

to biotechnology and pharmaceutical companies are ion channels and G-protein-coupled receptors, both of which have lately proven more amenable to x-ray crystallographic study. There is still much work to be done in terms of the design of fragment libraries. At present, we do not know with any certainty the optimum library size or the best way to maximize the potential of a library to generate chemical diversity during synthetic elaboration of fragment hits. Moreover, we do not yet know how best to screen fragment libraries. Various organizations have their respective biases, which reflect institutional memory, resource constraints, experience base, and the availability of particular skills, and so on. There is always the sobering possibility that fragment approaches will go the way of HTS, which appears to have fallen well short of expectations. We think it unlikely that fragment approaches will disappoint and we remain committed to exploring the potential of the method and continuously evolving our own process to maximize the likelihood of discovering development candidates suitable for entry into oncology clinical trials of targeted therapeutic agents.

ACKNOWLEDGMENTS

We thank all members of the SGX organization, past and present, who contributed to the manifold aspects of our FAST fragment-based structure-guided drug discovery process both as innovators and practitioners. We also acknowledge contributions to the field by competitors, who are too numerous to identify individually. Use of the Advanced Photon Source was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357. SGX Pharmaceuticals, Inc., constructed and operates the SGX Collaborative Access Team (SGX-CAT) beam line at Sector 31 of the Advanced Photon Source.

REFERENCES

1. Allen, K. N.; Bellamacina, C. R.; Ding, X.; Jeffery, C. J.; Mattos, C.; Petsko, G. A.; Ringe, D. An experimental approach to mapping the binding surfaces of crystalline protein. *J. Phys. Chem.* **1996**, *100*, 2605–2611.
2. Verlinde, C. I. M. J.; Rudenko, G.; Hoi, W. G. J. In search of new lead compounds for trypanosomiasis drug design: a protein structure-based linked-fragment approach. *J. Comput. Aided Mol. Des.* **1992**, *6*, 131–147.
3. Kuntz, I. D. Structure-based strategies for drug design and discovery. *Science* **1992**, *257*, 1078–1082.
4. Kuntz, I. D.; Meng, E. C.; Shoichet, B. K. Structure-based molecular design. *Acc. Chem. Res.* **1994**, *27*, 117–123.
5. Caffisch, A.; Miranker, A.; Karplus, M. Multiple copy simultaneous search and construction of ligands in binding sites: application to inhibitors of HIV-1 aspartic proteinase. *J. Med. Chem.* **1993**, *36*, 2142–2167.
6. Shuker, S. B.; Hajduk, P. J.; Meadows, R. P.; Fesik, S. W. Discovering high affinity ligands for proteins: SAR by NMR. *Science* **1996**, *274*, 1531–1534.
7. Nienaber, V. I.; Richardson, P. I.; Klighofer, V.; Bouska, J. J.; Giranda, V. I.; Greer, J. Discovering novel ligands for macromolecules using x-ray crystallographic screening. *Nat. Biotechnol.* **2000**, *18*, 1105–1108.
8. Bohacek, R. S.; McMartin, C.; Guida, W. C. The art and practice of structure-based drug design: a molecular modelling perspective. *Med. Res. Rev.* **1996**, *16*, 3–50.
9. Hann, M. M.; Leach, A. R.; Harper, G. Molecular complexity and its impact on the probability of finding leads for drug discovery. *J. Chem. Inf. Comput. Sci.* **2001**, *41*, 856–864.
10. Hann, M. M.; Oprea, T. I. Pursuing the lead likeness concept in pharmaceutical research. *Curr. Opin. Chem. Biol.* **2004**, *8*, 255–263.
11. Oprea, T. I.; Davis, A. M.; Teague, S. J.; Leeson, P. D. Is there a difference between leads and drugs? A historical perspective. *J. Chem. Inf. Comput. Sci.* **2001**, *41*, 1308–1315.
12. Teague, S. J.; Davis, A. M.; Leeson, P. D.; Oprea, T. The design of leadlike combinatorial libraries. *Angew. Chem. Int. Ed.* **1999**, *38*, 3743–3748.
13. Congreve, M.; Chessari, G.; Tisi, D.; Woodhead, A. J. Recent developments in fragment based drug discovery. *J. Med. Chem.* **2008**, *51*, in press.
14. Gill, A. I.; Frederickson, M.; Cleasby, A.; Woodhead, S. J.; Carr, M. G.; Woodhead, A. J.; Walker, M. T.; Congreve, M. S.; et al. Identification of novel p38ct MAP kinase inhibitors using fragment-based lead generation. *J. Med. Chem.* **2005**, *48*, 414–426.
15. Lesuisse, D.; Lange, G.; Deprez, P.; Benard, D.; Schoot, B.; Delettre, G.; Marquette, J.-P.; Broto, P.; et al. SAR and X-ray: a new approach combining fragment-based screening and rational drug design: application to the discovery of nanomolar inhibitors of Src SH2. *J. Med. Chem.* **2002**, *45*, 2379–2387.
16. Card, G. I.; Blasdel, I.; England, B. P.; Zhang, C.; Suzuki, Y.; Gillette, S.; Fong, D.; Ibrahim, P. N.; et al. A family of phosphodiesterase inhibitors discovered by cocrystallography and scaffold-based drug design. *Nat. Biotechnol.* **2005**, *23*, 201–207.
17. Lipinski, C. A.; Lombardo, E.; Dominy, B. W.; Feeney, P. J. Experimental and computational approaches to estimate solubility and permeability in drug discovery and development settings. *Drug Deliv. Res.* **1997**, *23*, 3–25.
18. Congreve, M.; Carr, R.; Murray, C.; Jhoti, H. A “rule of three” for fragment-based lead discovery? *Drug Discov. Today* **2003**, *8*, 876–877.
19. Wenlock, M. C.; Austin, R. P.; Barton, P.; Davis, A. M.; Leeson, P. D. A comparison of physicochemical property profiles of development and marketed oral drugs. *J. Med. Chem.* **2003**, *46*, 1250–1256.
20. Vieth, M.; Siegel, M. G.; Higgs, R. E.; Watson, I. A.; Robertson, D. H.; Savin, K. A.; Durst, G. I.; Hipskind, P. A. Characteristic physical properties and structural fragments of marketed oral drugs. *J. Med. Chem.* **2004**, *47*, 224–232.
21. Paolini, G. V.; Shapland, R. H. B.; van Hoorn, W. P.; Mason, J. S.; Hopkins, A. L. Global mapping of pharmacological space. *Nat. Biotechnol.* **2006**, *24*, 805–815.
22. Blaney, J.; Nienaber, V.; Burley, S. K. In: *Fragment-Based Approaches in Drug Discovery*, Jahnke, W.; and Erlanson, D. A.; Eds. Weinheim: Wiley VCH; **2006**, 215–248.