After the First Cell arose, mutations occurred and sometimes the mutant organisms would grow and prosper. Prospering would mean displacing the parental type, but it would also mean displacing other mutants and other organisms if they were not quite as fit. Selection of the better organisms is called (in addition to the “survival of the fittest”) the “competitive exclusion principle of Gause”. This latter phrase is used particularly when we talk of competition between species. Most students of evolution believe that almost all biological development took place under the auspices of Gause’s principle. I believe that the stringent form of this rule controlled evolution until after the time when the bulk of the many cellular processes in the world today were developed that are possessed by typical cells. Before this, because of the strong competition no more than one stable species existed at a time (in a habitat). Consequently, much evolution of cellular mechanisms took place before the time that stable diversity arose. The almost unique organism present in the world at this time is variously identified with a variety of terms, such as the Last Universal Ancestor (LUA), the progenote, the cenancestor, and several others. The point is that there was before this time one species, which need not be given a name, although “prokaryote” would be suitable. At the time of the LUA there was one world species and one mutant of it that evolved into the domain of Bacteria. Around this time there also came the formation of the Archaea/Eukarya precursor, and soon the parental prokaryote population was eliminated by competition. The time of these events is about 3.0–3.4 billion years ago. This is to be compared with the time that the earth cooled enough and the number of meteorites hitting the earth slowed enough for life to be able to start. That time was at about 4.1 billion years ago.

Development of cell physiology from the time of the First Cell to the time of the LUA must have been a slow and arduous process. There were many processes and systems to be made functional and effective and this had to have taken many millions of years.

In a pre-sexual world with few resources and limited metabolic capabilities, the argument of Gause is almost certainly correct and replacement by the single most effective new form would have occurred over and over again when the habitats overlapped. But how did the world’s biota ever become diverse? The fact is that permanent diversity arose only after a sophisticated and complete
system of cell physiology arose. This basic cell physiology with variations is common to all organisms today. The initiation of stable diversity is not at all trivial. The diversification of a monophyletic world containing only the single organism, that is the best to have evolved up to that time, required a mechanism leading to the reduction of competition of new mutant forms versus the old. Of course, it is the best (and most successful) organism evolved so far.

Therefore this leads to the proposition that, for evolution to lead to the diverse Domain of Bacteria and its separation from the precursor of the Archaea/Eukarya that led to the Domains of Archaea and Eukarya, something very special had to occur. There had to be to a newly arisen basic problem that faced all extant organisms at that time. At that time, this one problem must have been independently solved with two different biological solutions. It was this combination of events that opened up new ways to grow without competing with other classes of organisms. The probable advance that led to the splitting off of the Domain of Bacteria, I believe, was the development of a strong enclosing wall, called the sacculus. This allowed the innovator that first formed it, and its descendants, to survive when the cell's biochemical success caused the internal osmotic pressure to become too large. However, as important as this advance was, it would not be enough to create diversity. That required another advance that occurred at near the same time to overcome the same problem. In our world this led to the development of the Archaea/Eukarya line. This favored their growth and prevented their displacement by Bacteria as the latter came to be more abundant and became able to occupy new niches and, of course, vice-versa.

CLASSES OF METABOLIC SYSTEMS THAT HAVE DEVELOPED IN THE LIVING WORLD

New metabolic processes were developed by the descendants of the First Cell to allow organisms to cope more effectively and reproduce more successfully (Koch, 1994). We come back below to the classes of systems that are characteristic of modern cell physiology. However, the enormity of the various biochemical mechanisms and of the cellular physiology that developed after the time of the First Cell and before the time of the Last Universal Ancestor must be considered here. Figure 4.1 brackets these developments between the start of life and when it started to have stable diversity.

SEMI-CONSERVATIVE REPLICATION AND TRANSLATION

Semi-conservative replication is vital for information copying, but the mechanism for translating the nucleic acid language into a protein code is very