
**BIOLOGICAL APPLICATIONS OF SYNCHROTRON
RADIATION: AN EVALUATION OF THE STATE OF
THE FIELD IN 2002**

Bibliographic Information: Structural Biology Synchrotron Users Organization (BioSync), *Biological Applications of Synchrotron Radiation: An Evaluation of the State of the Field in 2002*, San Diego Supercomputer Center, San Diego, Calif.: BioSync, October 2002 (available at http://biosync.sdsc.edu/BioSync_Report_2002.pdf). Committee chair: Peter B. Moore.

PURPOSE

The Structural Biology Synchrotron Users Organization (BioSync) prepared this report to provide information on the current status of biological research being done at synchrotron facilities and highlight the issues related to the continuing rapid growth in the use of synchrotron facilities for biological research.

BACKGROUND

Since the 1960s, the unique properties of synchrotron radiation have been recognized as extremely useful tools for conducting experiments that traditionally relied on conventional sources of electromagnetic radiation. Also since the 1960s, facilities have been built that are dedicated to the production of synchrotron radiation. The radiation produced at these facilities allows for faster and more accurate collection of information on the structural characteristics of a wide range of macromolecules.

These facilities have had a major impact on the field of structural biology, and the demand for access to such facilities has been growing at an increasing rate in recent decades. This heightened demand has accompanied the rapid development of new applications and new technologies associated with the use of synchrotron radiation in biological experiments. As a result, synchrotron facilities must race to update their equipment while planning for increased staffing and other resources to meet scientists' demands.

The Structural Biology Synchrotron Users Organization was formed in 1990 to promote access to synchrotron facilities for North American scientists interested in using synchrotron radiation to study biological systems. BioSync has since published three reports—one in 1991, one in 1997, and one in 2002—on the status of biological research at synchrotron facilities. The first report surveyed managers of synchrotron radiation facilities and biological users and predicted a large demand for synchrotron access in the near future. The second documented an accelerated growth in the use of these facilities, consistent with the predictions of the previous report.

The third BioSync report was prepared by a committee chaired by Peter Moore of Yale University.¹ The report deals with the application of synchrotron radiation to three fields of structural biology, macromolecular crystallography, X-ray spectroscopy, and X-ray scattering. The report does not cover X-ray imaging. All of the synchrotron facilities in the United States equipped with radiation beamlines were considered in the analysis for this report.

METHODS/APPROACH

Consistent with previous BioSync committees, the 2002 committee conducted surveys of facility managers and biological users. The information gathered from these surveys, and from investigation of each of the facilities themselves, was analyzed for its application to the three fields of structural biology mentioned earlier. The 2002 report describes and identifies the current status of and future trends

¹See Structural Biology Synchrotron Users Organization (2002), p. 4, for a complete list of committee members.

in each field and includes a discussion of significant issues unique to the structural biology field in general.

FINDINGS AND RECOMMENDATIONS

From the individual treatment of the three fields of structural biology covered in the BioSync report, the committee drew several conclusions about the issues affecting the use of synchrotron radiation for biological research in general. The committee's findings and recommendations on synchrotron radiation facility trends and facility needs are as follows:²

Use of Synchrotron Facilities by the National Institutes of Health

Finding. As the chief sponsor of synchrotron-based biology research, the National Institutes of Health (NIH) has received significant increases in funding, whereas the U.S. Department of Energy (DOE) and the National Science Foundation (NSF) have not.

Recommendation. Either Congress must be persuaded to increase the budgets of the DOE and NSF to support the increased work load caused by the increased demand, or a mechanism must be found that enables the NIH to pay for the radiation used by the scientists it sponsors.

Upgrades to Eastern U.S. Facilities

Finding. Two facilities, the National Synchrotron Light Source (NSLS) and the Cornell High Energy Synchrotron Source (CHESS), have the potential to be highly useful to researchers in the future and keep the United States competitive with the world's other advanced light sources. These two facilities are also geographically closest to synchrotron users on the East Coast and therefore must be maintained to ensure hands-on access to state-of-the-art beamlines for users in that part of the country.

²See Structural Biology Synchrotron Users Organization (2002), pp. 6–8.

Recommendation. CHESS and NSLS should be upgraded, and additional resources provided so that existing beamlines at *all* synchrotrons can also be upgraded.

Staffing

Finding. Approximately five staff members per crystallographic beamline are required for round-the-clock coverage. The average beamline does not have that level of staffing. Non-crystallographic beamlines require fewer staff people, but those beamlines, too, are inadequately staffed to meet their potential output.

Recommendation. The level of staffing for beamlines needs to be increased. Both additional funds and efforts to make beamline staff jobs more desirable are needed to adequately address this issue. BioSync should organize a committee to study this problem.

Beamline Demand and Capabilities

Findings

- The BioSync committee reports that by the end of 2002 close to 48 beamlines in the United States will be dedicated to biological crystallography. If all 48 beamlines are well funded and well staffed, this number should be adequate to meet the demands for synchrotron radiation in the immediate future. The committee notes, however, the real possibility that actual demand could exceed the anticipated demand, and the construction of new beamlines needed in such a case could take several years to complete.
- The committee's forecast about the sufficiency of crystallographic beamline resources assumes that substantial increases in productivity will be realized from automation initiatives now under way. Automation is essential for increasing throughput.
- Substantial advantages for users would be realized if all crystallographic beamlines accepted the same crystal mounting hardware. Similarly, there would be sizable benefits if the interfaces that control beamline operations were the same at all beamlines at all facilities.

- Survey responses showed that the greatest impediment to beamline access is the length of time that scientists applying for beam time must wait before actually gaining access.

Recommendations

In conjunction with its findings on beamline demand and capabilities, the committee recommended that the federal government

- closely monitor the number of crystallographic and non-crystallographic beamlines in future assessments to gauge current levels of demand
- support efforts to automate crystallographic beamlines
- encourage designers and operators to agree on both equipment and software standards (This standardization would be a huge help to experimenters who work at more than one facility.)
- standardize and streamline the beamline application process.

OTHER ITEMS OF INTEREST

The geographical distribution of beamline facilities is a major issue affecting beamline scientific output and accessibility. The loss of certain key facilities and the deterioration of others threaten the ability of the scientific communities that depend on regional beamlines to conduct their research. The added travel costs and labor time from flying to facilities across the country would have a significant negative impact on productivity and may even make some projects impossible.

Additionally, the issue of beamline upgrades versus the construction of new facilities is becoming increasingly important as older facilities age and as new technology becomes available. The significant cost savings from upgrading a facility must be weighed against the realistic assessments of the facility's long-term usefulness and compatibility with future technological developments. Failure to anticipate when older facilities may become obsolete could result in significant lag times before the needed construction of new facilities is completed.

Several recommendations of the BioSync committee and some of the commentary in other parts of the 2002 BioSync report warn that the issues of geographical distribution of beamline facilities and beamline upgrades versus the construction of new facilities have the potential to adversely affect all biology fields currently making use of synchrotron radiation facilities.