ESSENCE OF LIGHT

Bringing Ocean Literacy to Land-Locked States Grant, NOAA-OER 2009-2010

For more information, please contact WhaleTimes, Inc. PO Box 2702, Tualatin, OR 97062

business@whaletimes.org

NOAA-OER Lesson Plans to complement this slide show at:

http://oceanexplorer.noaa.gov

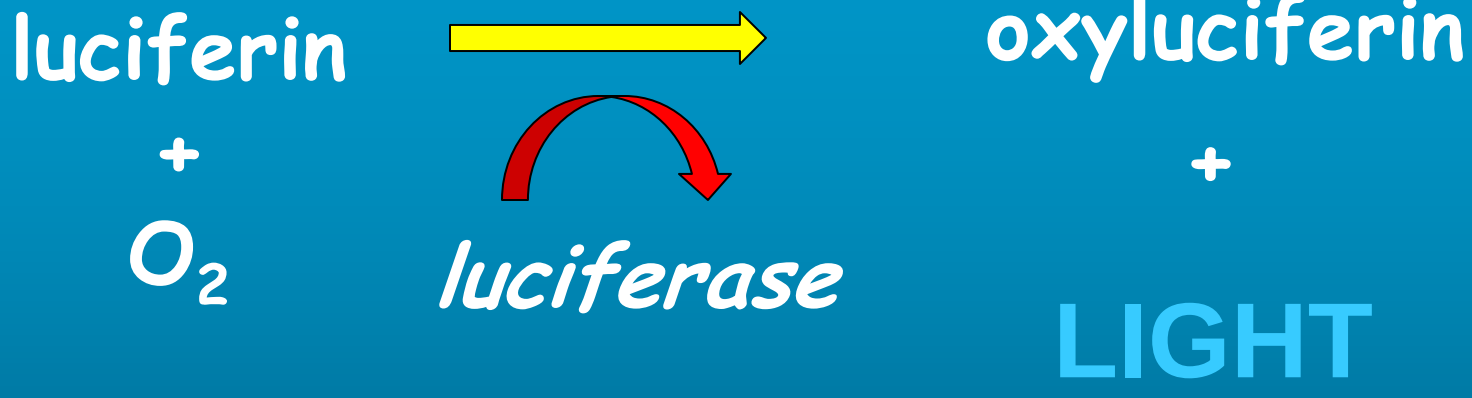
Essence of Light

Bioluminescence

- Chemical "cold" light produced by animals

  - no energy wasted in heat production

- Bioluminescence has arisen independently over a dozen times



Basic reaction

- light emitting molecule - luciferin
- enzyme - luciferase
- source of oxygen

Color of bioluminescence depends on the structure of the chemicals involved

- land animals (fireflies,other beetles) - greens and yellows
  - relatively rare

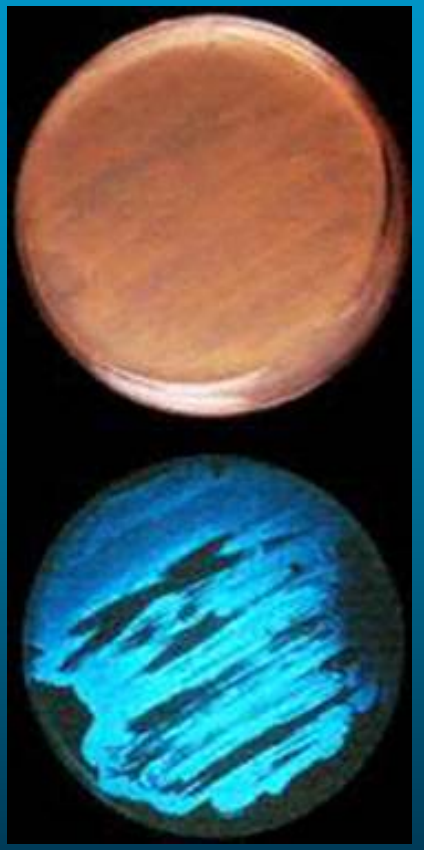
- marine animals – blue, blue-green, green
  - 90% of animals between 200 and 1000 m are bioluminescent

http://www.ted.com/index.php/talks/view/id/206

Ted talk by Dr. David Gallo – contains videos bioluminescent marine organisms

Forms

- Steady glow
  - bacterial
  - leave marine fish fillet on counter for several days and see what happens



Flashlight fish – harbor colony of bioluminescent bacteria in organ beneath eye

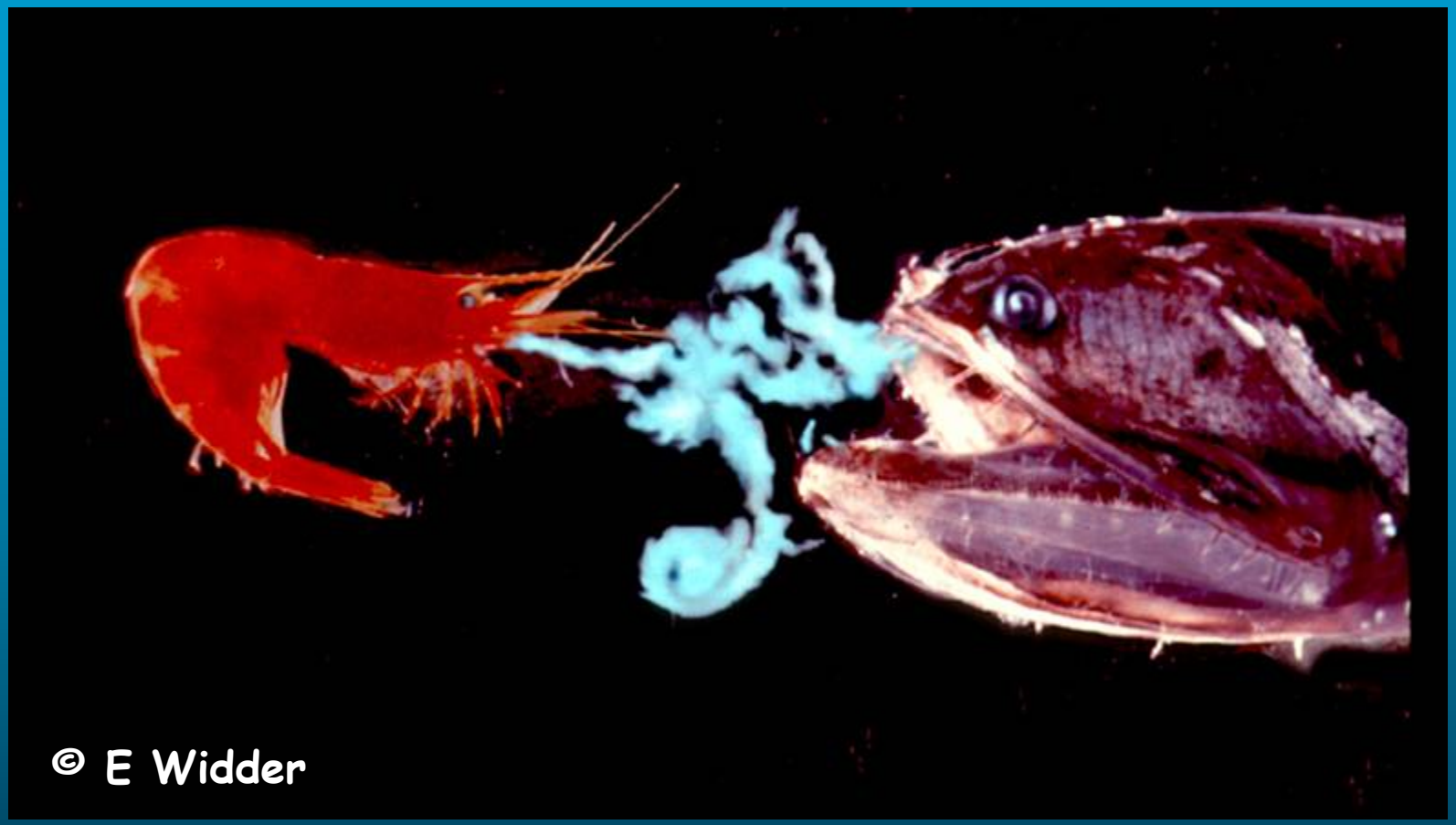
Photo ©David C. Powell
http://school.discoveryeducation.com/schoo
ladventures/planetocean/light.html

Most bioluminescence in marine animals is NOT bacterial

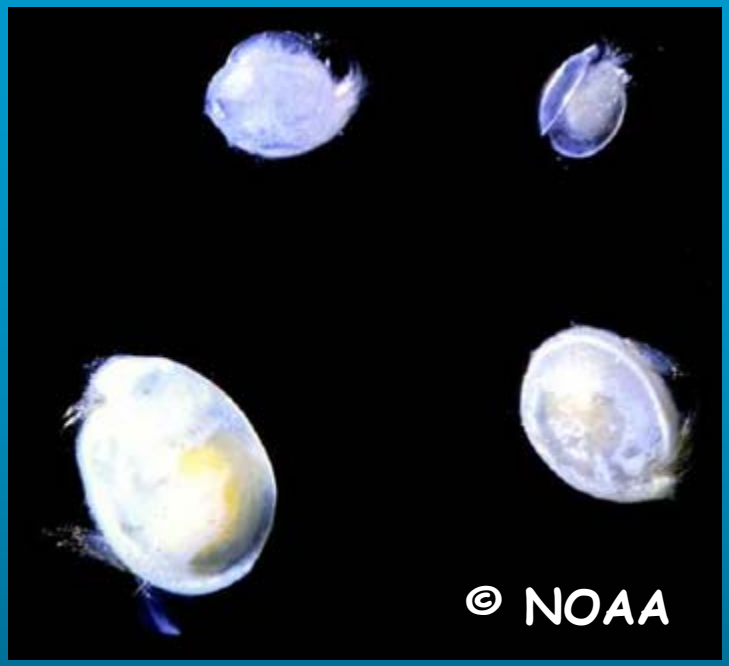
- Most is under internal control

Photophores on belly - counterillumination

Photophores under eyes - finding prey



Bioluminescent spew - defense



Ostracods – sea fireflies

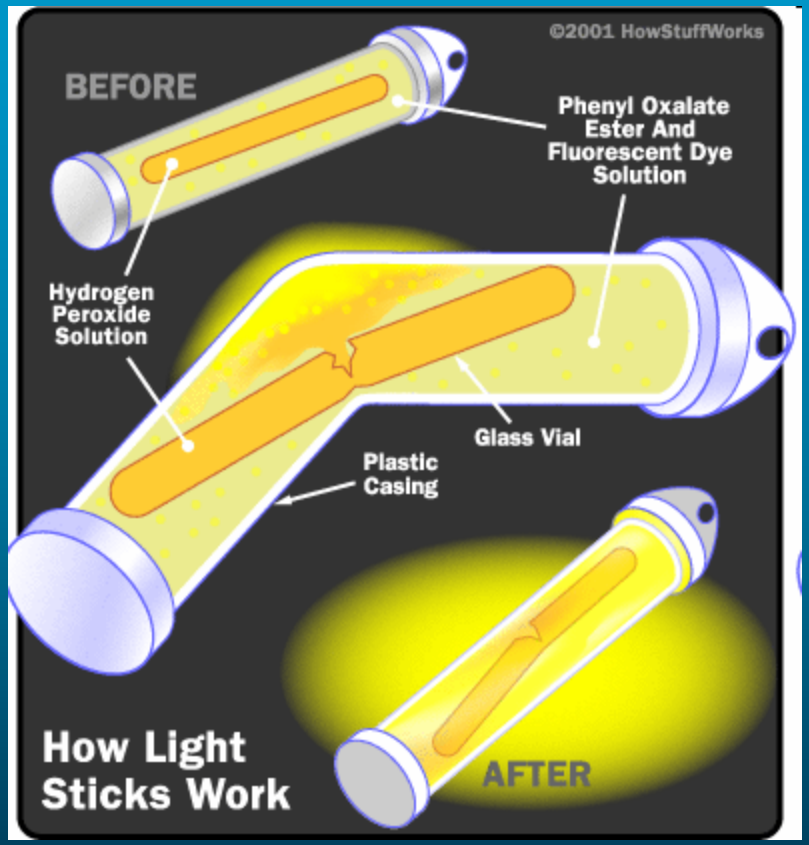
- size of tomato seeds
- string of pearls display
- when dried, crushed, and hydrated, luminescence reactivated

Chemiluminescence – chemical reaction that results in the production of light

- bioluminescence is chemiluminescence produced by animals
- used in cyalume sticks

Image from www.happyglow.com

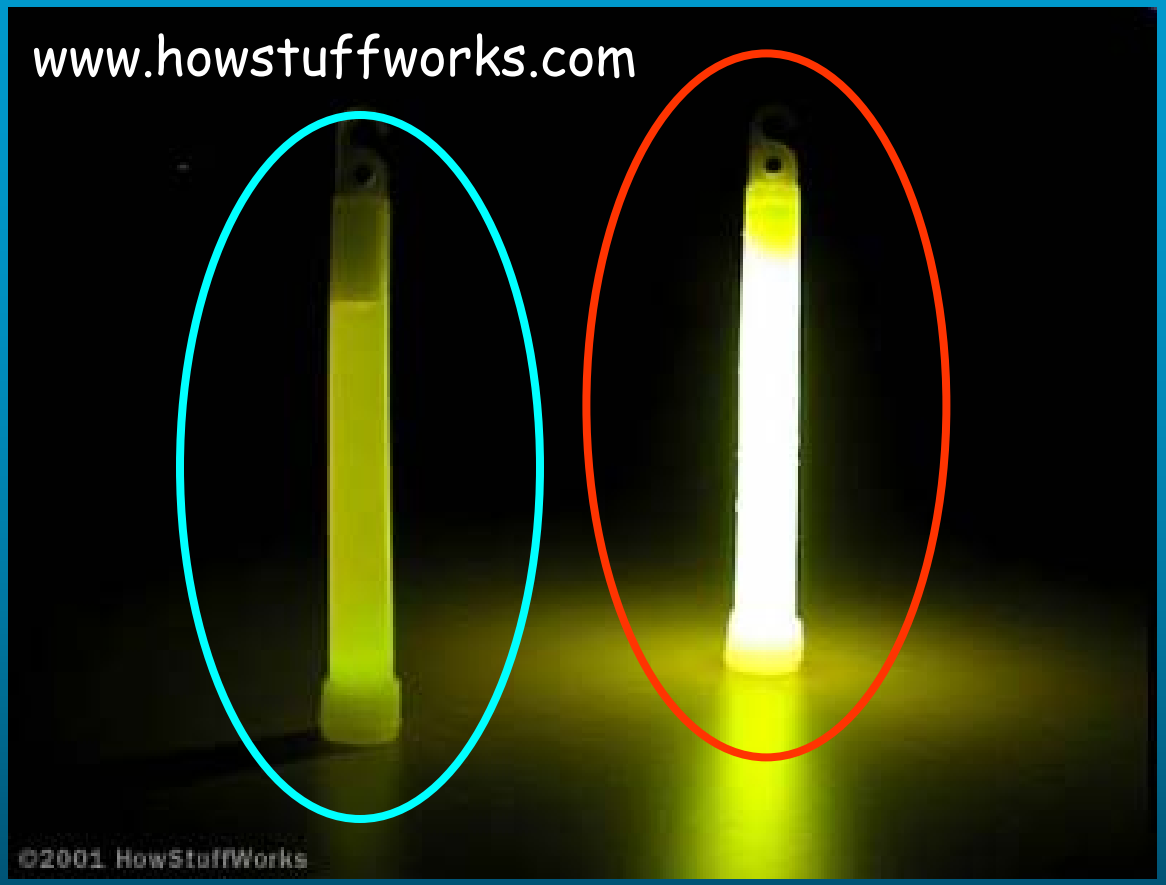
http://science.howstuffworks.com/light-stick2.htm



- cyalumes contain
  - 2 chemicals
  - fluorescent dye
- dye and one chemical (phenyl oxalate ester) fill light stick
- other chemical, usually hydrogen peroxide, inside small glass vial

- Break vial by bending stick
  - peroxide mixes with the ester
  - reaction releases photons of light
  - color of emitted light depends on structure of dye
    - different dyes produce glow sticks with different colors

- Adjust concentration of two chemicals
  - dim, long duration glow stick
  - bright, short duration glow stick
- Temperature also affects "brightness"

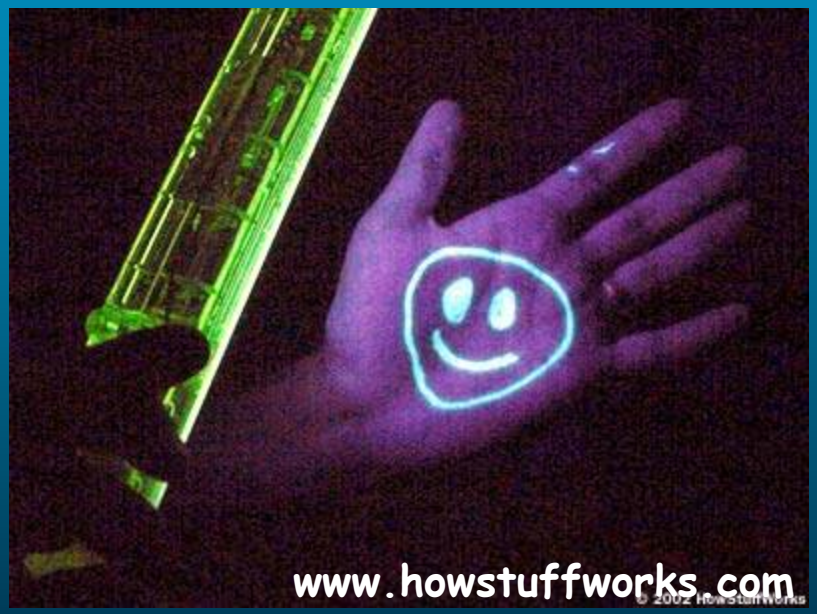


Cold temperatures slow reaction rate
- dimmer, but longer duration

Hot temperatures increase reaction rate
- brighter, but shorter duration

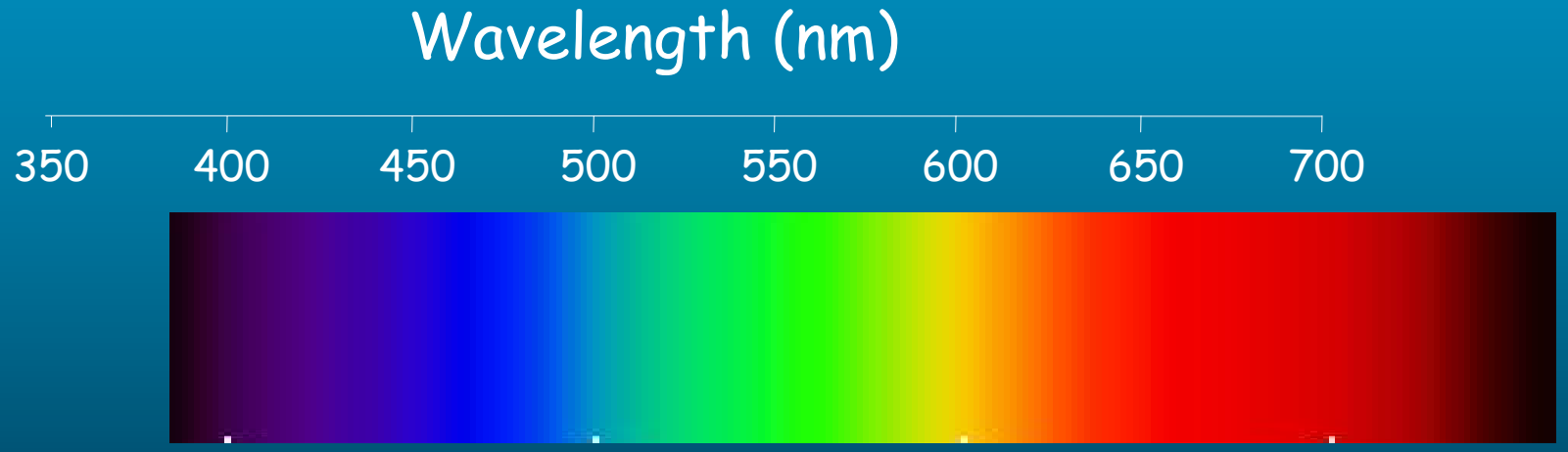
* Dyes that emit red light are unstable when stored with other chemicals in light sticks
    - fluorescent red pigment molded into plastic of tube
    - absorbs yellow light emitted from dye and re-emits as red

Fluorescence – absorption of light at one wavelength and re-emission at different, lower energy wavelength



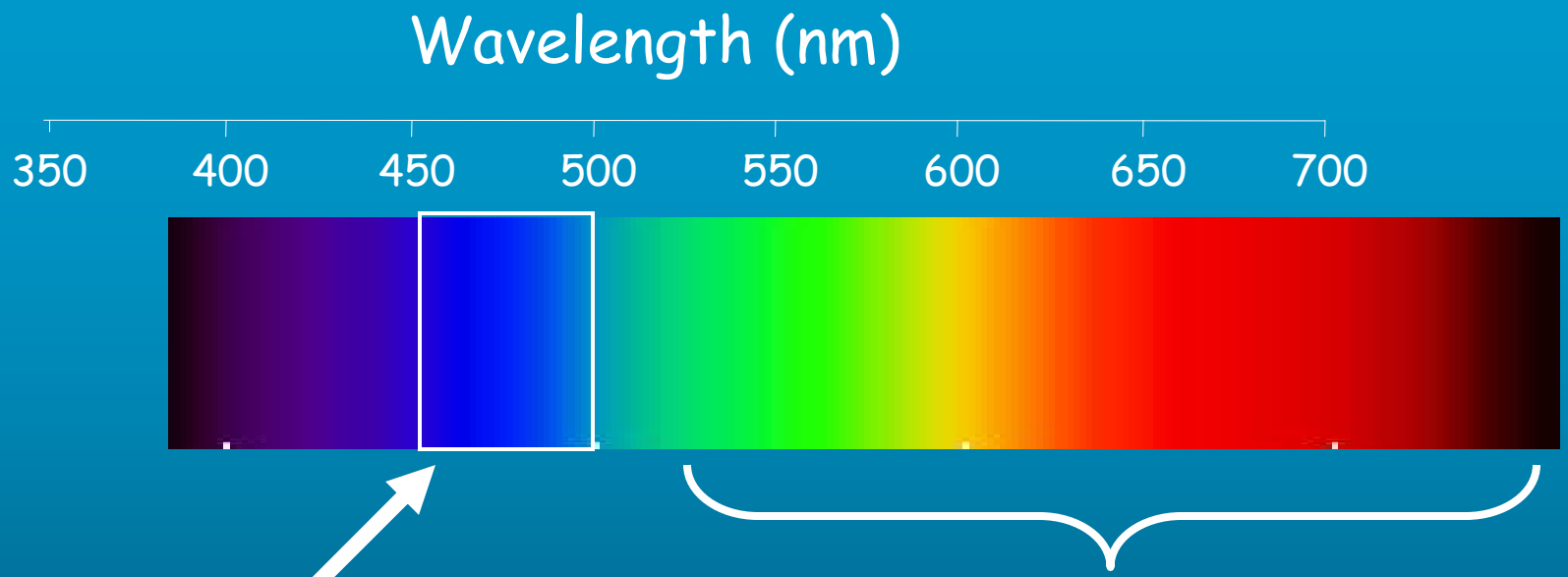
"Black light" fluorescence

Fluorescence – absorption of light at one wavelength and re-emission at different, lower energy wavelength



shorter wavelength
= higher energy

longer wavelength
= lower energy



* deep-sea – only remaining light is blue

* fluorescence will be green, yellow, orange or red

Fluorescence – absorption of light at one wavelength and re-emission at different, lower energy wavelength

On land during daylight hours, nearly all fluorescent signals are too dim to see

- chlorophyll fluoresces red

- require special lighting and viewing conditions to see it

- bright blue light to "excite" fluorescence

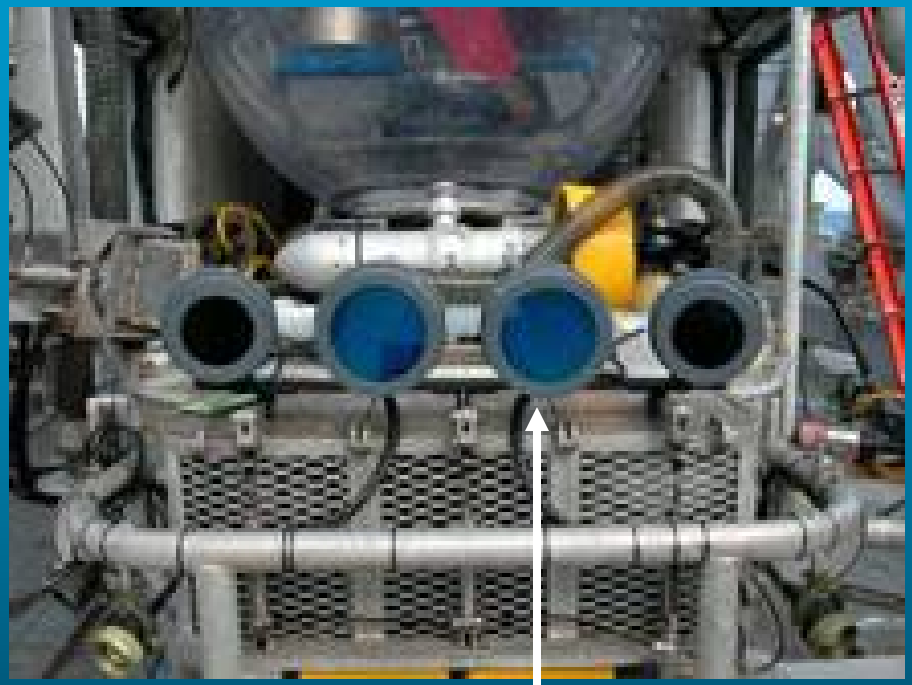
- yellow goggles to block blue light so that dimmer fluorescence is visible

Fluorescence may be by-product of tissue chemistry

- chitin in exoskeleton of arthropods
- not localized to any particular body region

©teslad ownunder.com/nuclearxray.htm

Process for detecting fluorescence in ocean

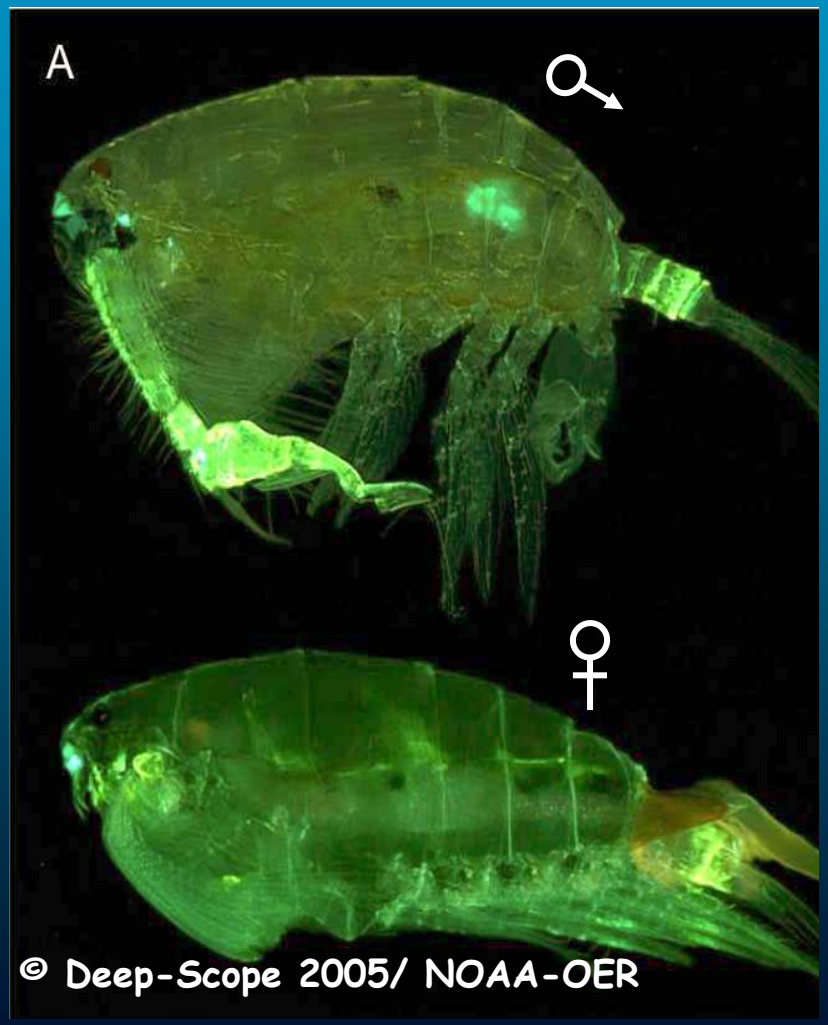


- shine bright blue light on sea floor

- use yellow filter to block out blue light that is reflected back, leaving only fluorescence

Fluorescence probably just byproduct of tissue chemistry

However, below 100 m in ocean, light mostly blue
- green fluorescence would be visible to animal with green sensitive visual pigment



Shallow water copepods

Pontella securifer

Common items that are fluorescent

- leaves (usually around veins when overlying tissue is thinner)
- red light sticks (due to red fluorescent pigment in plastic tube)
- olive oil
- honey

Phosphorescence

- similar to fluorescence - requires external light source
- different from fluorescence - continues to glow after light is turned off
- glow-in-the-dark-stickers
- glow in the dark paint

Triboluminescence - emission of light resulting from something being smashed, torn or rubbed together

- light from friction
- energy is input into atoms by friction
- when atoms return to usual state, energy released as light
- "lightning" on a very small scale

- rip duct tape off the role with gusto
  - if you're dark-adapted, in a very dark room, you will see light where the tape is leaving the role
- crunching on hard sugary candy containing sucrose or fructose
  - stressing sugar crystal results in light emission
  - sugar free candies don't work!

- **Wint-O-Green Mints work the best**

- oil of wintergreen is fluorescent

- triboluminescence is mostly UV (invisible to humans) light, with small amount of visible light

- oil of wintergreen absorbs UV and re-emits it at longer (more visible) wavelengths

- get blue sparks!

- if candy too wet with saliva, doesn't work as well

- crunching candy between pair of pliers works best