5.3: Bacterial Cell Walls

Function of bacterial cell walls = prevent osmotic lysis

- What is osmotic lysis?
- Osmosis: the diffusion of water from an area of high water concentration to an area of low water concentration across a semi-permeable membrane
  - Because solutes (ions, molecules) take up space, there is an inverse relationship between solute concentration and water concentration:
    - If high solute concentration = low water concentration
    - If low solute concentration = high water concentration

-Because we are interested in what happens to cells, we need to describe the environment in which the cell is living

- Hypoosmotic /hypotonic environments: solute concentration of environment is less than within cell
- Hyperosmotic /hypertonic environments: solute concentration of environment is higher than within cell
- Isoosmotic /isotonic environments: solute concentration of environment is equal to that within cell

-If a compartment (for example a cell) has a higher solute concentration than its environment (outside of cell), the water concentration inside the cell will be less than outside the cell. Consequently there will be net movement/osmosis of water into the cell from the environment. As water moves in, pressure builds up inside the cell and eventually the cytoplasmic membrane will break in a process called osmotic lysis (similar to explosion of a water balloon). Osmotic lysis always kills a cell.
Figure 1: a. Cell in hypo-osmotic environment undergoing osmotic lysis. b. Bacterial cell wall peptidoglycan prevents osmotic lysis

**Bacteria cell wall peptidoglycan prevents osmotic lysis:** Most bacteria grow in hypo-osmotic environments. How do bacteria prevent osmotic lysis? Most bacteria synthesize a strong cell wall made of cross-linked peptidoglycan. The cell wall is outside the cytoplasmic membrane similar to a “boiler plate” or suit of armor. The cell wall peptidoglycan is similar to cross-linked wire. The peptidoglycan of the cell wall prevents osmotic lysis when water moves into the cell, but ONLY if the cell wall peptidoglycan is cross-linked. Anything which prevents the cross links from forming or which cuts the cross-links will weaken the peptidoglycan so that it no longer can prevent osmotic lysis.

---

**Peptidoglycan**

**Peptidoglycan** is made up of long chains of modified sugars, alternating N-acetylglucosamine (“NAG”) and N-acetylmuramic acid (“NAM”). Strong covalent bonds link the sugars together in chains (polymers). The Nam subunits have short “tails” made of 4 amino acids. Special bacterial enzymes link these “peptide tails” to cross-link the peptidoglycan. Bacterial enzymes which help crosslink peptidoglycan are called *bacterial transpeptidases*. See diagram passed out in lecture

Peptidoglycan: NAM= N-acetylglucosamine NAM= N-acetylmuramic acid aa=amino acid

```
NAM----NAG-----NAM------NAG------NAM------NAG-----NAM
aa      aa      aa      aa
aa      aa      aa      aa
aa      aa\      /-> aa      aa
aa\      aa /-> aa \-> aa/      aa      aa      aa
\-> aa/      aa      aa      aa
     aa      aa      aa      aa
     aa      aa      aa      aa
NAM----NAG-----NAG------NAG------NAG-----NAG-----NAM
```

- /-> Indicates bonds formed by bacterial transpeptidase; these bonds are not formed in the presence of beta-lactam antibiotics

https://bio.libretexts.org/LibreTexts/Sacramento_City_College/SCC%3A_Biology_342%3A_The_New_Plagues/5%3A_Introduction_to_Bacterial_Cell_Structure_and_Antibiotics
*Key Idea: Beta-lactam antibiotics (e.g. penicillin, ampicillin, amoxicillin, oxacillin methicillin) bind to and inhibit bacterial transpeptidase. Consequently peptidoglycan is not crosslinked, is weakened and cannot prevent osmotic lysis and the bacterium dies.

Humans infected with bacterial pathogens can thus take beta-lactam antibiotics such as penicillin or ampicillin, triggering lysis and death of the bacteria without harming the human cells.

Vancomycin is another powerful antibiotic which also inhibits cross-linking of bacterial peptidoglycan causing osmotic lysis in growing bacteria.