Intro to Digital Photography: Light Notes

*** Slide 1 Photography can be compared to painting; in fact, early photography in France was placed under the French Academy of Arts as a sub-set of painting. In painting, the painter has his subject: a landscape, a still life, or a portrait. He paints on the canvas using different brushes for effects, and his medium is oil, watercolor, or acrylics.

*** Slide 2 In photography we have our subject: a landscape, a still life, or a portrait. We have as our canvas the memory cards which the images are written to; our final output may be to print or to the web which becomes the destination canvas. And our brush is the camera: we can change lenses to have different effects--wide angle, telephoto, macro, tilt-shift--and we can add filters to alter how the image looks--neutral density, polarizing, color, special effects. Our medium is light. Without light there is no photography. You should think of the classes for this semester as a journey of exploring light.

*** Slide 5 The human eye is the brain's visual access to the world. Although the region that processes vision is known, how the brain actually does the processing is still a mystery. However, we go have good knowledge on how the eye works.

Light passes first through the pupil. The size of the pupil is dependent upon how much light there is; dim light and the pupil is large, allowing more light in, bright light and it is small. Drugs can have an affect on pupil dilation, and pupils are known to respond to strong emotional stimuli. The iris, the colored part of the eye, opens and closes in this response to light, altering the size of the pupil.

Light then passes through the cornea, which is a lens that focuses the light onto the retina. The light then continues through the vitreous body, a relatively dense fluid that allows the eye to maintain it's shape. The light then hits the retina, which is comprised of different light-sensing cells, rods and cones. Rods are used for night vision and cones for color.

*** Slide 6 There are three types of cones; those that respond best to blue light, those that respond best to green light, and those that respond best to red light. Human vision has the greatest frequency response to green light; this is probably evolutionary in nature, given that many of humankind early predators hid among the greenery. (Humans are also good at pattern recognition, so good in fact that we tend to see patterns where there aren't any.)

The human eye has an effective f-stop range of 6.5 to 20. An f-stop, which we will talk about later, is a ratio where a unit of light is either doubled or halved: the difference between one f-stop and another f-stop is either twice or half the amount of light, depending upon which way you're going; going brighter and you're doubling the light, going dimmer and you're halving the amount of light. Cameras that we can afford have, at best, a 9 f-stop range. So you can see that human f-stop dynamic range far exceeds that of the camera: you can easily see detail in shadows and highlights on a bright summer day, while with a camera to get detail in the shadows you'd have to over-expose (blow out) the highlights, and to get details in the highlights you'd have to under-expose the shadows, making them completely black. High dynamic range photography makes up for this lack of dynamic range, and we'll talk about this later in the semester.

*** Slide 7 The structure of the camera is very similar to that of the human eye. You have a lens structure (also called the lens barrel) that contains at least 2 lenses--the cornea in the human eye--and a diaphragm--the iris/pupil. The simplest lens has two lenses, one in front and one in back, and they have a single focal length, such as 50mm. Zoom lenses have variable focal lengths, and as such, have a far more complex lens structure. In DSLR (digital single lens reflex) cameras, the light is bounced off a mirror through a pentaprism (which makes the image right-side up) and through the eyepiece: when you look through the eyepiece of most DSLRs, you're looking through the lens of the camera. (One caveat: the diaphragm is wide open and doesn't change until you press the shutter, or the preview button on some cameras, so the image you're looking at isn't necessarily the image you will take, especially if you have a small aperture--more on this in another class.)

When you press the shutter things happen in sequence: the diaphragm closes down to the aperture you or the camera have selected (note: some lenses you have the ability to manually set the aperture); the mirror flips up out of the way to allow the image to hit the shutter (most are mechanical shutters, but many point-and-shoots have electronic shutters); the shutter opens and light hits the sensor which records the image, then the shutter closes after a pre-determined amount of time has passed; the image is converted to an electronic signal by the sensor (CCD or CMOS), processed by the onboard computer, and then written out to the memory card--in the old days the sensor was film, which was also the recording media.

*** Slide 8 The heart of the digital camera is the sensor. There are two types: CCD (charge coupled device) or CMOS (complementary metal-oxide semiconductor) for the majority of digital cameras sold; a third sensor, known as Foveon, is used exclusively by Sigma in their line of cameras. Regardless of what type of sensor is used they all do the same task of converting photons to electrons.

*** Slide 9 Without the Bayer filter all digital images would be monochrome. This pattern of red-green-blue filters make color images possible. Each filter will only pass that color, so the red makes red pixels, green makes green pixels, and blue makes blue pixels. The percentages of red-green-blue is 25-50-25, which mimics the frequency response of the human eye.

***** CHARACTERISTICS OF LIGHT *****

*** Slide 10 For photography, light is defined the following ways: Source: what is generating the light? Intensity: how bright, or dim, is the light? Quality: how "good" is the light? (This is subjective in that all light is good, it just is that some light is better for a specific type of shooting.) Direction: where is the light coming from? Contrast: is there a strong contrast where light and dark prevail, or is there a low contrast where mid-tones prevail? Color: why red, green, and blue?

*** Slide 11 Source. Unless you have a specific light source in an otherwise completely dark room, most light is ambient light, which is the light that is around you. Most ambient light is a mixture of different sources, such as sunlight and skylight, overhead lights, table lights, light from the computer monitor or TV. If you stand by a window and have overhead lights, the ambient light is predominantly coming from the outside during the day, and from overhead at night. Most cameras do a fairly good job with balancing out the different types of light, but sometimes they have trouble if different lights are about equally as bright.

*** Slide 12 Intensity is broken down into subcategories: Incident & Reflected Reflectance Fall off (inverse square law)

*** Slide 13 Intensity: incident & reflected. Regardless of the light source, all light falling onto an object is known as incident light. Incident light that is reflected off the object is known as reflected light. Without reflected light an object would be invisible to the eye. Incident light is brighter than reflected light because the object will absorb some of the light as well as causing the light to scatter (and the air also absorbs / scatters light too). The brightest of all light is transmitted light.

*** Slide 14 Reflectance. Reflectance varies based upon multiple factors: the type of material of the object doing the reflecting, the angle of the primary incident light to the object, and the angle of the camera to the object. In general, wet items reflect more than dry, light items reflect more than dark, and smooth items reflect more than items with texture. It stands to reason, therefore, that wet, light, and smooth items will reflect more than dry, dark, and textured items. Compare a chrome bumper off a car to a piece of black felt.

*** Slide 15 Fall off (inverse square law). Light falls off at a predictable rate based upon the inverse square law. As you move an object away from a light source (or vice versa), the amount of light from the light source hitting the object decreases by a factor of four. You have a light bulb shining on an object that is 1 foot away, at at this distance the object is getting 100 watts of light. Now move the object away from the light source by 1 foot, so now it is 2 feet away. It is now getting only 1/4 of 100 watts, or 25 watts. Double the distance again, from 2 feet to 4 feet, and again the amount of light decreases by a factor of 4, or 6.25 watts. Knowing this is especially useful when using studio lights and flashes: you can control the amount of light hitting your subject by varying the power of the light or by moving the subject and/or light closer together or further apart. If you're shooting outdoors in the sun, you're out of luck in trying to use the inverse square law to increase / decrease the amount of light, you can't get 186 million miles away from or 46.5 million miles closer to the sun.

*** Slide 16 Fall off. Here is a good example using f-stops (you'll learn about them later in the semester) of how light falls off. As you can see, light falls off rather quickly, dropping off 5 f-stops within 4 units. In real world terms, if you were doing a group photography, where would you want them in respect to the light; close to the light or far away? Closer to the light means that some people may be over- or under-exposed due to the rapid fall off. You would want to place the light further away where there is a wider range of distance before the light drops off a stop.

*** Slide 17 Quality. Quality is divided into two subcategories, harsh light or soft light. The smaller the source of the light, the harder or harsher it will appear. New Mexico is blessed with many, many cloudless days that result in very hard, very harsh light. While the sun is really big, it's also far away and appears as a small spot in the sky: take a dime and hold it out at arm's length so that the disc is facing you--this is the approximate size of the sun in the sky, now take a look at how much sky there is from horizon to horizon. The sun is very small. Hard / harsh light tends to have hard shadows, very vivid colors, and high contrast.

Soft light is just the opposite in that the large the source is, the softer the light. Overcast skies is a great example of soft light in that the light appears to come from everywhere. Soft light is excellent for portrait photography for it diminishes the shadows cause by lines and wrinkles in the face. Soft light tends to have minimal to no shadows, muted colors, and low contrast.

*** Slide 18 Direction. The direction that light is falling plays an important role in creating shadows, something that is needed to define three-dimensional subjects, such as portraits, on a two-dimensional medium such as print or screen. In a studio setting, you can control light, it's quality, color, and direction by using times to block, channel, and reflect light.

Outside it's completely different. You have little control over light other than for using reflectors to bounce light--either bringing your own reflectors for finding ones in the environment to use such as glass windows, chrome & other metals, or water / snow / sand. You also have very little control over the quality--hard or soft--of light. If it is an overcast day then you have soft light that you can augment by the use of flash or other light; if it is a bright sunny day, you can have someone hold a diffuser over the subject to make the light softer. Typically, however, as a photographer you have to use whatever light is available.

*** Slide 19 Direction. Here is a good example of how the direction of light and shadow sculpts a face. From left to right you have straight on light, good for minimizing wrinkles because there is very few shadows cast; side lighting (extreme case of 90 degrees); back lighting, good for silhouettes and transluscent things (stained glass, flowers); top down lighting, note how the shadows sculpt the cheeks, making the face look thinner; bottom up lighting, dramatic lighting causing the shadows to go the wrong way (we are used to seeing shadows fall "down" away from the Sun in the sky).

*** Slide 20 Contrast. Contrast is defined by the degree of difference between light and dark. A high contrast is one where there are primarily only lights and darks with very little mid-tones. A high contrast black-and-white image, for example, is a high contrast image. Most good black-and-white images start out as images with a high contrast before they are converted. A note about converting images from color to black-and-white; most cameras now offer a black-and-white (or monochrome) setting: DO NOT USE IT! A true black-and-white image depends upon a subtile mixing of red, green, and blue to bring out detail. The black-and-white / monochrome modes on digital cameras throw out the green and blue channels, leaving you only the red as black-and-white (using the red channel for black-and-white goes back to using red filters on black-and-white film to increase the contrast--early black-and-white film was very sensitive to red light). It is like trying to make a pizza out of dough, sauce, and cheese and only having one of the ingredients; you don't get a very good pizza. To get really good black-and-white photographs, take the image into an image processing application like Adobe's Photoshop / Photoshop Elements / Lightroom or Apple's Aperture.

A low contrast image is one where mid-tones dominate and there are no really bright whites or dark blacks. A photo of a giraffe eating from a tree would be a low contrast image, even thought the color of the giraffe contrasts with the green of the tree, there are no real whites or blacks (other than the giraffe's eyes). You may hear in portrait photography of "low key" images; these are images that are very soft low contrast: a face covered with a veil in soft white light, for example, is a low key image.

*** Slide 21 Contrast. Here are examples of a high contrast (low key) and low contrast (high key) lighting. High contrast lighting is usually created by one light that is not diffused, so it is a very hard light. Shadows predominate in a low key photograph, with the background typically being black. A high key (low contrast) photograph is just the opposite in that the shadows are very soft and the photograph is flooded with light. Because these types of images tend to be soft, they are used for baby images.

*** Slide 22 Color. We will be delving into color in a separate presentation. For now, know that white light is composed of only three colors: red, green, and blue. All of the other colors that we see are a mix of red, green, and blue light. The visible spectrum is a very narrow part of the total electromagnetic spectrum at only 300 nanometers wide. going from 400 to 700 nanometers.

We tend to divide colors into warm (reds, yellows, oranges) and cool (blues, greens, purples). Warm colors are firelight, candlelight, and incandescent light; anything that puts out this red-orange-yellow color. Cool colors are light from flashes, fluorescent lights, LED lights; anything that puts out this blue-green-white color. Light during the day is a mixture of light: the Sun is yellow, thus is a warm color, while the sky is blue and considered cool. We will see in the presentation on color that the camera thinks that what we consider to be warm and cool are just the reverse.