23.20 Antibiotics and Antibiotic Resistance: Environmental and Anthropogenic Contexts

In this section, a typical chain of events starting from a discovery of antibiotic to the extensive use, to the emergence resistance, and to the continuous race against resistance is illustrated using tetracycline antibiotics as an example. The fate of other antibiotics is very similar (Aminov 2017), and the main lesson learned here is that the appearance and dissemination of antibiotic resistance is just an issue of time, although it could be considerably affected by the usage practices involved. It becomes increasingly clear, however, that the current global problem of antibiotic resistance cannot be efficiently managed within the narrow remits of clinical microbiology but should include other aspects such as ecological, evolutionary, agricultural, and economical. Antibiotic producers that are used by humans for industrial production of antibiotics have been acquired from natural reservoirs, where they are involved in production of signaling molecules, antibiotics, which regulate various functions of the environmental microbiota. Thus, an extensive summary of the role played by antibiotic producers/antibiotics/antibiotic resistance is also given in the chapter. Economical background for nontherapeutic use of antibiotics in agriculture is also given.

In brief, the path of antibiotic usage by humans can be condensed to a few principal steps. First, the antibiotics, which serve as signaling molecules at low concentrations in natural ecosystems, are selected for killing activity at high concentrations. Then they are extensively used in clinical medicine, veterinary, agriculture, and other applications, thus creating hot spots of high antibiotic concentrations. In these hot spots, the naturally occurring antibiotic resistance genes are selected and amplified. At this stage, antibiotic resistance genes are integrated into the normal bacterial metabolism via reducing the fitness cost associated with their carriage. At this stage, antibiotic resistance becomes very resilient against eradication, even in the absence of antibiotic selective pressure. The pool of the antibiotic resistance genes amplified at hot spots is then released, together with the concomitant antibiotics, into other ecological compartments. These are further disseminated to even more distant ecological compartments, including pathogens, via extensive horizontal gene exchange mechanisms.

What can be done to reduce the size and "temperature" of the hot spots? The biggest consumer of antibiotics is agriculture, where a considerable proportion of antibiotics is used for nontherapeutic purposes (Koike et al. 2017). Analysis of the current strategies implemented in the development of agricultural practices forecasts a rapid growth in antibiotic consumption by this sector (Van Boeckel et al. 2015). This hasty surge of antibiotic consumption by agriculture is driven by economic incentives offered by large-scale intensive farming