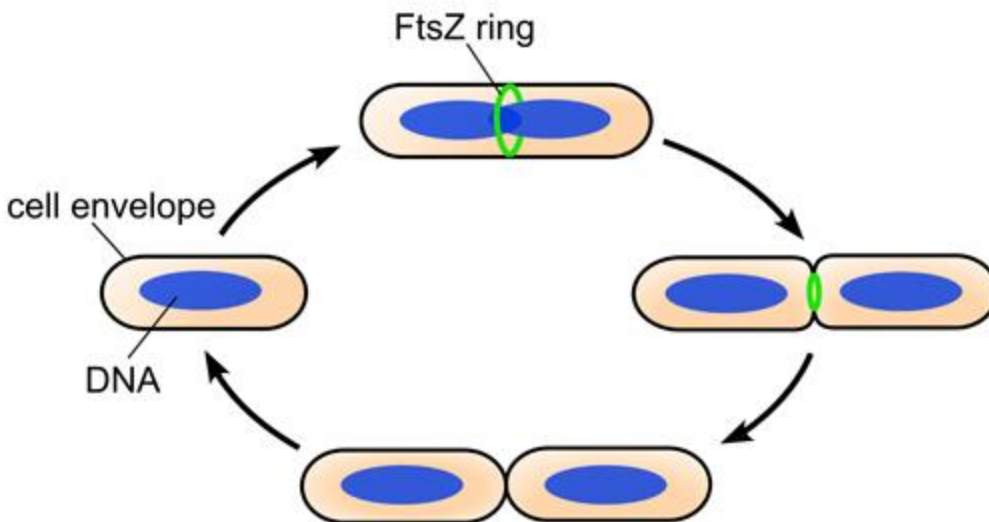


Binary Fission and other Forms of Reproduction in Bacteria

Binary Fission

Most bacteria rely on binary fission for propagation. Conceptually this is a simple process; a cell just needs to grow to twice its starting size and then split in two. But, to remain viable and competitive, a bacterium must divide at the right time, in the right place, and must provide each offspring with a complete copy of its essential genetic material. Bacterial cell division is studied in many research laboratories throughout the world. These investigations are uncovering the genetic mechanisms that regulate and drive bacterial cell division. Understanding the mechanics of this process is of great interest because it may allow for the design of new chemicals or novel antibiotics that specifically target and interfere with cell division in bacteria.

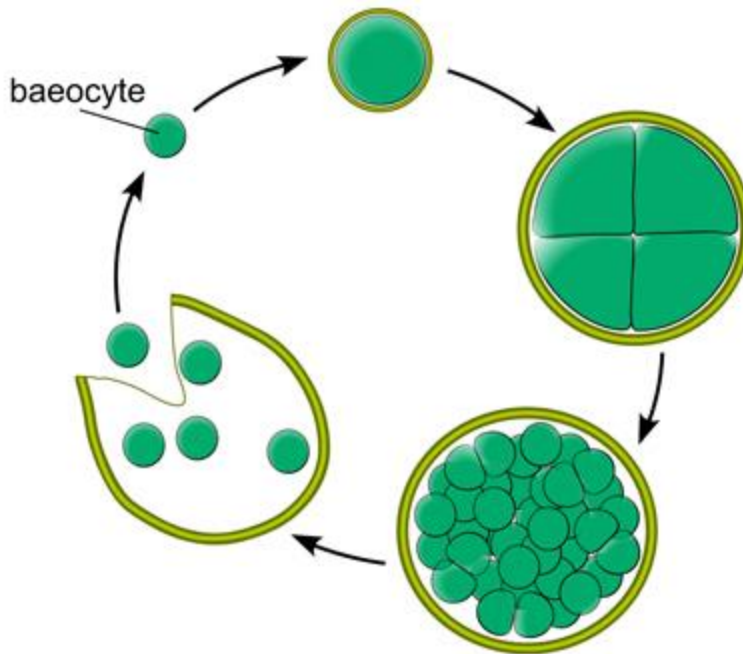
BINARY FISSION:



Before binary fission occurs, the cell must copy its genetic material (DNA) and segregate these copies to opposite ends of the cell. Then the many types of proteins that comprise the cell division machinery assemble at the future division site. A key component of this machinery is the protein FtsZ. Protein monomers of FtsZ assemble into a ring-like structure at the center of a cell. Other components of the division apparatus then assemble at the FtsZ ring. This machinery is positioned so that division splits the cytoplasm and does not damage DNA in the process. As division occurs, the cytoplasm is cleaved in two, and in many bacteria, new cell wall is synthesized. The order and timing

of these processes (DNA replication, DNA segregation, division site selection, invagination of the cell envelope and synthesis of new cell wall) are tightly controlled.

THE *STANIERIA* LIFE CYCLE:



Some Unusual Forms of Reproduction in Bacteria:

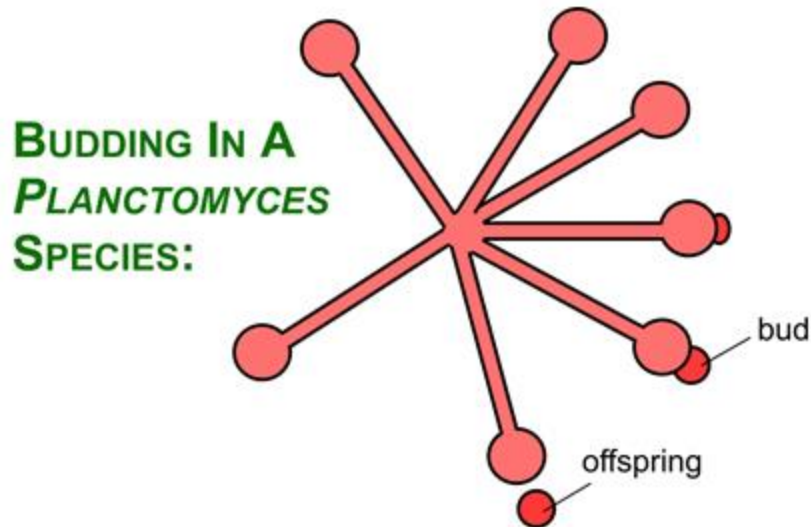
There are groups of bacteria that use unusual forms or patterns of cell division to reproduce. Some of these bacteria grow to more than twice their starting cell size and then use multiple divisions to produce multiple offspring cells. Some other bacterial lineages reproduce by budding. Still others form internal offspring that develop within the cytoplasm of a larger "mother cell". The following are a few examples of some of these unusual forms of bacterial reproduction.

Baeocyte production in the cyanobacterium *Stanieria*

Stanieria never undergoes binary fission. It starts out as a small, spherical cell approximately 1 to 2 μm in diameter. This cell is referred to as a baeocyte (which literally means "small cell"). The baeocyte begins to grow, eventually forming a vegetative cell up to 30 μm in diameter. As it grows, the cellular DNA is replicated over and over, and the cell produces a thick extracellular matrix. The vegetative cell eventually transitions into a reproductive phase where it undergoes a rapid succession of cytoplasmic fissions to produce dozens or even hundreds of baeocytes. The extracellular matrix eventually tears open, releasing the baeocytes. Other members of the Pleurocapsales (an Order of

Cyanobacteria) use unusual patterns of division in their reproduction (see Waterbury and Stanier, 1978).

Budding in bacteria

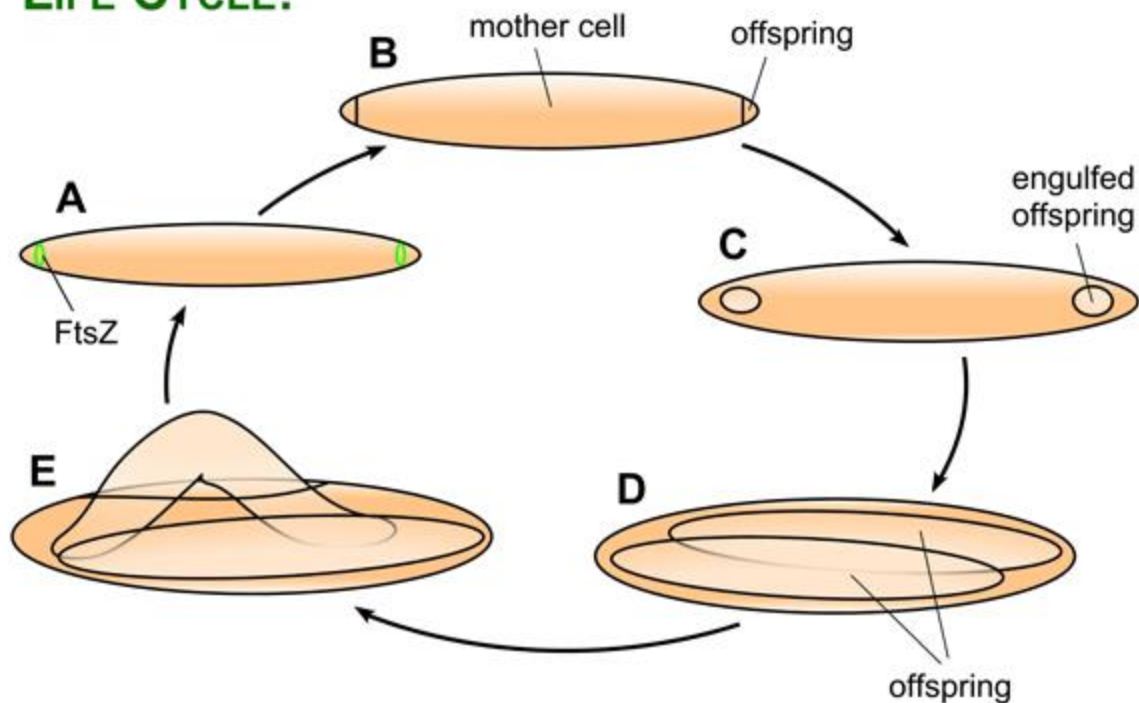


Budding has been observed in some members of the Planctomycetes, Cyanobacteria, Firmicutes (a.k.a. the Low G+C Gram-Positive Bacteria) and the prosthecate Proteobacteria. Although budding has been extensively studied in the eukaryotic yeast *Saccharomyces cerevisiae*, the molecular mechanisms of bud formation in bacteria are not known. A schematic representation of budding in a *Planctomyces* species is shown below.

Intracellular offspring production by some Firmicutes

Epulopiscium spp., *Metabacterium polyspora* and the Segmented Filamentous Bacteria (SFB) form multiple intracellular offspring. For some of these bacteria, this process appears to be the only way to reproduce. Intracellular offspring development in these bacteria shares characteristics with endospore formation in *Bacillus subtilis*.

THE *EPULOPISCIIUM* LIFE CYCLE:



In large *Epulopiscium* spp. this unique reproductive strategy begins with asymmetric cell division, see The *Epulopiscium* Life Cycle Figure. Instead of placing the FtsZ ring at the center of the cell, as in binary fission, (A) Z rings are placed near both cell poles in *Epulopiscium*. (B) Division forms a large mother cell and two small offspring cells. (C) The smaller cells contain DNA and become fully engulfed by the larger mother cell. (D) The internal offspring grow within the cytoplasm of the mother cell. (E) Once offspring development is complete the mother cell dies and releases the offspring.

Our lab studies the mechanisms of intracellular offspring development in *Epulopiscium* and *Metabacterium polyspora*. We are interested in what mechanisms are conserved between these unusual reproductive processes and endospore formation. We hope to gain an understanding of how this novel form of cell reproduction developed over time and how it benefits these intestinal symbionts.