Archaea cell wall components

A microbial cell wall is a well-defined polymer matrix located just outside a cell's plasma membrane. Cell walls can consist of polysaccharides, proteins, lipids, or a combination of these. Cell walls provide increased mechanical strength and resistance to light ice by osmotic shock (water moves into the cell). Cell walls are found in the cells of eubacteria, archaebacteria, fungi, algae and plants. The cell walls vary greatly in their compositions: Eubacteria. Almost all eubacterial species have cell walls that contain a polysaccharide called peptideoglycan. Among eubacteria, differences in cell wall structure are an important element used in the classification of these organisms. Two main groups can be distinguished: Gram positive bacteria Gram negative bacteria Archaebacteria. The cell walls of archaebacteria are characteristic of those of eubacteria. Archaic cell walls consist of different polysaccharides and proteins without peptidoglycan. Many archaebacteria have cell walls made of polysaccharid pseudomurein. Mushrooms. Fungal cell walls are typically composed of polysaccharides chitin and cellulose. Algae and plants. The cell walls of algae and plants consist mainly of polysaccharid cellulose. External Links Page ID8847 Contributed with BoundlessGeneral Microbiology on Boundless Archaeal cell walls differ from bacterial cell walls in their chemical composition and lack of peptidoglycans. Learning goalsMode the similarities between the cell walls of the archaea and bacteria Key Points Archaea are single-cell microorganisms that lack a cell nucleus and membrane-bound organelles. Like other living organisms, archaea has a semi-rigid cell wall that protects them from the environment. The cell wall of the archaea is composed of S-layers and lacks peptidoglycan molecules with the exception of methanobacteria, which have pseudopeptidoglycan in their cell wall. cellulose: A complex carbohydrate that forms the main component of the cell wall in most plants and is important in the manufacture of many products, such as paper, textiles, pharmaceuticals and explosives. chitin: A complex polysaccharide, a polymer of N-acetylglucosamine, found in exoskeletons of arthropods and in the cell walls of fungi; believed to be responsible for certain types of asthma in humans. cytoplasm: The contents of a cell with the exception of the nucleus. It includes cytosol, organelles, vesicles, and cytoskelete. As with other living organisms, archaeal cells have an outer cell membrane that acts as a protective barrier between the cell and its environment. Within the membrane is the cytoplasm, where the living features of the archeon take place and where DNA is located. Around the outside of almost all archaeal cells is a cell wall, a semi-rigid layer that helps the cell maintain its shape and chemical equilibrium. All three of these regions can in the cells of the bacteria and most other living organisms. Figure: Archaea: Cluster of halobacterium (archaea) A closer look at each region reveals structural similarities, but large differences in chemical composition between bacterial and archaeal cell wall. Archaea builds the same structures as other organisms, but they build them from different chemical components. For example, the cell walls of all bacteria contain the chemical peptidoglycan. Archaeal cell walls do not contain this substance, although some species contain a similar one. It is collected from surface-layer proteins called S-layers. Similarly, archaea does not produce walls of cellulose (like plants) or chitin (as do mushrooms). The cell wall of the arkæean is chemically separated. Methanogens are the only exception and possess pseudopeptidoglycan chains in their cell wall that lack amino acids and N-acetylmuramic acid in their chemical composition. The most striking chemical differences between Archaea and other living things lie in their cell membrane. There are four fundamental differences between the archaeal membrane and that of all other cells: (1) chirality of glycerol, (2) ether bonding, (3) isoprenoid chains and (4) branching of side chains. Prokaryotes are divided into two different domains, Bacteria and Archaea, which, together with Eukarya, encompasse the three areas of life (Figure 1). Figure 1. Bacteria and Archaea are both prokaryotes, but differ enough to be placed in separate domains. An ancestor of modern Archaea is believed to have given rise to Eukarya, the third domain of life. Archaeal and bacterial phyla are shown; the evolutionary relationship between these phyla is still open to debate. The composition of the cell wall varies considerably between the domains Bacteria and Archaea. The composition of their cell walls also differs from the eukaryotic cell walls found in plants (cellulose) or fungi and insects (chitin). The cell wall acts as a protective layer and is responsible for the shape of the organism. Some bacteria have an outer capsule outside the cell wall. Other structures are present in some prokaryotic species, but not in others. For example, the capsule found in some species allows the organism to attach to surfaces, protects it from dehydration and attack of phagocytic cells, and makes pathogens more resistant to our immune response. Some species also have flagella (singular, flagellum) used for movement, and pili (singular, pilus) is used for attachment to surfaces. Plasmids, which consist of extra-chromosomal DNA, are also present in many species of bacteria and archaea. Phylum Proteobacteria is one of up to 52 bacteria phyla. Proteobacteria is further divided into five classes, Alpha through Epsilon (Table 1). Table 1. Bacteria of Phylum Proteobacteria class representative organisms Representative micrograph Alpha Some species are photoautotrophic, but some are symbiotes of plants and animals, and others are pathogens. Eukaryotic mitochondria are believed to be derived from bacteria in this group. Rhizobium: Nitrogen-fixing endosymbiont associated with roots of legumes Rickettsia: Obligate intracellular parasite that causes typhoid and Rocky Mountain Spotted Fever Rickettsia rickettsia, staid red, grows inside a host cell Beta proteobacteria This group of bacteria are divers. Some species play an important role in the nitrogen cycle. Nitrosomas: Species from this group oxidize ammonia in nitrite Spirillum minus: Causes rat-bite fever Spirillum minus Gamma proteobacteria Many are beneficial symbiometers that populate the human gut, but others are well-known human pathogens. Some species from this subgroup oxidize sulfur compounds. E. coli: Usually beneficial microbe of the human gut, but some strains cause disease Salmonella: Certain strains cause food poisoning or typhoid V. cholera: Causative agent of cholera Chromatium: Sulfur-producing bacteria that oxidize sulfur, produce H2S Vibrio cholera Delta proteobacteria Some species generate a spore-forming fruit under adverse conditions. Others reduce sulfate and sulfur. Myxobacteria: Generate trace-forming fruit substances under adverse conditions Desulfovibrio vulgaris: Anaerobic, sulphate-reducing bacterium Desulfovibrio vulgaris Epsilon proteobacteria Many species inhabit the animals' digestive tract as symbions or pathogens. Bacteria from this group have been found in deep-sea hydrothermal vents and cold oesle habitats. Campylobacter: Causes blood poisoning and intestinal inflammation H. pylori: Causes ulcers Campylobacter (credit Rickettsia rickettsia: change of work by CDC; credit Spirillum minus: change of work by Wolframm Adlassnig; credit Vibrio cholera: change of work by Janice Haney Carr, CDC; credit Desulfovibrio vulgaris: change of work by Graham Bradley; credit Campylobacter: change of work by De Wood, Pooley, USDA, ARS , EMU; scale-bar data from Matt Russell) Clemicdia , Spirochetes, Cyanobacteria, and Gram-positive bacteria are described in Table 2. Note that bacterial form is not phylum-dependent; bacteria in a phylum can be cocci, rod-shaped, or spiral. Table 2. Bacteria: Chlamydia, Spirochetes, Cyanobacteria, and Gram-positive Phylum Representative organisms Representative micrograph chlamydias All members of this group are committing intracellular parasites of animal cells. Cell walls lack peptides andlycan Chlamydia trachomatis: Common sexually transmitted disease that can lead to blindness In this cell smear, Chlamydia trachomatis appear as pink inclusions inside cells Spirochetes Most members of this phylum, which has spiral-shaped cells, are free-living anaerobs, but some are pathogens. Flagella run on the periplasmic space between the inner and outer membrane Treponema pallidum: Kausative agent of syphillis Borrelia burgdorferi: Kausative agent for Lyme disease Treponema pallidum Cyanobacteria Also known as blue-green algae, these bacteria get their energy through photosynthesis. They are ubiquitous, found in terrestrial, marine and freshwater environments. Eukaryotic chloroplasts are believed to be derived from bacteria in this class. Prochlorococcus: Believed to be the most abundant photosynthetic organism on earth, it is responsible for generating half the world's oxygen Phormidium Gram-positive Bacteria Earth-dwelling members of this subgroup breaking down organic matter. Some species cause disease. They have a thick cell wall and lack an outer membrane. Clostridium botulinum: Causes Botullism Steptomyces: Many antibiotics, including streptomycin, are derived from these bacteria Mycoplasmas: These small bacteria, the least known, lack a cell wall. Some are free-living, and some are pathogenic Clostridium difficile (credit Chlamydia trachomatis: change of work by Dr. Lance Liotta Laboratory, NCI; credit Treponema pallidum: change of work by Dr. David Cox, CDC; credit Phormidium: change of work by USGS; credit Clostridium difficile: change of work by Lois S. Wiggs, CDC; scale-bar data from Matt Russell) Archaea is divided into four phylalaea is divided into four phylalaea is divided into four phylaea is divided into four phylaea is divided into four phylaeas : Euryarchaeota, Crenarchaeota, Nanoarchaeota and Korarchaeota. Table 3. Archaea Phylum Representative Organisms Representative micrograph Euryarchaeota This phylum includes methanogens that produce methanogens that produce methane as a metabolic waste product, and halobacteria that live in an extreme saltwater environment. Methanogens: Methanegen: Methane production causes flatulence in humans and other animals. Halobacteria: Large flowers of this salt-loving archaea appear reddish due to the presence of bacteriorhodopsin in the membrane. Bacteriorhodopsin is related to the retinal pigment rhodopsin. Halobacterium strain NRC-1 Crenarchaeota Members of this ubiquitous phylum play an important role in the fixation of carbon. Many members of this group are sulfur-dependent extremophiles. Some are thermophilic or hyperthermophilic. Sulfolobus: Members of this genus grow in volcanic sources at temperatures between 75º and 80º C and at a pH-3. Sulfolobus becomes infected with bacteriophage Nanoarchaeota This group currently contains only one species: Nanoarchaeum equitans. Nanoarchaeum equitans: This species was isolated from the bottom of the Atlantic Ocean and from a hydrothermal vent in Yellowstone National Park. It is a commit symbiont with Ignicoccus, another species of archaea. Nanoarchaeum equitans (small dark spheres) are in contact with their larger host, Ignococcus Korarchaeota This group is considered to be a the most primitive forms of life. Members of this has only been found in Obsidian Pool, a hot spring at Yellowstone National Park. No members of this species have been cultivated. This image shows a number of corarchaeota species from the Obsidian Pool at Yellowstone National Park. (credit Halobacterium: change of work by NASA; credit Nanoarchaeotum equitans: change of work by Karl O. Stetter; credit korarchaeota: change of work by Office of Science in the U.S. Dept. of Energy; scale-bar data from Matt Russell) The plasma membrane Plasma membrane is a thin lipidtay (6 to 8 nanometers) that completely surrounds the cell and separates the inside from the outside. Its selectively permeable nature keeps ions, proteins and other molecules in the cell and prevents them from spreading into the extracellular environment, while other molecules can move through the membrane. Recall that the general structure of a cell membrane is a phospholipid two-layer consisting of two layers of lipid molecules. In archaeal cell membranes, isoprene (phytanyl) chains attached to glycerol replace fatty acids attached to glycerol in bacterial membranes. Some archaeal membranes are lipid mons and whites instead of two-layer eras (Figure 2). Figure 2. Archaeal phospholipids differ from those found in bacteria and Eukarya in two ways. First, they have branched phytanyl sidechains instead of linear ones. Second, an ether bond instead of an ester bond connects lipid to glycerol. The cell wall Cytoplasm of prokaryotic cells has a high concentration of dissolved dissolved solutions. Therefore, the osmotic pressure in the cell is relatively high. The cell wall is a protective layer that surrounds some cells and gives them shape and stiffness. It is located outside the cell membrane and prevents osmotic lysis (blasting due to increasing volume). The chemical composition of the cell walls varies between archaea and bacteria, and also varies between bacterial species. Bacterial cell walls contain peptides and lycan, which consist of polysaccharide chains that are cross-in combinationd with unusual peptides containing both L and D amino acids, including D-glutamic acid and D-alanine. Proteins usually only have L-amino acids; As a consequence, many of our antibiotics work by mimicking D-amino acids and therefore have specific effects on bacterial cell wall development. There are more than 100 different forms of peptideoglycan. S-layer (surface layer) proteins are also present on the outside of cell walls of both archaea and bacteria. Bacteria are divided into two large groups: Grams positive and Gram negative, based on their reaction to Gram dyeing. Note that all Gram-positive bacteria belong to a phylum; bacteria in the other phyla (Proteobacteria, Chlamydias, Spirochetes, Cyanobacteria, and others) are Gram-negative. The Gram dyeing method is named after the inventor, the Danish researcher Hans Christian Gram The various bacterial reactions to the dyeing procedure are ultimately due to cell wall structure. Gram-positive organisms are typically missing the outer membrane found in Gram-negative organisms (Figure 3). Up to 90 percent of the cell wall in Gram-positive bacteria is composed of peptidoglycan, and most of the rest is composed of acidic substances called teichoic acids. Teichoic acids can be covalently associated with lipids in the plasma membrane to form lipoteichoic acids. Lipotic acids anchor the cell wall to the cell membrane. Gram-negative bacteria have a relatively thin cell wall consisting of a few layers of peptidoglycan (only 10 percent of the total cell wall), surrounded by an outer envelope containing lipopolysaccharides (LPS) and lipoproteins. This outer envelope is sometimes referred to as another lipid twolayer. However, the chemistry of this outer envelope is very different from the typical lipid two-layer that forms plasma membranes. Bacteria are divided into two large groups: Gram positive and Gram negative. Both groups have a cell wall consisting of peptides: in Gram-positive bacteria, the wall is thick, while the wall of Gram-negative bacteria is thin. In Gram-negative bacteria, the cell wall is surrounded by an outer membrane containing lipopolysaccharides and lipoproteins. Porins are proteins in this cell membrane that allow substances to pass through the outer membrane of Gram-negative bacteria. In Gram-positive bacteria, lipoteic acid anchors the cell wall to the cell membrane. Figure 3. Gram-positive and -negative bacteria (credit: change of work by Franciscosp2/Wikimedia Commons) Which of the following statements is true? Gram-positive bacteria have a single cell wall anchored to the cell membrane with lipotichoic acid. Porins allow the onset of substances in both Gram-positive and Gram-negative bacteria. The cell wall of Gram-negative bacteria is thick, and the cell wall of Gram-positive bacteria is thin. Gram-negative bacteria have a cell wall made of peptideoglycan, while Gram-positive bacteria have a cell wall made of lipoticho acid. Archaic cell walls do not have peptidoglycan. There are four different types of Archaean cell walls. One type is composed of pseudopeptidoglycan, which is similar to peptidoglycan in morphology, but contains different sugars in the polysaccharid chain. The three other types of cell walls are composed of polysaccharides, glycoproteins, or pure protein. Table 4. Structural differences and similarities between bacteria and archaea structural characteristic bacteria Archaea Cell type Prokaryotic Prokaryotic Cell morphology Variable Cell Wall Contains peptidoglycan Does not contain peptidoglycan cell membrane type Lipid bilayer Lipid billags or lipid monolayer Plasma membrane lipid fatty acids Fatty acids Phytanyl groups Bacteria and Archaea differs in lipid membranes and the characteristics of the cell wall. In archaeal membranes, phytanyl units, rather than fatty acids, are linked to glycerol. Some archaeal membranes are lipid monolayers instead of two-layer. The cell wall is located outside the cell membrane and prevents osmotic lysis. The chemical composition of cell walls varies from species to species. Bacterial cell walls contain peptideoglycan. Archaic cell walls do not have peptidoglycan, but they may have pseudopeptidoglycan, polysaccharides, glycoproteins, or protein-based cell walls. Bacteria can be divided into two large groups: Gram positive and Gram negative, based on Gram stain reaction. Gram-positive organisms have a thick cell wall along with teichoic acids. Gram-negative organisms have a thin cell wall and an outer envelope containing lipopolysaccharides and lipoproteins. Contribute! Did you have an idea to improve this content? We'd love your input. Improve this pageLear more

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