable astronomers to use them as probes of the Universe at great distances and hence at epochs when the Universe was about 20% of its current age. This was a period when many important events took place—the formation and and rapid early evolution of galaxies, the beginnings of the collapse of large structures such as clusters of galaxies and superclusters, and the rapid turn-on of QSOs.

All QSO spectra show discrete absorption lines, caused by the absorption of the QSO continuum by atoms in intervening gas clouds that have nothing to do with the QSO. Traditionally, QSO absorption lines have been grouped into two classes: the "Lyman-α forest" and the "metal-line" systems. The Lyman-α forest clouds are extremely numerous (like trees in a dense forest, hence their whimsical name) and show absorption by hydrogen but not by any heavier elements. These clouds are fascinating because they may represent material with primordial abundances, that is, material that has never been contaminated by the products of nucleosynthesis from stars. Hence they may represent protogalactic or pregalactic material. The "metal-line" systems, on the other hand, probably arise in clouds in the gaseous halos or disks of very distant galaxies. These systems are of interest because they allow astronomers to study relatively normal galaxies, that is, galaxies that are not QSOs and that are much too distant and too faint to study any other way.

Ironically, with ground-based optical telescopes it is easiest to study absorption lines from the most distant clouds and relatively difficult to study the absorption lines from clouds nearby. This is because most of the strongest absorption lines are in the extreme ultraviolet part of the electromagnetic spectrum, which is blocked by Earth's atmosphere. The most distant objects are moving away from us at high velocities owing to the cosmological expansion of the Universe, so their ultraviolet spectra are Doppler-shifted into the optical and infrared ranges, which are observable from the ground. Objects nearby, on the other hand, are not moving as fast, and the most interesting parts of their spectra are in the extreme ultraviolet, observable only from space.

With the Hubble Space Telescope, scheduled for launch next spring, astronomers will for the first time be able to study the ultraviolet spectra of QSOs in detail comparable to that in the optical spectra obtainable with large ground-based telescopes. These observations will provide insight into the origin and physical conditions of the absorbers by allowing astronomers to study ones that are close enough to permit detailed comparisons with well-studied objects such as local galaxies.

The symposium that gave rise to this book was intended to take place shortly after the launch of HST. With the postponement of the launch after the Challenger tragedy, the focus of the conference shifted from space-based work to a review of the ground-based work of the last 10 years.

Despite the lack of data from HST, there were many new results to report. R. Hunstead and R. F. Carswell showed conclusive evidence that the number density of Lyman-α forest clouds has decreased sharply with

time, so that there were many more in the past. W. L. W. Sargent reported on a large survey of metal-line systems that showed that they cluster much as present-day galaxies cluster: further evidence that they arise in galaxies like our own. D. Turnshek, C. B. Foltz *et al.*, and J. P. Ostriker discussed how QSOs themselves affect their immediate environment, in some cases spewing forth clouds of material, in other cases merely altering existing clouds with their intense radiation. A. M. Wolfe and F. H. Briggs summarized their long-term study of the "damped Lyman-α" systems, metal-line systems that arise in the disks of early spiral galaxies. The most controversial results were presented by D. Tytler, who argued that there are not two fundamentally different types of clouds but a single population with a continuous distribution of cloud sizes, hydrogen column densities, and metallicities. Two years later, this controversy is still unresolved, and there remains persuasive evidence for both views.

One good feature of this book is that verbatim transcripts of the discussions are included, giving a sense of the stimulating atmosphere of the conference. An unfortunate feature is that only the review talks are included, with the contributed papers issued separately in a preprint that has not been widely circulated. (This reviewer has been unable to get a copy despite numerous requests.) The contributed papers are liberally referred to in the review talks and in many cases report the newest and most influential ideas and results. Still, this book provides a good starting point for students and researchers seeking an introduction to the subject.

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Postmortems

Recent Vertebrate Carcasses and Their Paleobiological Implications. JOHANNES WEIGELT. University of Chicago Press, Chicago, 1989. xviii, 188 pp. + plates. $60; paper, $19.95. Translated from the German edition (Leipzig, 1927) by Judith Schaefer.

Death, decay, decomposition, putrefaction, destruction, burial—these are the subjects of a classic 60-year-old monograph by Johannes Weigelt now translated and accessible to a wide audience for the first time. Weigelt (1890–1948) was a pioneer of taphonomy (though he used the term *biostratinomy*). The German taphonomic tradition did not take root in North America (although Zangerl and Richardson's 1963 monograph on Pennsylvanian black shales was an outgrowth of that tradition). The taphonomy that is popular today follows the Russian tradition of I. Efremov, as introduced to the United States by E. C. Olson in 1962, which blossomed in the 1970s under the leadership of A. K. Behrensmeyer.

Weigelt reviews the processes of decomposition of vertebrate remains and provides an exhaustive classification of causes of death, with abundant examples of mass death (including lemmings in the sea, reindeer in lakes, massive fish kills due to changes in temperature and salinity, the ill effects of El Niño on marine life, and the effects of cold and drought on terrestrial life). He stresses the importance of the moisture content of the burial medium: when the medium is too dry, natural mummification occurs; when it is too moist, decomposition is also inhibited, and a natural anaerobic process of saponification occurs, resulting in a carcass in which the soft parts are preserved as *adipocere*. Macabre examples of these two phenomena include mummies of knights in castle towers and in cathedral crypts and the undecomposed corpses in the Cemetery of the Holy Innocents in Paris. Weigelt recounts his observations of carcasses of cows, turtles, alligators, and garfishes that were killed by severe winter cold at Smithers Lake along the Texas Gulf Coast in December 1924, an event that claimed 1.25 million cattle. He tracks decomposition unflinchingly with an extensive series of photographs taken over a ten-month period. He demonstrates the relevance of the Texas carcasses for interpreting fossil fish and tetrapod remains.

Many of the themes of Weigelt's work (the role of insects in decomposition; burial of land vertebrates in marine strata; carcasses on facies boundary lines) have been discovered independently by modern workers. I am intrigued by his mention *en passant* of alligators regurgitating bone. It is well known that crocodilians have very low stomach *p*H and bone-free feces; thus paleontologists have discounted the role of crocodiles as agents of bone accumulation in the past. Is it possible that crocodiles faced with coarse, bony prey such as turtles and gars (rather than the dainty rodents of experimental studies) actually do regurgitate bone and thus may be agents of bone accumulation?

Conspicuously lacking in taphonomy today are studies of modern mass mortalities that can serve as models for the deposits that are so conspicuous in the fossil record. (We all know that wildebeests drown in great numbers when a herd crosses a river in flood, but who has ever studied the resultant carcasses?) Weigelt's book will serve as an indispensable resource and as a welcome stimulus for some much-needed basic research in taphonomy.

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