1.3. BIOLOGISTS AND ENGINEERS DIFFER IN THEIR APPROACH TO RESEARCH

The fundamental trainings of biologists and engineers are distinctly different. In the development of knowledge in the life sciences, unlike chemistry and physics, mathematical theories and quantitative methods (except statistics) have played a secondary role. Most progress has been due to improvements in experimental tools. Results are qualitative and descriptive models are formulated and tested. Consequently, biologists often have incomplete backgrounds in mathematics but are very strong with respect to laboratory tools and, more importantly, with respect to the interpretation of laboratory data from complex systems.

Engineers usually possess a very good background in the physical and mathematical sciences. Often a theory leads to mathematical formulations, and the validity of the theory is tested by comparing predicted responses to those in experiments. Quantitative models and approaches, even to complex systems, are strengths. Biologists are usually better at the formation of testable hypotheses, experimental design, and data interpretation from complex systems. Engineers are typically unfamiliar with the experimental techniques and strategies used by life scientists.

The skills of the engineer and life scientist are complementary. To convert the promises of molecular biology into new processes to make new products requires the integration of these skills. To function at this level, the engineer needs a solid understanding of biology and its experimental tools. In this book we provide sufficient biological background for you to understand the chapters on applying engineering principles to biosystems. However, if you are serious about becoming a bioprocess engineer, you will need to take further courses in microbiology, biochemistry, and cell biology, as well as more advanced work in biochemical engineering. If you already have these courses, these chapters can be used for review.

1.4. THE STORY OF PENICILLIN: HOW BIOLOGISTS AND ENGINEERS WORK TOGETHER

In September 1928, Alexander Fleming at St. Mary's Hospital in London was trying to isolate the bacterium, *Staphylococcus aureus*, which causes boils. The technique in use was to grow the bacterium on the surface of a nutrient solution. One of the dishes had been contaminated inadvertently with a foreign particle. Normally, such a contaminated plate would be tossed out. However, Fleming noticed that no bacteria grew near the invading substance (see Fig. 1.1).

Fleming's genius was to realize that this observation was meaningful and not a "failed" experiment. Fleming recognized that the cell killing must be due to an antibacterial agent. He recovered the foreign particle and found that it was a common mold of the *Penicillium* genus (later identified as *Penicillium notatum*). Fleming nurtured the mold to grow and, using the crude extraction methods then available, managed to obtain a tiny quantity of secreted material. He then demonstrated that this material had powerful antimicrobial properties and named the product penicillin. Fleming carefully preserved the culture, but the discovery lay essentially dormant for over a decade.