Why do some mineral change color when you turn them?

There are minerals that change colors you turn them in the light. Perhaps they go from dusky yellow to purple as in cordierite, or purple to amber as in axinite or blue to violet to green as in tanzanite. These minerals show the amazing property of pleochroism.

Pleochroism ("many colors") is a well-known property to geologist. Normally, to see this property, rocks are sliced and ground down to 0.03 mm "thick" and placed under a microscope that uses polarized light. Polarized light is light filtered so that it vibrates in only one direction, rather than many different ways. The polarized light interacts with thin grains of various minerals producing different optical effects, including pleochroism, which help geologists to identify the minerals. For example, various amphiboles are strongly pleochroic properties in thin section.

But looking down a microscope and seeing a property in carefully filtered light is one thing. Seeing it in a big chunk of a mineral in regular sunlight is another. How does this happen?

Light and minerals interact in lots of ways. The interactions are complex enough that using filtered polarized light makes them manageable, which is why geologists use the microscopes that they do. Light always slows down when passing through a mineral. Sometimes it is split into 2 or 3 different rays by the particular arrangement of atoms in a mineral's structure. This is best seen in "Iceland Spar" calcite, where images seen through the calcite are doubled due to the fact that calcite splits light into 2 rays. Lots of minerals do this, but in most minerals the separation of the images is so slight you can't see it. But the separation of the images in calcite is unusually large. By the way, the rays that come out of a mineral like calcite are also polarized by the mineral's structure. In pleochroic minerals, these 2 or 3 light rays also differ in the wavelengths of colors they absorb as they move in different paths through the mineral's atomic structure. Thus when you turn the mineral, you will see different colors in different directions. Axinite, tanzanite and cordierite have unusually strong difference in the ways they absorb light, hence the pleochroism shows up even in large samples. That being said, then, how do these minerals show this effect in sunlight, rather requiring a fancy microscope with carefully filtered light?

It turns out that polarized light can be made in lots of ways. Light can be polarized by bouncing off a surface, such as a pond or a road surface (this is the glare your polarized car windshield cuts down). It's polarized by passing through plastic films made of long polymers oriented in the same direction. This makes the Polaroid you get in sunglasses and camera filters. But, most importantly here, light is partially polarized by passing through the air. If you take Polaroid sunglasses and look at the sky (NOT AT THE SUN) and rotate the glasses around when looking north, south, east and west, you'll see the sky lightens and darkens in different directions. It darkens in the places where some of the light polarized by the air can't get through the filter of your sunglasses. With the right mineral, pleochroism can be seen in the polarized light that reaches us every day. Our observant ancestors knew this fact. Strongly pleochroic minerals such as cordierite were used as compasses before the age of GPS. Since this effect is noticeable even on cloudy days, it is useable for navigation in all kinds of weather, when stars are not visible.

-Dr. Bill Cordua, U. Wisconsin- River Falls