Black and White Infrared Photography

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Metro Continuing Education

Course Goals

- The B&W Infrared 'look'
- Infrared light reflection in natural scenes (vegetation, water, sky, clouds, skin, etc.)
- The electromagnetic radiation spectrum and the qualities of infrared light
- Film and silicon sensors; how manufacturers modify what the sensor sees in the infrared part of the spectrum
- A simple test to check for infrared sensitivity, what we can do if our camera is not infrared sensitive. Shopping/converting an infrared-capable camera

Course Goals

- Basic exposure estimation (photometric measurement/trial and error)
- Use of filters for infrared photography
- Photoshop/GIMP techniques for infrared image enhancement
- Photoshop/GIMP for creating the IR 'look' with software
- Infrared lens focusing
- Color Infrared (optional)
- Assignment

Scientific applications of infrared photography

- Remote sensing (air photo, satellite)
  - Forestry
    - Disease detection
    - Inventory
  - Agriculture
    - soil moisture content
  - Military
    - camouflage detection
- Criminology
  - Document forging
- Astronomy
  - Radiation analysis
- Medicine
  - Skin problems
  - Circulation
  - Retinal analysis

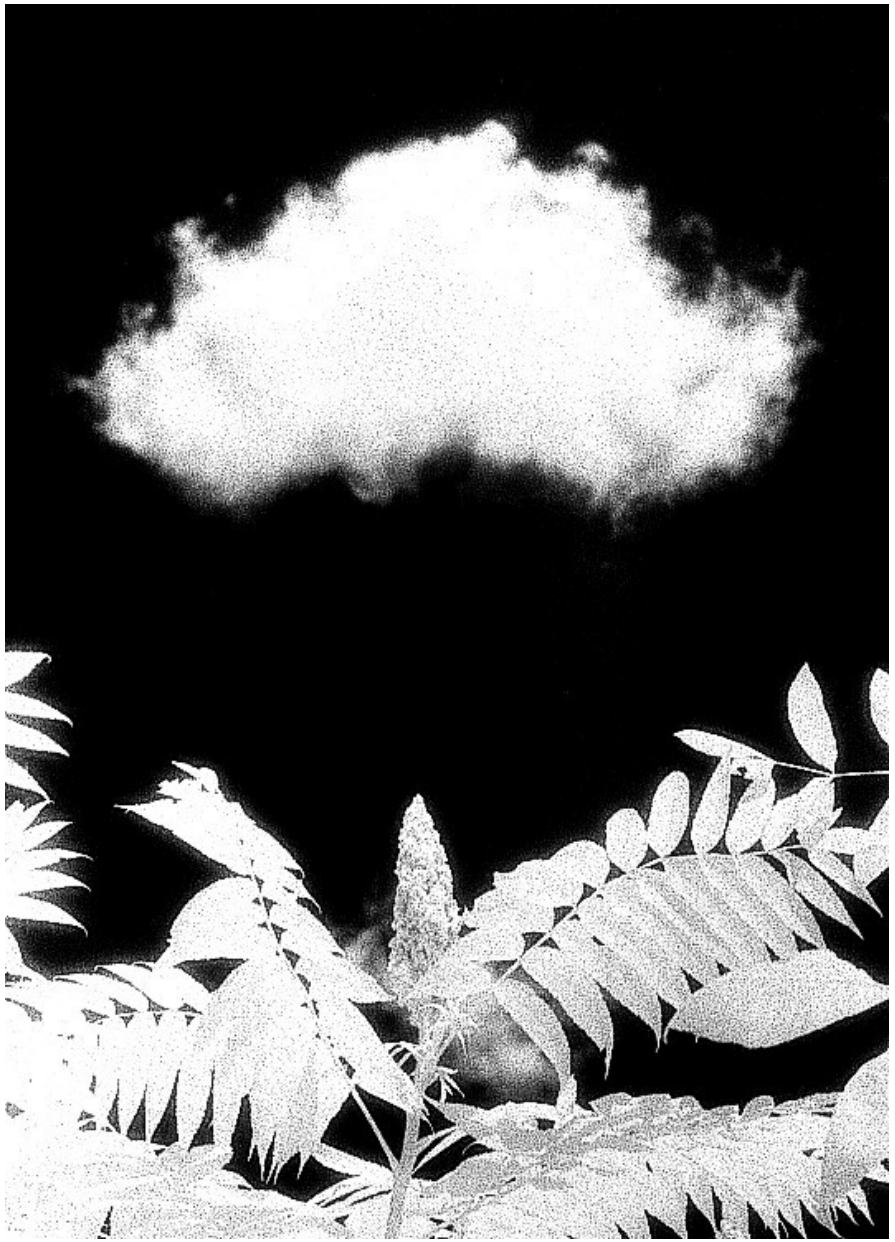
Pictorial infrared photography

- Landscape photography
  - Surreal, dreamy, fantasy-like images inducing a sense of other-worldliness.
- People photography
  - Fair, soft, angelic-like skin, producing a pleasant ethereal effect.
  - Wedding photographers are using the technique with greater frequency, especially with the advent if digital cameras.
- Psychedelic Art
  - The color distortion produced by color infrared has been used for music posters and LP sleeve art.

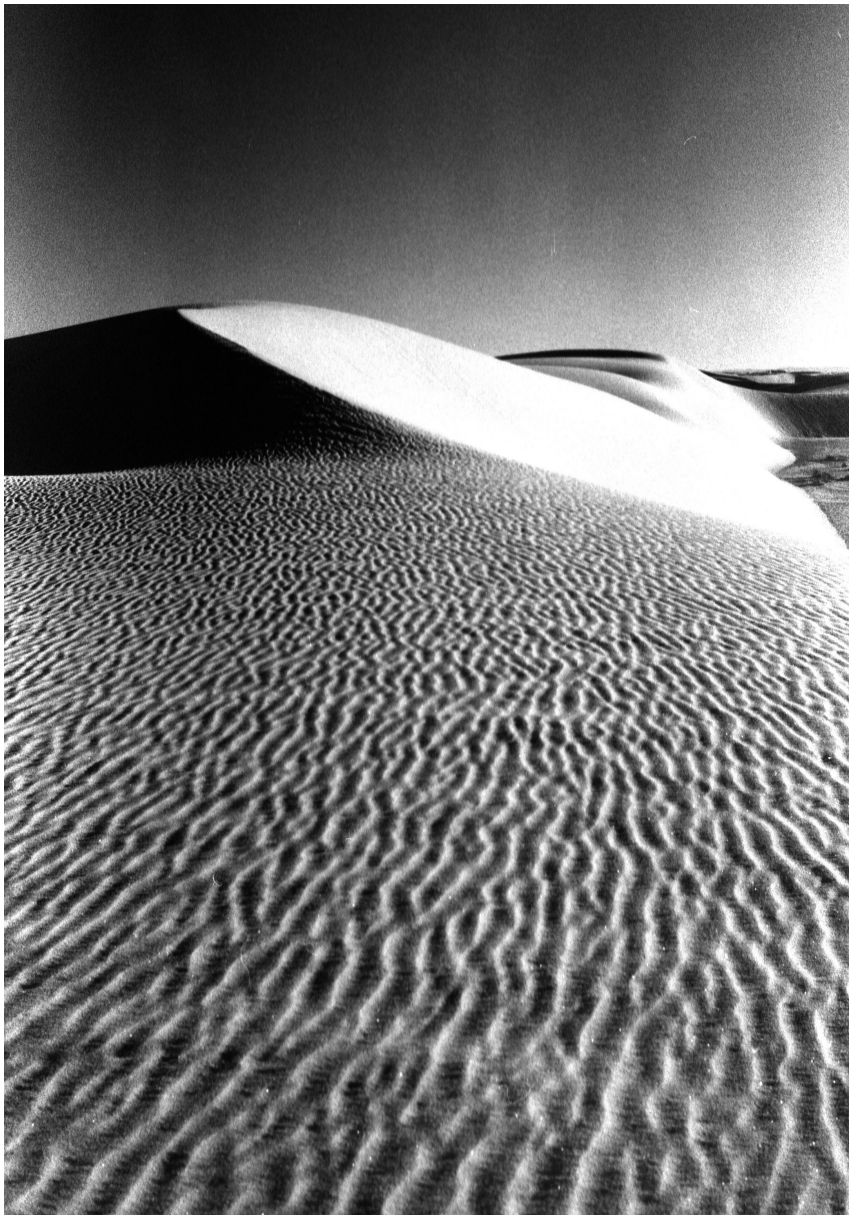
Pictorial Infrared Photography

examples

More examples



More examples



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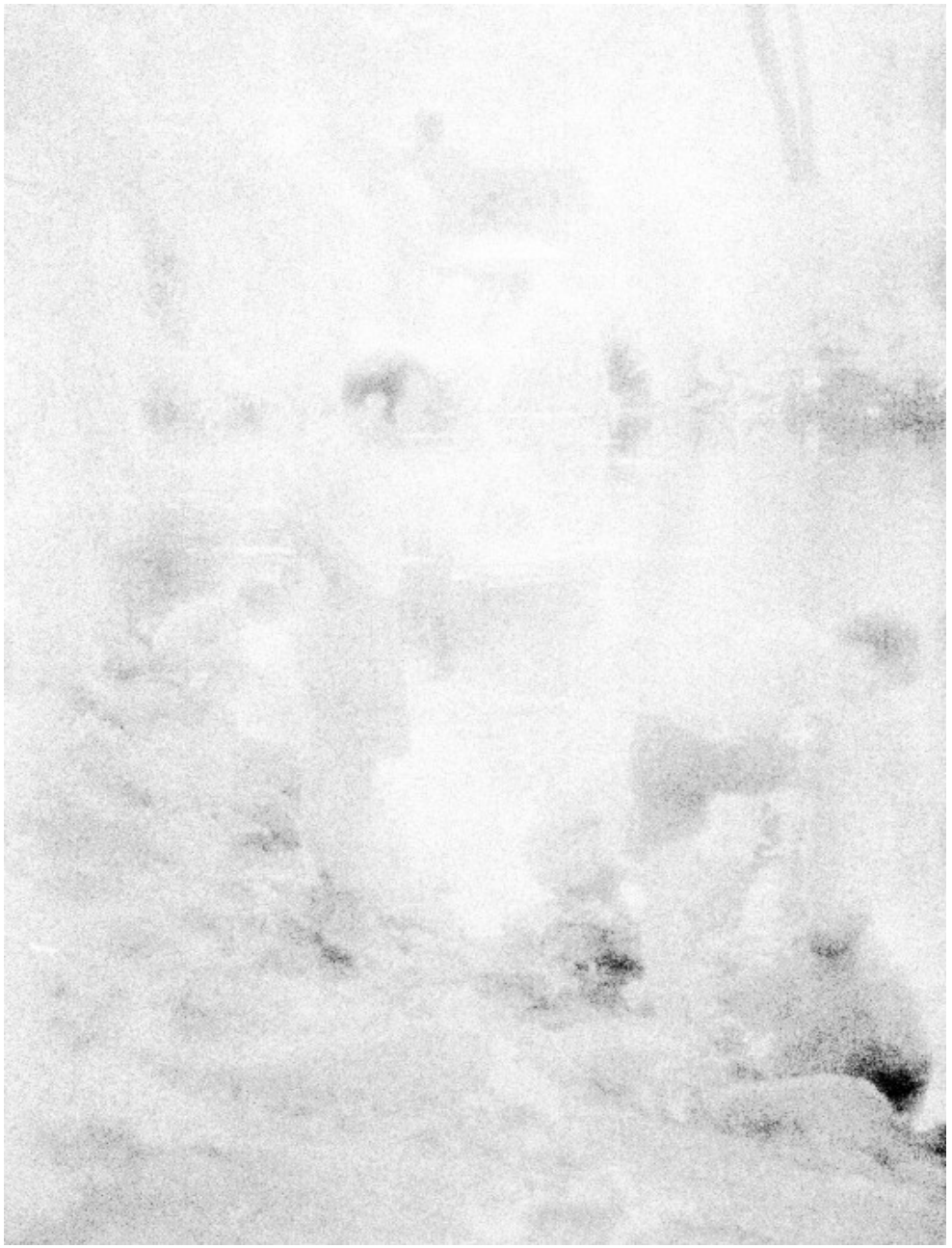
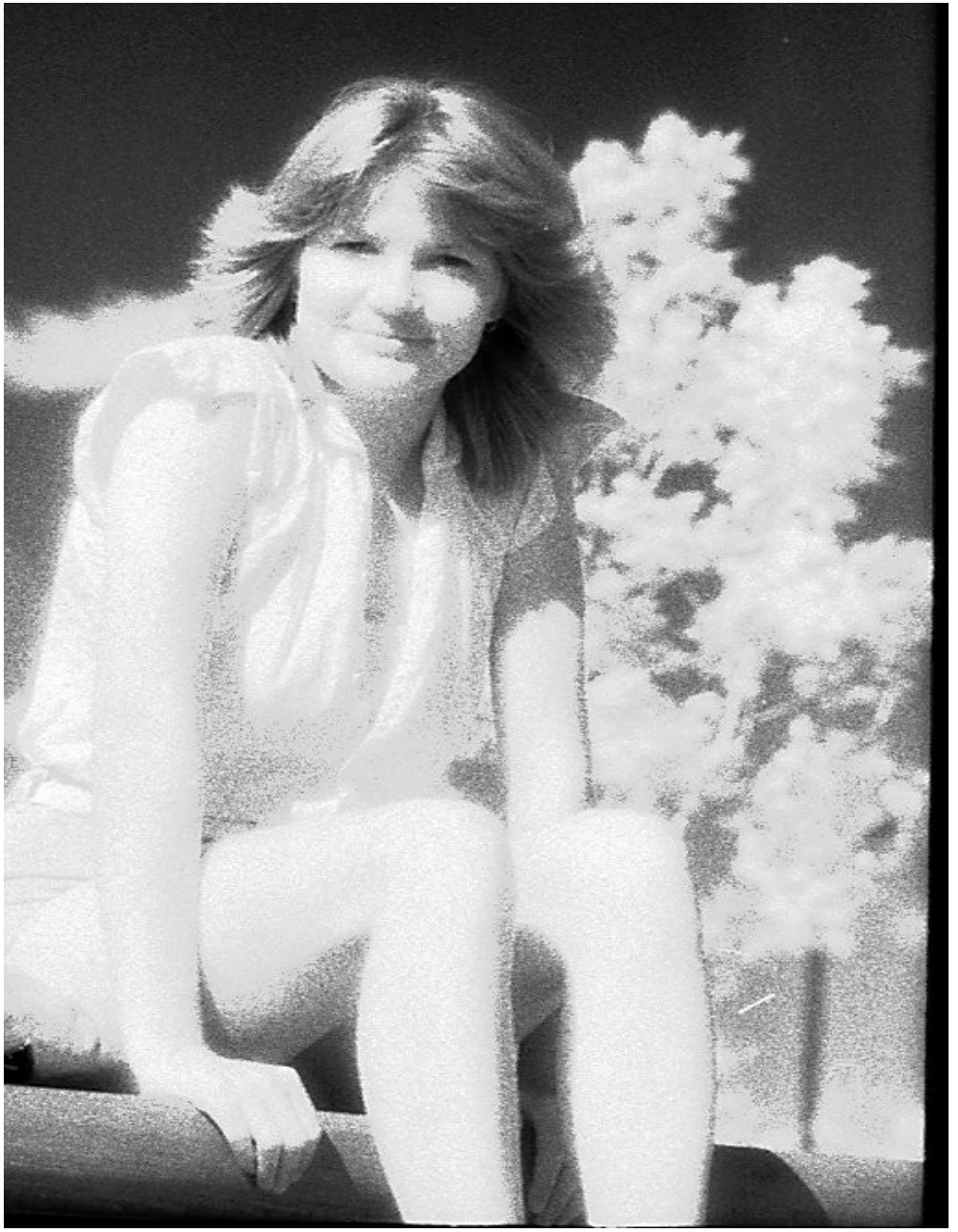
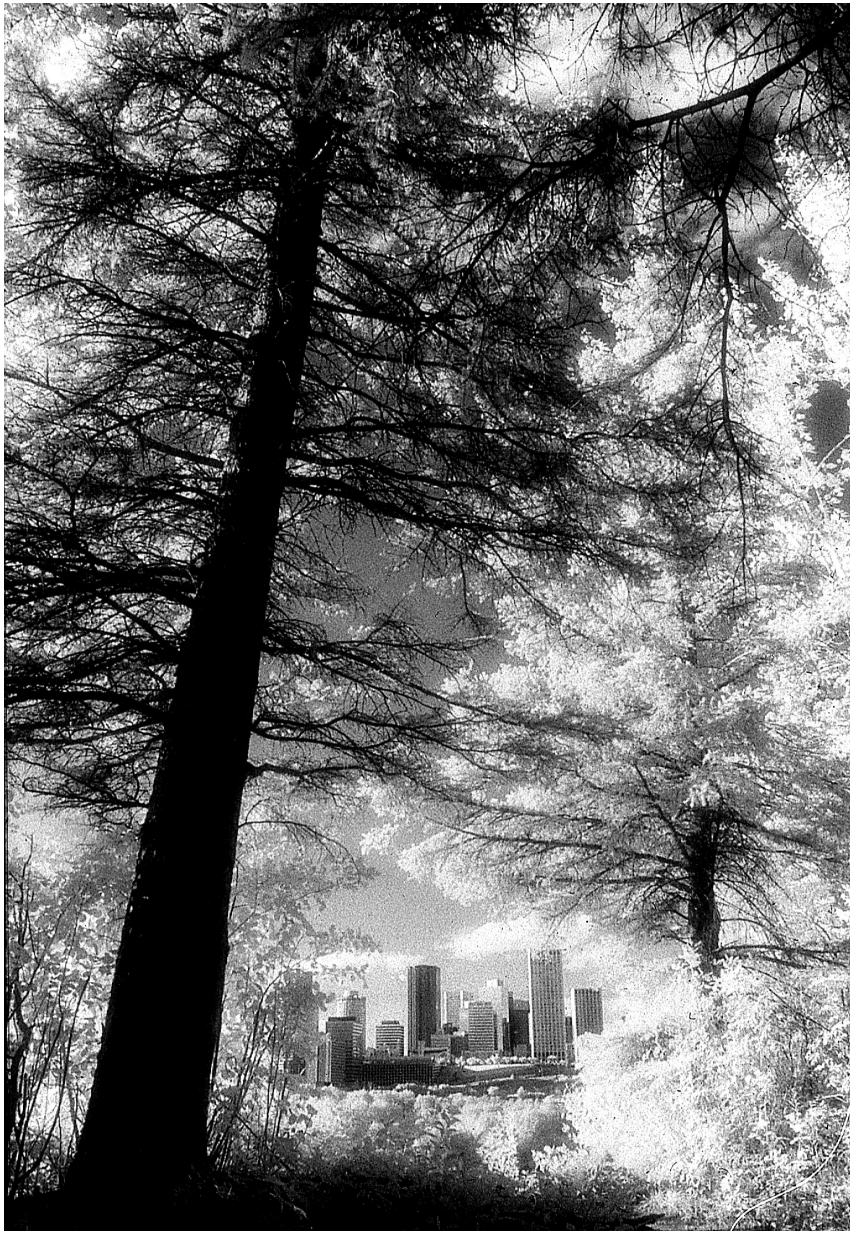




More examples



Preliminary Assessment

How are the following objects and surfaces rendered?

- Blue sky (dark, almost black)
- Foliage (white, conifers are darker)
- Clouds (white)
- Water bodies (black)
- Human skin (Caucasian - lighter than normal)
- Bare ground (neutral)

Understanding how these surfaces render tones in infrared photography allows us to compose images with maximum tonal impact..

Some basics for maximizing tonal contrasts in the infrared

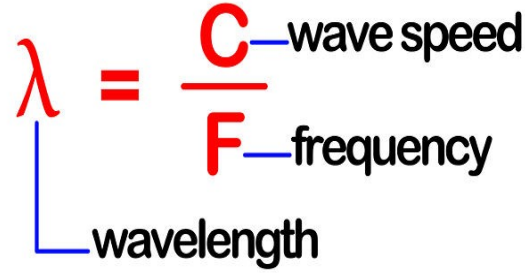
- Clouds against a blue sky
- Foliage against a blue sky
- Foliage against a water body
- Foliage reflected off a water body
- Caucasian skin against blue sky, water

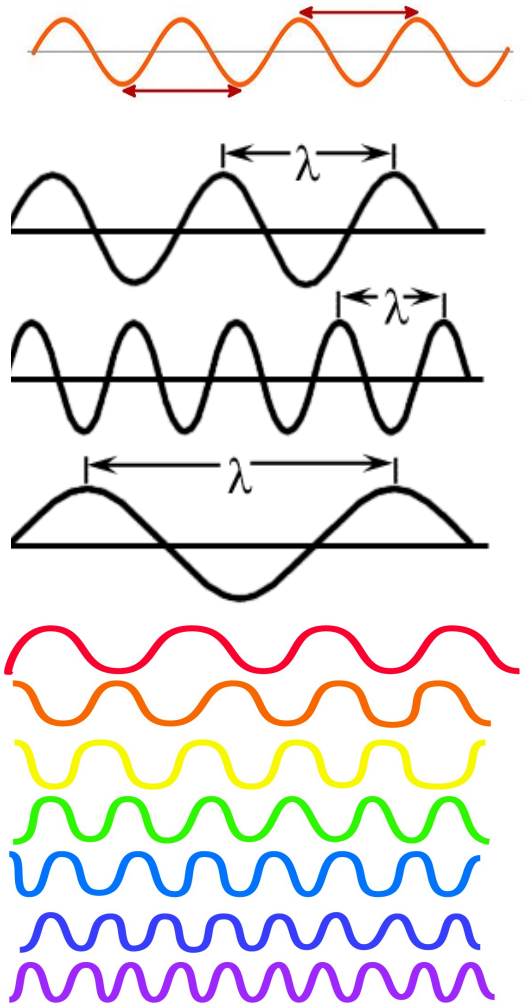
Analyzing the 'building blocks' of an infrared scene

- Source: characteristics of sunlight
- Sensors:
  - what we see (our eyes)
  - What film sensors see (sensitized silver halide)
  - What digital sensors see (silicon)
- How objects reflect light:
  - Skin, water, vegetation, clouds, etc..
- How we modify light (filter light)
  - Infrared filters, hot mirrors, Bayer filters

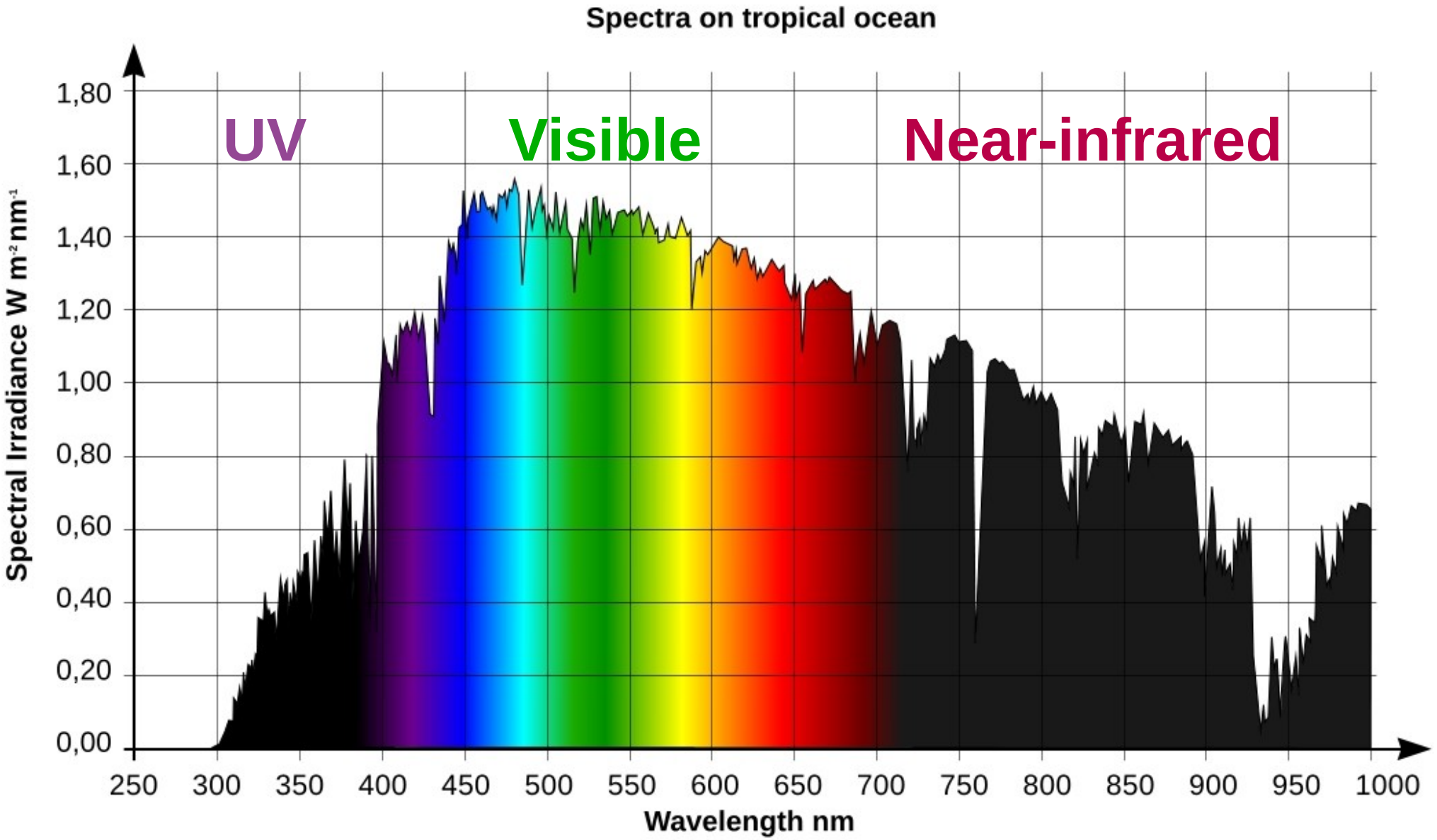
A little bit of science..

- A basic property of light (electromagnetic radiation) is that it acts like a wave. The distance from one wave crest to the next one is the wavelength, it is measured in nanometres or nm.
- The wavelength determines the 'color' of light: blue light has a smaller wavelength (~450nm) than green light. Green light (~525nm) has a smaller wavelength than red light (~625nm). These are the wavelengths that our eyes are sensitive to.
- Infrared wavelengths are beyond red light (longer than 700nm) and therefore not visible. So, we can never 'see' our infrared photo compositions at time of photographing!
- And now some 'painless' graphs.....



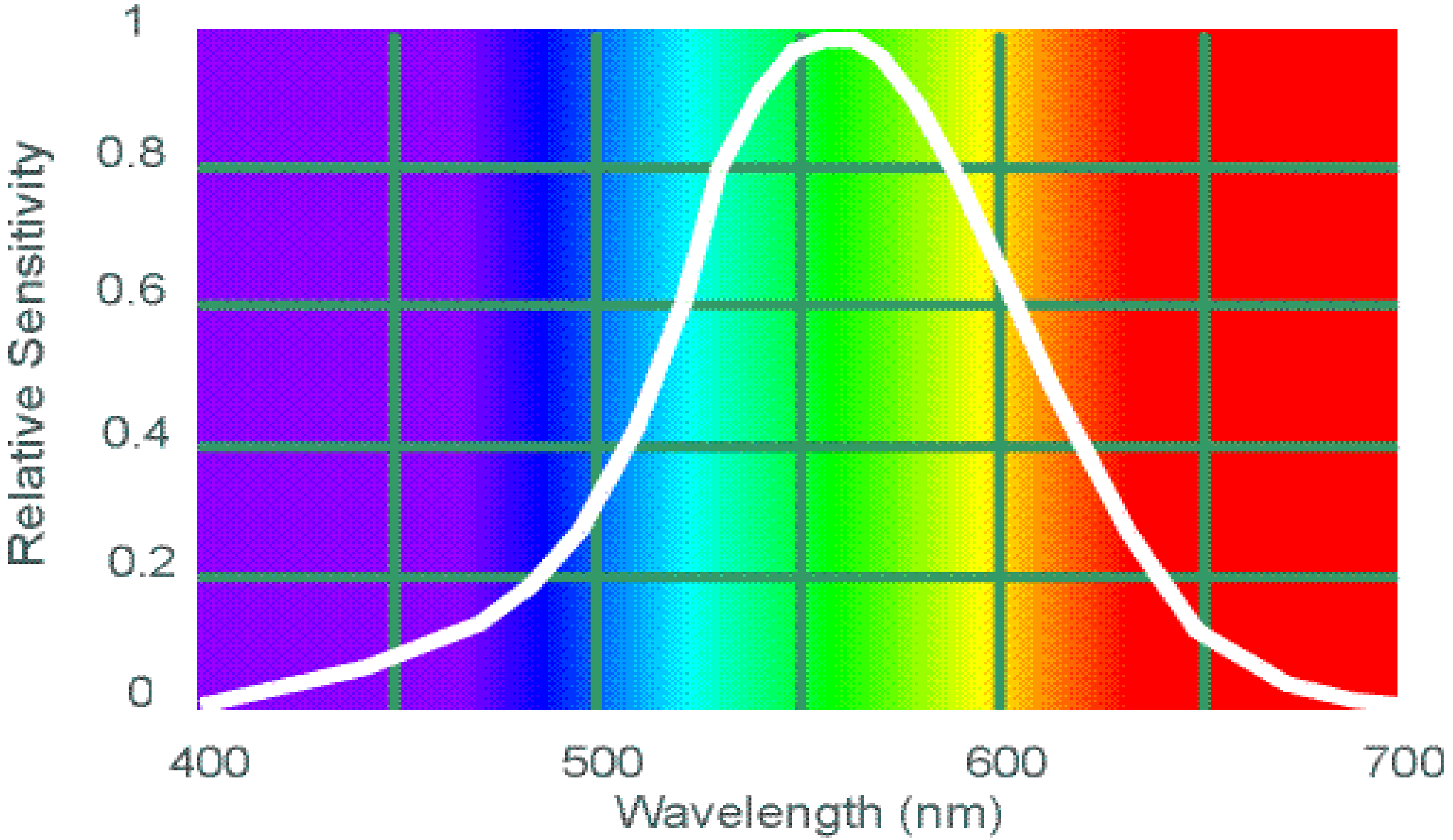


The spectral characteristics of sunlight

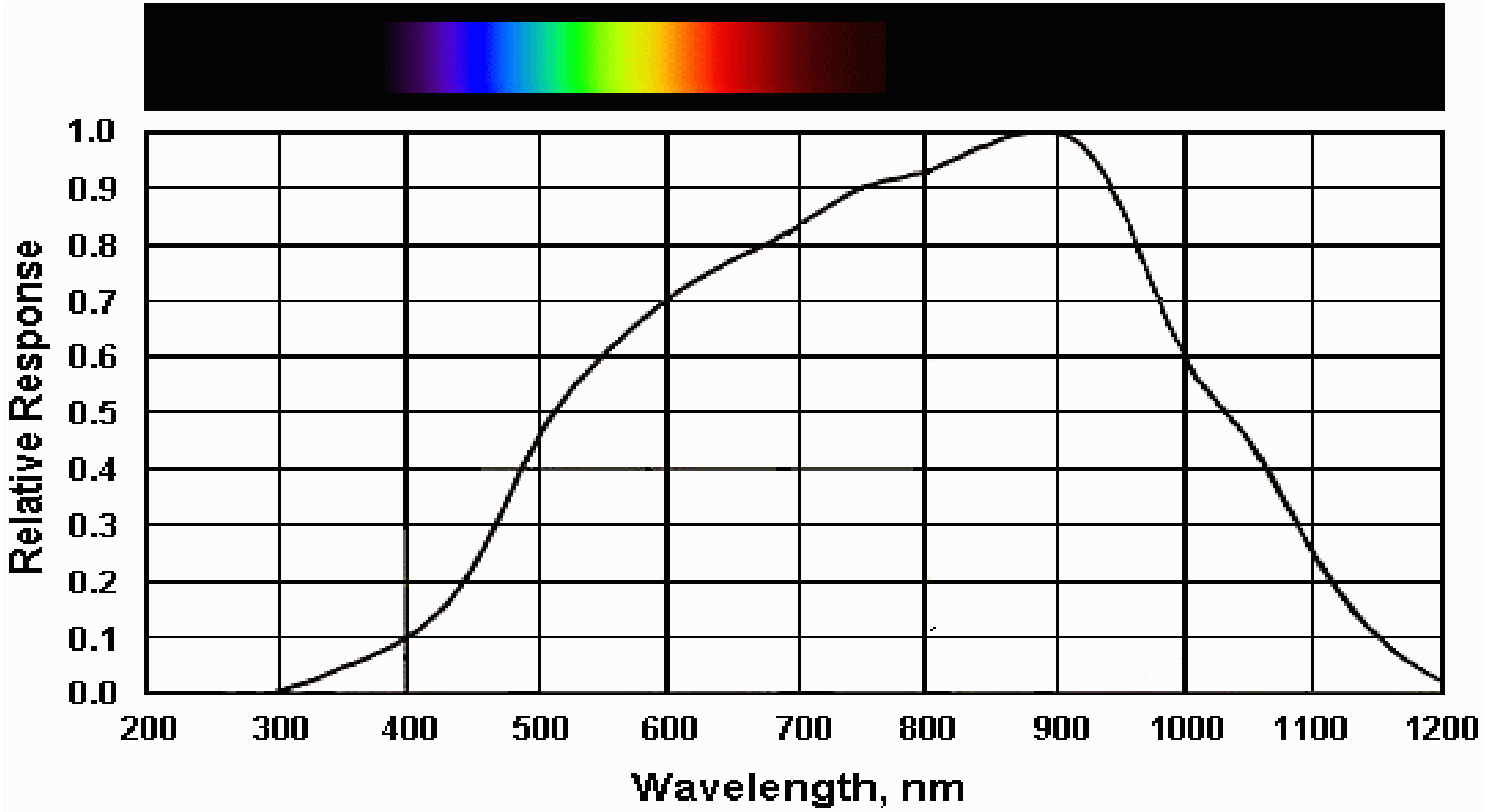


What can we see?

Spectral sensitivity of the eye (the photopic curve)

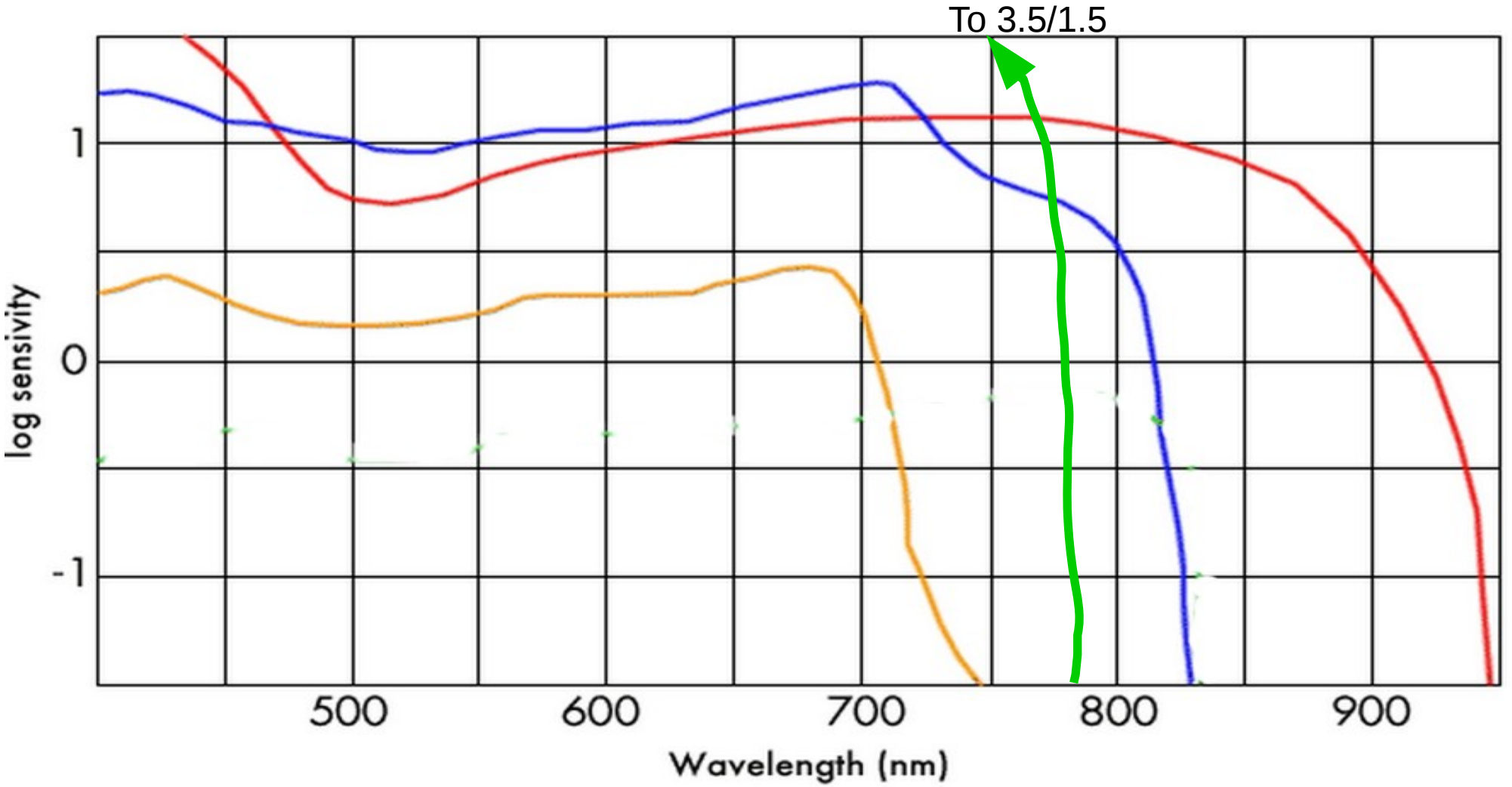


Spectral sensitivity of silicon sensors



Typical Silicon Photodiode Spectral Response

Spectral sensitivity of film (silver halide sensors)



Film types available

- Ilford SFX 200 (35mm)

  Spectral sensitivity to 720nm

- Rollei Retro 400s/80s

  spectral sensitivity to 750nm+

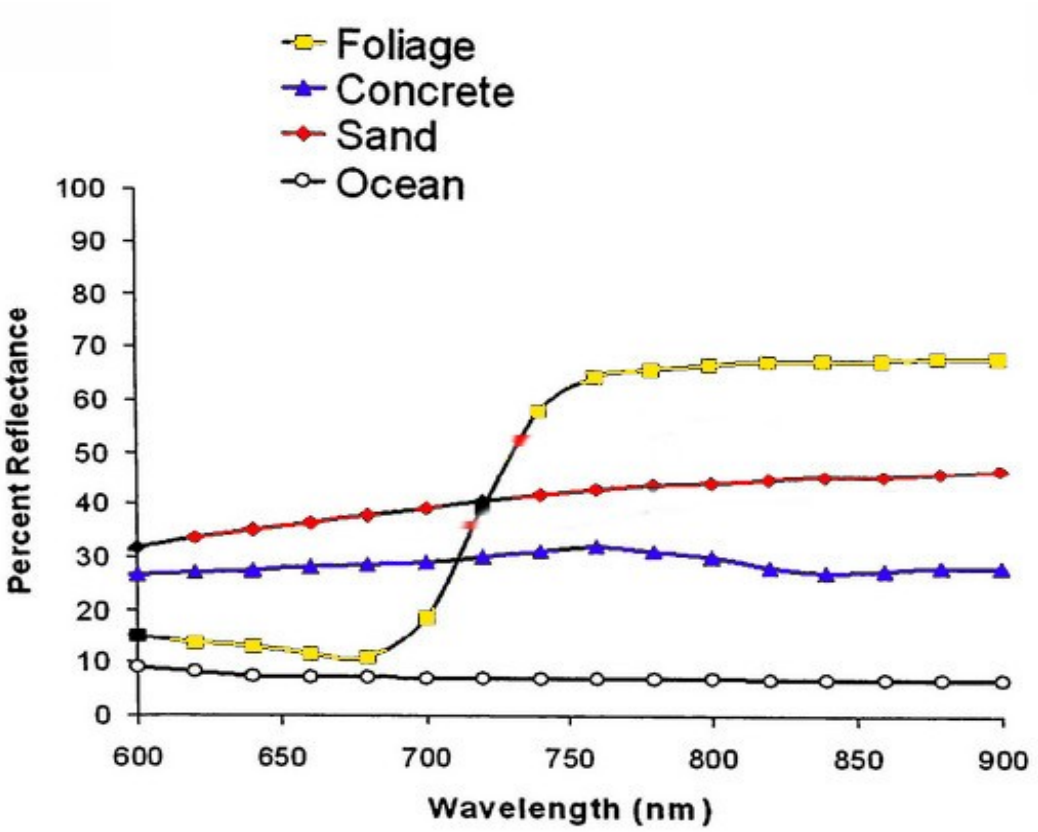
  35mm, 120 (400s: 120 only)

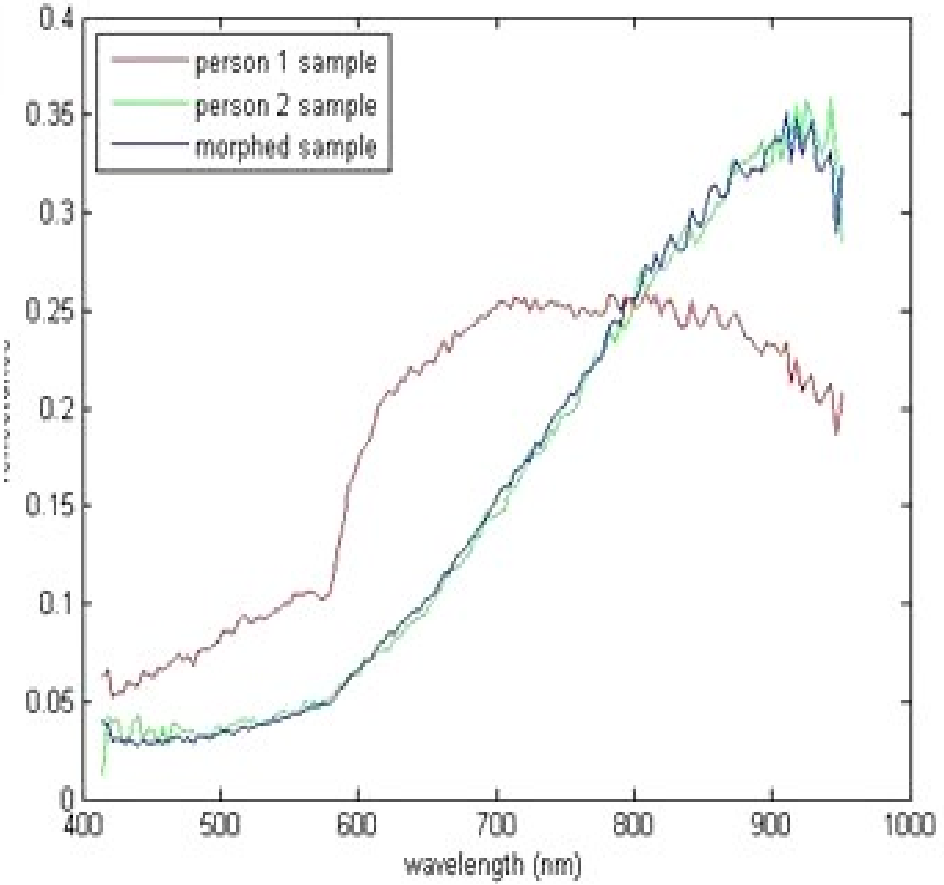
- Rollei Infrared ISO 400

  Spectral sensitivity to 820 nm

  35mm, 120, 4X5

And one final spectral piece of information..object reflectance





Summarizing our spectral information

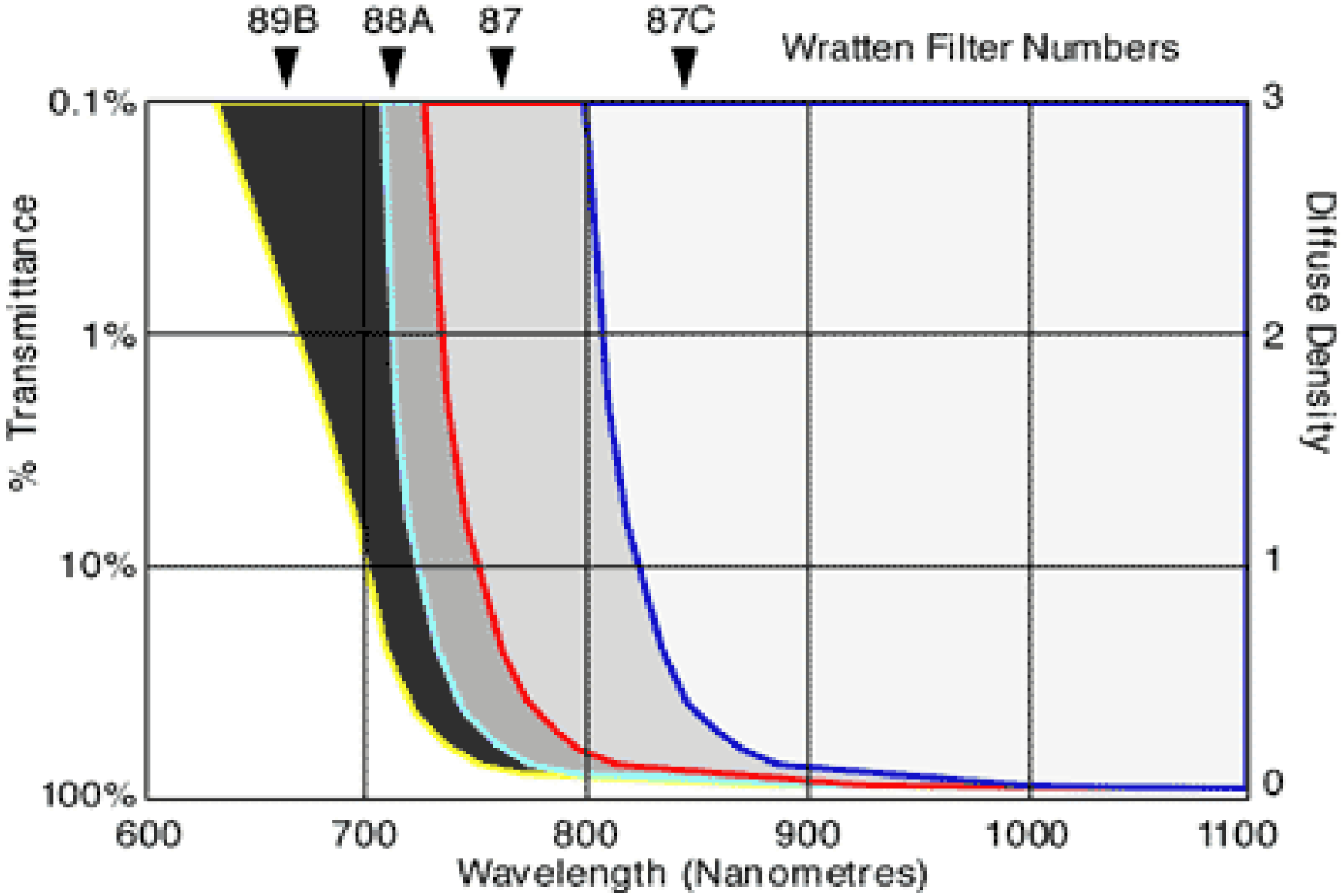
- Visible light ranges from 400nm to about 700nm
- Near-infrared light accounts for about 30% of solar radiation and extends out from 700nm to about 1100nm
- Special films which are sensitized in the infrared are required to photograph near-infrared light, current films limit us to around 800nm.
- Silicon sensors (CCDs and CMOS photodiodes) are inherently sensitive to infrared light, to about 1100nm
- Our eyes are sensitive from 400nm to 700nm; Infrared light (>700nm) is therefore not visible to humans.

Introducing filters

- For IR photography, filters are used to 'filter out' or block the visible light. These filters range from red (which allows red light and enables the photographer to compose through the lens) to deep red (700nm) and onto the true IR filters (750nm and beyond)
- With film, filter considerations would end here, with exposures about 3X-4X more than a pan monochrome film.

Filters for IR photography

Kodak Wratten series are shown below



Examples of filter use: 700(89B)-750(88A)

Rollei IR 400 film (120) – f/11, 1/8-1/4 sec

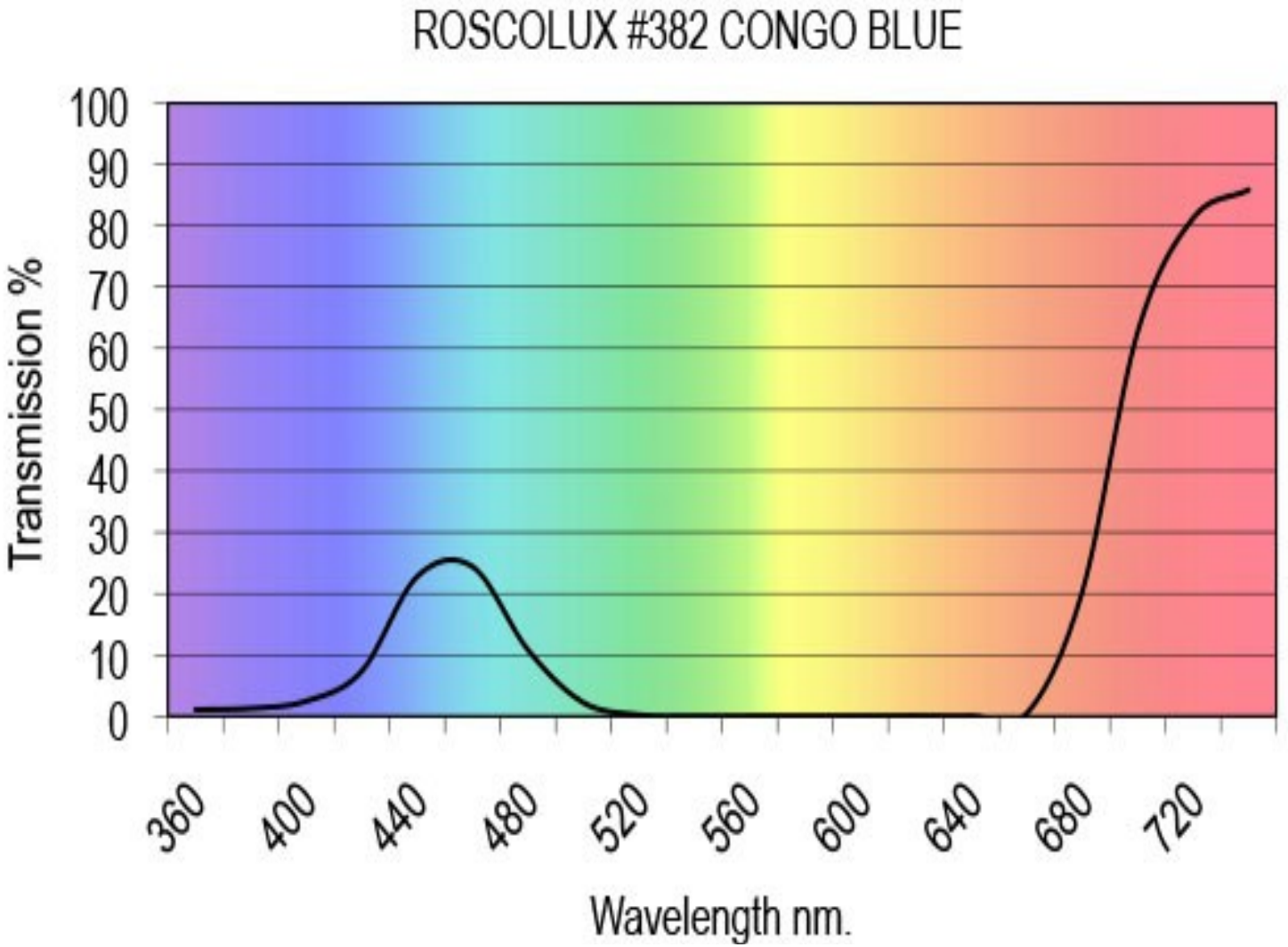
Available infrared filters

- Infrared filters are essential for IR photography but they can be relatively expensive.
- Kodak Wratten gel filters may be about $107US while a glass screw mount filter (Hoya R72) may be as much as $200 or more depending on the diameter of the filter
- Fortunately, there are cheaper DIY alternatives, these are some techniques to check out the capabilities of your digital camera BEFORE you invest in an expensive IR filter.

1. Use unexposed processed slide film. (???chrome).
2. Try stacking red (25A) and green (X1) filters together, red filter blocks green and blue while green filter blocks red (and blue), both allow IR from ~700nm+.
3. Gel sheets of Roscoe Congo Blue #382 lighting material will produce a similar effect as an #89B (available at Allstar for $8.50). Let's investigate..

The “Roscoe #382” gel lighting filter for infrared photo

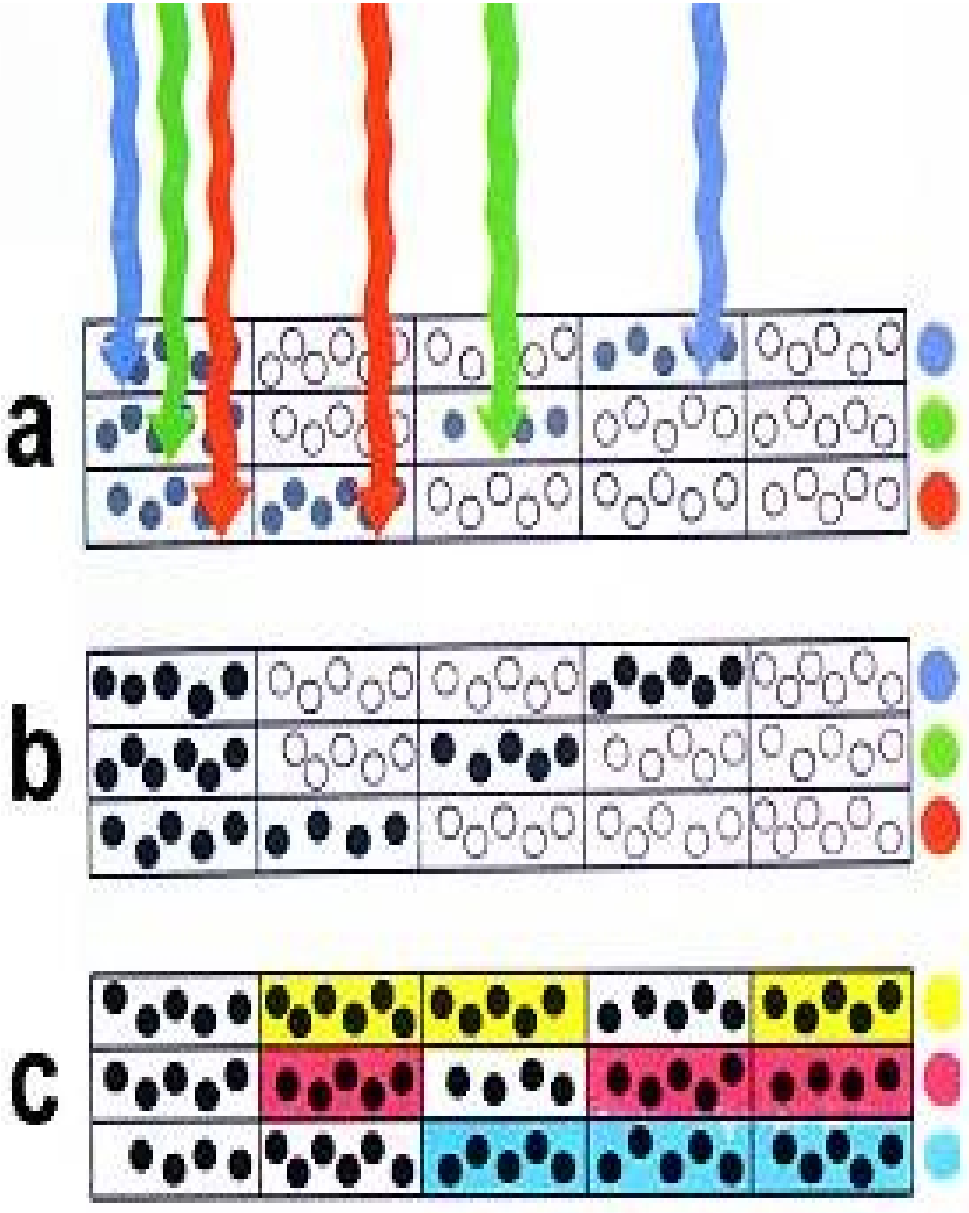
What else do you need to do in this situation to get ONLY Infrared light going to the camera sensor?
(provide a couple of options)

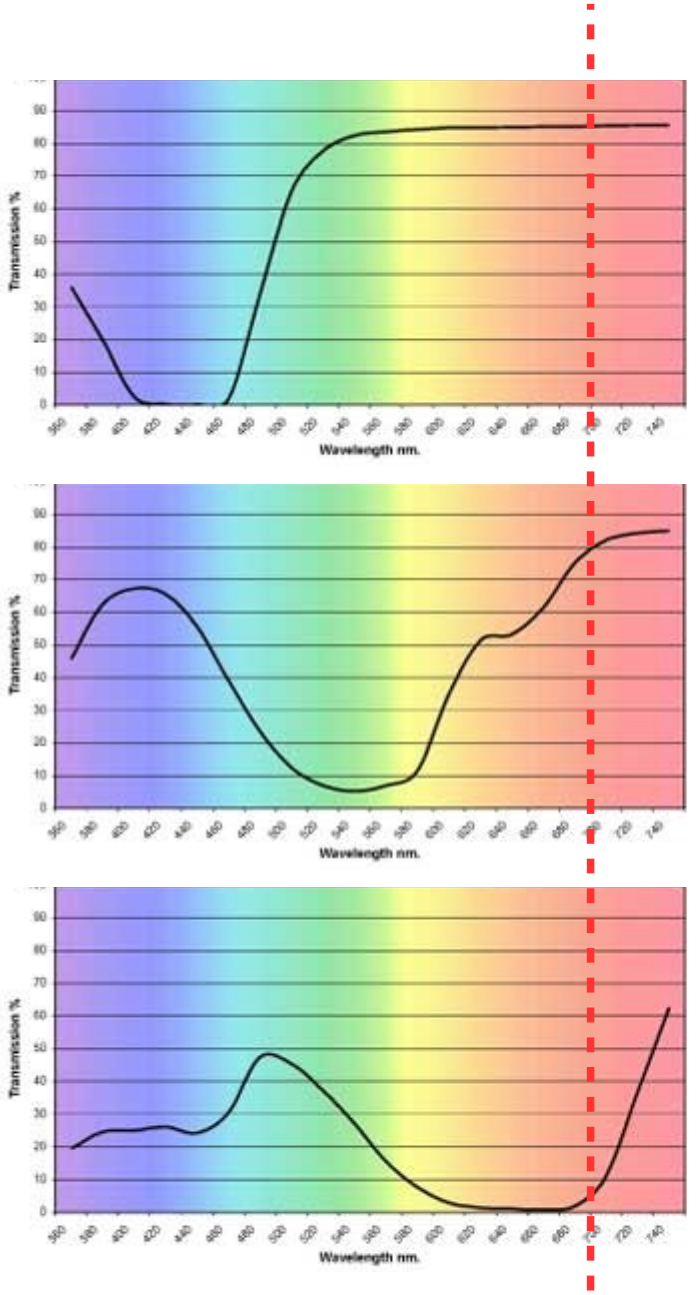


Examples of Roscoe gel use: #382 Congo Blue & #27 Red

Sigma SD1 w/hot mirror

The Ekta/Fujichrome film filter



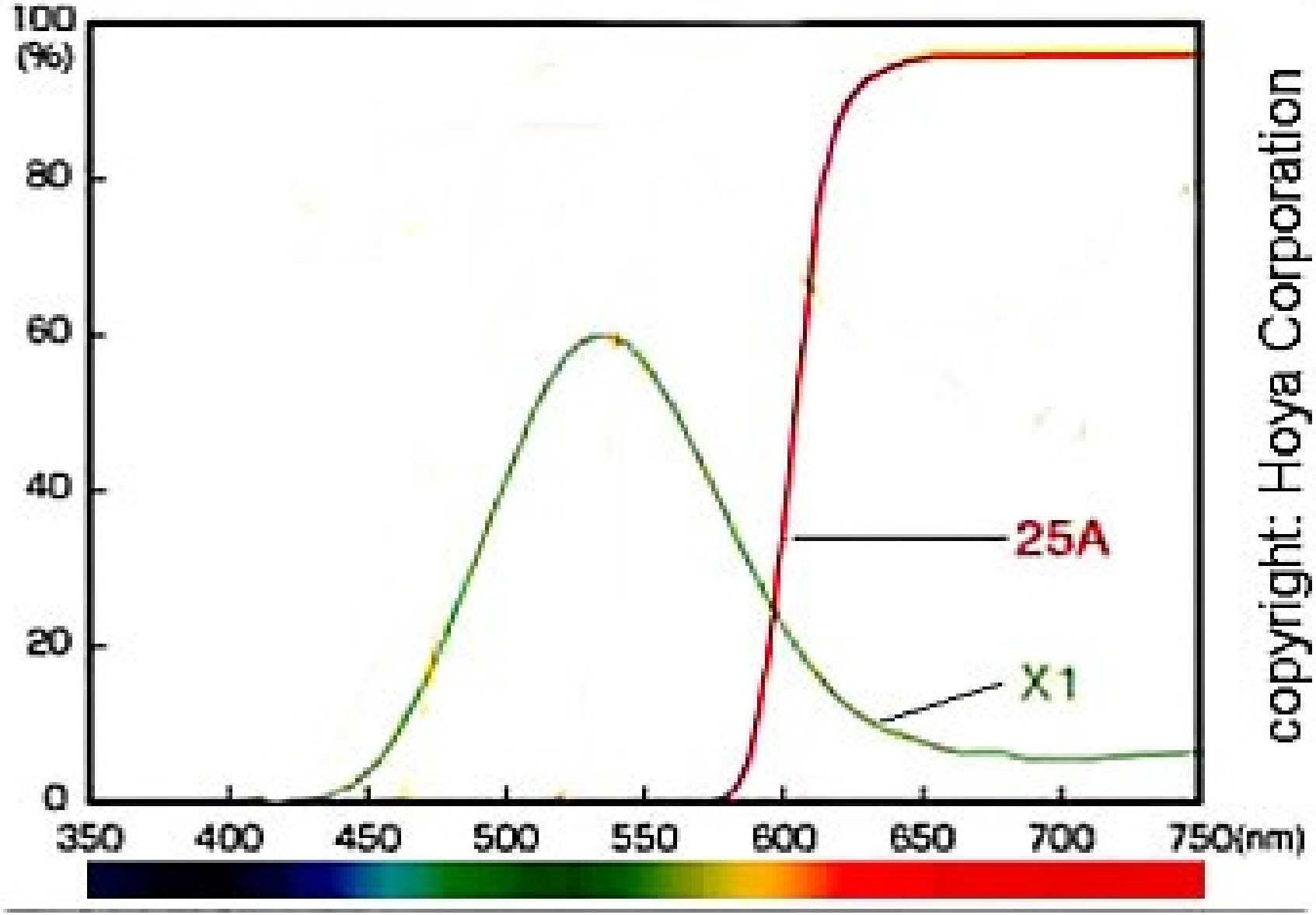


Examples of filter use: Ektachrome-unexposed

One sheet of unexposed processed Ektachrome 4X5

No filtration, B&W exposure mode

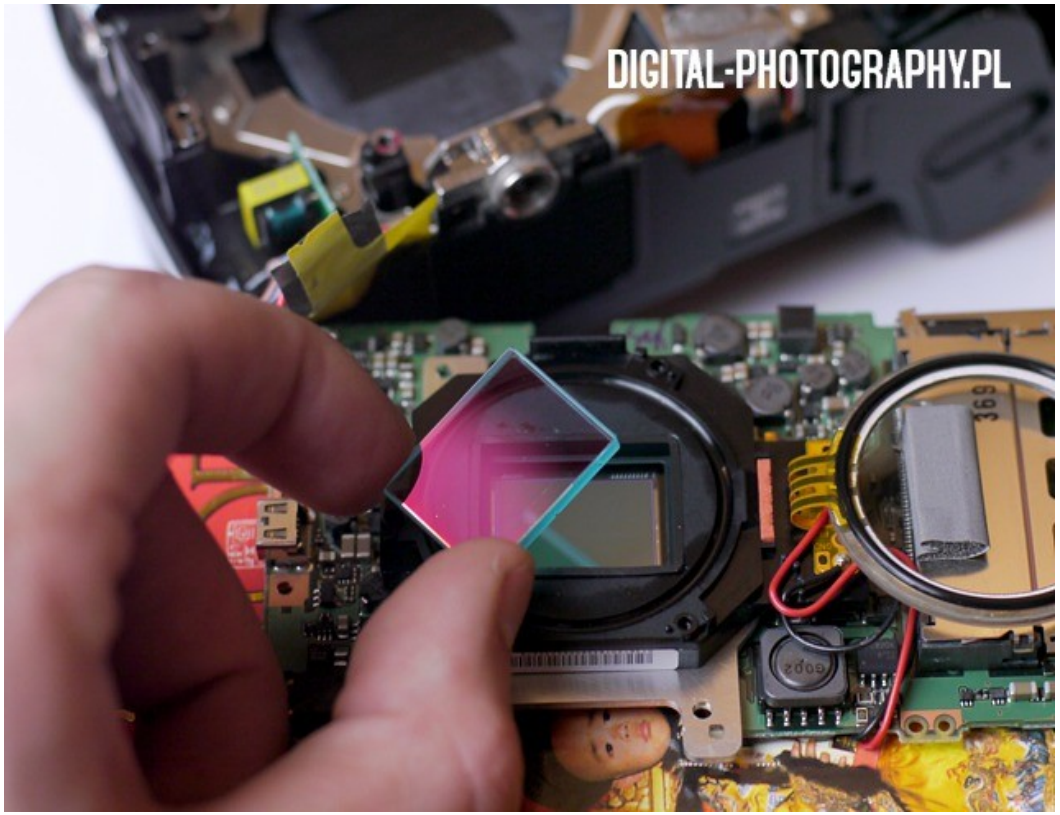
Red (25A) and Green (X1) filters



Red-Green filtration

The digital camera filter problem

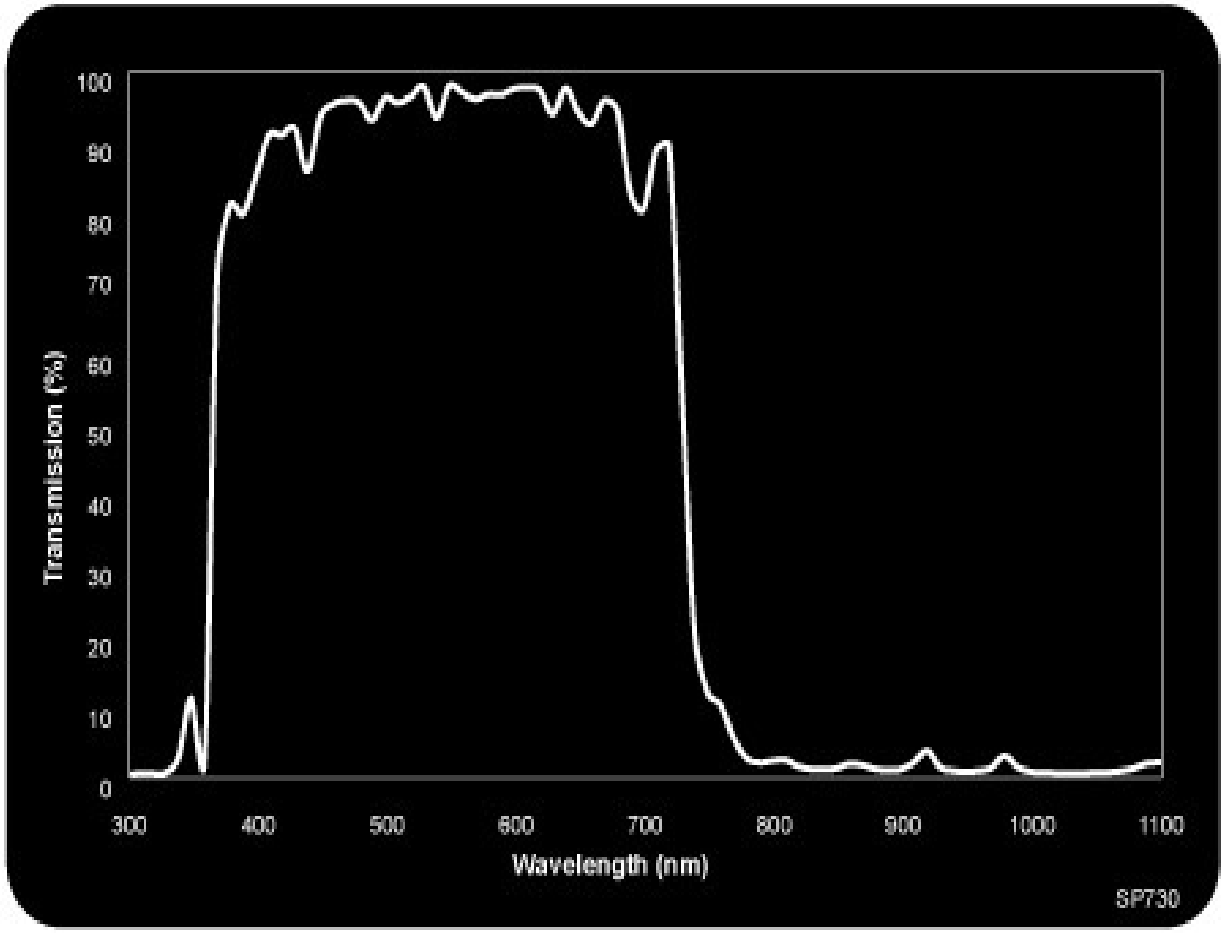
- As noted silicon sensors are inherently sensitive to IR but since IR light tends to degrade visible image sharpness (the longer wavelength light focuses at a different point), camera manufacturers install an IR cutoff filter (also called a '**hot mirror**') to **stop** IR light from falling onto the sensor.



The 'Hot Mirror' filter

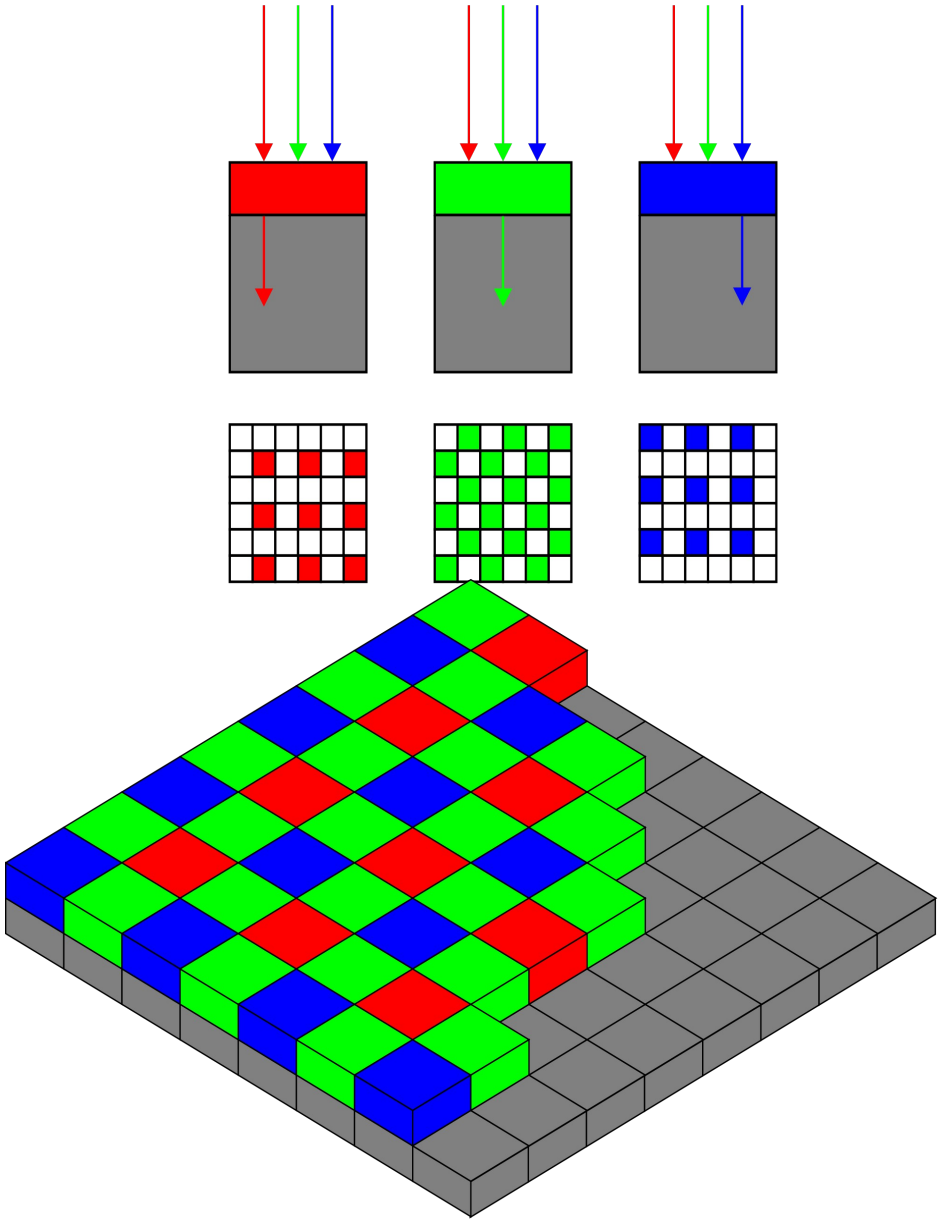
ex. Kodak 301A filter

- The efficiency of these IR cutoff filters is quite good (about 95-99%) but they tend to vary with camera manufacturers so different brands and models will vary in how well they stop IR light.
- This situation presents a significant problem for the digital infrared photographer, but one can adapt!

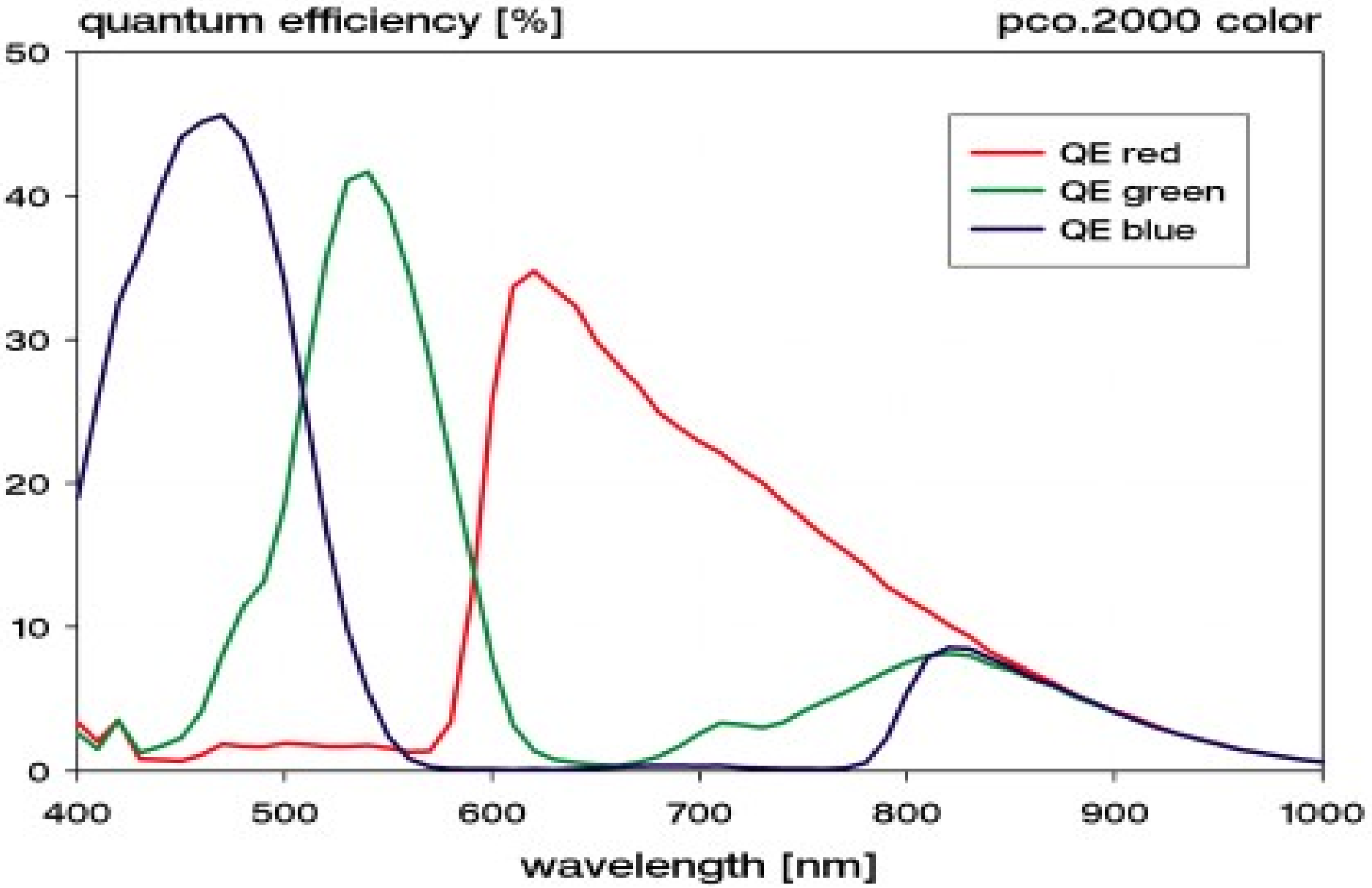


Another digital camera filter 'issue'

- All digital camera sensors (except the Foveon sensor) are overlaid with a ***Bayer filter*** which creates an alternating pattern of red, green, and blue pixels. There are twice as many green pixels as red and blue (to mimic a photopic response).



The Bayer filter and infrared light



Exposure for IR photography:
starting with film: Rollei Infrared 400

- As seen an infrared filter (say 89B, R72) reduces the light quantity by about 3 or 4X (depending on sunlight quality); you need to meter your scene for ~ISO 25 (400->25)
- We can also look at the exposure reduction from a filter factor perspective, the 89B and R72 have a filter factor of 16. This means exposure is reduced by 4X (filter factor = 2^x, $x = \log_2 16$, $x = 4$)
- All else being equal, a 'normal' exposure (no filter) of f/11 @ 1/125 sec will end up as f/11 @ 1/8 sec with IR filtration.

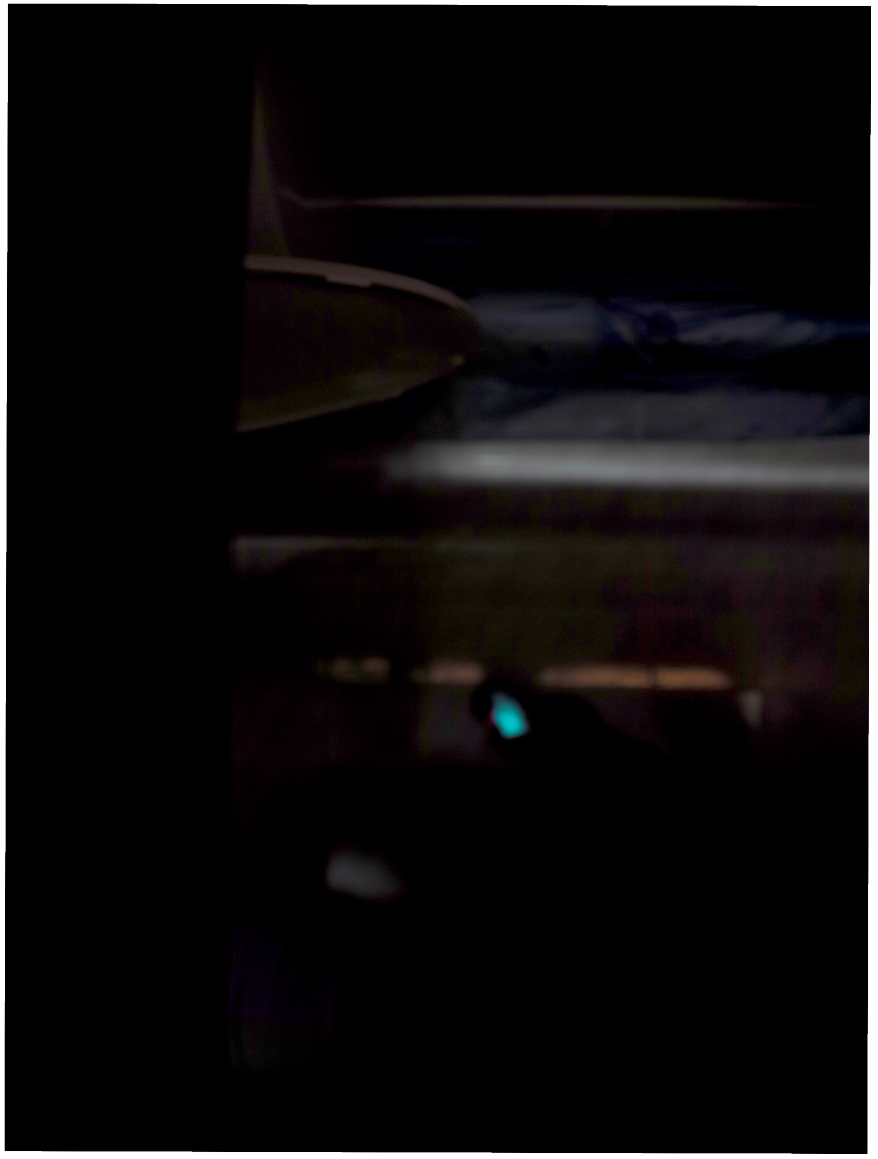
Exposure for IR photography:
Digital

- From our previous discussion, adding an infrared filter reduces the light quantity by about 4X, exposure being f11 @ 1/8 sec.
- For Bayer sensor digital cameras, we've seen the Bayer filter reduces the light by another 60% (f11 @1/4)
- With the camera 'hot mirror' reducing infrared light by about 95-99% (or about 6-7 stops) , the compensating exposure now would have to be around f11 @ 16 sec.
- These kind of exposures impose limitations on what and how things can be photographed....

Is your camera IR sensitive?

A quick camera test

- Hot mirrors vary with each manufacturer (and camera model); test to check for sensitivity.
  - Using a TV remote, press and hold any button and point it towards the camera to determine if you can see it in 'live view' or take a photo of it. (start: max f/stop, shutter ~ 10sec.)
- Generally speaking cheaper and older model cameras are better for IR photo (a highly efficient hot mirror is expensive)

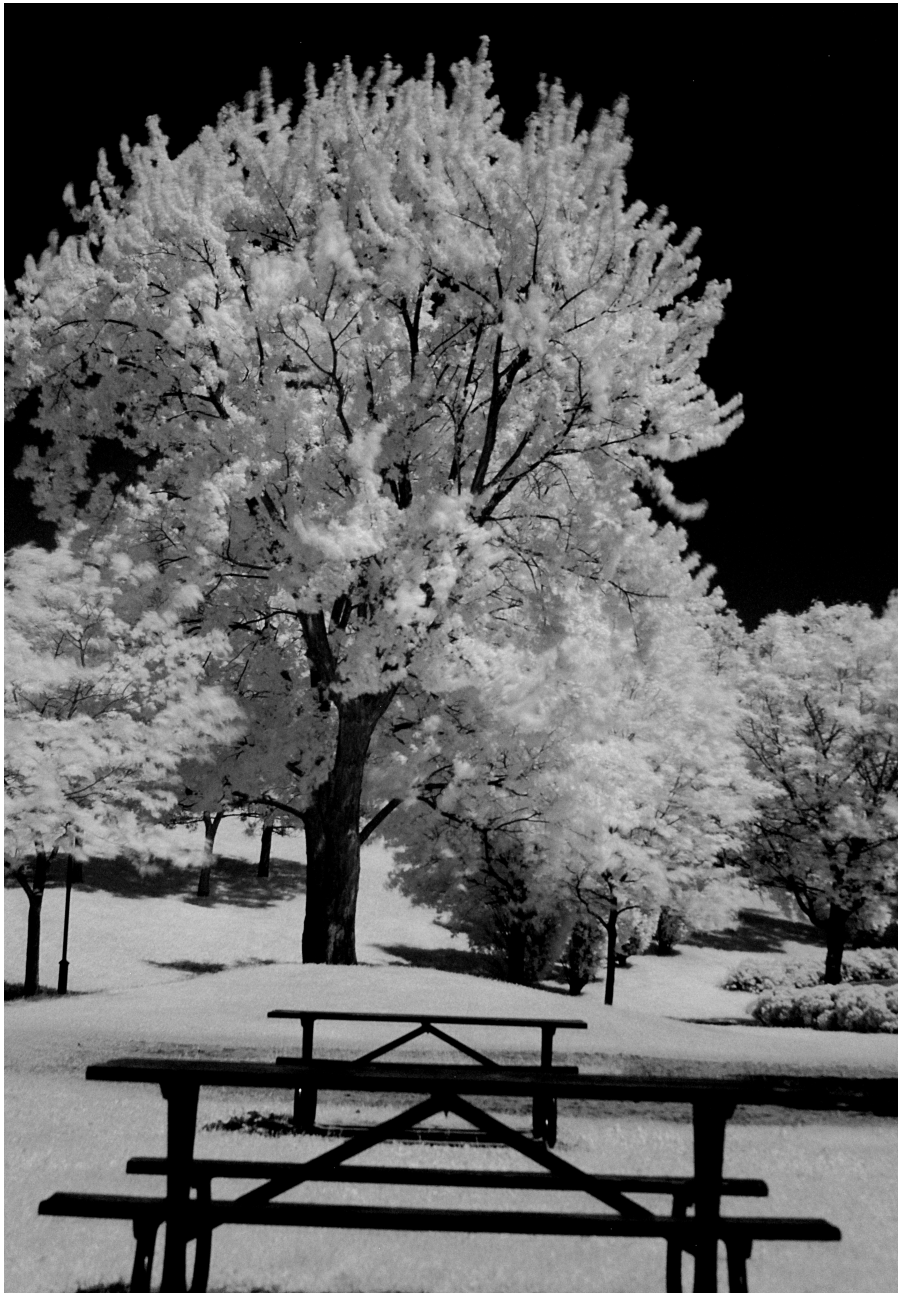


General Examples

f/4, 2sec, ISO800

Canon EOS T4i

f/5.6, 4sec, ISO 800

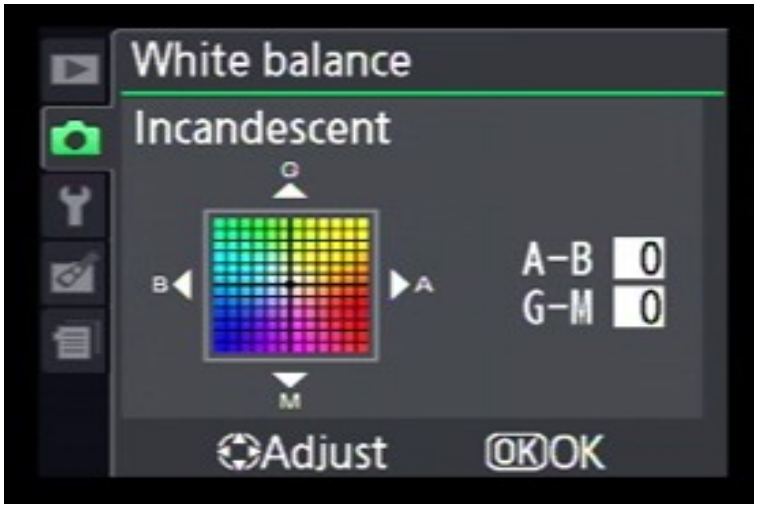


Practical considerations for digital infrared photography

- With exposures close to one second or more, a tripod becomes essential.
- Subject matter also becomes quite limited to static objects (landscapes, no wind, or very still people!)
- Either a timed shutter release or cable release is best to prevent any camera movement.
- Sunny days are essential to maximize the amount of infrared light and to take advantage of infrared reflectance characteristics
- Consider your subject matter: enhance contrast with foliage against sky, foliage reflected off water, skin in water..

Other exposure considerations for IR photography

- Consider a higher ISO setting to reduce the exposure time. Actually, introducing 'noise' to the image somewhat mimics traditional infrared film which was (is) relatively grainy.
- Set your camera to monochrome. Although you can revert to 'greyscale' in software, seeing the B&W image at time of exposure is very helpful.
- Set a white balance of about 2000 (if you can set a number) it is not essential for B&W but, again, aids in looking at the quality of your image and exposure at the time of photographing.



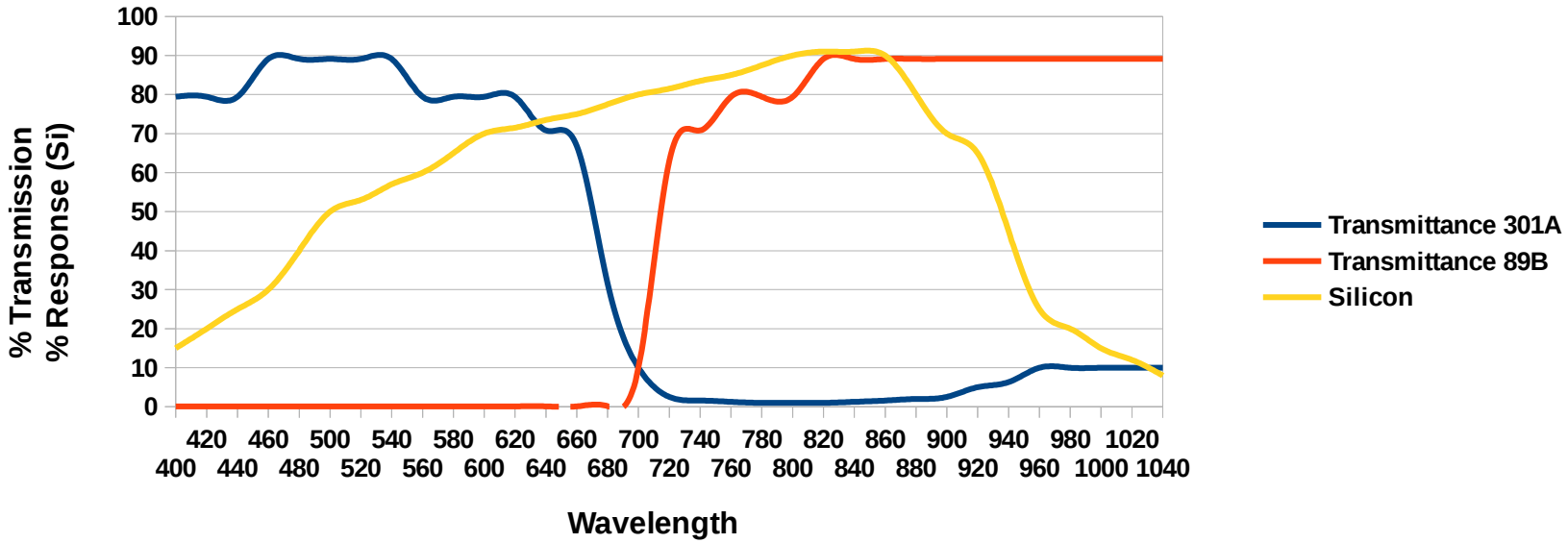
Is practical photography (fast shutter) possible with IR?

- Short answer is “yes”, but you would need to modify your camera by removing the 'hot mirror' on the sensor – a meticulous and potentially destructive task
- There are a few firms that will do this for a nominal price (about $250US), one such firm is LifePixel:

  www.lifepixel.com
- In the commercial realm the Sigma SD series (~$500-$2000) allows for the hot mirror to be easily removed and replaced at will, while the Fuji Finepix IS-1 (~$900) and Leica M8 (~$2000) were built without a hot mirror.
- Check http://www.dpreview.com/forums/post/41088569 for other digital camera possibilities
- And of course, don't underestimate film, it is possibly the most practical way to photograph in infrared and lends new life into those mothballed film cameras!

For modified digital cameras or a non-hot mirror cameras..

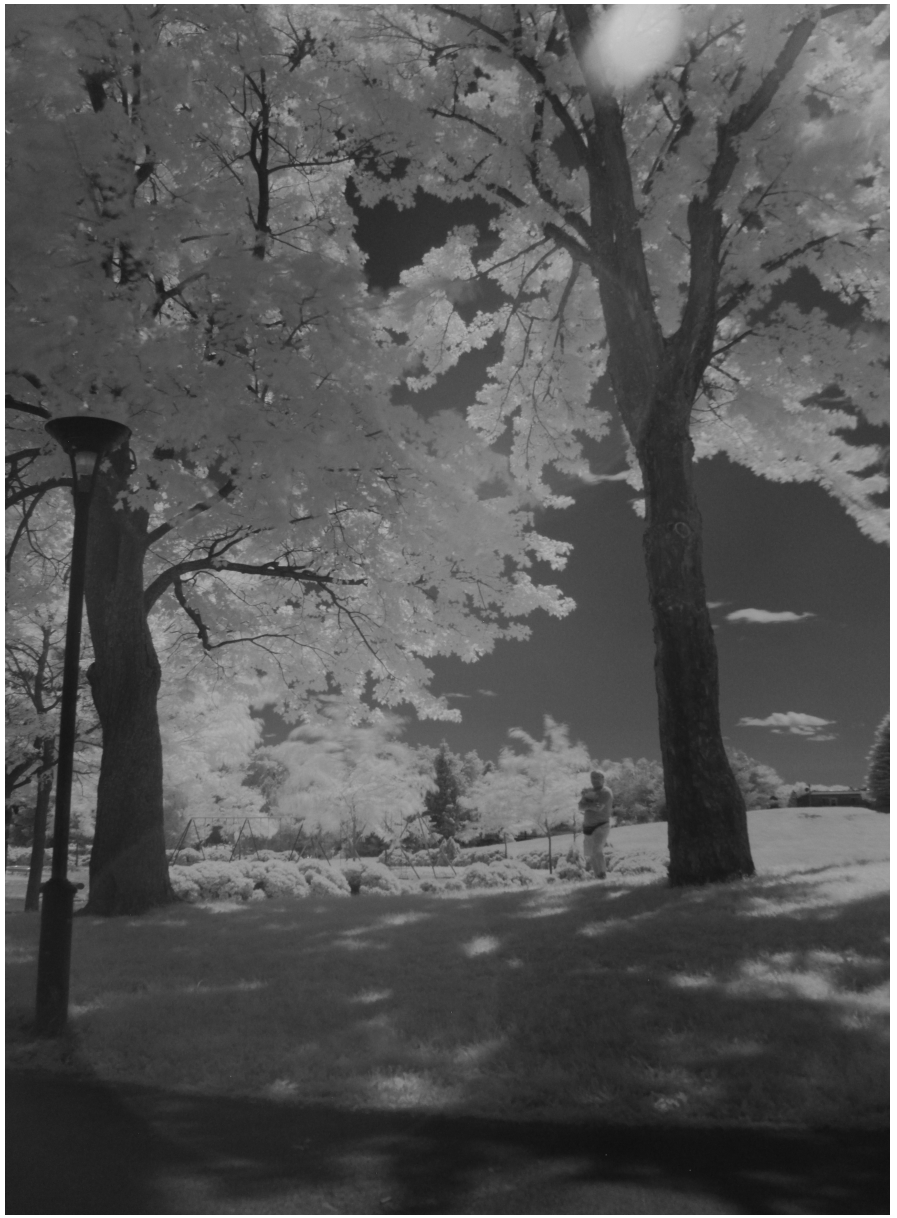
Because the sensor is filter free you must, either, manually use a 'hot mirror' filter (301A) when doing ordinary photo or manually use an IR filter (89B) when doing IR photo. Lifepixel also provides for a number of options for filtration.

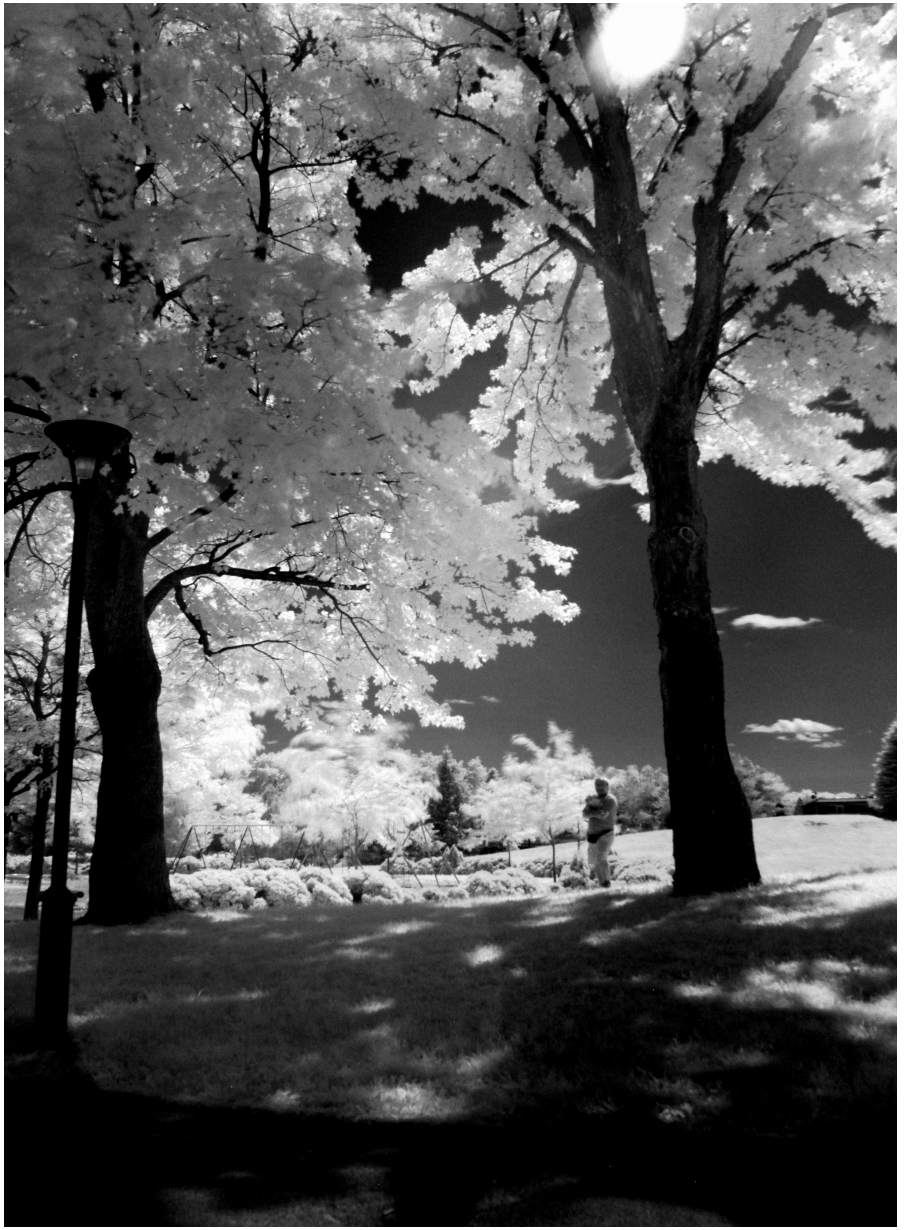


Traditional characteristics of infrared images (film standard)

- The traditional characteristics of infrared imagery as established by decades of film use are as follows:
  - Generally contrasty images emphasizing high reflecting infrared objects such as foliage or bright white objects such as clouds against low infrared reflecting objects such as water or absorbed blue light sky (by the IR filter).
  - Graininess
  - A surreal glow caused by the lack of an anti-halation layer in Kodak's High Speed Infrared Film

Software enhancement of IR images – Contrast/Brightness

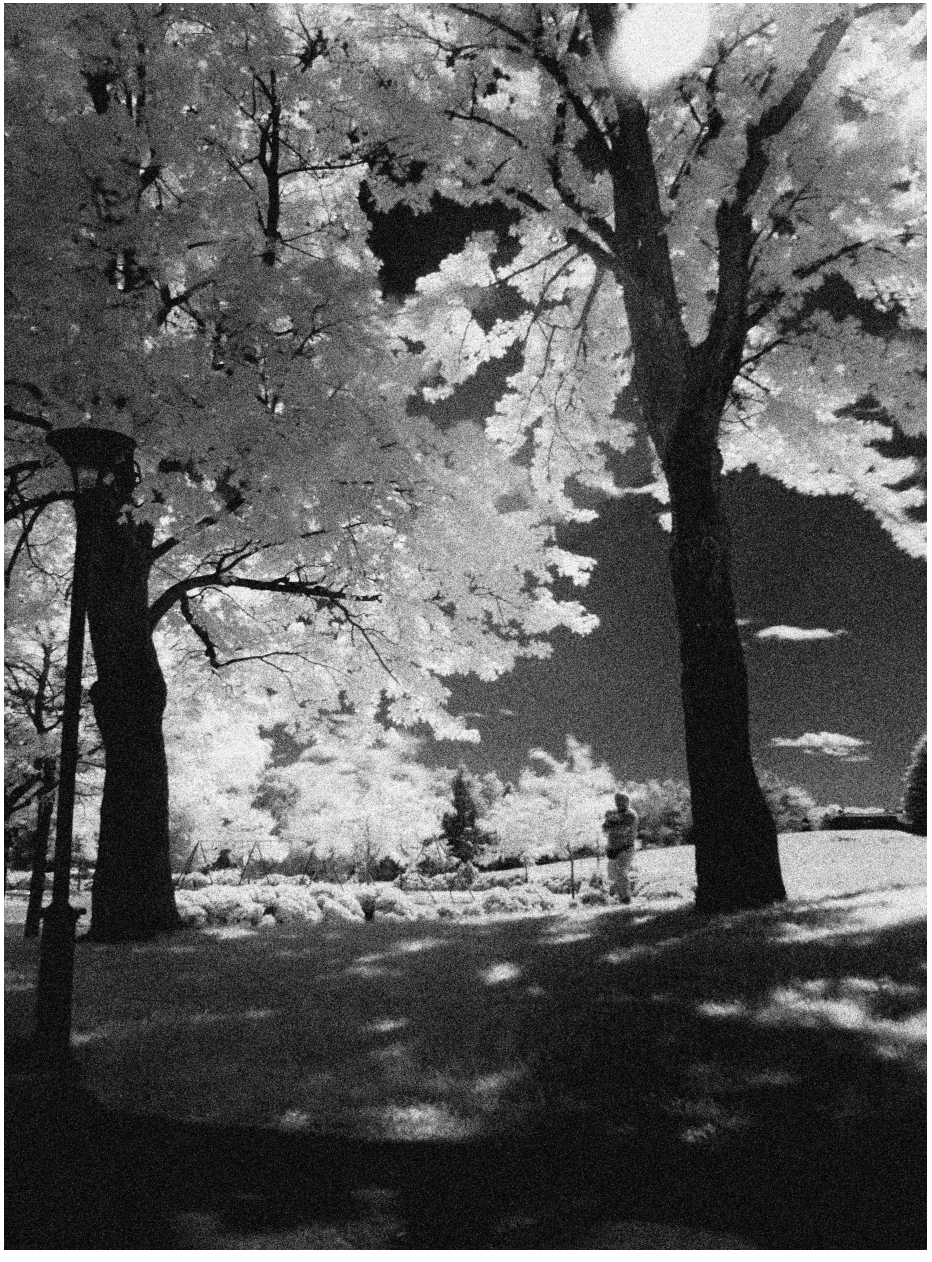




Software Enhancement: Graininess

The original Kodak Infrared film was quite grainy. Simulating this look in digital can be accomplished in a couple of ways:

- Incorporate noise in the original exposure by using a high ISO setting.
- Control the amount of grain by using the 'Noise' filter in Photoshop or GIMP. The techniques are described below:

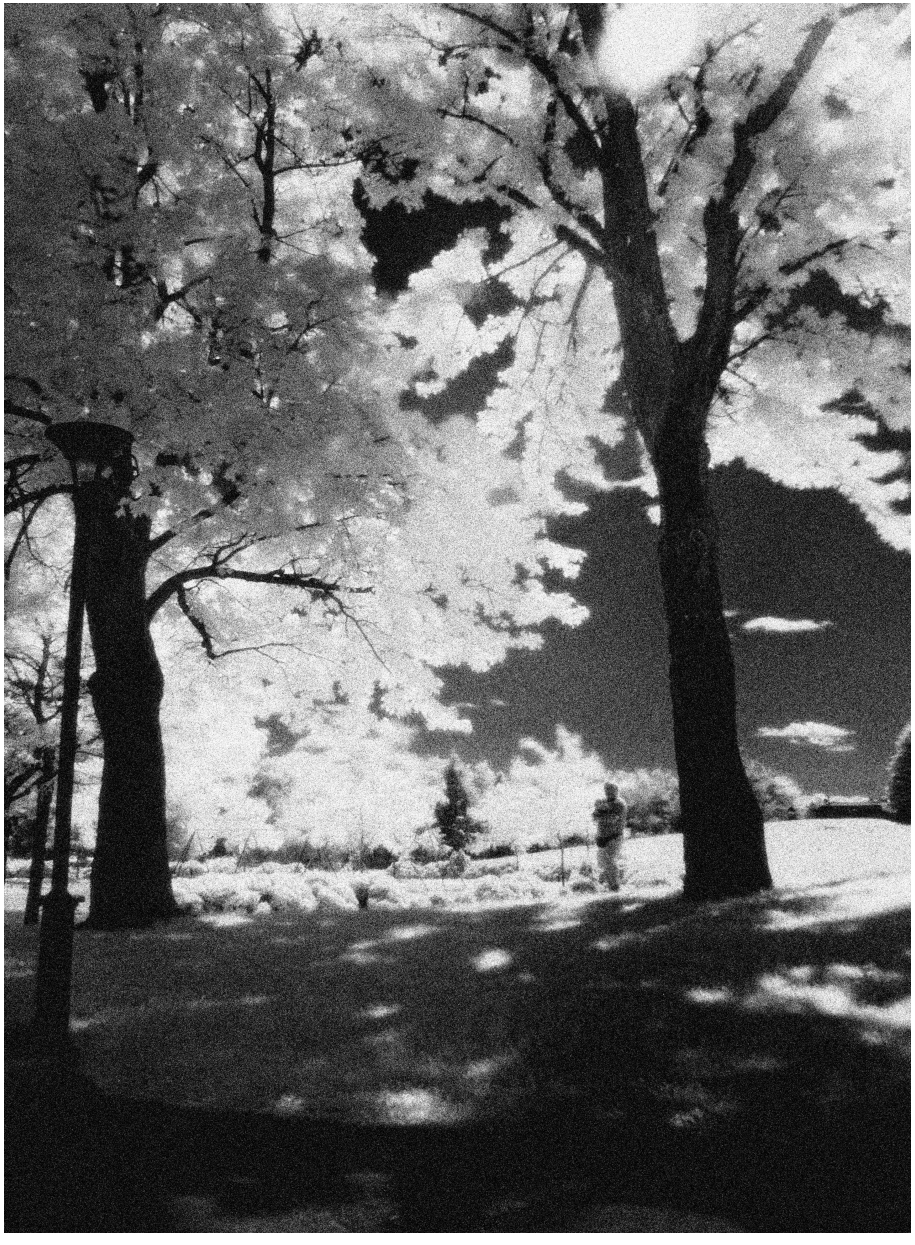


Adobe Photoshop
http://www.photoshopessentials.com/photo-effects/film-grain/

GNU Image Manipulation Program
https://www.youtube.com/watch?v=i-df0bf62bM

Software Enhancement: Halo

Again, using the Kodak Infrared Film as the the standard, its lack of anti-halation backing produced images with a characteristic 'glow' around bright edges. This glow can be reproduced with imaging Software through use of the blurring filter. The 'Gaussian blur' filter works quite well in reproducing the glow effect:



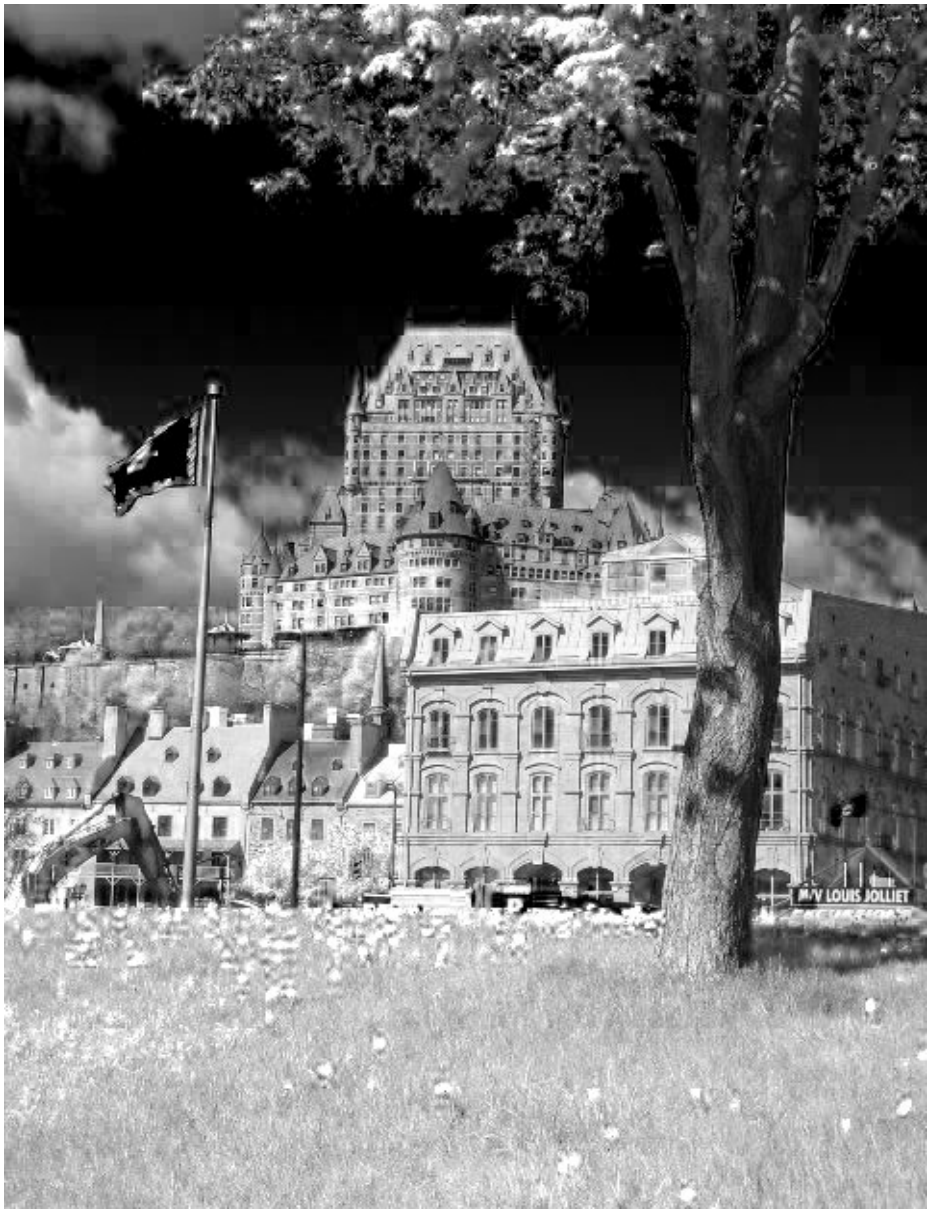
Software simulated IR

using Photoshop, GIMP, etc

- It is possible to simulate an IR effect using software.
  - Use Photoshop's Infrared adjustment in the Layers menu or reproduce the effect manually:
    - Use a RGB image (color)
    - Modify the image (using the color mixer in your software) such that the green channel is maximized while the blue channel is minimized (if there is blue sky and foliage)
    - Convert the image to monochrome
    - You can create grain and halo effects as previously noted.
- Follow the techniques here:
    - http://www.photoshopessentials.com/photo-effects/infrared-photo/
    - http://www.mora-foto.it/en/tutorials-gimp/infrared-photography.html

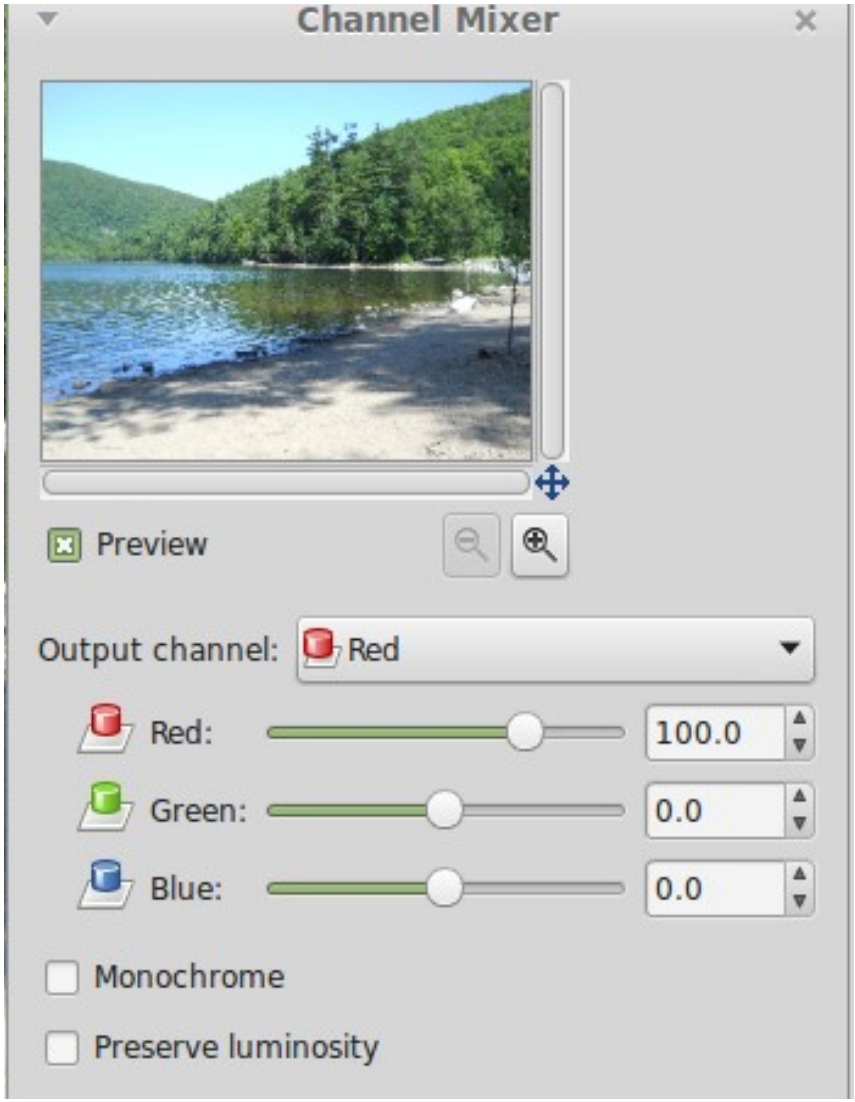
Software simulated IR

using Photoshop, GIMP, etc



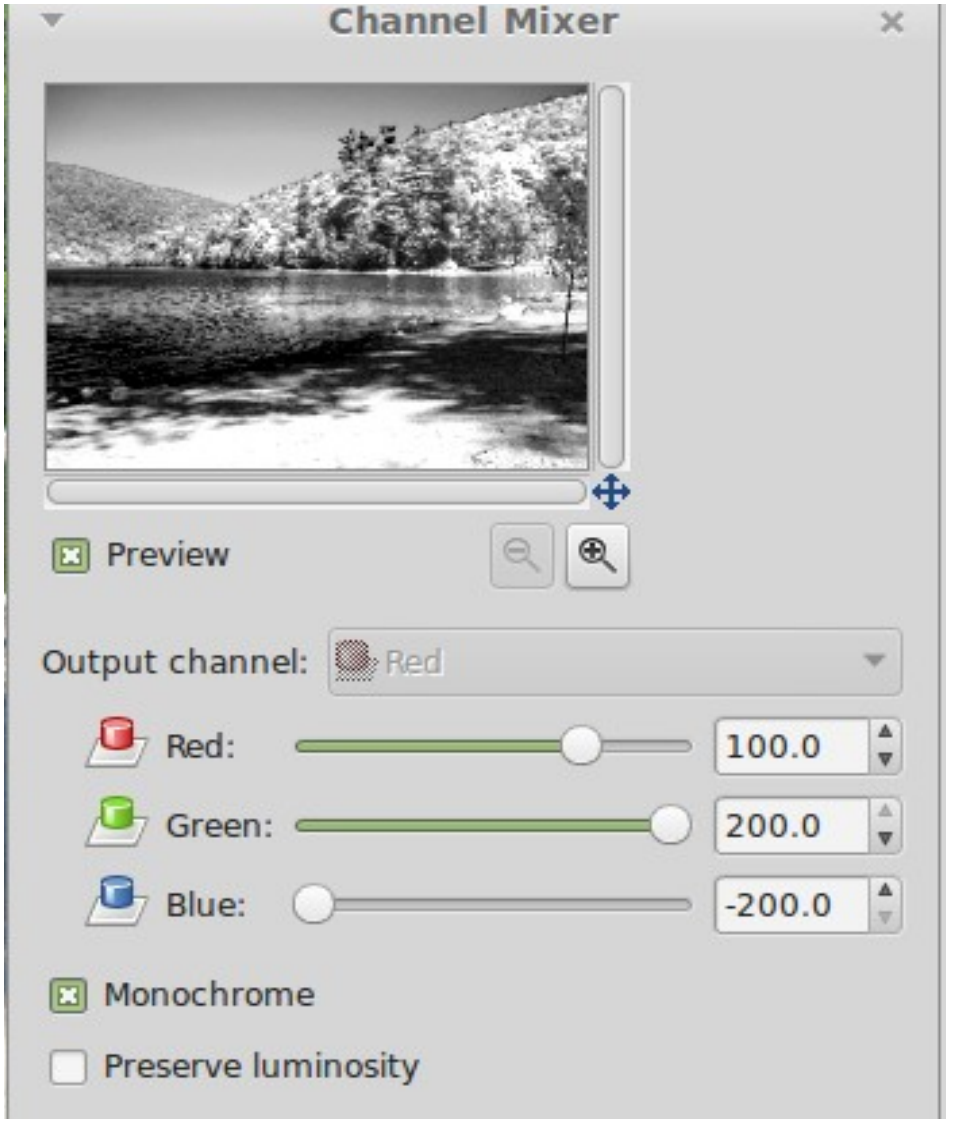
Software simulated IR

using GIMP – color->components



Software simulated IR

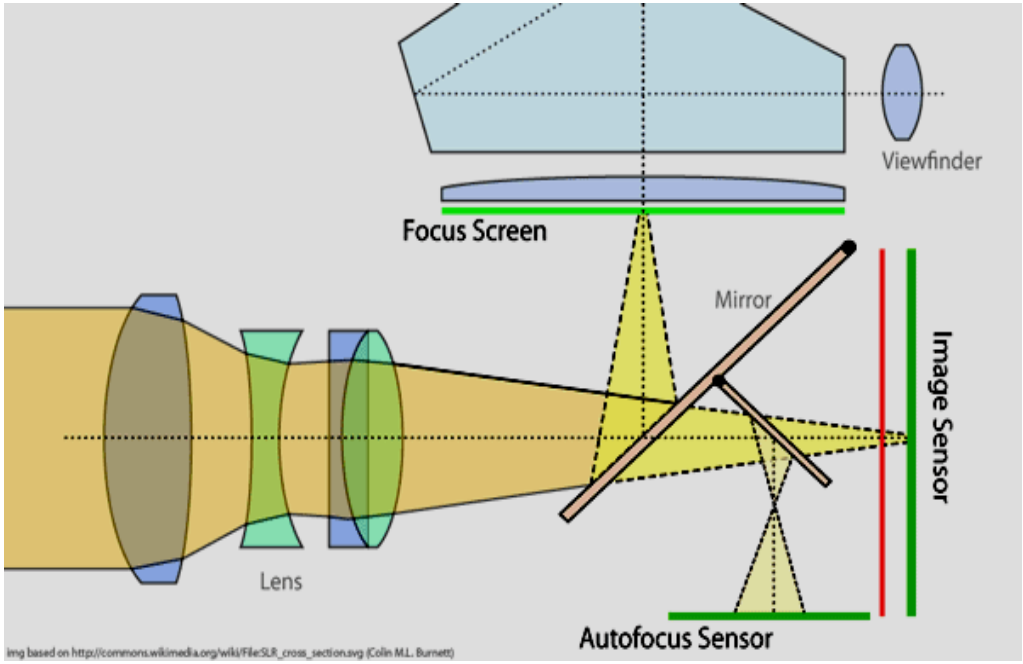
using GIMP – color->components

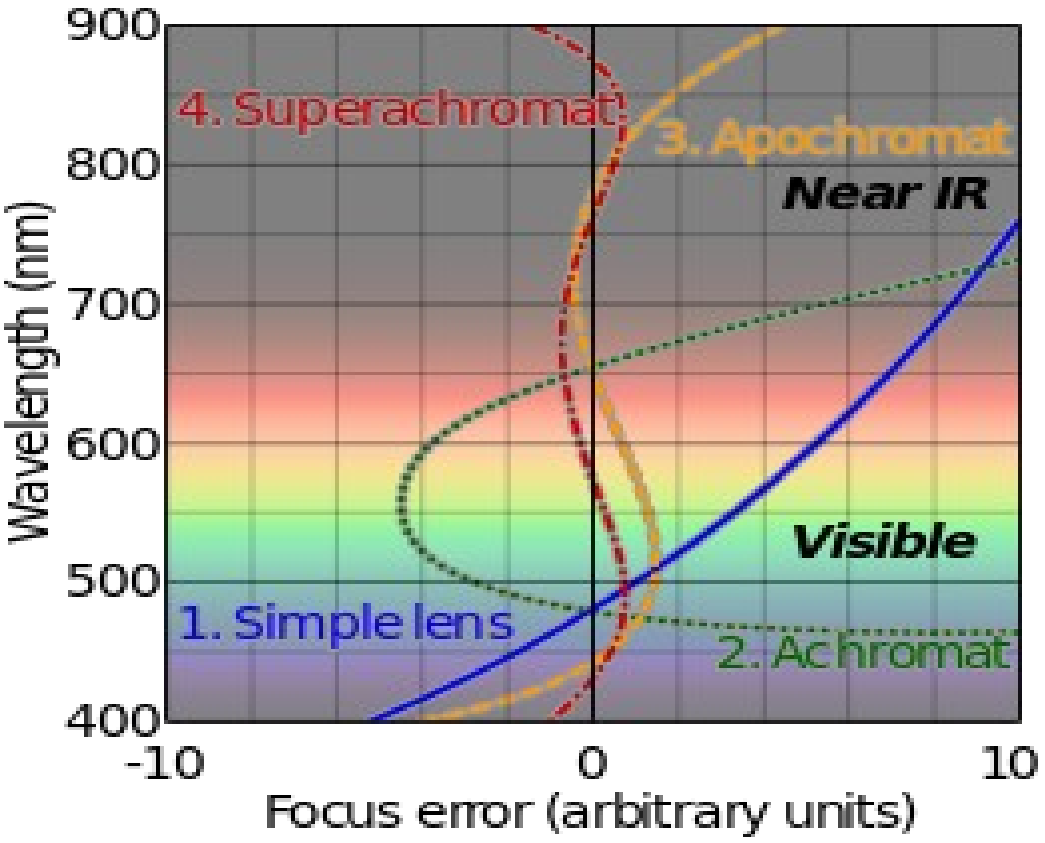


Focusing IR light:

Chromatic aberration issues

- Since infrared radiation has longer wavelengths than visible light, the image focal plane is offset (chromatic aberration). Lens design compensates for this effect but not all lenses are made equal! Superachromatic lenses align wavelengths best and minimize focus compensation for infrared light.

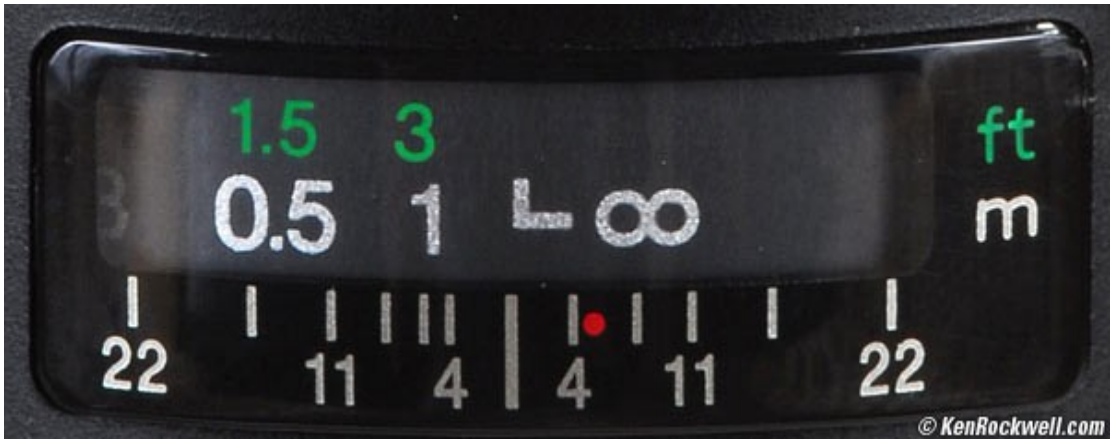




Focusing infrared light

- Focus manually (turn off the autofocus feature)
- Increase depth-of-field with smaller apertures (not really an option with hot mirror cameras)
- Manually adjust the focus by a slight offset of the focusing ring to the next f/stop indicator on the depth of field scale on the lens.
- The adjustment varies depending on the focal length and lens quality.

Canon 14mm f/2.8



Summary

- Objects in nature reflect infrared light differently than visible light, this allows for B&W photography with a surreal feel.
- Digital cameras can be used to photograph infrared but are limited to long exposure times; these cameras can be modified for the true enthusiast (Lifepixel)
- Film cameras have an advantage for this type of photography because of IR sensitized film speed, no hot mirror, and IR focusing indicators on their lenses .
- An infrared filter is a 'must' for this type of photography; you want to photograph only infrared light. Typical filters include the 89B or 88A, they are relatively expensive. Roscoe #382 gel filters (with red filter) are a cheap alternative.

Summary

- Long exposure times make a tripod mandatory
- Image enhancement (gamma, noise, blur) is typically needed to make images with more visual impact.
- The Monochrome setting is recommended for strictly B&W end products so that the images can be previewed. If setting is RGB then set the white balance at 2000 or at least tungsten light.
- Software IR simulation of RGB images is possible but tends to be a 'hit/miss' depending on the scene's colors.
- Attempt to expose with smaller apertures (difficult) to avoid issues of IR focus. Use a relatively high ISO setting

Assignment

- Check your digital camera for IR sensitivity (Remote Ctl. test)
- Using an IR filter or the Roscoe gel filter and a red filter with a tripod, find some scenes to photograph.
- Also photograph a normal color image of the same scene(s)
- The scenes should have lots of foliage, blue sky, maybe a building(s) or water body. Depending on your exposures, try some people.
- Photograph in late AM or as close to solar noon as possible, in Edmonton in May this would be around 1:30 PM.
- Log all your exposure data (most digital cameras do this)
- Apply the software enhancements to your B&W image and also try to convert the RGB (color) image to BW IR using the software techniques presented.
- Be prepared to present the photos and technical details when you present your images at the next class.

A radiometric test

1. Take a radiometric reading and determine the total quantity of light (in μW/cm^2).
    a) Place the hot filter on the sensor, record the visible light reading
    b) Place the IR filter, record the leftover IR light reading
2. Convert the irradiance reading to a camera setting: Irradiance (μW/cm^2) → illuminance (Lux) → Exposure Value (EV) → f-stop, shutter speed.

    http://www.endmemo.com/sconvert/luxwatt_squarecentimeter.php

    http://www.intl-lighttech.com/support/calculators/calculator05

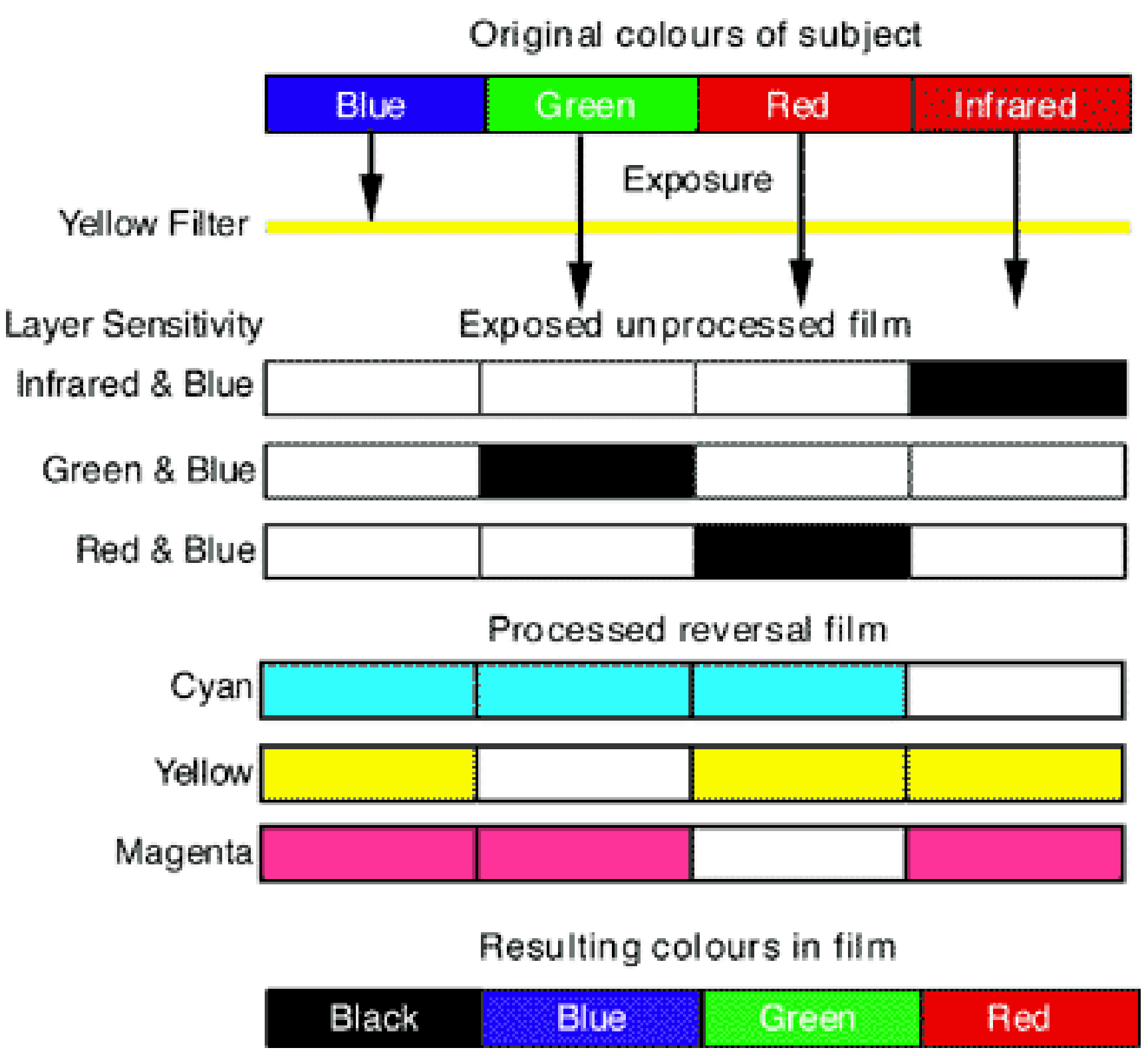
    http://www.endoflow.com/exposure/

3. Relate the EV value to an f/stop and shutter speed
4. Test with a camera exposure

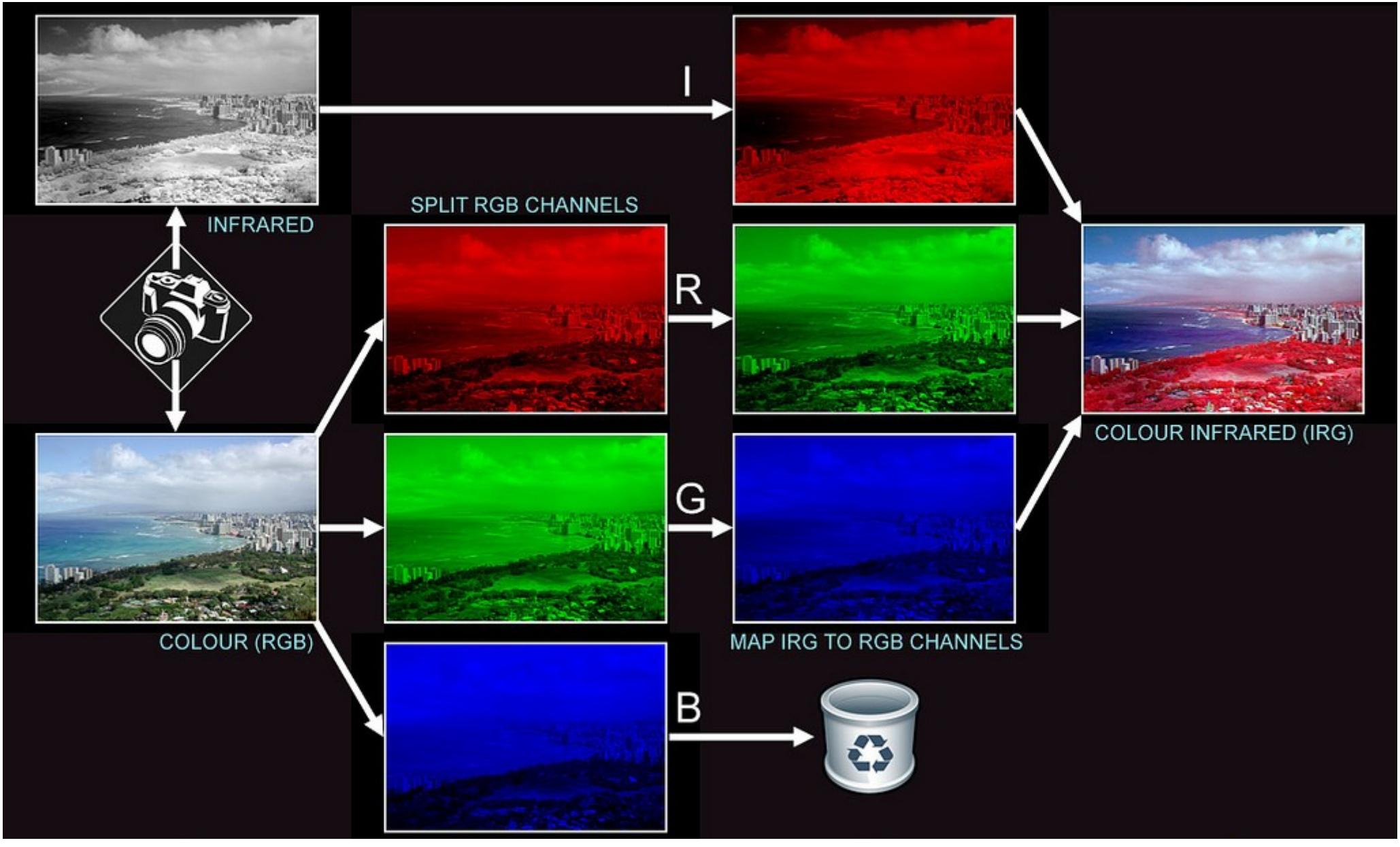
Why not include Color IR?

- Could not give it proper review in this current two session course format.
- Today's digital color infrared has a quite different look (hues) than the traditional film standard Kodak Ektachrome Infrared. Film had its own layer to record IR (the blue layer), current digital cameras record IR at every RGB pixel.
- The traditional look can still be achieved but requires special exposure and software processing (Photoshop, GIMP)

Kodak Ektachrome IR Film



Simulating Kodak Ektachrome IR film in with image processing



Traditional CIR vs. Today's CIR

Examples

Kodak Ektachrome Infrared EIR film

Healthy vegetation is portrayed by Magenta/reddish hues

This film required a yellow #12 Filter (minus blue)

Digital infrared:

Healthy vegetation is cyan-white

An infrared filter is required for this type of photography

References

Books

- Digital Infrared Pro Secrets – David Busch
- Digital Infrared Photography – Patrick Rice
- http://evtifeev.com/wp-content/files/books1/Complete%20Guide%20to%20Digital%20Infrared%20Photography.pdf

Web

- http://www.bythom.com/infrared.htm
- http://www.digitalcameraworld.com/2012/07/09/how-to-shoot-haunting-digital-infrared-photography/
- http://www.apogeephoto.com/may2003/odell52003.shtml
- http://dpanswers.com/content/irphoto_sensors.php (Camera capabilities)
- http://www.liviofentphotoscience.com/Research.html

Film

- http://www.rolleifilm.com/

Camera Conversion

- http://www.lifepixel.com/