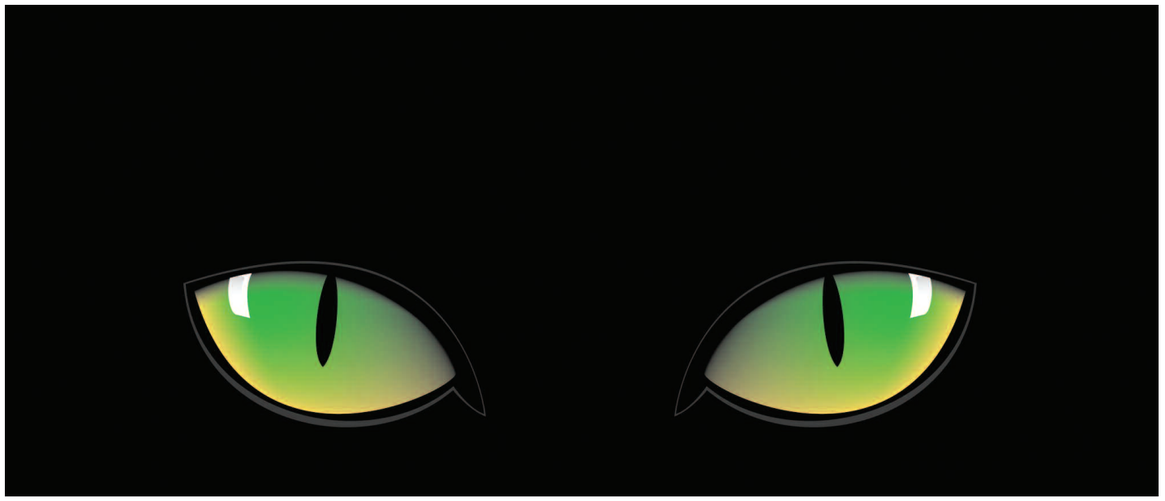
Night vision



The Gothic green light had bathed everything in shades of green, grey and black for several hours. Moments later we were cutting through the cold night air, freefalling down to the cloud layer that would provide a blanket of darkness to conceal our final descent and touchdown. In those few moments of calm before the storm, I gazed in amazement at the crystal-clear night sky around, the Milky Way prominent like a fluorescent strip-light. The head torch that I had been issued with also give off this surreal green light and I've continued to use it for navigating at night since.

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Last month I was training advanced military navigation to Special Forces aspirants, soldiers who been through briefing and are about to go through their Selection. They were interested in why I used this colour of light in preference to the older standard red filter. The answer 'I got it for free' didn't seem to be appropriate!

Back at my office, the ubiquitous Google offered me more confusion than answers, with seemingly everyone having an opinion about which light is best for preserving night vision, most providing little or no empirical evidence to support their standpoint.

My first port of call was to contact the manufacturers of head torches that have colour filters available, commonly red, green and blue. They were helpful and talked about different coloured lights used for signalling, yet most could not state in what situations each colour should be used, and if they did they referred to studies that can best be described as 'marketing science'.

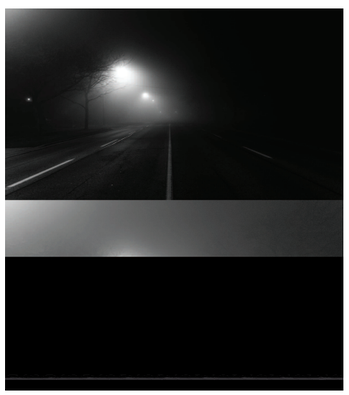
My next port was the US Department of Defence, who referred me to the National Centre for Biotechnology Information, US National Library of Medicine, a brilliant repository of millions of scientific papers from all over the world, written by credible scientists, mostly working in universities or clinical specialists, who for medical research, have taken an interest in Scotopic Vision = Night Vision. This article is my distillation of the various meetings and calls I've had with these scientists.

There are many reasons to try and preserve an element of night vision in low light levels, but not quite dark environments: from pilots, who, when landing aircraft at night, need to see both their instruments and the runway, to mountain rescue responders, who need to read maps, search and move across difficult terrain. Head torches cannot illuminate everything within our field of vision.

THERE ARE TWO TYPES OF PHOTORECEPTORS IN THE HUMAN RETINA: RODS AND CONES

RODS

- Active at low light levels
  (Scotopic vision = Night vision)
- Not sensitive to colour
- Concentrated at the outer edges of the retina and used in peripheral vision
- Unable to detect sharp accurate images.



Top: Green cat's eyes © Alejandro Duran. Dreamstime. **Above:** These simulated images are a good example of how our field of vision improves within low light levels **after 10 minutes**.

CONES

- Active at higher light levels
  (Photopic vision = Daytime vision)
- Used for distinguishing colours
- Essential for receiving a sharp accurate image.

In normal daylight conditions the cones are almost exclusively responsible for our sight: photopic vision*

In very low levels of light, the rods are exclusively responsible for our sight: scotopic vision

However, pure scotopic vision has several drawbacks:

- Inability to distinguish colours
- Unable to see sharp accurate images (unable to read print)
- Difficulty in viewing objects directly, instead needing to look around them
- Static objects can appear to move (Autokinesis).

There is a misconception that pure scotopic vision is what most professionals, who work in low light, but not quite dark lighting situations, require. Actually, all of these professionals need a combination of photopic (day) and scotopic (night) vision and this combination is called mesopic vision. MR responders are a good example as they must be able to see detail and colour, not least to read maps, which is impossible in pure scotopic vision.

The second misconception is that the colour of the light is important. This is only true for pure scotopic vision when red light should be used, as scotopic vision is produced exclusively through rod cells which are completely insensitive to wavelengths longer than about 640 nm (deep red).

In mesopic vision, the intensity of the light (brightness) is of far greater importance than the colour of the filter, making good light hygiene essential for preserving it.

So my informed answer to 'the boys' is that the military operate primarily using mesopic vision and it is moving over to green light. This is because the cones, needed to provide high visual acuity (focus and sharpness), are most sensitive to wavelengths of light around 498nm (green-blue). Furthermore, night vision goggles, standard military issue now, produce a green image and therefore, by using the same colour of light for head torches, they are not compounding the problem of dark adaptation recovery.

Furthermore, map reading is an essential of the job in MR and red light does not show the brown contour lines on maps, whereas green light does, plus, it shows up blood!

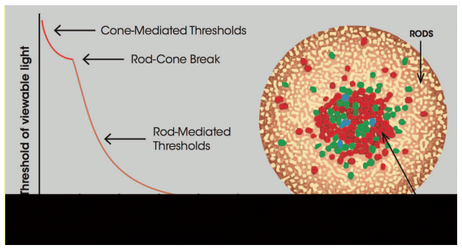
** In bright light conditions the retina repurposes the rod cells to increase contrast information.*

Above: Top to bottom: Photopic vision, Mesopic vision and Scotopic vision. A quirk of mesopic vision to be aware of is something called the Purkinje Effect. In photopic vision the red petals are bright against the dull green of their leaves, or adjacent blue flowers. In mesopic vision, the contrast is reversed, with the red petals appearing a dark red or black, and the leaves and blue petals appearing relatively bright.

TEN GOLDEN RULES FOR ADAPTING TO MESOPIC VISION AND MAINTAINING IT

1. In darkness, after around 10 minutes, most of our cones have shut down. This process is most efficient in complete darkness. To assist your eyes, completely cover them with your hands, keeping them open, as tightly closing them can affect focus, for 1 minute.
2. The time from last seeing a bright light and the length of time you were exposed to it are the principal determinants of how quickly your eyes will adapt to mesopic vision. So, if you are in a vehicle and not driving, do not look at other vehicles lights and if possible avoid seeing the area lit by the headlights of the vehicle you are in.
3. Use a head torch that is fully adjustable for brightness and use the minimum intensity you need to complete your task.
4. For fastest dark adaptation recovery use a green filter.
5. Choose LED coloured lights, as opposed to coloured filters, as these emit light at one specific wavelength, ideally around 498nm (blue-green).
6. If you need to see all colours, such as when treating a casualty, use the dimmest white light for the shortest amount of time.
7. Visual acuity at low light levels diminishes with age and by individual, so don't be prescriptive about head torch settings, allow the individual to determine what suits them best.
8. Use a head torch that can swivel to point at your feet and help reserve other hill party members mesopic vision by never shining your head torch directly into their face.
9. In groups keep your head torch pointed ground wards and set the dimmest level.
10. If a bright light appears, such as a car headlight or flare, cover your leading eye with your hand to minimise flash blindness.

TYPICAL SENSITIVITY OF HUMAN EYES AS THEY ADAPT TO DARKNESS



The cone cells adapt within 10 minutes but then are overtaken in performance by the rod cells. The rod cells can take several hours to become completely dark adapted and reach their peak sensitivity to low light conditions.

Note that this plot is only representative of the general trends. The actual curve varies from person to person, from one spot on the eye to the next, and from one day to the next.