General comparisons between prokaryotic cells and eukaryotic cells:

<table>
<thead>
<tr>
<th>Prokaryotes</th>
<th>Eukaryotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&quot;pre-nucleus&quot;)</td>
<td>(&quot;true nucleus&quot;)</td>
</tr>
<tr>
<td><strong>Cells typically 0.2-2.0µm diameter</strong></td>
<td><strong>Cells typically 5-100µm diameter</strong></td>
</tr>
<tr>
<td><strong>No nuclear membrane around genetic material</strong></td>
<td><strong>Nucleus with double nuclear membrane houses genetic material separate from cytoplasm</strong></td>
</tr>
<tr>
<td><strong>DNA = one circular chromosome</strong></td>
<td><strong>DNA = multiple linear chromosomes</strong></td>
</tr>
<tr>
<td><strong>DNA not associated with histones</strong></td>
<td><strong>DNA wound around histone proteins</strong></td>
</tr>
<tr>
<td><strong>Lack membrane-enclosed organelles</strong></td>
<td><strong>Have membrane-enclosed organelles: Mitochondria, Endoplasmic Reticulum, Golgi Complex, Lysosomes, Chloroplasts, etc.</strong></td>
</tr>
<tr>
<td><strong>Chemically complex cell walls e.g. peptidoglycan</strong></td>
<td><strong>Chemically simple cell walls (if present) e.g. chitin, cellulose</strong></td>
</tr>
<tr>
<td><strong>Simple flagella: two protein building blocks, no cilia</strong></td>
<td><strong>Complex flagella or cilia composed of microtubules with membrane</strong></td>
</tr>
<tr>
<td><strong>Capsule or slime layer glycocalyx (if present)</strong></td>
<td><strong>Glycocalyx in cells that lack a wall</strong></td>
</tr>
<tr>
<td><strong>No carbohydrates or sterols in plasma membrane</strong></td>
<td><strong>Plasma membrane contains sterols and carbohydrates</strong></td>
</tr>
<tr>
<td><strong>Cytoplasm lacks cytoskeleton and cytoplasmic streaming</strong></td>
<td><strong>Cytoskeleton and cytoplasmic streaming present in cytoplasm</strong></td>
</tr>
<tr>
<td><strong>Small 70s ribosomes</strong></td>
<td><strong>Large 80s ribosomes</strong></td>
</tr>
<tr>
<td><strong>Cell division by binary fission</strong></td>
<td><strong>Cell division by mitosis</strong></td>
</tr>
<tr>
<td><strong>Genetic recombination involves DNA fragment exchange</strong></td>
<td><strong>Genetic recombination involves meiosis</strong></td>
</tr>
<tr>
<td><strong>Bacteria and Archaea</strong></td>
<td><strong>Algae, Protozoa, Fungi, Plants, Animals</strong></td>
</tr>
</tbody>
</table>
Basic Bacterial Shapes and Arrangements

Cocci

(a) Diplococci
(b) Tetrad
(c) Sarcinae
(d) Staphylococci

Bacilli

(a) Single bacillus
(b) Diplobacilli
(c) Streptobacilli
(d) Coccobacillus

Spiral

(a) Vibrio
(b) Spirillum
(c) Spirochete
Representative Prokaryotic Cell

Note that not all bacteria have all the structures shown. Structures labeled in red are found in all bacteria. Both the drawing and the micrograph show a bacterium sectioned lengthwise to reveal the internal composition.
Bacterial Cell Walls

(a) Structure of peptidoglycan in gram-positive bacteria
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(b) Gram-positive cell wall
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(c) Gram-negative cell wall
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SCCC BIO244 Chapter 4 Handout
Chromosome is replicated and isolated to one side of the cell by an in-growth of membrane called the spore septum.

(a) Sporulation, the process of endospore formation

1. Chromosome is replicated and isolated to one side of the cell by an in-growth of membrane called the spore septum.
2. Plasma membrane starts to surround DNA, cytoplasm, and membrane isolated in step 1.
4. Peptidoglycan layer forms between membranes.

(b) An endospore in *Bacillus anthracis*

5. Protein spore coat forms around the outer membrane.
6. Endospore is freed from cell.

Parent cell lyses to release the endospore.

The forespore dehydrates and matures into an endospore containing only DNA, ribosomes, and enzymes.
Stylized Eukaryotic Cell

(a) Highly schematic diagram of a composite eukaryotic cell, half plant and half animal

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(b) Plant cell (Tribonema vulgare), an algal cell

Animal cell, an antibody-secreting plasma cell

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Mitosis

Prophase: chromatin condenses into chromosomes that pair with their duplicate: sister chromatids attached by a centromere
nuclear envelope breaks down
centrioles migrate to opposite poles
spindle fibers form and attach to centromeres

Metaphase: chromosomes align on the metaphase plate

Anaphase: centromeres split and sister chromatids are pulled to opposite poles by the spindle apparatus (once separate they are called chromosomes)

Telophase: nuclear membranes form
cchromosomes decondense into chromatin
spindle disassembles

Cytokinesis occurs: cytoplasm constricts at the metaphase plate forming a cleavage furrow that pinches the cells apart
Meiosis

Interphase events
As in mitosis, meiosis is preceded by events occurring during interphase that lead to DNA replication and other preparations needed for the cell division process. Just before meiosis begins, the replicated chromatids, held together by centromeres, are ready and waiting.

Meiosis I

Prophase I
As in prophase of mitosis, the chromosomes coil and condense, the nuclear membrane and nucleolus break down and disappear, and the spindle is formed. However, a unique event not seen in mitosis, called synthesis, occurs in prophase I of meiosis. Synapsis involves the coming together of homologous chromosomes to form tetrads, little packets of four chromatids. While in synopsis, the "arms" of adjacent homologous chromatids become wrapped around each other, forming several points of crossover or chiasmata. Generally speaking, the longer the chromatids, the more chiasmata are formed. (This process of crossover is shown in one tetrad of the prophase I view, and the result of that one event of crossing over is followed through meiosis II.) Prophase I is the longest period of meiosis, accounting for about 90% of the total period. By its end, the tetrads have attached to the spindle and are moving toward the spindle equator, and the sister chromatids have exchanged parts at points of crossover.

Metaphase I
During metaphase I, the tetrads align on the spindle equator in preparation for anaphase.

Anaphase I
Unlike the anaphase events of mitosis, the centromeres do not break during anaphase I of meiosis, and so the sister chromatids (dyads) remain firmly attached. However, the homologous chromatids do separate from each other and the dyads are moved toward opposite poles of the cell.

Telophase I
The nuclear membranes re-form around the chromosomal masses, the spindle breaks down, and the chromatin reappears as telophase and cytokinesis are completed, forming two daughter cells. The daughter cells (now haploid) enter a second interphase-like period, called interkinesis, before meiosis II occurs. There is no second replication of DNA before meiosis II.

Meiosis II

Prophase II
Metaphase II
Anaphase II
Telophase II and cytokinesis
Products of meiosis

Meiosis II begins with the products of meiosis I (two haploid daughter cells) and undergoes a mitosis-like nuclear division process referred to as the equational division of meiosis. After progressing through prophase, metaphase, anaphase, and telophase, followed by cytokinesis, the product is four haploid daughter cells each genetically different from the original mother cell.
Mitosis produces two daughter cells that are clones of the original parent cell.

Meiosis produces four sex cells/spores that each only have half the number of chromosomes as the parent (parent is diploid, resulting cells are haploid). None of the four cell are identical to the parent, and they are usually not identical to each other.