Power Point No. 4

Intracellular bacterial cell structure

- In comparison to eukaryotes, the intracellular features of the bacterial cell are extremely simple. Bacteria do not contain organelles in the same sense as eukaryotes. Instead, the chromosome and perhaps ribosomes are the only easily observable intracellular structures found in all bacteria. They do exist, however, specialized groups of bacteria that contain more complex intracellular structures
- **The bacterial chromosome and plasmids**
- Unlike eukaryotes, the bacterial chromosome is not enclosed inside of a membrane-bound nucleus but instead resides inside the bacterial cytoplasm. This means that the transfer of cellular information through the processes of translation, transcription and DNA replication all occur within the same compartment and can interact with other cytoplasmic structures, most notably ribosomes.

- The bacterial chromosome is not packaged using histones to form chromatin as in eukaryotes but instead exists as a highly compact supercoiled structure and containing spermine and spyrmidine , the function of which remains unclear.
- Most bacterial chromosomes are circular although some examples of linear chromosomes exist (e.g. *Borrelia burgdorferi*). Along with chromosomal DNA, most bacteria also contain small independent pieces of DNA called plasmids that often encode for traits that are advantageous but not essential to their bacterial host. Plasmids can be easily gained or lost by a bacterium and can be transferred between bacteria as a form of horizontal gene transfer

Ribosomes and other multiprotein complexes

- In most bacteria the most numerous intracellular structure is the ribosome, the site of protein synthesis in all living organisms. All prokaryotes have 70S ribosomes while eukaryotes contain larger 80S ribosomes in their cytosol. The 70S ribosome is made up of a 50S and 30S subunits. The 50S subunit contains the 23S and 5S rRNA while the 30S subunit contains the 16S rRNA. These rRNA molecules differ in size in eukaryotes and are complexed with a large number of ribosomal proteins, the number and type of which can vary slightly between organisms. While the ribosome is the most commonly observed intracellular multiprotein complex in bacteria, other large complexes do occur and can sometimes be seen using microscopy.

- **Intracellular membranes**
- While not typical of all bacteria some microbes contain intracellular membranes in addition to (or as extensions of) their cytoplasmic membranes. An early idea was that bacteria might contain membrane folds termed mesosomes, but these were later shown to be artifacts produced by the chemicals used to prepare the cells for electron microscopy. Examples of bacteria containing intracellular membranes are phototrophs, nitrifying bacteria and methane-oxidising bacteria. Intracellular membranes are also found in bacteria belonging to the poorly studied Planctomycetes group, although these membranes more closely resemble organellar membranes in eukaryotes and are currently of unknown function.

- **Cytoskeleton**
- The prokaryotic cytoskeleton is the collective name for all structural filaments in prokaryotes. It was once thought that prokaryotic cells did not possess cytoskeletons, but recent advances in visualization technology and structure determination have shown that filaments indeed exist in these cells. In fact, homologues for all major cytoskeletal proteins in eukaryotes have been found in prokaryotes. Cytoskeletal elements play essential roles in cell division, protection, shape determination, and polarity determination in various prokaryotes.

- **Nutrient storage structures**
- Most Bacteria do not live in environments that contain large amounts of nutrients at all times. To accommodate these transient levels of nutrients. Bacteria contain several different methods of nutrient storage in times of plenty for use in times of want. For example, many bacteria store excess carbon in the form of polyhydroxyalkanoates or glycogen. Some microbes store soluble nutrients such as nitrate in vacuoles. Sulfide is most often stored as elemental (S^0) granules which can be deposited either intra- or extracellularly. Sulfur granules are especially common in bacteria that use hydrogen sulfide as an electron source.

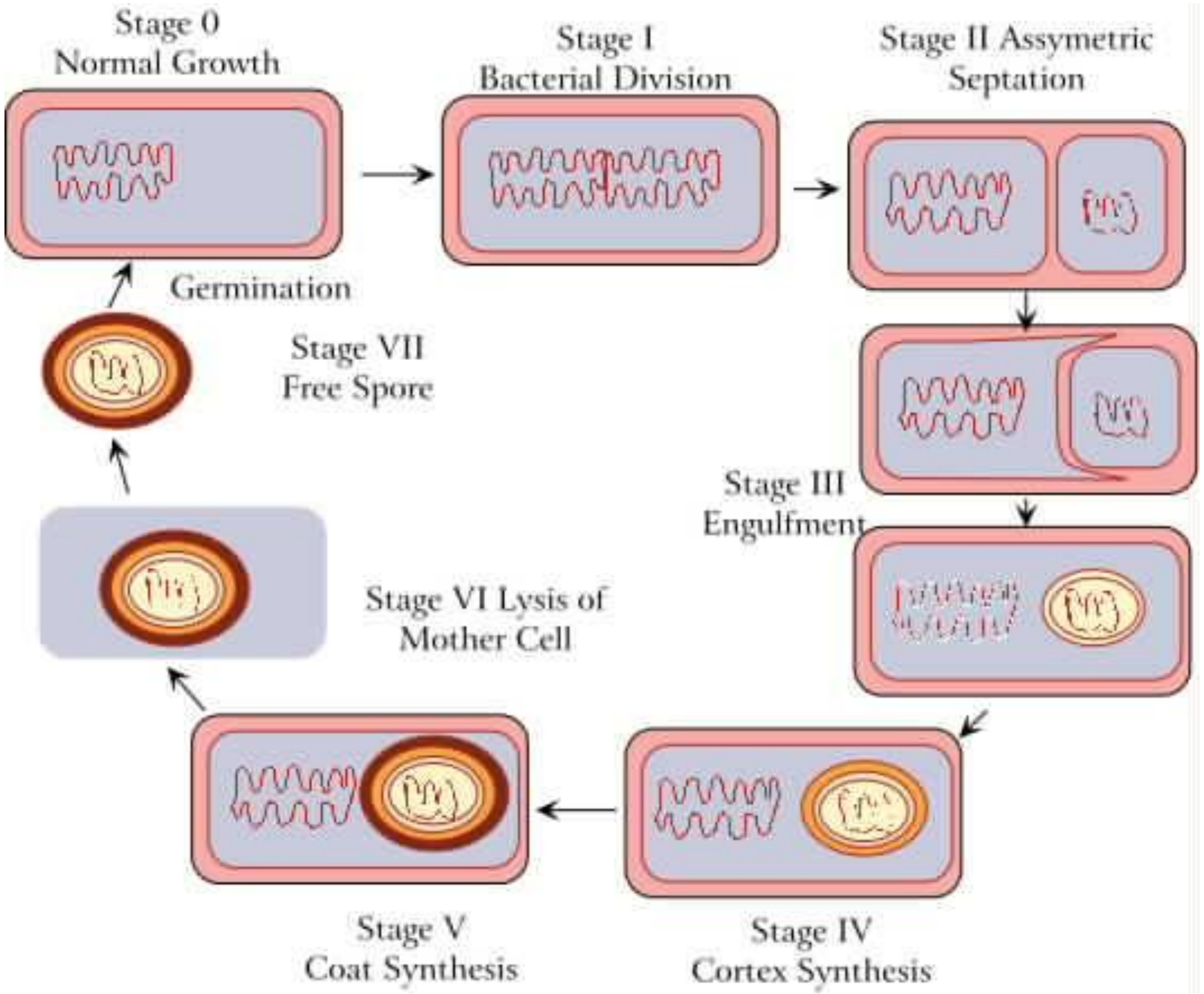
- **Gas vesicles**
- Gas vesicles are spindle-shaped structures found in some planktonic bacteria that provides buoyancy to these cells by decreasing their overall cell density. They are made up of a protein coat that is very impermeable to solvents such as water but permeable to most gases. By adjusting the amount of gas present in their gas vesicles bacteria can increase or decrease their overall cell density and thereby move up or down within the water column to maintain their position in an environment optimal for growth.

- **Carboxysomes**
- Carboxysomes are intracellular structures found in many autotrophic bacteria such as *Cyanobacteria, Knallgasbacteria*, and *Nitrobacteria* .They are proteinaceous structures resembling phage heads in their morphology and contain the enzymes of carbon dioxide fixation in these organisms (especially ribulose bisphosphate carboxylase/oxygenase (RuBisCO) and carbonic anhydrase). It is thought that the high local concentration of the enzymes along with the fast conversion of bicarbonate to carbon dioxide by carbonic anhydrase allows faster and more efficient carbon dioxide fixation than possible inside the cytoplasm. Similar structures are known to harbor the coenzyme B12-containing glycerol dehydratase, the key enzyme of glycerol fermentation to 1,3-propanediol, in some Enterobacteriaceae (e. g. *Salmonella*).

- **Magnetosomes**
- Magnetosomes are intracellular organelles like structure found in magnetotactic bacteria that allow them to sense and align themselves along a magnetic field (magnetotaxis). The ecological role of magnetotaxis is unknown but it is hypothesized to be involved in the determination of optimal oxygen concentrations. Magnetosomes are composed of the mineral magnetite and are surrounded by a lipid bilayer membrane. The morphology of magnetosomes is species-specific.

- **Endospores**
- Perhaps the most well known bacterial adaptation to stress is the formation of endospores. Endospores are bacterial survival structures that are highly resistant to many different types of chemical and environmental stresses and therefore enable the survival of bacteria in environments that would be lethal for these cells in their normal vegetative form. It has been proposed that endospore formation has allowed for the survival of some bacteria for hundreds of millions of years (e.g. in salt crystals).. Endospore formation is limited to several genera of Gram-positive bacteria such as *Bacillus* and *Clostridium*. It differs from reproductive spores in that only one spore is formed per cell resulting in no net gain in cell number upon endospore germination. The location of an endospore within a cell is species-specific and can be used to determine the identity of a bacterium.

Steps of bacterial endospore formation



- **Intracellular Structures of Eukaryotic Microorganisms**
- **Microbodies:**
- Microbodies are a family of organelles bounded by single membrane. They carry out a range of functions in fungal cells. The major groups are peroxisomes that contain at least one oxidized enzyme that produce hydrogen peroxide (H_2O_2) together with peroxidase which decompose hydrogen peroxide to produce oxygen or oxidize substrates. Some peroxidase have another functions in the oxidation of fatty acids to give Acetyl-CoA as in the case of *S. cerevisiae* . Another function to provide site action of enzymes of glyoxylate cycle which required to covert carbon compounds to carbohydrate and this microbody named Glyoxysome

Peroxisomes plays an important roles in utilization of a wide range of carbon and nitrogen sources as in *Hansenula polymorpha* which contain enzymes for oxidation of methanol and methylamine. Other peroxisomes contain uricase enzyme which hydrolyze uric acid as in the case of *Candida lipolytica*. Peroxisomal enzymes allow a range of yeast species to grow on unusual substrate such as alkanes, alkylamine, fatty acids amino acids and uric acids.

- **Reserve Materials:**
- They also reserve glycogen 1-10 million molecular weight which is water soluble, but that of 100 million molecular weight are insoluble in water. Glycogen is a polymer of glucose molecules forming alfa-glucans linked together in identity α(1-4) glycosidic bonds forming long chains. After 10 glucose molecules it linked to third glucose molecules by α(1-6) glycosidic bond forming chain branching.
- Reserve materials in fungal cells also found as a soluble carbohydrates and the common one is trehalose as a disaccharide. Basic amino acids and poly phosphate were found in some fungal cells as a reserved materials.

- **Mitochondria and Mitochondrial DNA:**
- Mitochondria are the site of oxidative phosphorylation in eukaryotic cells such as fungi. The enzymes concerned with electron transport and ATP production located in the inner membrane of mitochondria. The area of which are increased by invagination named cristae.
- Mitochondria are derived from preexisting mitochondria and both parent contribute mitochondria. Fusion may occur between mitochondria and then fragmentation of large mitochondrion to yield several smaller mitochondrial organelles. Under anaerobic conditions the number of mitochondria decreased, become less complex smaller

in size and electron transport enzymes such as cytochromes disappear as in the case of *Saccharomyces cerevisiae*. The mitochondria are multiplied by simple fission in some fungi as in *Physirum polycephalum*. Mitochondria contain circular double stranded DNA (MitDNA). MitDNA constitutes the mitochondrial genome and contain gene for tRNA, rRNA and for some enzymes involved in oxidative phosphrylation as in *S. cerevisiae*.

- In *Neuorospora crassa* gene present in both nucleus and mitochondria involved in the production of these enzymes. The mitochondrial genome size in fungi is different from species to species and this size ranged between 26000bp in *Phycomyces* to about 8000bp in *S. cerevisiae*.

- **Lipid Particles: (Sphaerosomes):**
- Fungi like other organisms can accumulate lipids as a carbon source and the reserved oil droplets can be observed under light microscope in older cells. Function as storage vesicles which may serve as lipid reservoir for yeast membrane biosynthesis. They contain mainly sterol ester, but not triglycerides , and small amounts of phospholipids, protein and unsaturated fatty acids. The content of the latter are known to increase in backers yeast at the end of stationary growth phase in batch culture.

- **Proteasomes**:
- Are large multisubunit protease enzyme complexes found in cytoplasm of yeast cells with no apparent association with intracellular structures. In *S. cerevisiae,* 20S and 26S proteasomes exist whose function in regulating protein levels is essential for cell viability. The 26S particlesis assembled from the 20S units which are cylindrical particles composed of four stacked rings. The 26S proteasomes acts an ATP dependent. Protease in the ubiquitin pathway which is responsible

- for the rapid degradation of short lived, abnormal proteins that are detrimental to the cell.
- Specific yeast physiology functions in which proteasomes are involved include cell cycle control, signal translocation , mating and adaptive stress responses. These multifunctional roles of proteasomes have postulated by Hilt and Wolf (1996).

- **Vacuoles:**
- Vacuoles are very abundant in fungal cells and most obvious organelle seen under light microscope. It is dynamic structure, playing multiple roles in hyphal and yeast cell growth rather than being inert depositories for storage of water and nutrients or waste materials.
- In growing fungi vacuole play an important in storage of metabolites, Regulator of pH, as an equivalent to an animal lysosomes, with range of lytic enzymes more than 60 enzymes such as proteases, nucleases, phosphatases, trahalase, lipases and glucosidases and secretion of extracellular polysaccharides. The vacuole surrounded by one layer membrane of lipoprotein named **Tonoplast** .

- The pH of the vacuole is about 4.5-5.5.
- Moreover, vacuole store amino acids as a source of nitrogen under the condition of nitrogen starvation and also store cations such $K^{+,}$ Ca^{+2}, mg^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2}. The vacuolar hydrolytic enzymes may regulate the recycling of cell materials during growth, developments, lyses of dead cells and Liquefaction of tightly gills of fruit bodies of cup mushroom which allows the release of spores from the gills. In higher fungi such ascomycetes and basidiomycetes the vacuoles accumulate fluorescent dyes such as 6-carboxy-fluorecein which can be detected under fluorescence microscope. Finally the vacuoles can be transported across the fungal cell cytoplasm up to 60um distant by the help of microtubules.

- **6- Plasmid:**
- Plasmid are pieces of DNA can replicated independently of replication of chromosomes or mitochondrial DNA. *Saccharomyces cerevisiae* contain circular plasmid of 2um double stranded DNA consist of about 6200base pair (bp) and have no any role in the life of yeast cells.
- The plasmid can be multiplied up to 100 copies providing important helps in the construction of vector for the genetic manipulation of the yeast.
- *Kluveromyces lactis* yeast also contain two linear plasmid of different length.

- One of them named killer plasmid producing an extracellular protein (toxin) that kill many yeasts such as *candida* and *Saccharomyces. Podospora anserine* contain plasmid originated from mitochondrial DNA causes fungal **senescence** in growth rate falls and vegetative propagation become impossible and this plasmid termed SecDNA which can be transmitted via parent materials to **ascospores.**