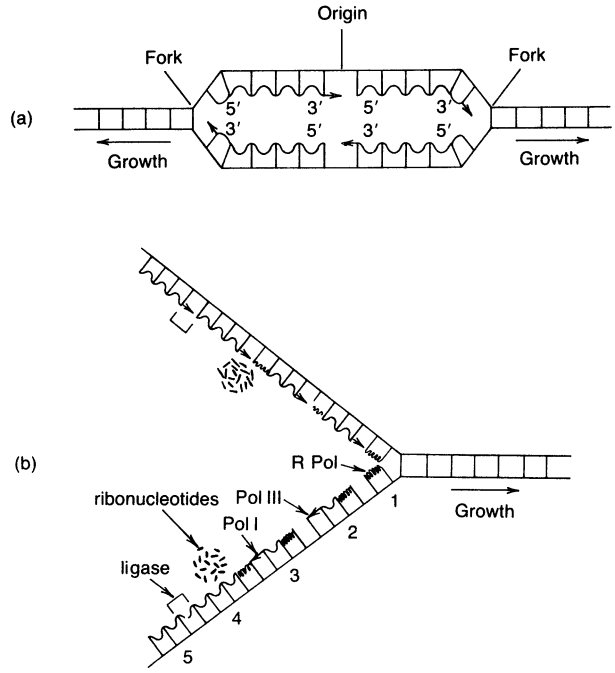

Figure 4.3. Schematic representation of the steps of replication of the bacterial chromosome. Part (a) represents a portion of a replicating bacterial chromosome at a stage shortly after replication has begun at the origin. The newly polymerized strands of DNA (wavy lines) are synthesized in the 5′-to-3′ direction (indicated by the arrows), using the preexisting DNA strands (solid lines) as a template. The process creates two replication forks, which travel in opposite directions until they meet on the opposite side of the circular chromosome, completing the replication process. Part (b) represents a more detailed view of one of the replicating forks and shows the process by which short lengths of DNA are synthesized and eventually joined to produce a continuous new strand of DNA. For purposes of illustration, four short segments of nucleic acid are illustrated at various stages. In (1), primer RNA (thickened area) is being synthesized by an RNA polymerase (R Pol). Then, successively, in (2) DNA is being polymerized to it by DNA polymerase III (Pol III); in (3) a preceding primer RNA is being hydrolyzed, while DNA is being polymerized in its place by the exonuclease and polymerase activities of DNA polymerase I (Pol I); finally, the completed short segment of DNA (4) is joined to the continuous strand (5) by the action of DNA ligase. (With permission, from R. Y. Stanier and others, *The Microbial World*, 5th ed., Pearson Education, Upper Saddle River, NJ, 1986, p. 133.)

DNA polymerase works only in the 5′-to-3′ direction, which means that the next nucleotide is always added to the exposed 3′-OH group of the chain. Thus, one strand (the *leading strand*) can be formed continuously if it is synthesized in the same direction as the replication fork is moving. The other strand (the *lagging strand*) must be synthesized discontinuously. Short pieces of DNA attached to RNA are formed on the lagging strand. These fragments are called *Okazaki fragments*. The whole process is summarized in Fig. 4.3. The enzyme, *DNA ligase*, which joins the two short pieces of DNA on the continuous strand, will be very important in our discussions of genetic engineering.