physeal union, eruption and calcification of the dentition, development of secondary sex characteristics, and the timing of the adolescent growth spurt and culminating in refined methods for the assessment of skeletal maturation of the knee and the hand and wrist.

The Fels study has longevity, and its course has changed somewhat. The current emphasis is more on health-related factors, providing opportunities for relating indicators of growth and maturation to aging and health. Body composition and risk factors for cardiovascular disease are a primary focus, especially issues related to methodology, fatness, fat distribution, tracking of risk factors, and so on. New methodology complements traditional anthropometry, the multicomponent estimation of body composition through measurement of bone mineral, body water, body density, and bioelectric impedance. With the addition of these new dimensions to the longitudinal data set, contributions to our understanding of growth, maturation, aging, and health status should continue.

The discussion that the book offers of the many facets of the Fels Longitudinal Study is, of necessity, superficial. Details of methods and results have been published in numerous papers; indeed, the reference list includes over 600 entries. Overall, the Fels Longitudinal Study is a blend of traditional and more recent technology. Not only have the participants grown and matured and now age, the data, including those obtained with newer technology, and their analysis have also grown and matured.

I thoroughly enjoyed reading this volume. It is a rich source of information on a unique center and should be required reading for students of auxology.

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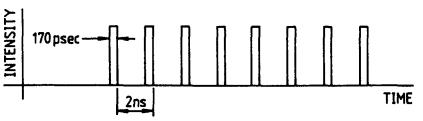
Looking at Crystals

Macromolecular Crystallography with Synchrotron Radiation. JOHN R. HELLIWELL. Cambridge University Press, New York, 1992. xix, 595 pp., illus. $165.

With ever-increasing frequency the three-dimensional crystal structures of biological macromolecules are being reported in the most widely read scientific journals. This explosion of information has been in part due to the availability of synchrotron radiation. In this timely and masterly work John Helliwell describes the uses of synchrotron radiation in macromolecular structure determination and puts its importance to the structural biologist in the context of modern-day scientific needs.

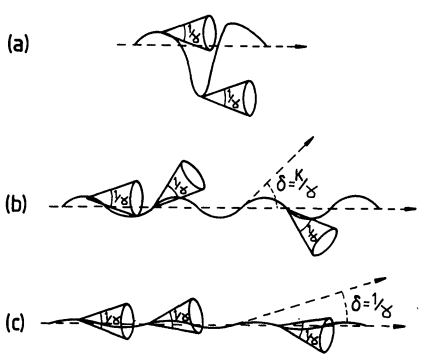


"The time structure of the X-ray beam derives from that of the electrons (or positrons) in the storage ring. The electrons travel in the ring in bunches and thus the radiation is emitted in pulses. The values shown are for the Daresbury [Synchrotron Radiation Source] in multibunch mode. In single bunch mode the light pulse occurs each orbital period of 0.321 μs." [From *Macromolecular Crystallography with Synchrotron Radiation*]

Used since the early 1970s to determine three-dimensional macromolecular structures, synchrotron radiation is ideal for the study of weakly diffracting crystals, those for which biochemists and biophysicists yearn to have structural data. Unexpectedly, the radiation damage to crystals is less with the use of synchrotron radiation than with conventional x-ray sources. Multiwavelength and very intense in character, synchrotron radiation is produced by high-energy electrons traveling at nearly the speed of light in an electron storage ring. Synchrotron radiation consists of pulses (on the nanosecond scale) and can be "tuned" to a specific required wavelength in the x-ray range by use of a monochromator crystal. It was originally considered a nuisance by-product in circular electron accelerators, which were not optimized for its use. Eventually, however, particle accelerators were designed with the necessary specifications for synchrotron radiation production, including continuous beams with long lifetimes, stable source positions, and magnetic insertion devices. Helliwell describes the appearance and operation of 32 storage-ring synchrotron x-ray sources, at 27 sites around the world, that are in use by scientists including x-ray crystallographers.

As Helliwell shows, crystallographers have discovered how to take advantage of the unique physical characteristics of synchrotron radiation to further the determination of macromolecular structures by crystal diffraction. For example, the multiwavelength nature of synchrotron radiation is useful in the phase determination of proteins or their derivatives that contain heavy atoms. Since synchrotron radiation can be tuned, it is possible to select a wavelength at which anomalous scattering by one component atom in the crystal occurs and then a wavelength at which this does not take place. The two sets of diffraction data are then compared and the results used as an aid in the solution of the phase problem. Furthermore, diffuse scattering, which gives information about the mobility and flexibility of molecules in the crystal, can be studied effectively at synchrotron radiation sources. This type of work will doubtless lead to greater knowledge of enzyme function, perhaps indicating which parts of the enzyme move during the catalytic reaction. Crystallographers are also succeeding at the formidable task of precisely interpreting the intensity data, and methods for circumventing attendant problems such as peak overlap that occur because of the multiwavelength character of the radiation are now being devised. The outcome is that tens of thousands of Bragg reflections can be measured in short periods of time and used with confidence in structure analyses.

Since von Laue performed his first experiment in 1912, x-ray diffraction studies have been conducted with monochromatic x-rays, because the analysis of the diffraction pattern is simpler. Now, as a result of new abilities to measure and interpret the diffraction intensity data, untuned synchrotron radiation is being used for Laue methods (multiwavelength radiation and a stationary crystal), because the time required for measurement of diffraction data for a protein crystal can be reduced to seconds. Crystal diffraction data can thus be monitored as a function of time so that reactions taking place in, for example, enzyme crystals—such as the phosphorylation of heptenitol to heptulose-2-phosphate by glycogen phosphorylase *b*, or GTP hydrolysis in the Ha-ras p21 protein—can be demonstrated in the equivalent of a motion picture of the action of an enzyme. Since there are probably several molecular conformers of substrate or product present in such crystals during the reaction, methods for analyzing the diffraction data with this in



"Schematic showing the electron motion and synchrotron cone emission for the three insertion devices: (*a*) wavelength shifter; (*b*) multipole wiggler; and (*c*) undulator." [From *Macromolecular Crystallography with Synchrotron Radiation*]

mind are currently under investigation; Helliwell describes these important studies in effective detail.

By describing the various ways in which synchrotron radiation can be used in diffraction studies of crystals, Helliwell has shown the enormous impact it can have on the elucidation of both the structure and the function of macromolecules. Anyone with an interest in macromolecular structure determination and enzyme mechanisms should consult this informative, well-produced, and profusely illustrated book. Those working directly in the field of macromolecular structure determination will find the volume indispensable.

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Anatomical Beginnings

Morphogenesis. An Analysis of the Development of Biological Form. EDWARD F. ROSSOMANDO and STEPHEN ALEXANDER, Eds. Dekker, New York, 1992. viii, 449 pp., illus. $165.

In embryonic development only a few days are required to transform a single cell, the fertilized egg, into a free-living multicellular larva possessing a variety of cell types that, in turn, are organized into the functionally adaptive patterns of the tissues and organs. Embryonic morphogenesis is the ensemble of processes that cooperate to organize the differentiating cells and tissues of the embryo into the patterned arrays that characterize the mature tissues, organs, and overall body form of the larva and the adult. Categories of morphogenetic process include morphogenetic movement, differential growth, morphogenetic cell death, and pattern formation. The embryo can move cells or tissues from one location to another (morphogenetic movement), can restrict increases in tissue volume to selected sites or along selected axes (differential growth), and can eliminate cells at selected locations (morphogenetic cell death). Undifferentiated tissues at various locations in the embryo can be stimulated to differentiate into the particular tissues destined to occupy those individual sites (pattern formation). Pattern formation itself encompasses a number of processes, including embryonic induction, the action of diffusible morphogens, and ooplasmic localization.

Our understanding of the mechanisms of embryonic morphogenesis has greatly improved in recent years, thanks largely to technical and intellectual advances in cell and molecular biology. The techniques of gene cloning, in situ hybridization, and gene transfection, coupled with a better understanding of the regulation of gene transcription, have made possible a molecular-genetic approach to understanding the spatially regulated cell differentiation that is the basis of pattern formation. Progress in the biochemistry of cellular adhesion has inaugurated investigation of directed cell motility in terms of specific molecules. The identification of peptide growth factors has advanced our understanding both of tissue growth and of embryonic induction.

In compiling this multiauthor volume Rossomando and Alexander have focused on the embryonic morphogenesis of specific organisms. The individual chapters of *Morphogenesis* are devoted to descriptions of the morphogenetic processes utilized by a wide array of organisms studied by experimental embryologists, including prokaryotes (the mycobacteria), lower eukaryotes (*Dictyostelium* and *Aspergillus*), and a variety of animals. The higher eukaryotes discussed include such stalwarts as hydras and the embryos of the fruit fly, sea urchin, amphibian, bird, and mouse. Important omissions include higher plants (*Arabidopsis*) and teleosts (*Brachydanio*). The quality of the individual reviews is high, even though the constraints of brevity conflict with the depth and breadth of current knowledge of morphogenetic mechanisms for many of the selected species. Noteworthy are the chapters on development of the embryos of tunicates, amphibians, sea urchins, and *Drosophila*. Tunicate development exemplifies the importance of ooplasmic determinants in subsequent tissue patterning; the sea urchin and amphibian embryos are especially well characterized with regard to the details of the morphogenetic movements of early development; and *Drosophila* is the best-characterized model for understanding the genetic basis for early pattern formation and embryonic segmentation.

Morphogenesis would have been improved by the inclusion of a synthetic chapter that reviewed the subject on the basis of morphogenetic mechanism and drew on examples from throughout the animal, plant, and microbial kingdoms, rather than centering around a particular organism. Despite this weakness, the volume will be useful for advanced undergraduate and graduate students and for university instructors seeking up-to-date reviews of embryogenesis of selected model organisms.

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