Engineering Optics

Lecture 16

by

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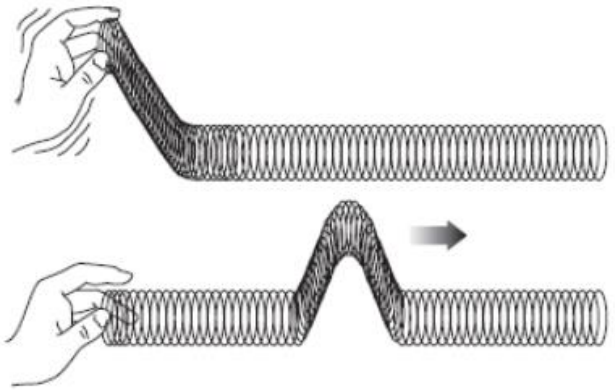
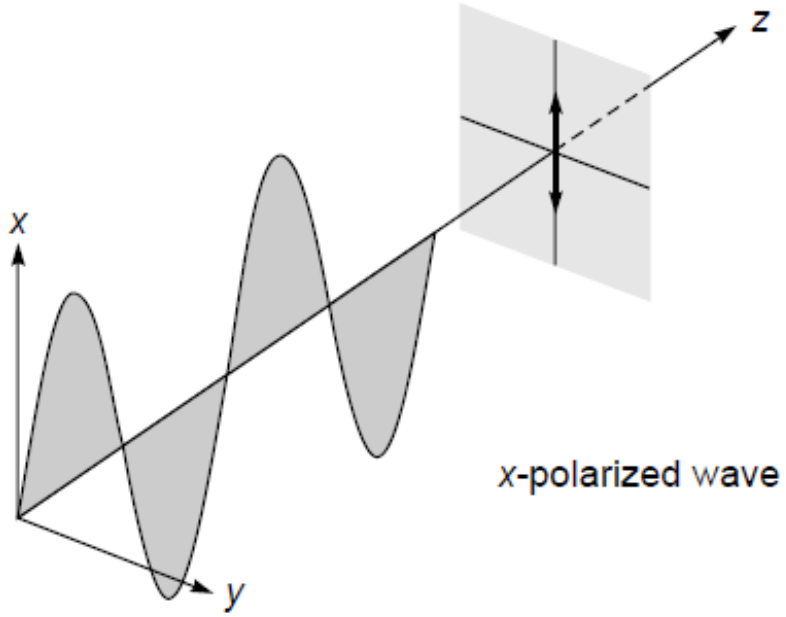
Introduction to Polarization

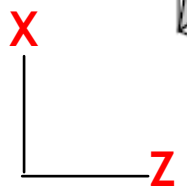
Reference: Optics, by Ghatak

Introduction



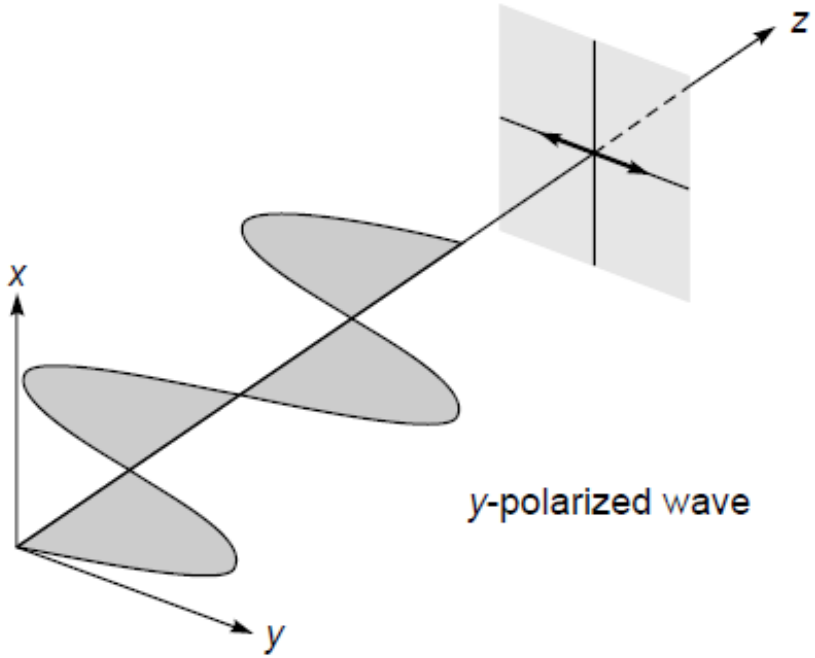


$$x(z,t) = a\cos(kz - \omega t + \phi_1)$$
$$y(z,t) = 0$$



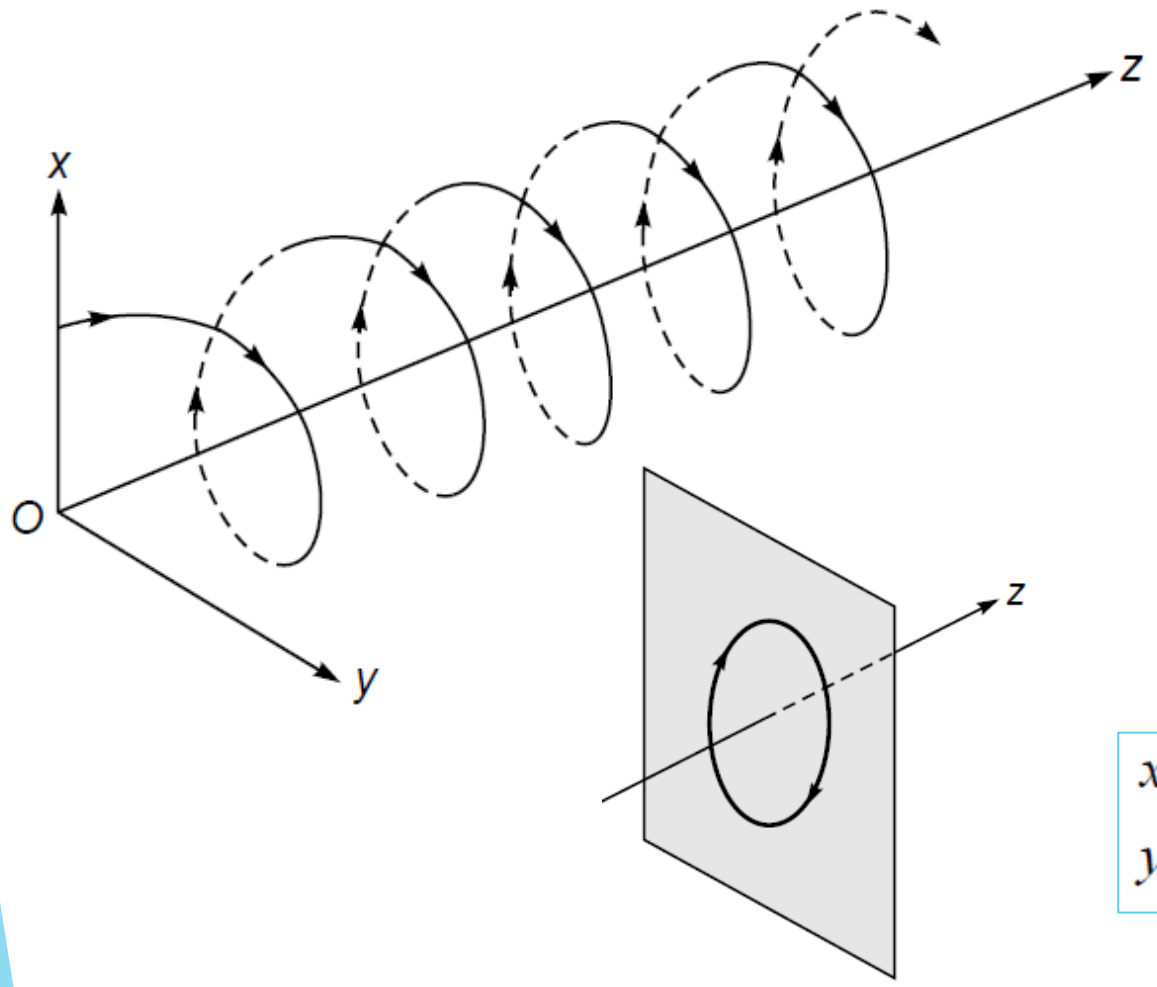
Oscillate in any plane containing *z* axis

- Each point of the string executes periodic oscillation in a straight line (*x* axis)
- wave → *linearly polarized wave*
- Also called *plane polarized wave* → string confined to *xz* plane



$$y(z,t) = a\cos(kz - \omega t + \phi_2)$$
$$x(z,t) = 0$$

Circular polarization



If one rotates the end of the string on the circumference of a circle

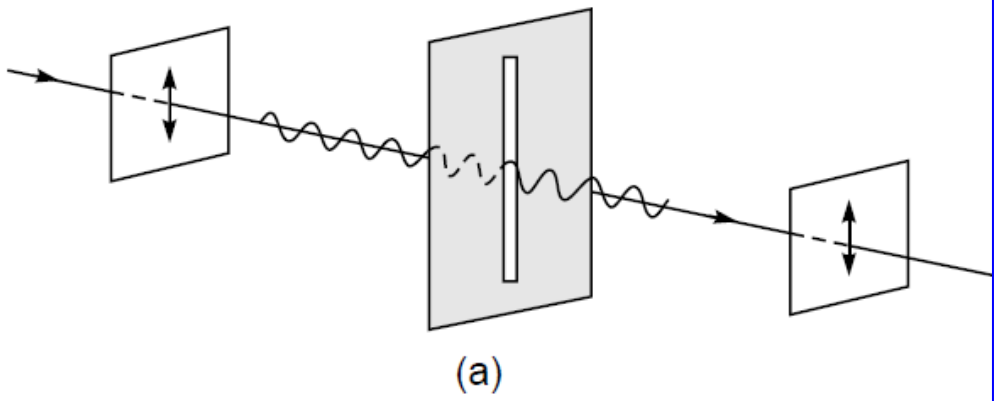
→ each point of the string will move in a circular path

Circularly polarized wave

$$x(z,t) = a\cos(kz - \omega t + \phi)$$
$$y(z,t) = a\sin(kz - \omega t + \phi)$$

$$x^2 + y^2 = a^2$$

To allow OR to block??



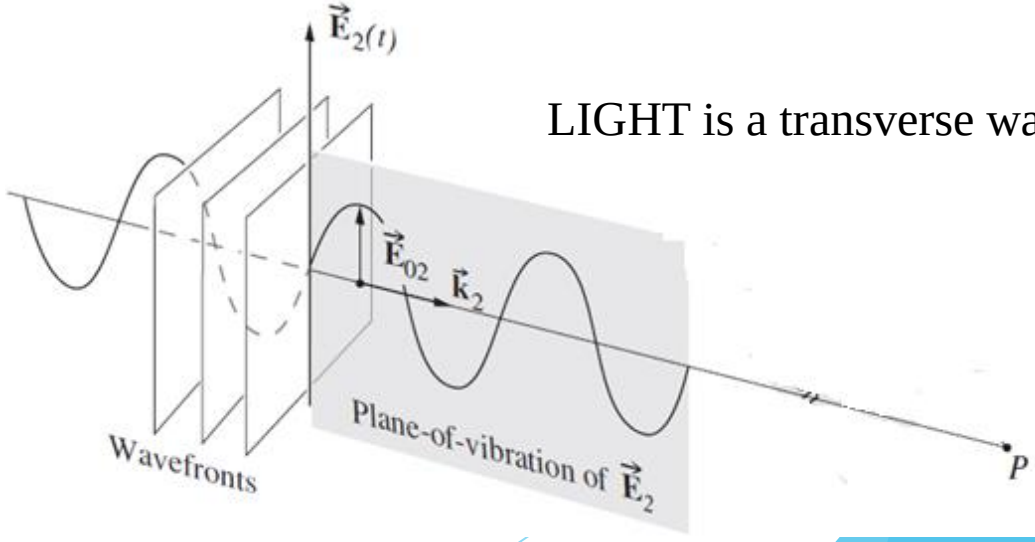
If a linearly polarized transverse wave (propagating on a string) is incident on a long narrow slit, then the slit will allow only the component of the displacement, which is along the length of the slit, to pass through.

- If the length of the slit is along the direction of the displacement, then the entire amplitude will be transmitted
- if the slit is perpendicular to the direction of the displacement, then almost nothing will be transmitted

Acts as a filter

Why bother about Transverse waves?

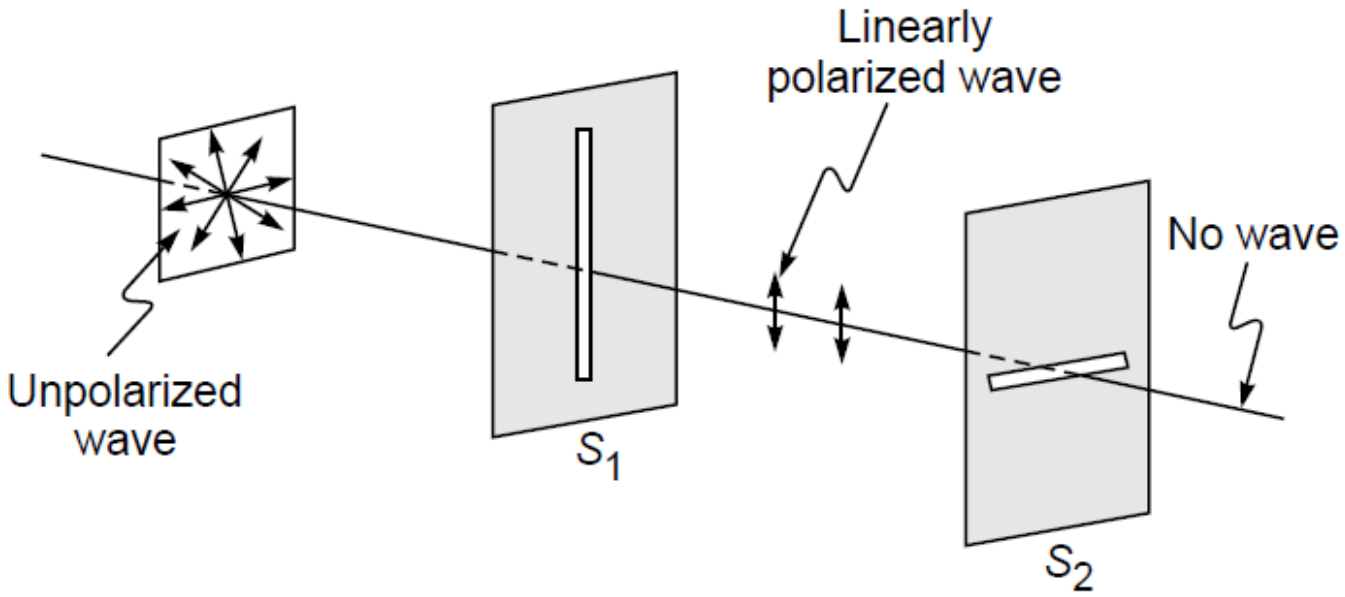
LIGHT is a transverse wave

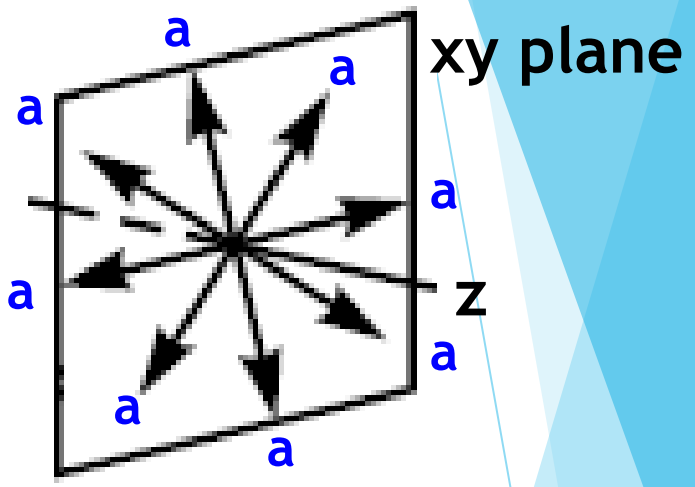


What is an un-polarized wave then?

Unpolarized wave

Plane of vibration is changed in a random manner in very short intervals of time





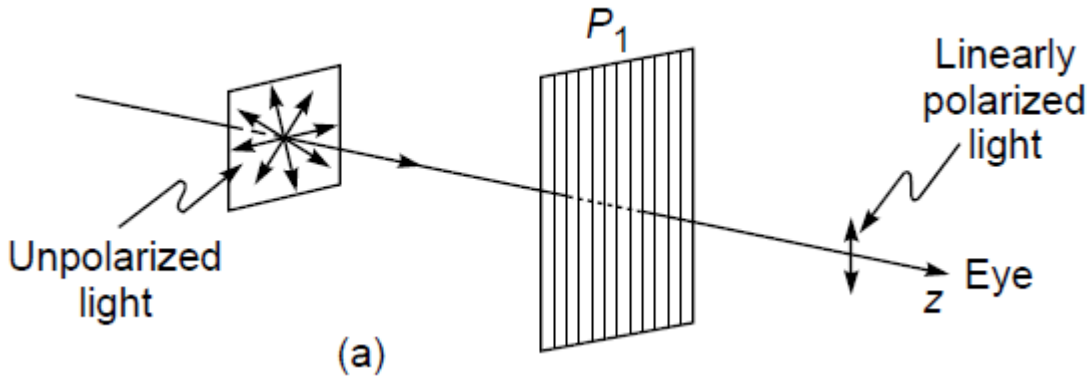
a = Amplitude

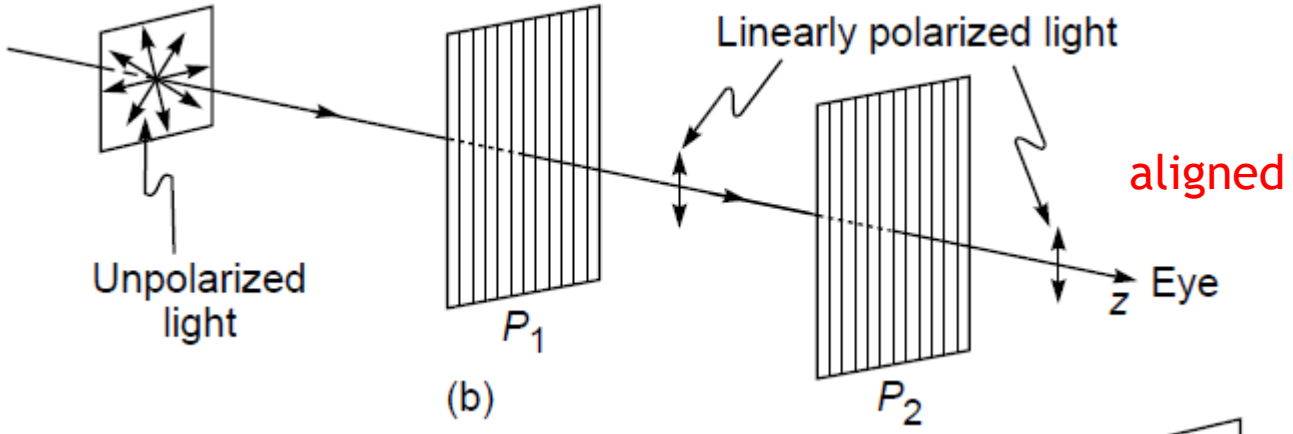
If an unpolarized wave propagating on a string is incident on a long narrow slit S_1, then the transmitted beam is linearly polarized and its amplitude does not depend on the orientation of S_1. If this polarized wave is allowed to pass through another slit S_2, then the intensity of the emerging wave depends on the relative orientation of S_2 with respect to S_1.

(a) For an unpolarized wave propagating in the $+z$ direction, the electric vector (which lies in the xy plane) continues to change its direction in a random manner. (b) For a linearly polarized wave, the electric (or the magnetic) vector oscillates along a particular direction.

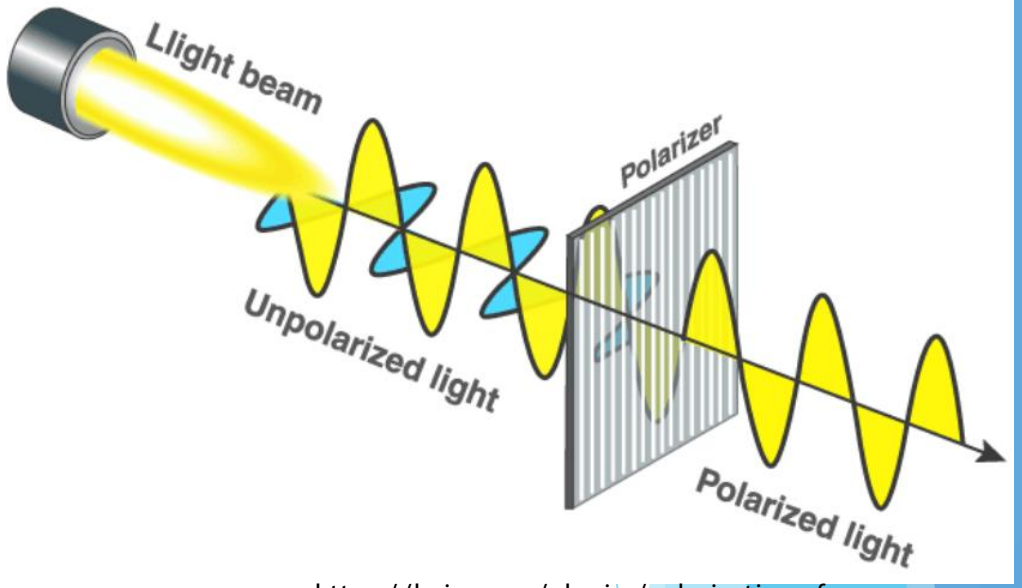
Polarizer?

Polarization of light



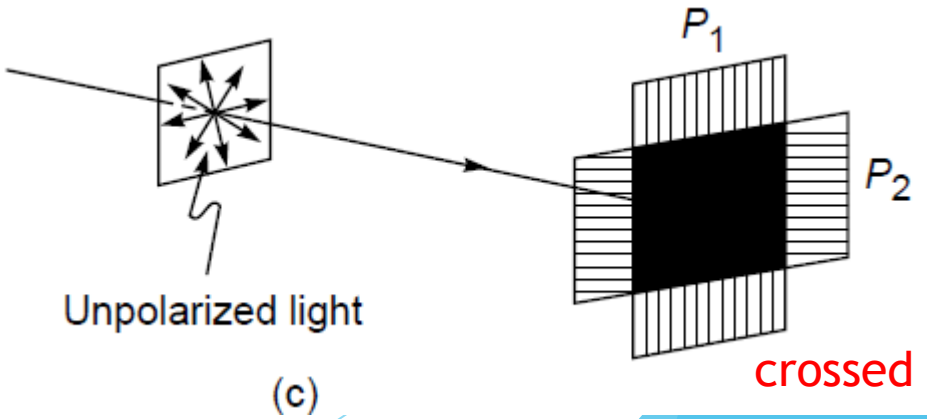


aligned



https://byjus.com/physics/polarization-of-light/#:~:text=Polarization%20Applications,for%20performing%20stress%20analysis%20tests.&text=Polarization%20is%20used%20for%20differentiating%20between%20transverse%20and%20longitudinal%20waves.

If an ordinary light beam is allowed to fall on a Polaroid, then the emerging beam will be linearly polarized; and if we place another Polaroid P_2, then the intensity of the transmitted light will depend on the relative orientation of P_2 with respect to P_1.

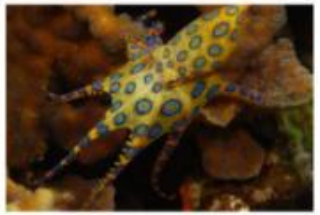


crossed

Polarization vision

- We cannot detect the polarization of light very well
- But some animals can see polarized light
- Many insects, octopi and mantis shrimps

https://www.google.com/imgres?imgurl=https%3A%2F%2Fimages.slideplayer.com%2F12%2F3533328%2Fslides%2Fslide_13.jpg&imgrefurl=https%3A%2F%2Fslideplayer.com%2Fslide%2F3533328%2F&tbnid=VPSfioQzX0ARDM&vet=12ahUKEwjKtfCsvdjwAhVuGrcAHe80DgAQMygXegUIARDjAQ..i&docid=vh0SETTyOhOj7M&w=960&h=720&q=animals%20that%20see%20polarized%20light&ved=2ahUKEwjKtfCsvdjwAhVuGrcAHe80DgAQMygXegUIARDjAQ



Bees have specially-adapted photoreceptors in their eyes, and birds, fish, amphibians and reptiles all have cone cell structures in their eyes which may **help them** to detect polarisation

Cuttlefish

https://medium.com/swlh/the-way-eye-see-it-from-cuttlefish-to-honey-bees-8d750b63973d

Scientists have discovered that greater mouse-eared bats use polarisation patterns in the sky to navigate -- the first mammal that's known to do this.

https://www.sciencedaily.com/releases/2014/07/140722111838.htm

The bats use the way the Sun's light is scattered in the atmosphere at sunset to calibrate their internal magnetic compass, which helps them to fly in the right direction, a study published in *Nature Communications* has shown.

https://sovs-newsletter.blogs.auckland.ac.nz/2018/07/25/octopus-vision/

Octopuses use their highly developed sense of vision to hunt, navigate, and communicate with others, even in turbid waters or under low light conditions. They are sensitive to polarised light, further enhancing their great sense of vision. Octopuses also possess an extraordinary ability to camouflage themselves, allowing them to hide

Thank You