Synchrotron Radiation and Muscle Contraction

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Synchrotron radiation has played an absolutely essential role in elucidating the molecular mechanism of muscle contraction. Conversely, muscle contraction was the driving force for the development of synchrotron radiation as an x-ray source. Muscle fibers give detailed semi-crystalline low-angle x-ray fibre diagrams which yield information about the molecular movements during a contraction. To interpret these data requires millisecond time resolution, which is not possible using conventional x-ray sources - hence synchrotron radiation. The first synchrotron x-ray diffraction pattern ever obtained was from a slice of insect flight muscle at the DESY synchrotron in Hamburg in 1970.[1] In the following two years, a laboratory was built on DESY with a fully remotely controlled x-ray beam line.[2] A curved quartz crystal was combined with a curved mirror to focus and monochromatize the beam. Data obtained allowed a time-resolved study of the strong equatorial reflexions.[3] The intensity however, was inadequate for the time-resolved registration of the meridional reflexions. These crucial measurements[4] were carried out later on the DORIS storage ring. The main components of muscle are the proteins actin and myosin. The atomic structures of actin and the fragment of myosin involved in contraction (the cross-bridge) have been elucidated by protein crystallography (using synchrotron radiation). By combining these structures with electron microscopy data, it has been possible to arrive at an atomic model of the actin-myosin complex. Electron microscope studies and crystal structures show that the outer end of the cross-bridge moves as a lever arm during contraction (see Ref. 5 for review). The lever arm movement can be followed by fiber diffraction (see K. Poole, this meeting).

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[1]Rosenbaum, G., K. C. Holmes, and J. Witz. 1971., Nature. 230:434-437.
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[3]Barrington Leigh, J. and G. Rosenbaum. 1976. Ann. Rev. Biophys. Bioeng. 5:239-270.
[4]Huxley, H. E., et al. 1981. Proc. Natl. Acad. Sci. USA. 78:2297-2301.
[5]Holmes, K. C. 1997. Current Biology. 7:R112-R118.