our bodies. But when antibiotics are used they kill off the nonresistant disease bacteria (and often many or most of the other, helpful bacteria), leaving the resistant bacteria to reproduce without competition. The resistant bacteria then take over our body without hindrance. As this process occurs with more and more people these resistant bacteria begin passing into the general human population. Eventually, most pathogenic bacteria end up immune to commonly used antibiotics. The susceptible ones have all been killed off.

In a way, we have created a kind of evolution in fast forward. We have supported a bacterial survival-of-the-fittest through our creation and use of pharmaceuticals. But the truth is even more complex, and frightening, than this picture reveals. For evolution, long thought to be merely a passive process — the fastest gazelle surviving to have babies, for instance — is much more complex indeed.

### *Adapting to Survive Antibiotics*

What our forefathers failed to understand in those heady decades of the 1940s and 1950s is that bacteria are a life-form, and like all life they have the drive to survive and reproduce. And like all life they adapt to threats to their survival. Not only are some bacteria naturally immune to antibiotics, but all of them respond remarkably quickly to changes in their environment. They are pure biochemical factories that respond to antibiotics with metabolic changes in an attempt to counter them. In other words, bacteria use a kind of trial-and-error process to create chemical responses to antibiotics. These chemicals allow them to survive antibiotics or even to disable the antibiotic itself. As physician Jeffery Fisher observes:

> *Bacteria don't do this instantly, but rather through evolutionary trial and error. Once the right biochemical combination to resist the antibiotic in question develops, the new mutated strain will flourish — a pure example of Darwinian survival of the fittest. Trial and error, of course, can take time, generally bacterial generations. Here again, however, the bacteria prove to have the perfect machinery. Unlike humans, who produce a new generation every twenty years or so, bacteria produce a new generation every twenty minutes, multiplying 500,000 times faster than we do.*