embryonic development it may never be detected. If the death is at a later stage, it may lead to a miscarriage. An appreciable fraction, very roughly one-fourth, of spontaneous abortions, shows a detectable chromosome aberration, and there is no way at present to know how many of the remainder are caused by gene mutations or by chromosome aberrations too small to detect by the microscope. If the embryo survives until birth there may be physical abnormalities. There are hundreds of known inherited diseases and probably many more that are unknown, all of which owe their ultimate cause to mutations. These are individually rare, but collectively account for a substantial fraction of human misery. And, perhaps most tragic of all, genetic factors play a role in the causation of mental deficiency and disease.

At the other extreme are genes with mild effects. Those with still smaller effects finally become imperceptible. In between these extremes are the whole gamut of minor to severe genetic defects. So, it is evident that the effect of an increased mutation and chromosome aberration rate is not something new, but rather an increased frequency of diseases, abnormalities, weaknesses, and assorted human frailties that are already occurring.

Many mutations produce effects that are similar to those produced by other, nongenetic causes. And, we must remember that spontaneous mutations are happening all the time. For all these reasons, the impact of environmental mutagens is statistical rather than unique. This problem is further complicated by the time-distribution of mutational effects. Some mutant genes are dominant, in which case, the abnormality or disease will appear in the very next generation after the mutation occurs. On the other hand, the gene may be recessive, that is to say it may require the abnormal genes in both homologous chromosomes (one derived from the male and the other from the female parent) to produce the effect. In this case, the disease or abnormality may be delayed for many generations until some unlucky child inherits a mutant gene simultaneously from each of his parents. The net effect of all this is that, although the first generation probably will manifest a larger effect than will any particular subsequent generation, the overall effect is spread over many generations. What happens in the first generation is only a fraction of the total impact of the mutation process.

That the great majority of mutations should be harmful to a greater or lesser extent (or at best, neutral), is both a deduction from the principle of natural selection and an empirical fact well established in experimental systems. In the human past, natural selection has ruthlessly eliminated those individuals whose mutant genes caused them to be abnormal, diseased, or even only slightly weakened. As