The Sun at the center of our Solar System is a massive ball of Hydrogen, some Helium, and trace amounts of other elements. The Sun is so large that it has 99.86% of the solar system's mass. That means that the planets, dwarf planets, moons, asteroids, comets, and solar system debris combined make up only 0.14% of the Solar System's mass, everything else is in the Sun! The above image shows the scale of the Earth compared to the Sun. You could fit over one-million Earths in the volume of the Sun!

The Sun has no solid surface, like the terrestrial planets do. It is a spherical ball of gas, held together by its own gravity, getting denser and denser with depth. At the core of the Sun, densities and temperatures are so high, that nuclear fusion spontaneously occurs fusing Hydrogen into Helium. The fusion reaction gives off extra energy in the form of photons. The photons created at the center of the Sun cannot directly leave the Sun, they have to make their way out via what scientists refer to as “the random walk of photons.” After a photon is created from the fusion at the core, it is emitted by the new Helium atom in a random direction. The photon is then very quickly absorbed by a nearby electron, which holds on to it briefly before re-emitting it in another completely random direction. This happens countless time as a photon slowly makes it's way out of the Sun. In fact it takes nearly a million years for a photon created at the core to make it's way to the surface via the random walk. Compare that time to the 8 minutes it takes a photon to travel from the Sun to the Earth.
Of course, Astronomers can't see the core of the Sun where fusion takes place directly because there is too much Hydrogen in the way. The radius at which light can finally make it through the opaque Sun to be emitted is called the photosphere. This is where the Sun's gases are no longer so dense that a photon is likely to continue on the random walk, and is emitted out of the Sun. This layer of the Sun is generally called the Solar Surface, and has an average temperature around 5800K.

One of the first things an observer might notice about the surface of the Sun, is that it appears mottled, or granulated. These granules are the size of a large continent on Earth, have lifetimes on the order of a few minutes, and are actually the top layer of the Sun's convection zone. The convection zone is the layer of the Sun just below the photosphere where the Sun's gases are very literally boiling up, just like a pot of water. The color difference between light and dark areas is due to a slight temperature difference between the upwelling boiling and the sinking. As the material reaches the top of the convection zone and meets the photosphere, the material is hotter. When it has released energy and starts to sink it is cooler. The temperature difference appears large by color difference but is really only about 500°C or K.
The Chromosphere is the inner atmosphere of the Sun, just above the photosphere. It is a little cooler at 4500K, and often hard to see because the photosphere so bright in comparison. The chromosphere emits mostly hydrogen alpha light at 656.28nm wavelength, because it is cool enough to allow molecular hydrogen to form and ionize. Using a hydrogen alpha filter on a solar telescope can help an observer see the features of the chromosphere. The chromosphere is the site of many solar storms, where long thin spikes of solar material erupt from the surface at high speed reaching high into the solar atmosphere. These spikes or tubes are known as spicules and appear darker than the surrounding solar material because they are cooler.

The Sun produces a very high magnetic field. The precise source of the Sun's strong magnetic field is still under scientific debate, but it is thought to be intimately connected with the fact that the Sun is a heated ball of ionic plasma. Regardless of the source of the Sun's magnetism deep in the Solar interior, it's effects on the surface have been observed for centuries.

The picture above and to the left shows the Sun with many sunspots on it's surface, and the picture to the right shows a closer view of a few sunspots. Sunspots were originally named exactly for what they sound like, dark spots on the Sun. They're typically the size of Earth, and often form in groups. The Sun goes through cycles of Sunspot activity of 11 years with high points of hundreds of sunspots on the Sun, and lows of no sunspots. The dark center of the sunspot is the umbra, and the lighter area around it is the penumbra. Physically, sunspots are areas of cooler gas that surround the ends of magnetic field lines. Sunspots change shape, number, and grouping over time. Single sunspots can last days or months. Notice the difference between tube-like spicules and the penumbra of a sunspot.

Images by: http://www.oneminuteastronomer.com/1018/sunspots/
http://www.windows2universe.org/sun/images/sunspots_earth_size_big_jpg_image.html
Prominences and filaments are loops or sheets of glowing gas ejected from the Sun's surface moving because of the magnetic field lines through the Chromosphere into the Corona. Prominence is the name for these loops and sheets when they are viewed at the edge of the Sun. Filament is what they are called when viewed on the Sun's disk. Prominences and filaments have temperatures like the Chromosphere, and so are often viewed with a Hydrogen Alpha filter as well. They are darker than the surrounding solar material when viewed on the disk because they are cooler. Prominences can extend many thousands of kilometers into the Corona.
Faculae are bright areas on the Sun, usually seen near the edge, where the magnetic field is much more compact than in sunspot areas.

The transition zone of the Sun is the atmosphere above the chromosphere where the temperature increases rapidly. Above the transition zone is the extremely hot Corona (3,000,000K!) or outer solar atmosphere. The corona is really only visible during a full solar eclipse, where all other solar light is blowcked out, or by special instruments on SOHO. Intuition tells us that the atmosphere of the Sun should get cooler as it goes farther out, because it's getting farther away from the core's heat source. But the magnetic disturbances of the photosphere are so high energy, that they excite the thin atmosphere to incredibly high temperatures.

The Solar Wind is the collection of high energy, high velocity particles that escape the Sun. The particles reach energies high enough to escape the Sun's gravity from the high temperature of the corona. The Sun is constantly losing matter this way, at a rate of about 2 million tons per second, but the Sun is so massive that this loss is completely negligible. These particles, mostly protons and electrons, take several days to reach Earth traveling at 500km/s.

Today's Exercise has two parts. In the first part, students should identify the solar features described in this lab on the high resolution solar images handed out in class. The second part of the exercise is to create a movie of the Sun's motion with a handy software package. This movie will show how Sunspots change over the course of a month, as the Sun rotates with respect to Earth.
Solar Feature Identification

Identify two examples of each solar feature just described in the preceding sections on the following two images. Do not print off these pictures on the lab printer, because they will be very low resolution. Use the pre-printed high quality sheets given as handouts. Circle the features and name them.
Using PhotoLapse to make a solar rotation movie.
All files provided by the Solar Dynamics Laboratory and NASA.

1. Double click on the PhotoLapse icon (looks like a ladybug).
2. Scroll down the folders list under c:\ to locate the folder “Solar Images”. Double click on “Solar Images”.
3. Click on “Load files from current folder”.
4. You will see the files listed in the bottom frame of the program window. All the files should have a check mark in the box to the left. If not select “Mark all”. All settings should be the default settings.
5. Click “Create Movie”.
6. You will be prompted for a file name. Give the file a name. Your name and date is a good file name and it is unique to you. i.e. debra20120921 That is: name_year_month_date. You could add a, b, c, d, etc. to the file name if you make additional movies. The file extension is .avi and is automatic so don’t add .avi to the name. Choose the location where you want to save your file (e.g. Desktop).
7. Select “Save”.
8. The Video Compression window will open. Select “OK”.
9. After a moment of processing, Windows Media Player should open and play the movie automatically.
10. Your .avi file (movie) should be in the location you chose previously. Save the movie to your thumb drive. .avi files tend to be large so be sure you have plenty of thumb drive storage. Files you create and leave on the computer are periodically removed so do not consider you file safe to be left on the computer.
11. Should you make an error at any time during the process, simply start over or, if all else fails, simply restart the program and be careful as you go.
12. If the movie is too fast, you may change the frame rate by changing the number in the FPS (1-30) box. You will have to start over and repeat the procedure. The higher the number, the faster the movie will run. Don’t forget to rename your file or simply overwrite the older one.