the complexity of the assay systems has increased again from high-throughput screens on purified proteins to high-content cellular screens allowing evaluation of the effects of new drugs on cells and within them on specific biological pathways.

4.2 Research Center Size and Distribution

In the 1990s it was fashionable to have scientists work in biotech like small groups that could be geographically disseminated under the assumption that their creativity would be better than in large research centers. More recently two factors have caused pharmaceutical research to be increasingly concentrated in large centers (campuses) with thousands of scientists working in walking distance from each other and as close to academic centers of excellence as possible (see below). The first factor is technological: some of the equipment needed to conduct modern drug discovery is very expensive and requires large infrastructures. Examples are robotized screening facilities, compound archives, state-of-the-art animal facilities, high-end microscopy, NMRs, and other analytical tools for chemistry. These tools are deployed in technological platforms that have become too onerous to be multiplied within the same organization at too many geographical sites. On the other hand, for a large pharmaceutical company, it is important to have access to top-quality talent in diverse cultures so that today they usually have Asian, European, and US hubs.

The second factor is biological. As our knowledge of biology grows, it becomes apparent that evolution has been reusing biological components and processes in different environments and in different organs and tissues. This applies prominently to proteins, signaling processes, and cellular pathways. Furthermore, diseases thought to be distinct because of different symptoms and occurrence in different organs turn out to have common molecular pathway malfunctions that simply cause different phenotypes but can be addressed by causal mechanism-specific interventions rather than by trying to correct the symptoms as was mostly the case in the past. An increasingly important consequence of this evolutionary conservatism at the molecular mechanism level is a trend to increasingly classify diseases not by symptoms and organs they occur in but by the causal mechanisms. This changed disease classification method is most advanced in the field of oncology but visible also in immunological disorders. This means that a successful research organization must have experts both in human disease and experts understanding molecular disease processes in all areas they want to be active in. As a drug affecting specifically a disease mechanism might be beneficial in diseases in different organs and with different symptoms, it is essential that scientists of different therapeutic areas interact closely to increase the probability that all potential applications of a drug are found thereby multiplying the clinical use and the returns on the investment. Drawbacks biotech companies must try to solve are that they often cannot afford all technologies needed for drug discovery and, as they