Hot Science Cool Talks

UT Environmental Science Institute

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Now You See Me, Now You Don't: Colorful Strategies for Surviving in Nature

Dr. Molly Cummings

November 22, 2013









Now You See Me: Now You Don't

Dr. Molly Cummings


Why the grand diversity in color?

- To communicate with Predators?
- To hide from Predators?
- To communicate to others of its own kind?
- Some combination of all three?

Photos by J.L. Brown

Why the grand diversity in color?

Natural Selection

- To communicate with Predators?
- To hide from Predators?

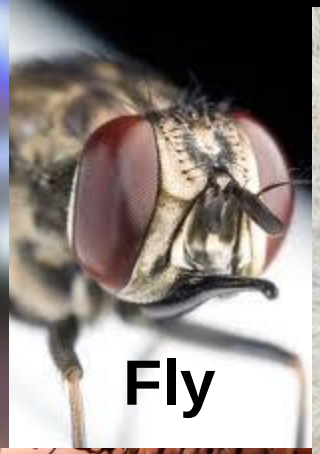
Sexual Selection

- To communicate to others of its own kind?

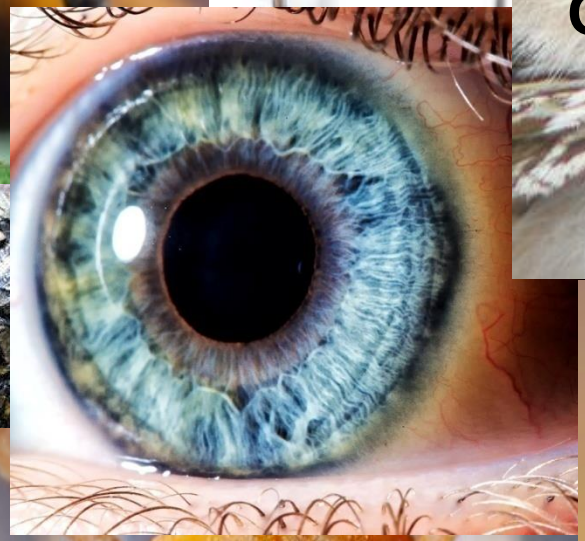
- Some combination of both Natural & Sexual Selection?

Photos by J.L. Brown


Yellowjacket


Fly

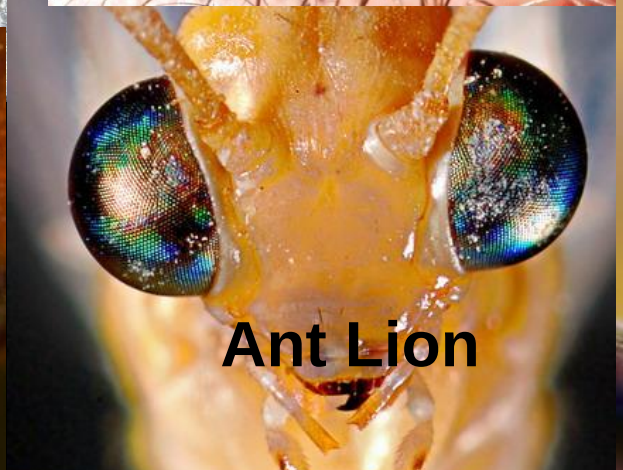

Owl

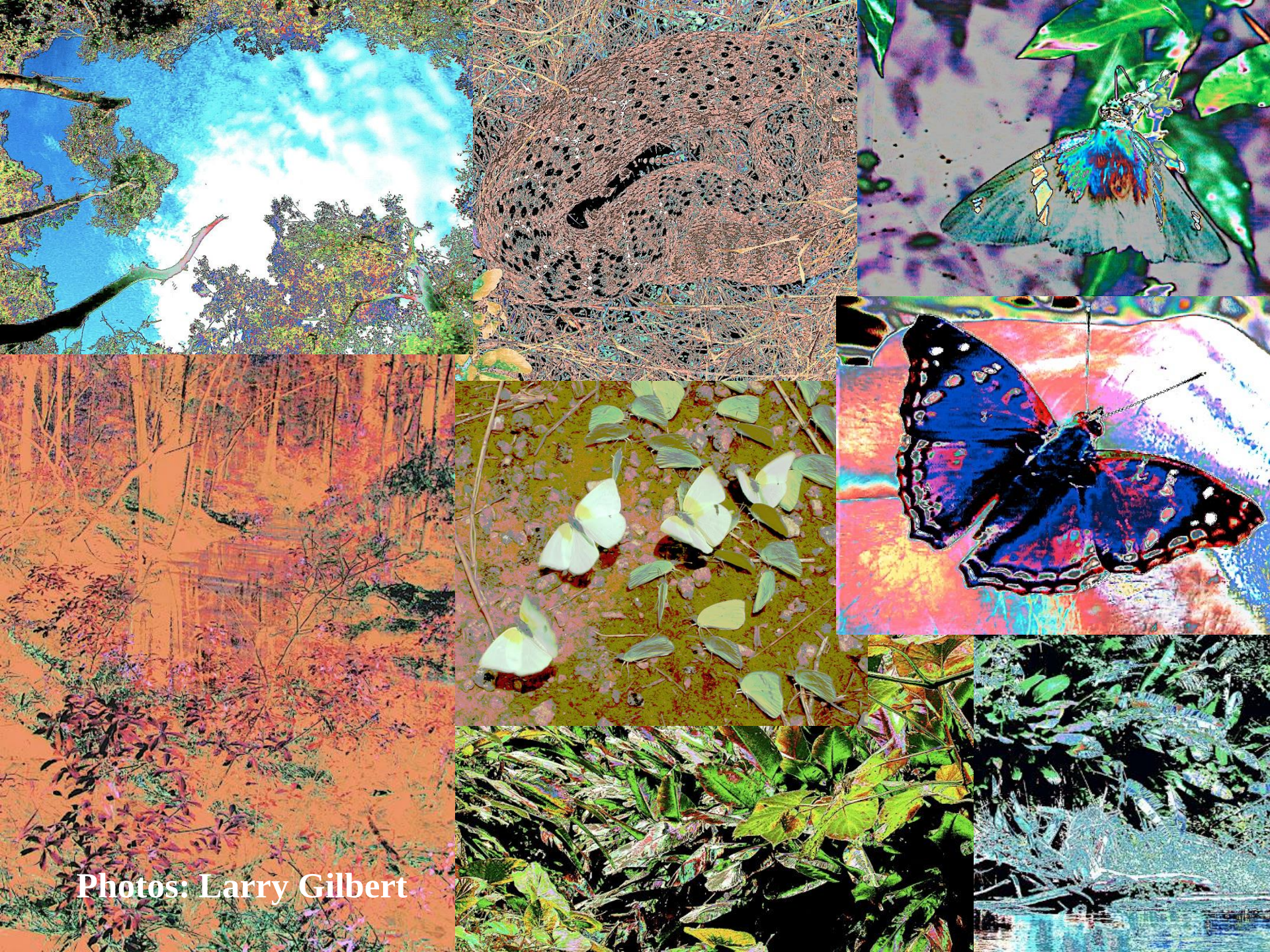



Crocodile


Jumping Spider


Dragonfly


Ant Lion

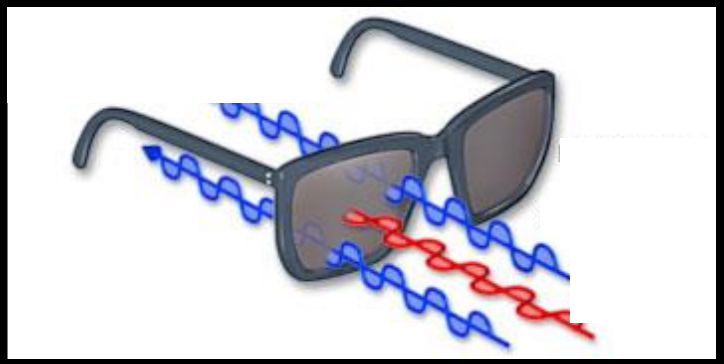

Photos: Larry Gilbert

Dynamics of Light

- **Brightness: How much light there is**

- **Color: Wavelengths of light**

- **Polarization: Direction of vibrating light waves**



Why the grand diversity in color?

Natural Selection

- Is it to communicate with Predators?
- Is it to hide from Predators?

To Hide or Not to Hide….

- Hide (not be detected)
- Advertise your Nastiness

Poison Dart frogs use their bright colors to communicate to predators that they are toxic

(“aposematism” or warning coloration)

How do poison dart frogs get their name?

Capt. Charles Cochrane described the effect (1825):
"A tiger when hit, runs ten or a dozen yards, staggers, becomes sick, and dies in 4 or 5 minutes."









How do poison dart frogs get their poisons?

By eating toxic Bugs!



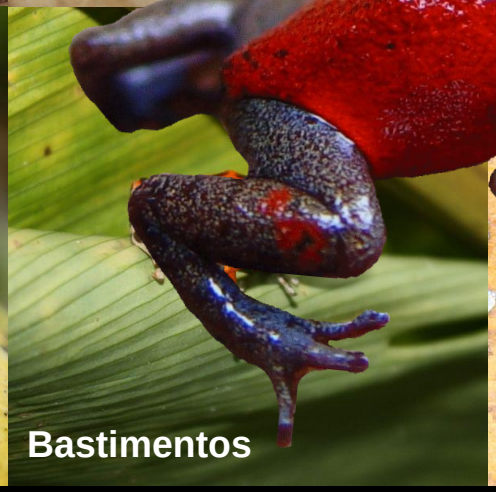
The famous strawberry poison frog

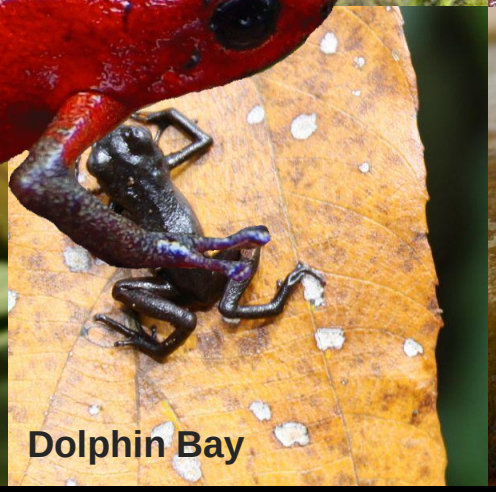

Bastimentos

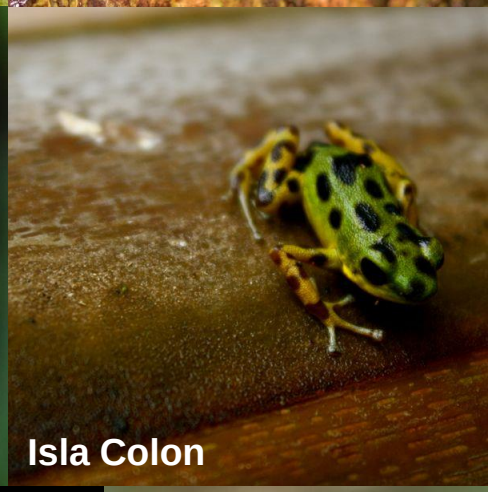

Solarte


Nancy


Pastores


Bastimentos


Dolphin Bay


Isla Colon

One of the most colorful animals on earth

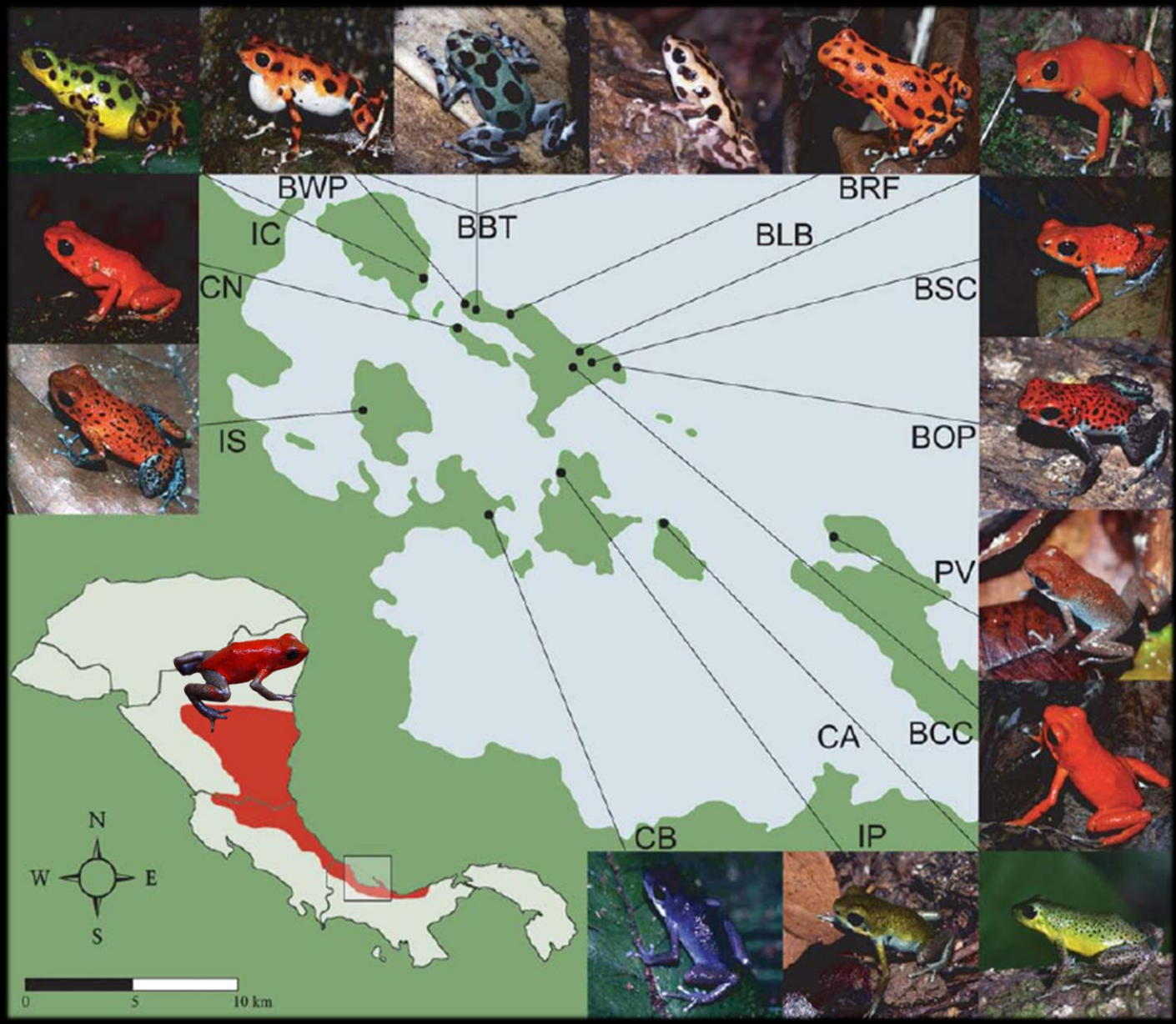

Dolphin Bay


Escudo de Veraguas

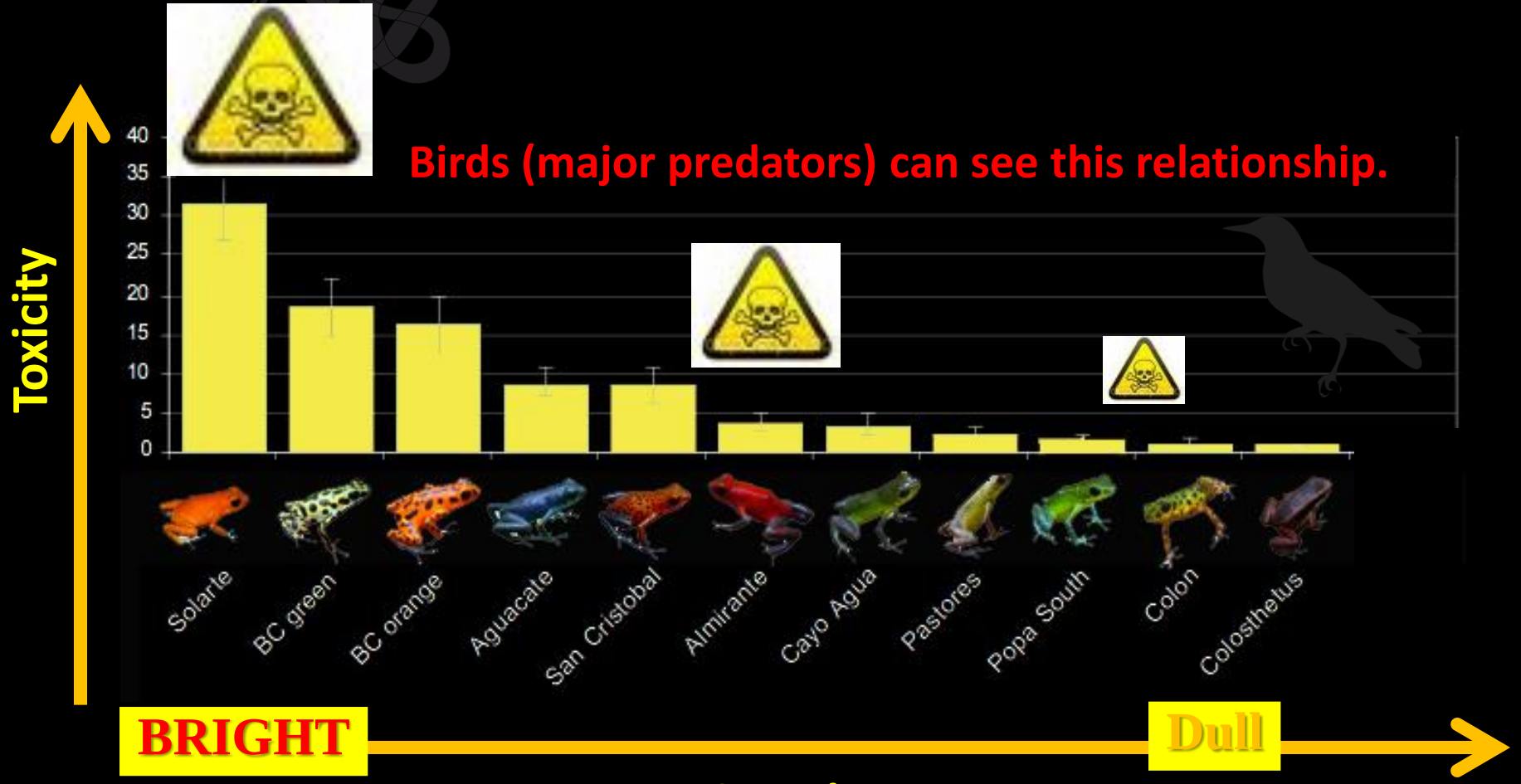

Escudo de Veraguas

Strawberry Poison Frog

Are the different colors communicating different information?



NATURAL SELECTION



Birds (major predators) can see this relationship.

Brighter populations are more toxic.

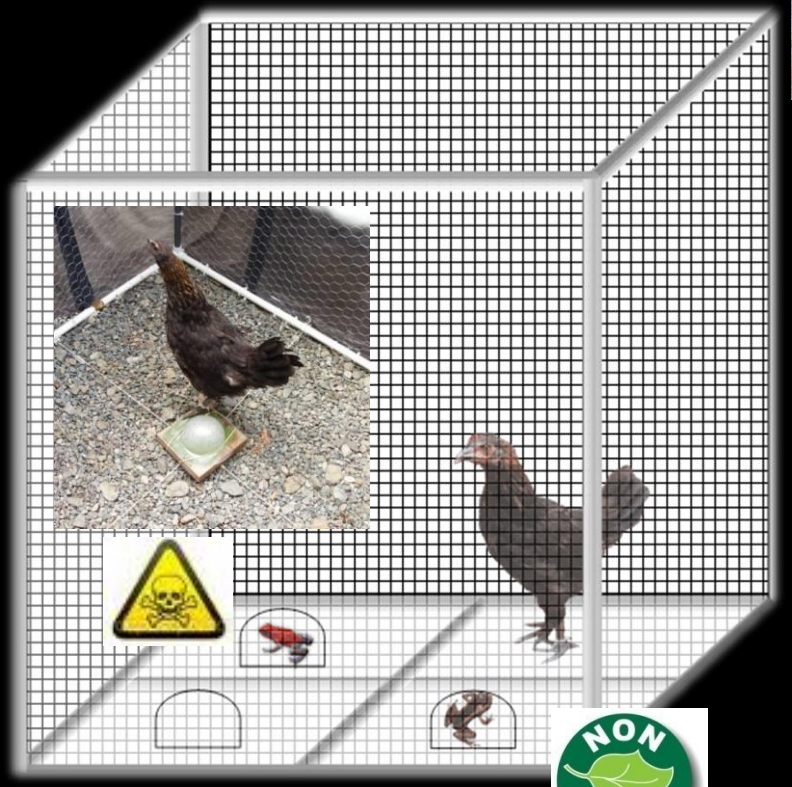
Maan & Cummings 2012

Brightness is an indicator of Toxicity

- Frog populations on islands with few toxic prey, became less toxic, and became less bright.

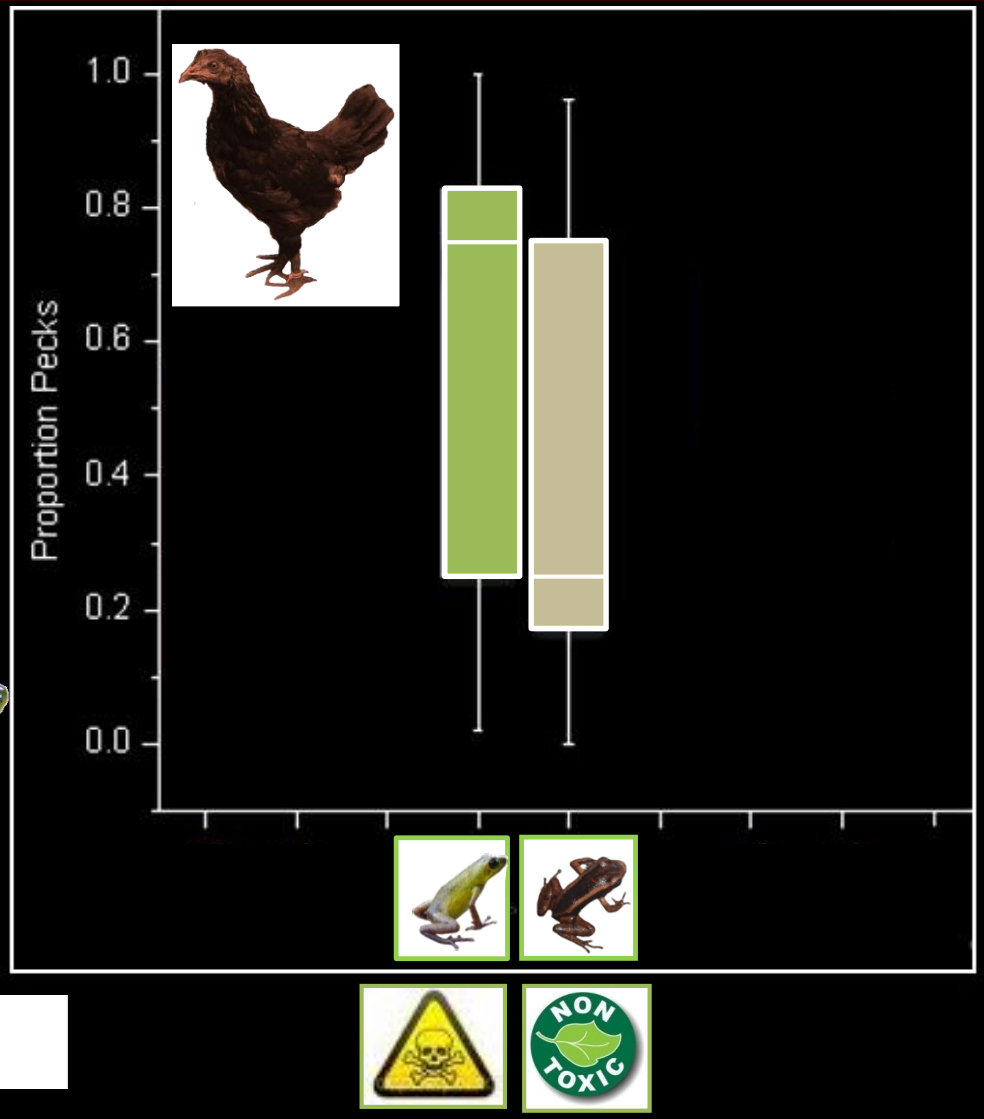
- Frog populations on islands with LOTS of toxic prey, became MORE toxic, and BRIGHTER.

Do birds really pay attention to these *warning colors*?

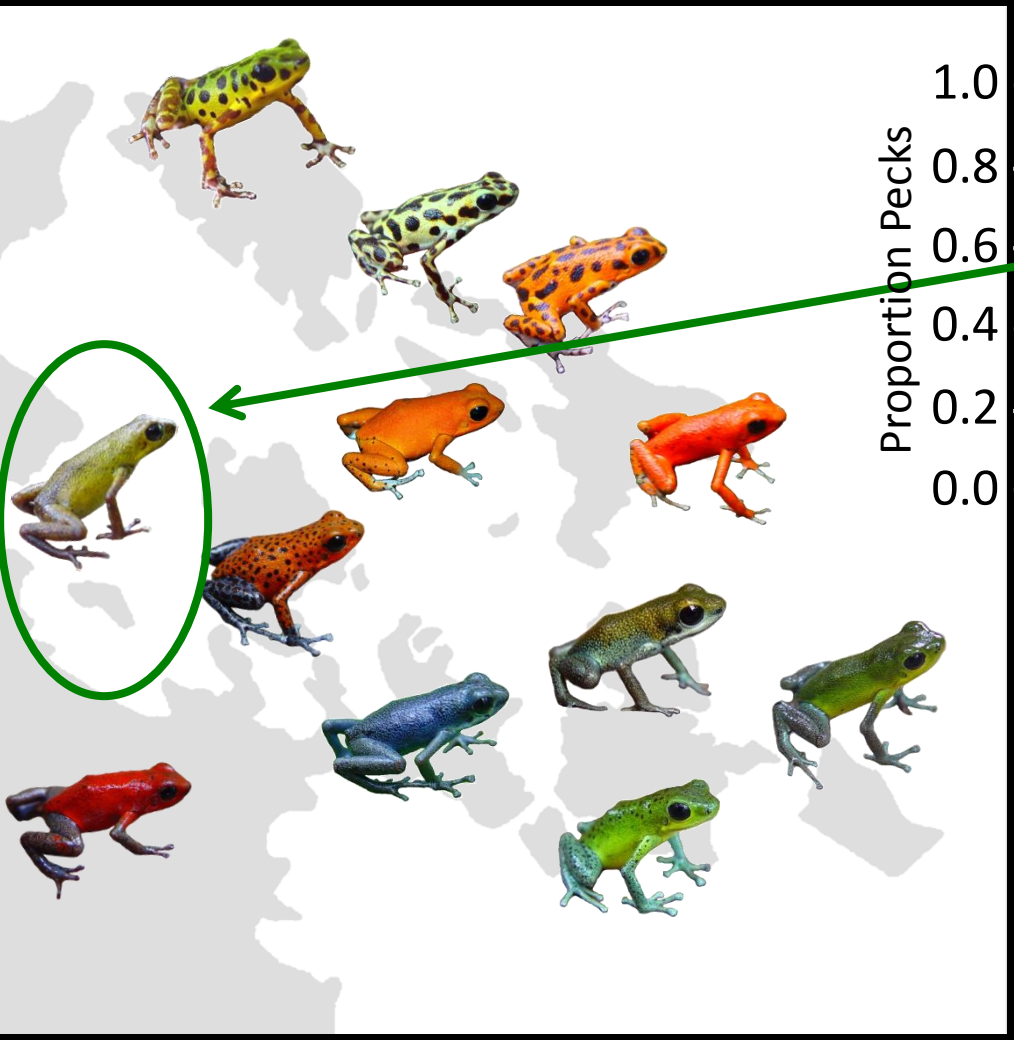

NON
TOXIC

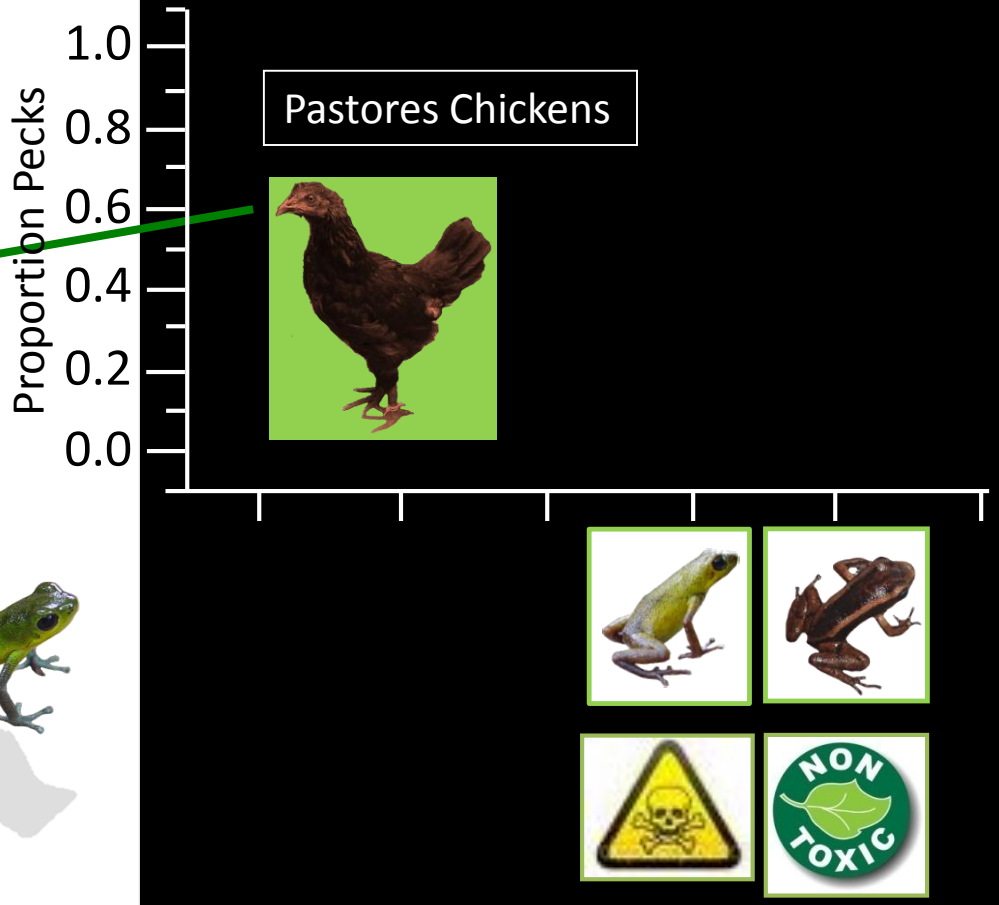

NON
TOXIC

Naïve Chickens (unfamiliar with poison frogs) don’t avoid the poison frog

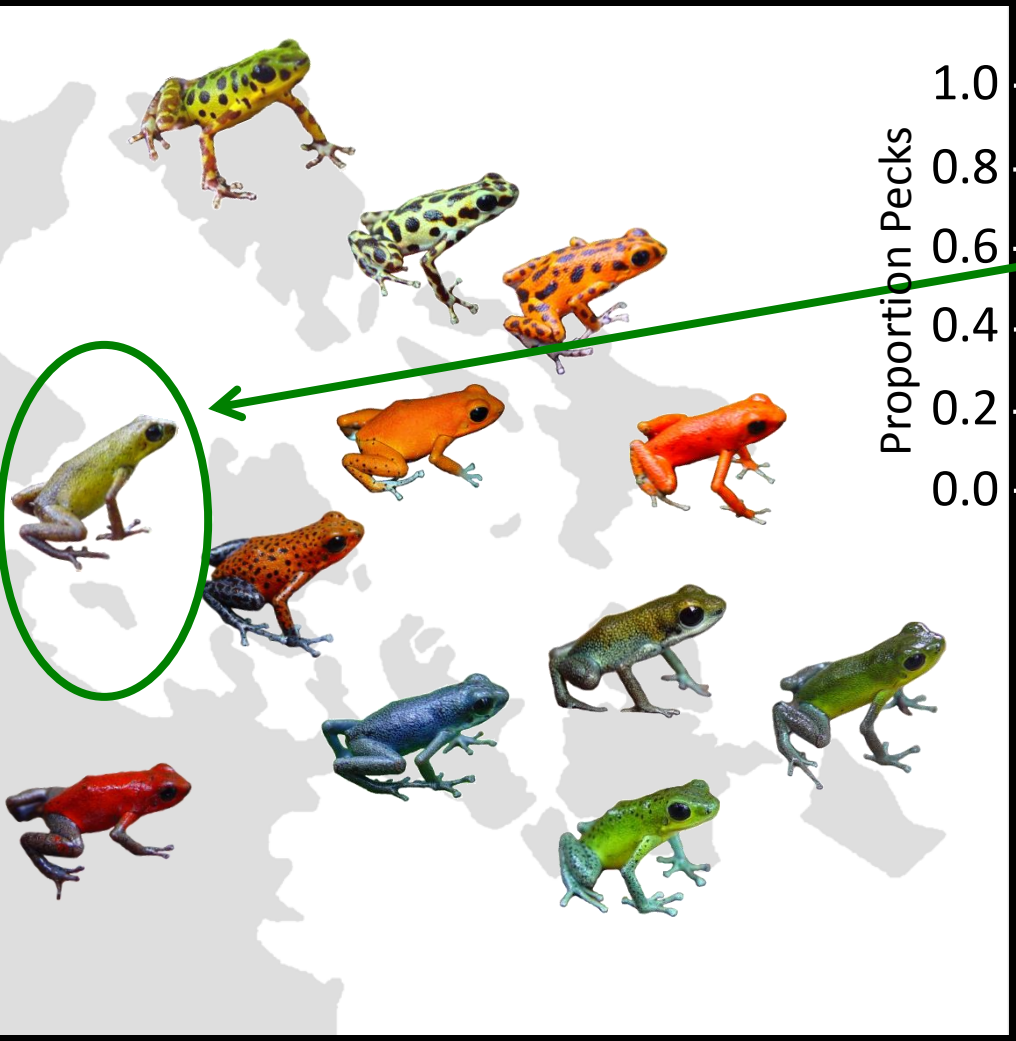


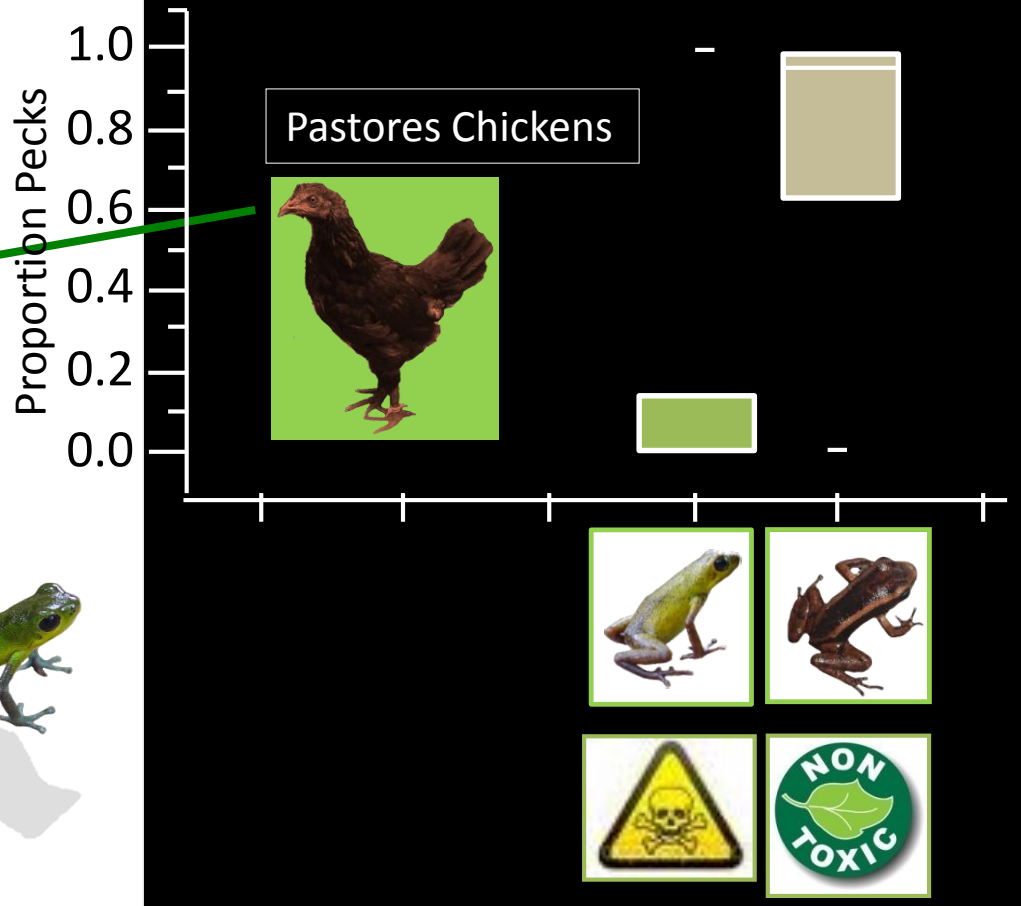
But experienced chickens. . .



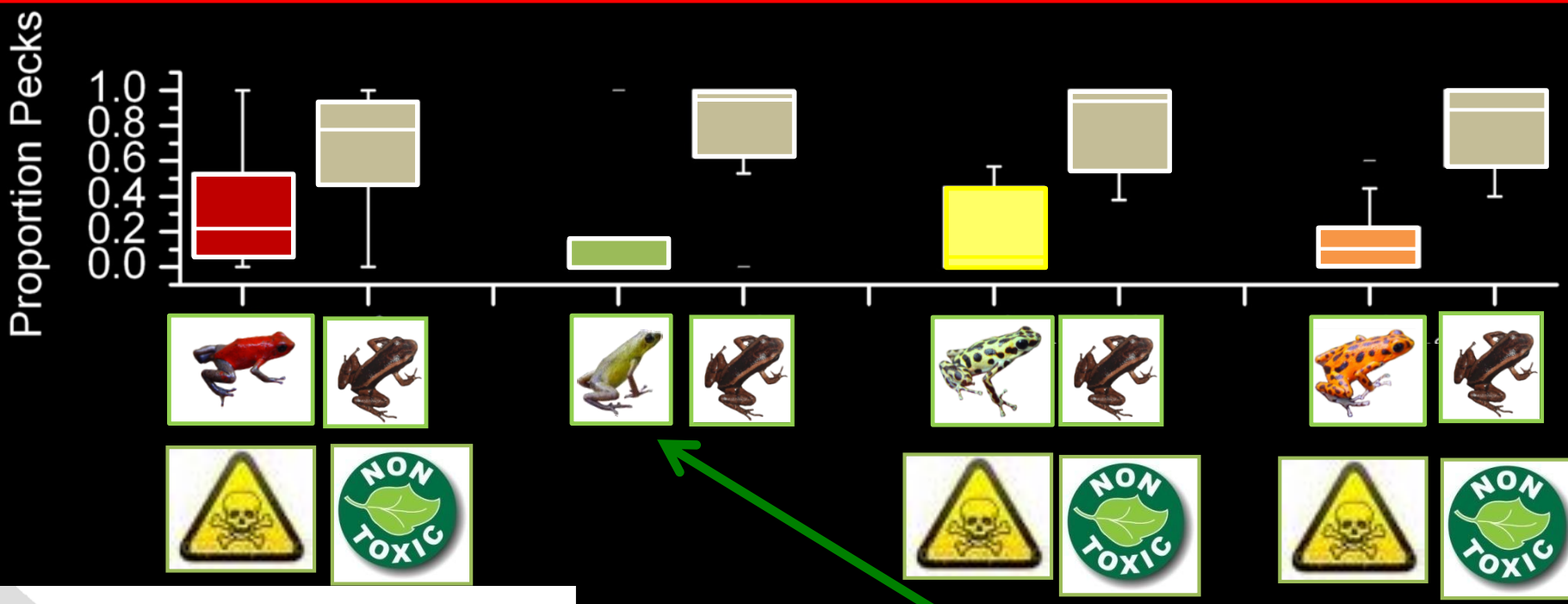


But experienced chickens do avoid their local poison frogs





Experienced chickens *also* avoid novel, *bright* colored frogs

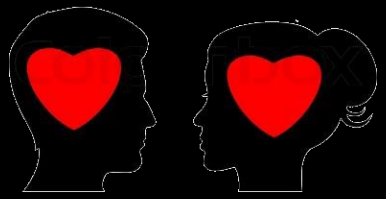


Why are there so many different colors?

Natural Selection

(1) Brightness informs predators how nasty *the frogs are*

(2) Once they've learned that one bright color is nasty, *they also avoid OTHER bright colors*



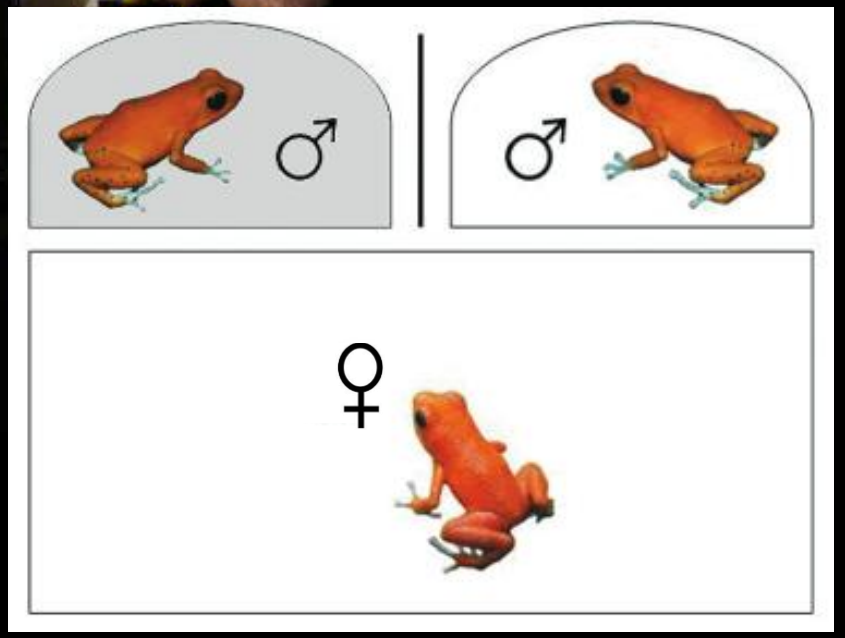
SEXUAL SELECTION

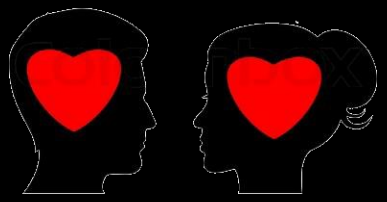
Animals have to attract mates

Animals evolve traits that make them attractive

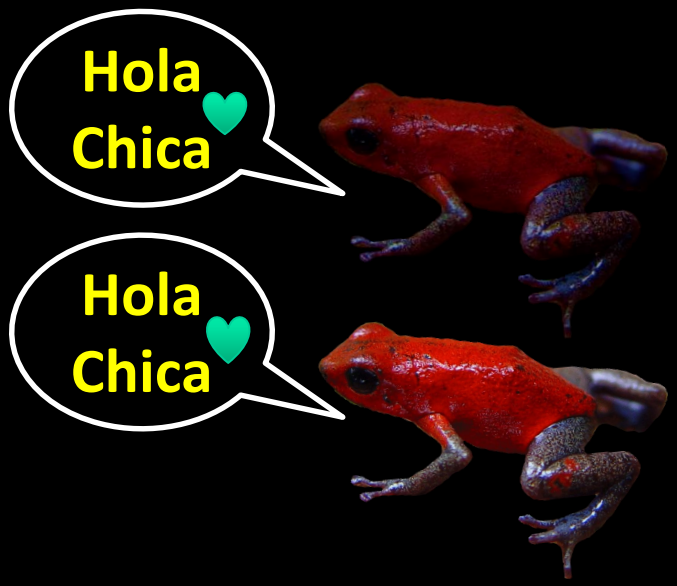

'SATURDAY NIGHT FEVER'

Frog Mate Choice Arena





SEXUAL SELECTION



Females prefer brighter males

Natural & Sexual Selection Operating Together

- Colors/Brightness indicate Toxicity
  - Less Toxic Frogs-> HIDE
  - More Toxic Frogs -> ADVERTISE
- Predators GENERALIZE their avoidance to new colors
- Mates may drive the evolution of Brighter colors

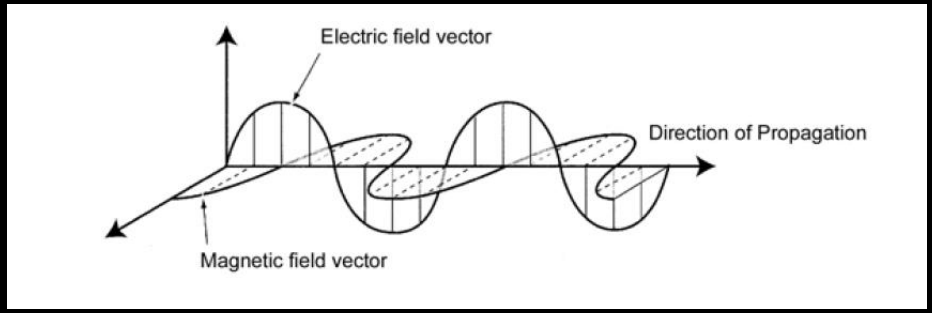
Less Toxic
& Cryptic

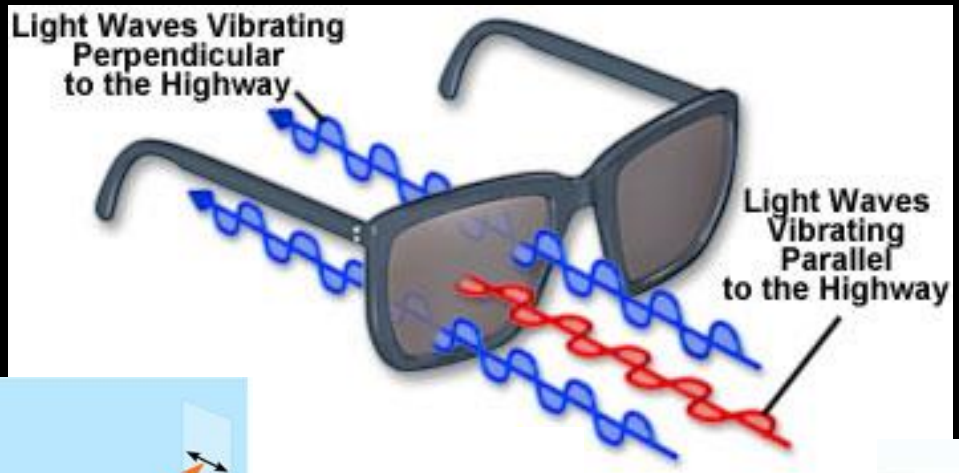
More Toxic
& Conspicuous

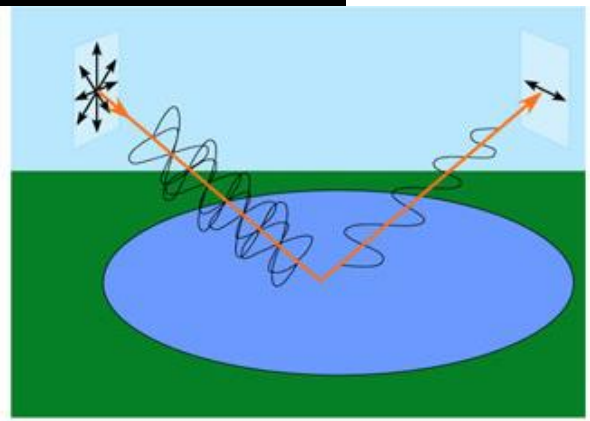
Now You See Me:
Now You Don't

Dynamics of Light

- Brightness
- Color
- Polarization





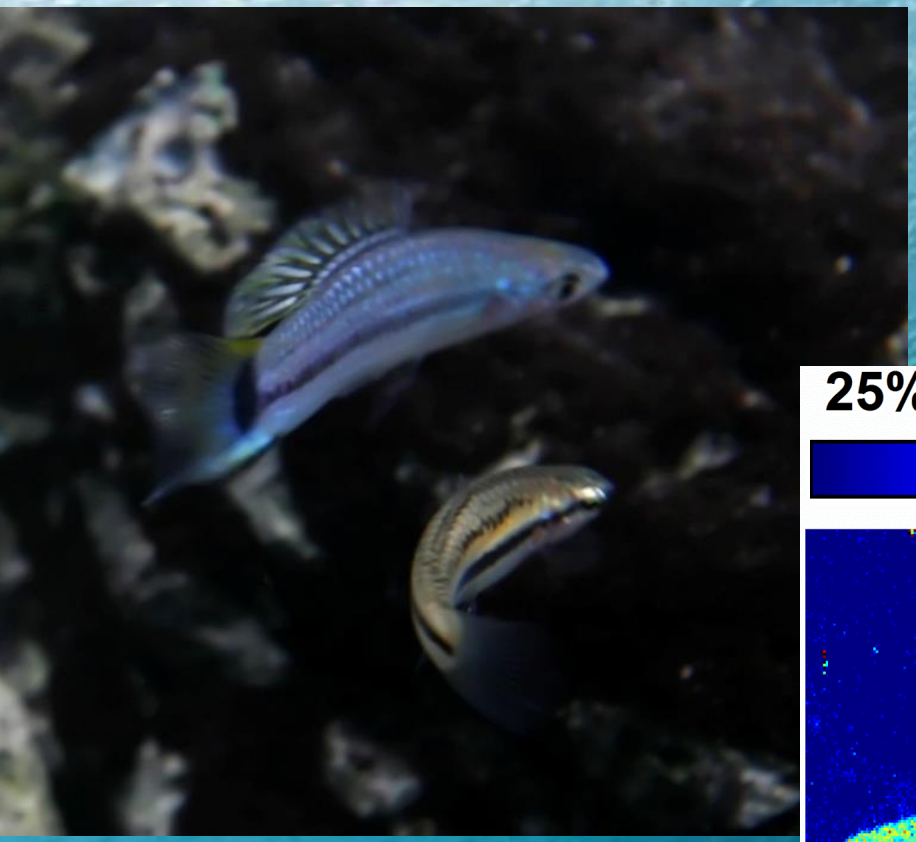


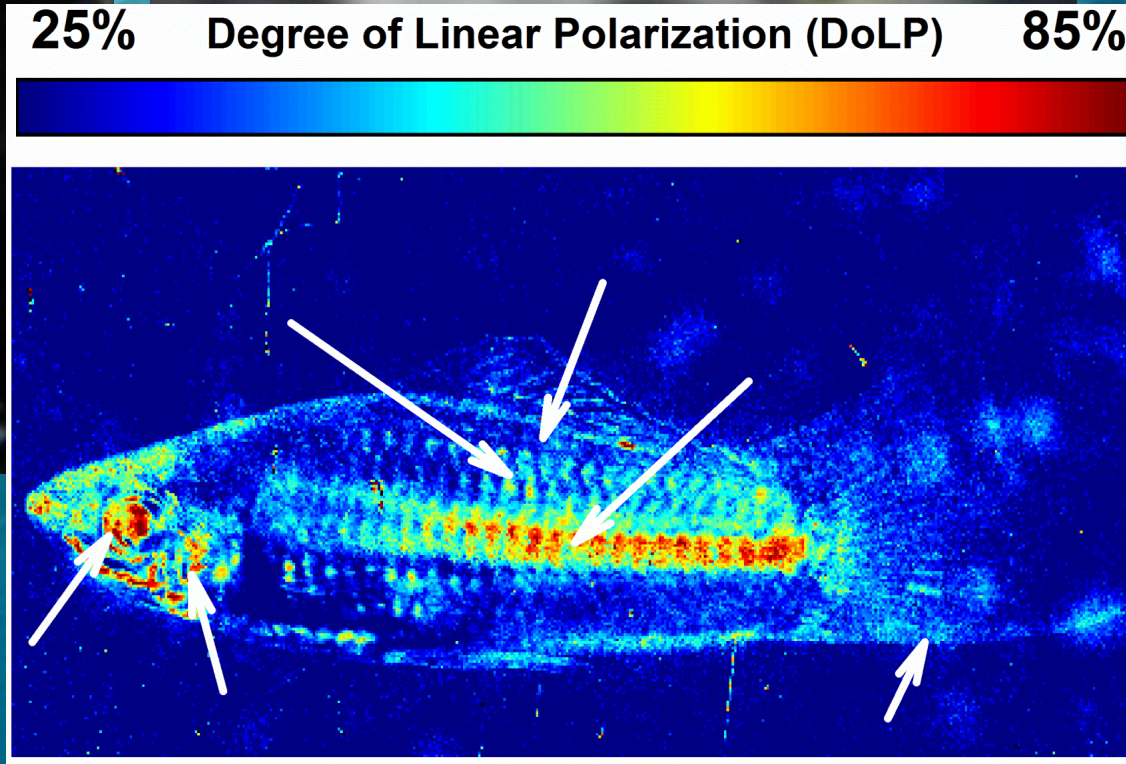
Two places on earth where light is LARGELY polarized

What if YOU could see polarized light?

Many animals can see polarized light

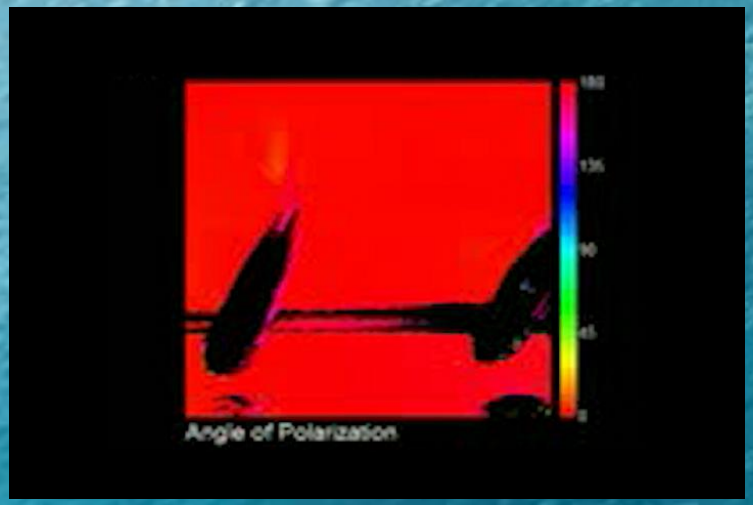
and some use it to communicate



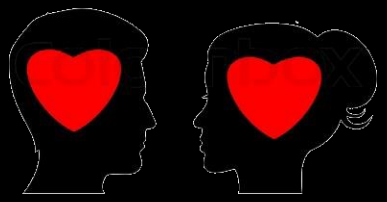


MANY animals can see polarized light

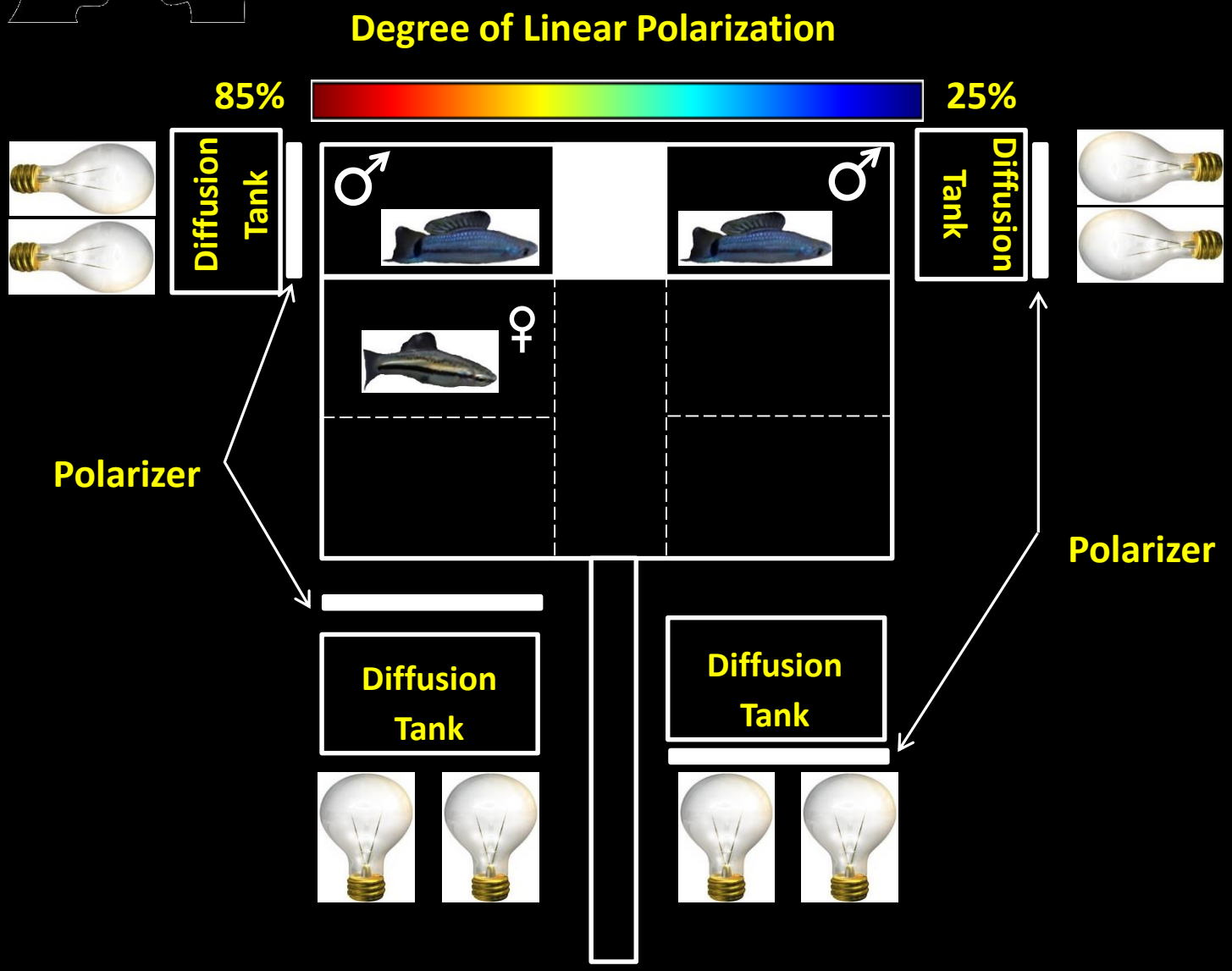
& some use it to communicate

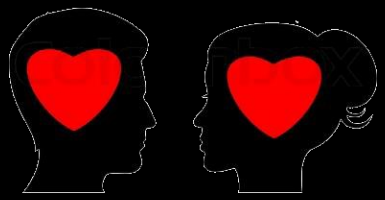


Video: Viktor Gruev



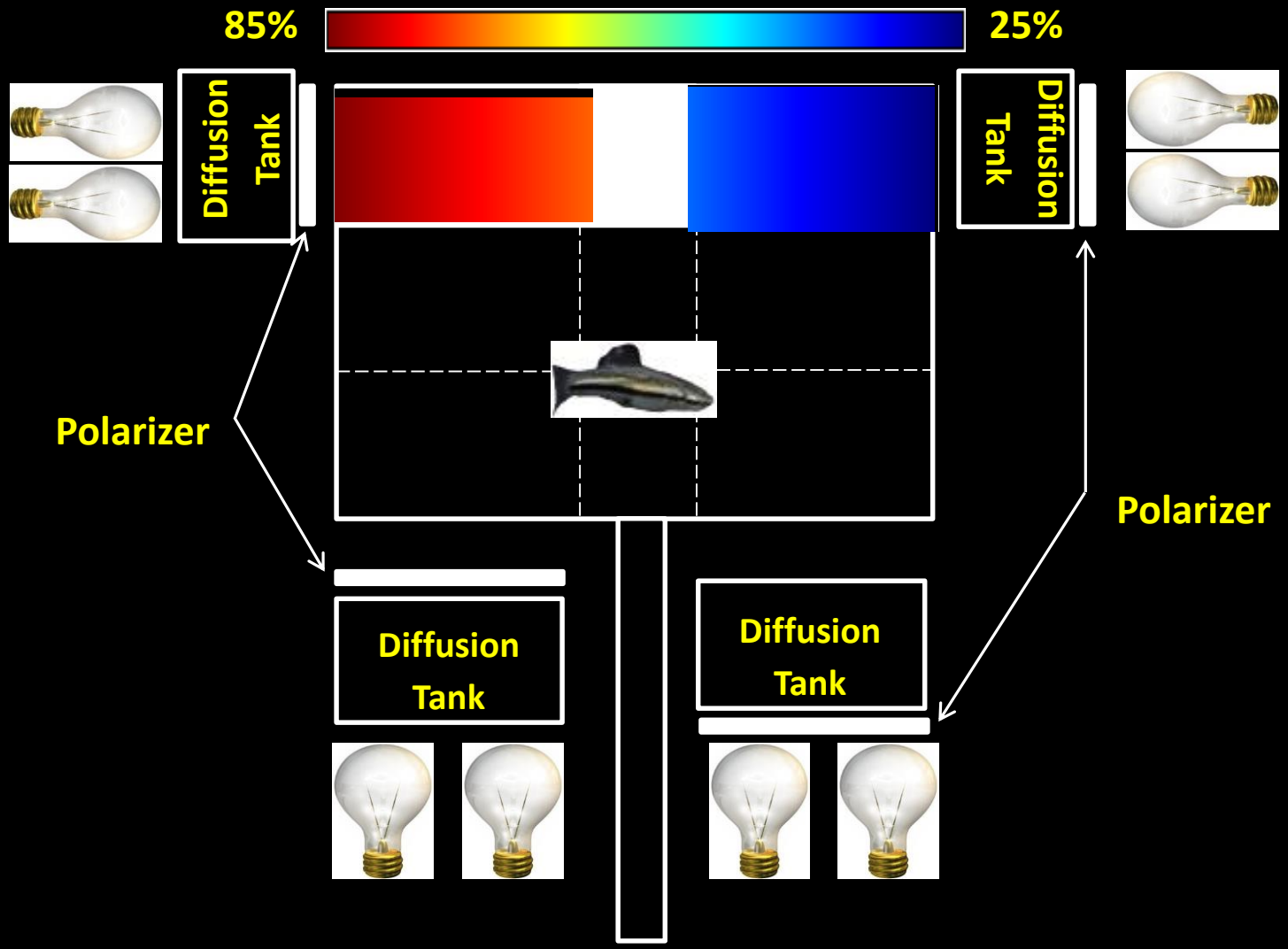
SEXUAL SELECTION

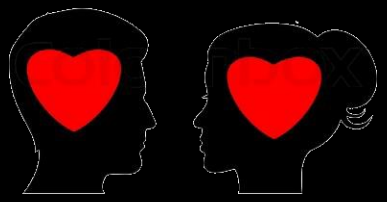




SEXUAL SELECTION

Degree of Linear Polarization





SEXUAL SELECTION

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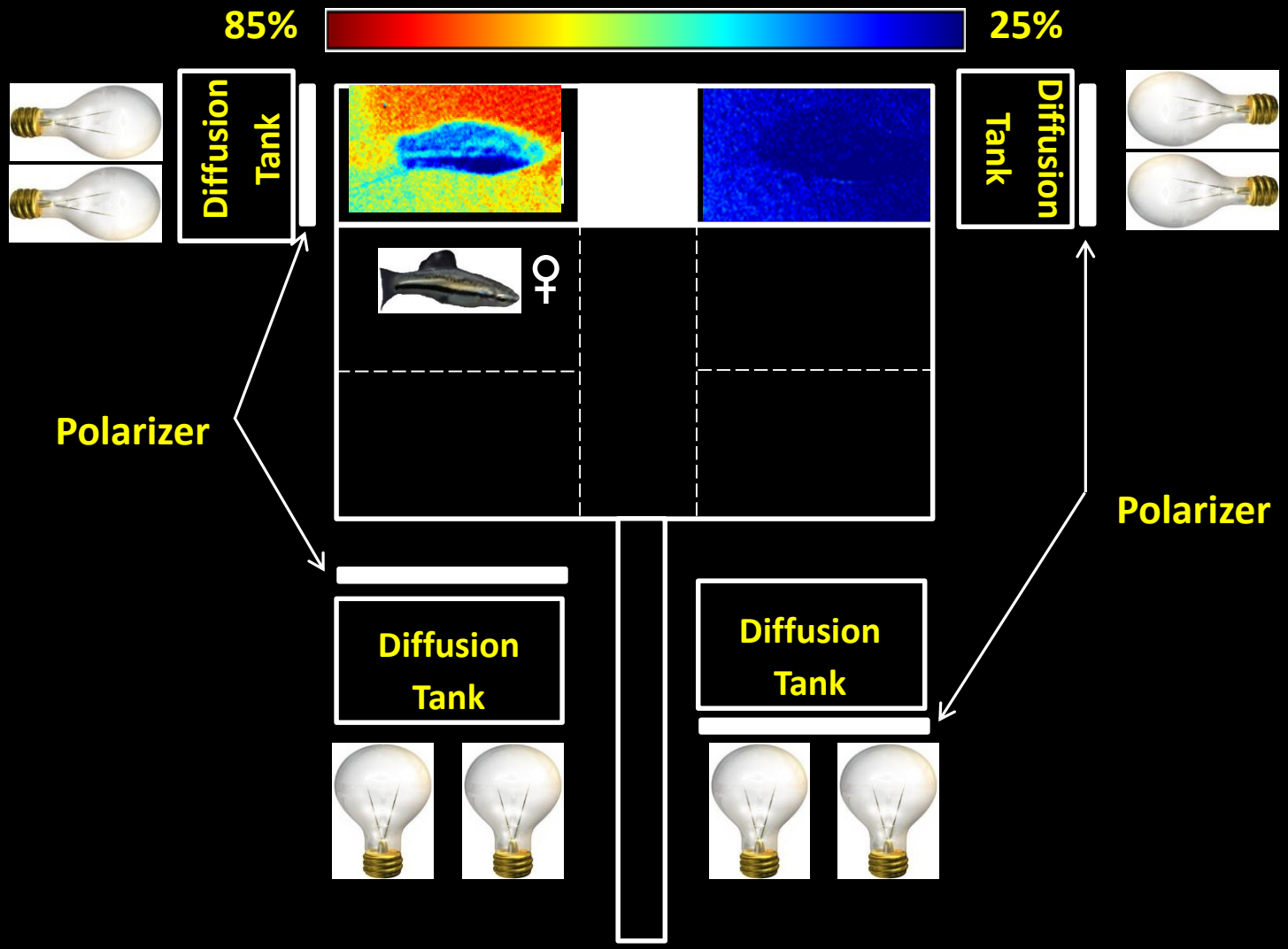
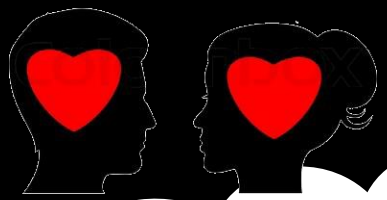
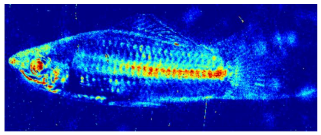


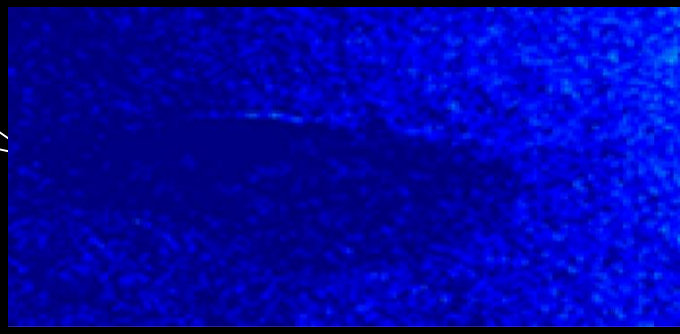
SEXUAL SELECTION



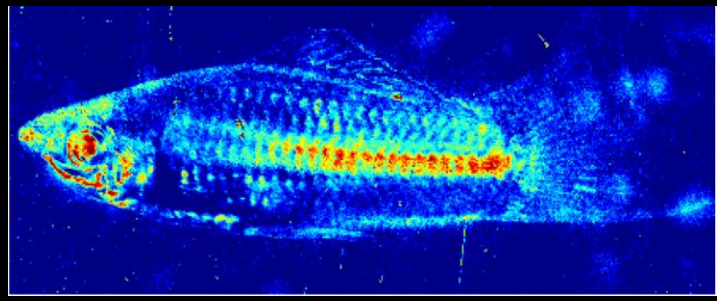
What a Handsome Polarized Gentleman



Hey Baby



Hey Baby



25% Degree of Linear Polarization (DoLP) 85%

Females prefer males with *polarized ornamentation*

Why the grand diversity in color?

Natural Selection

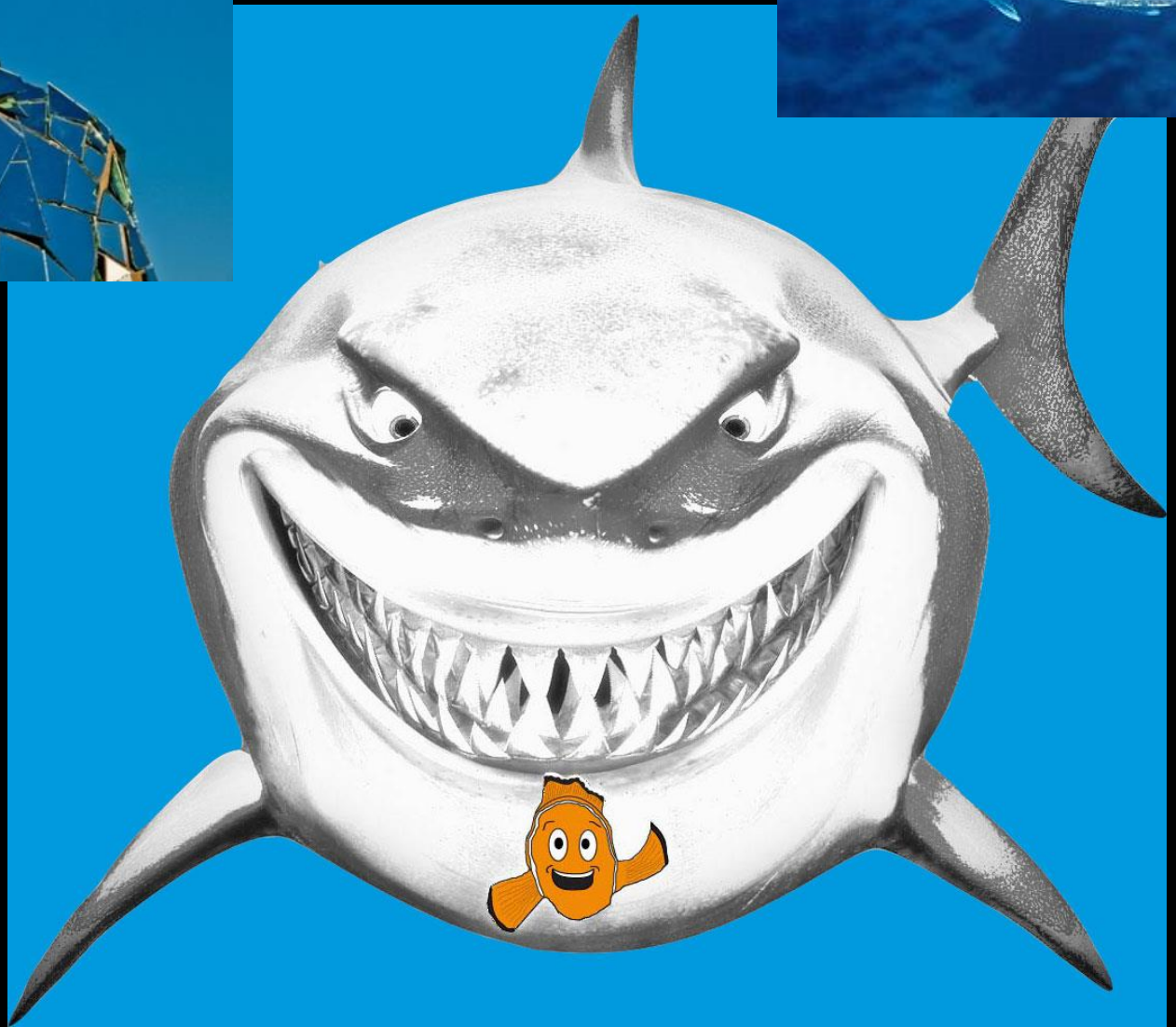
To hide…….

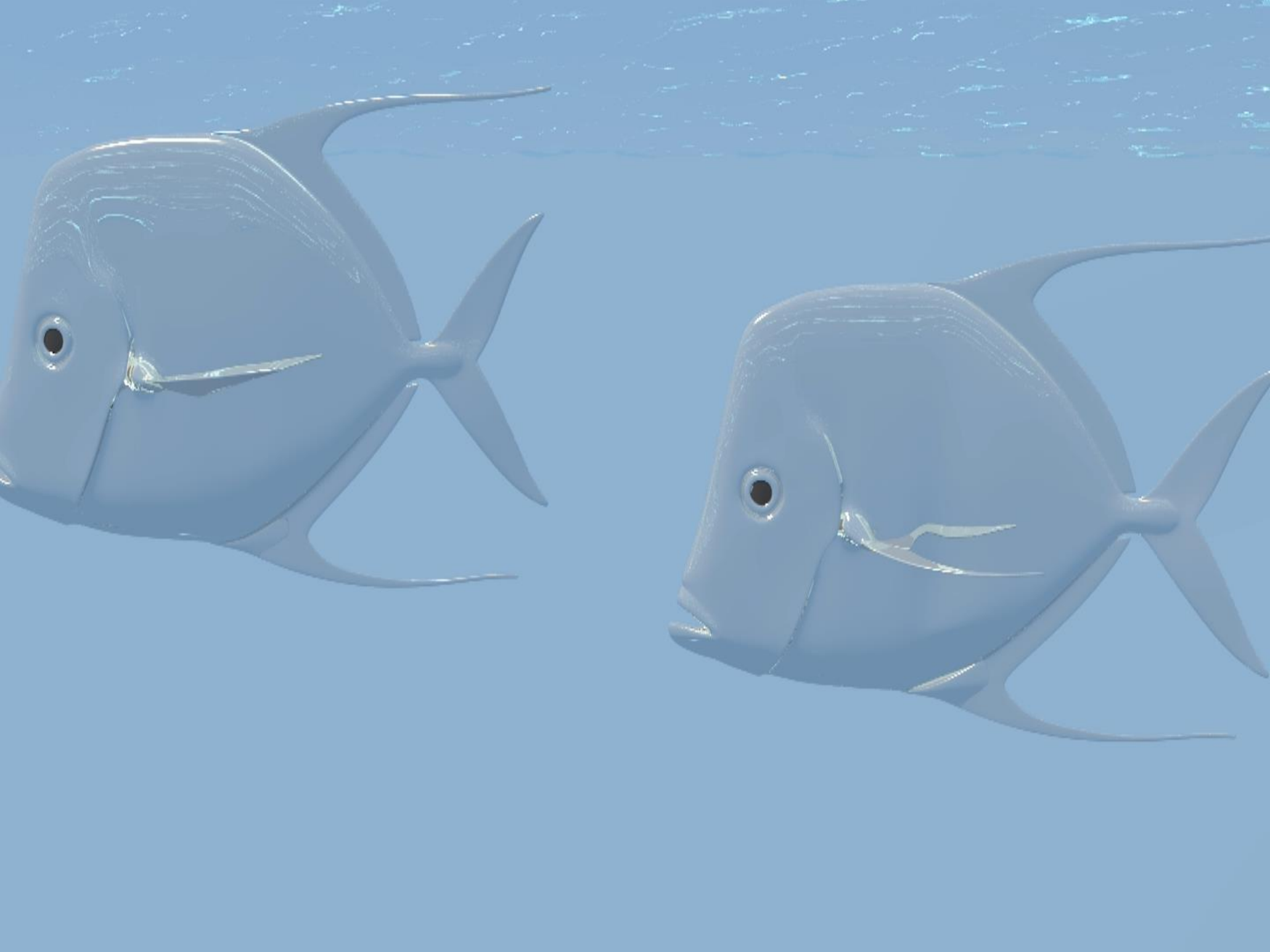
- **<u>Hide (not be detected)</u>**

Why the grand diversity in color?

Natural Selection

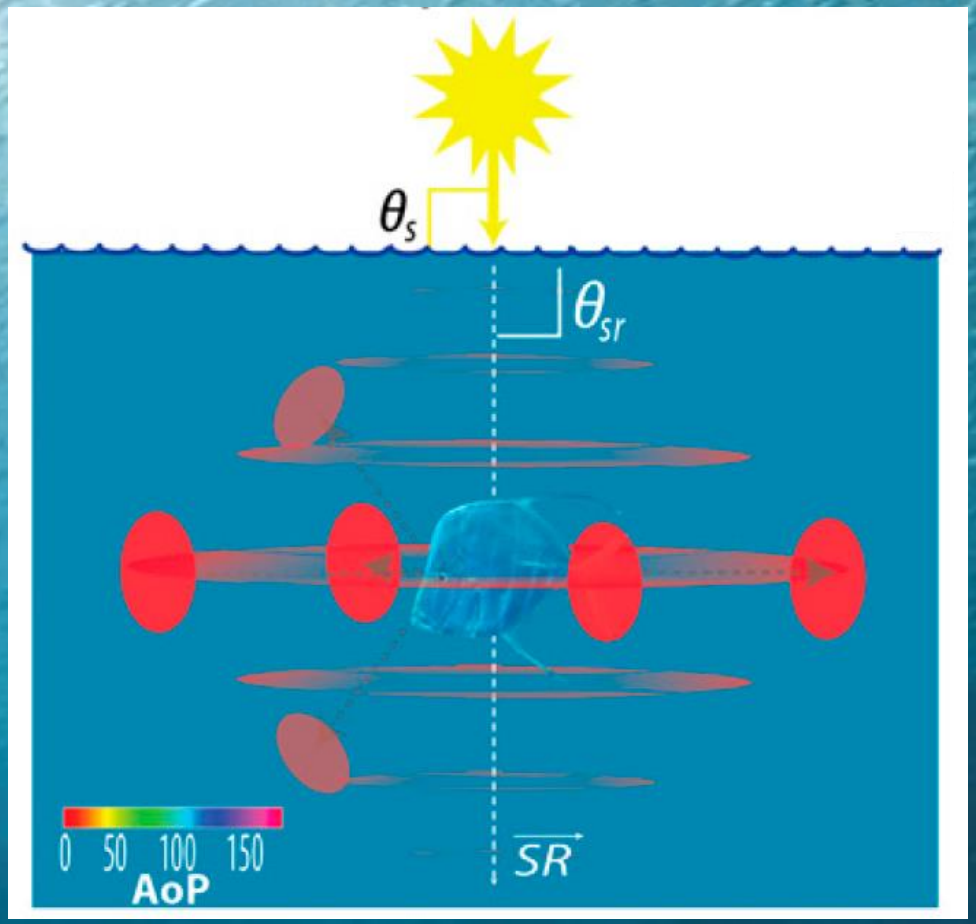
NATURAL SELECTION





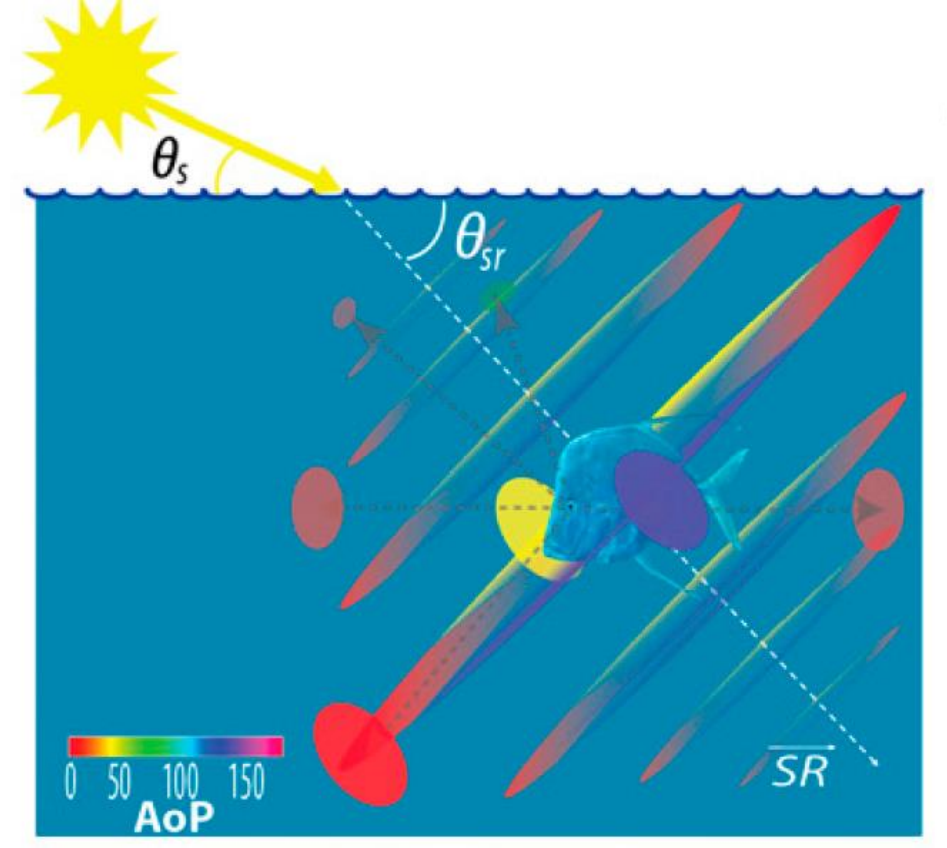
How do you hide in the polarized light field of the open ocean?

- High Noon=== Easy==act like a mirror

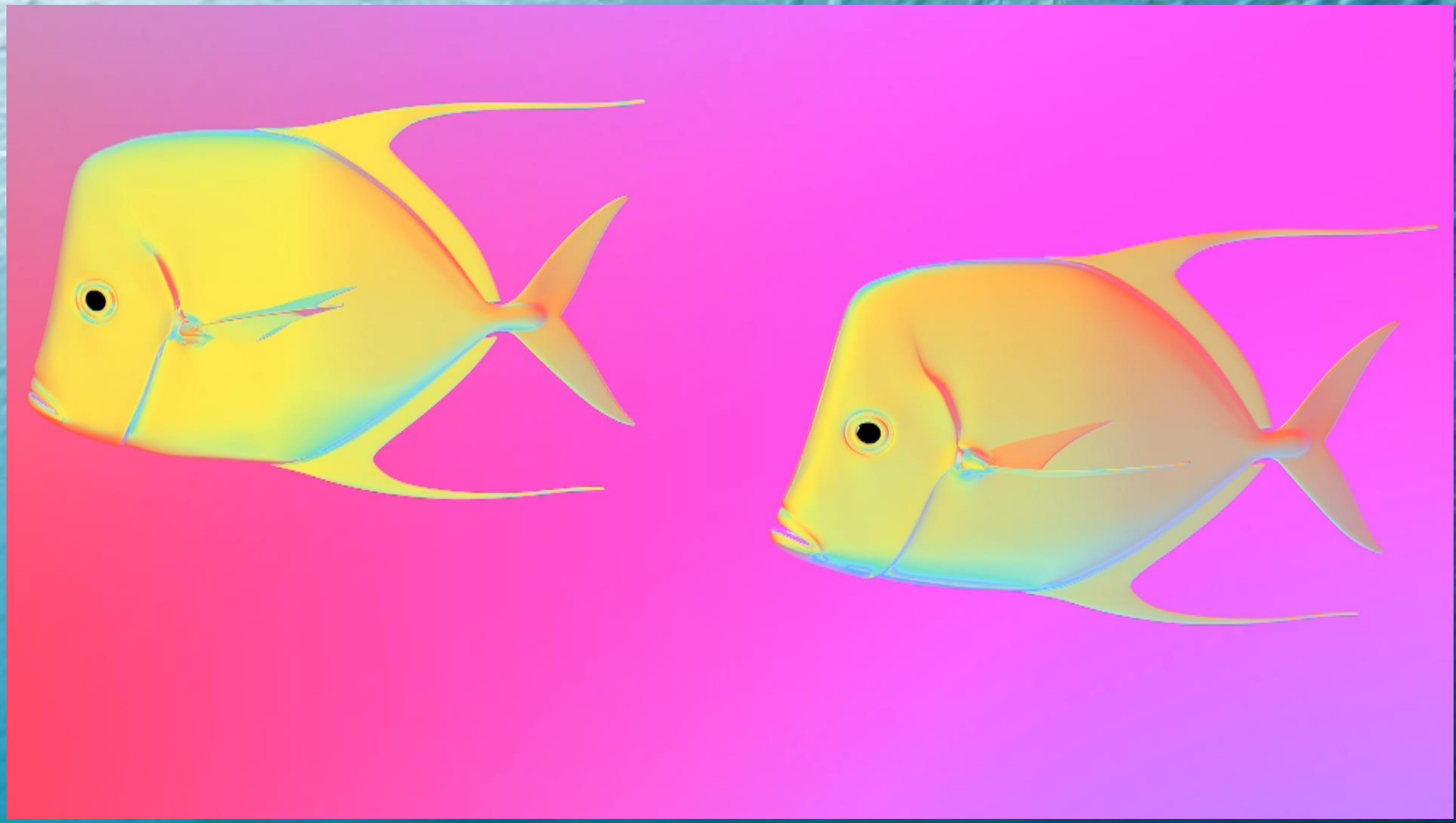


How do you hide in the polarized light field of the open ocean?

- Sunset=== More Complex==Mirror won't work

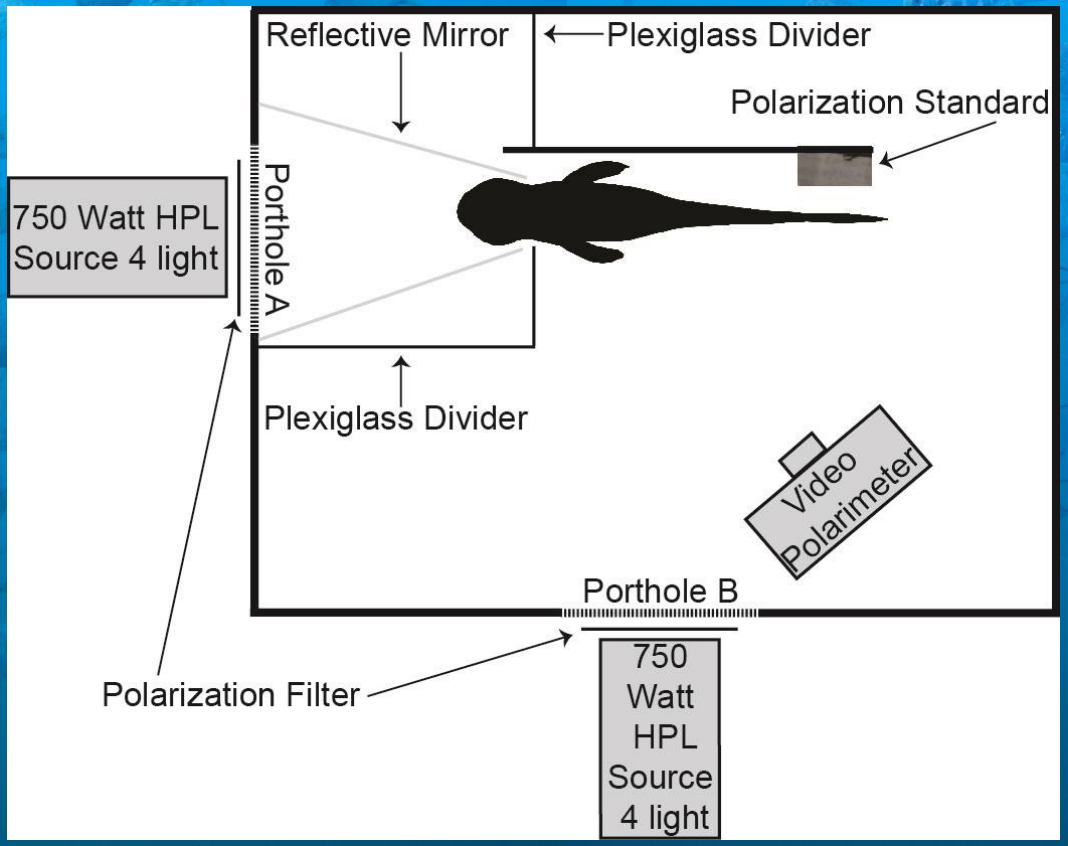


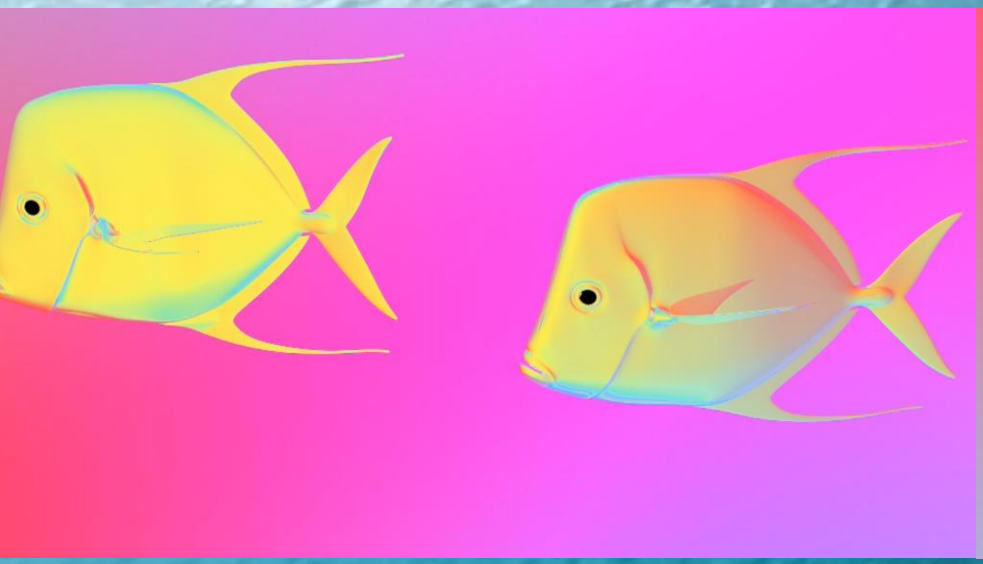
Brady et al 2013



Has nature conquered this problem?

- (1) Build a Videopolarimeter (Dr. Parrish Brady)
- (2) Go SCUBA diving with it
- (2) Measure fish

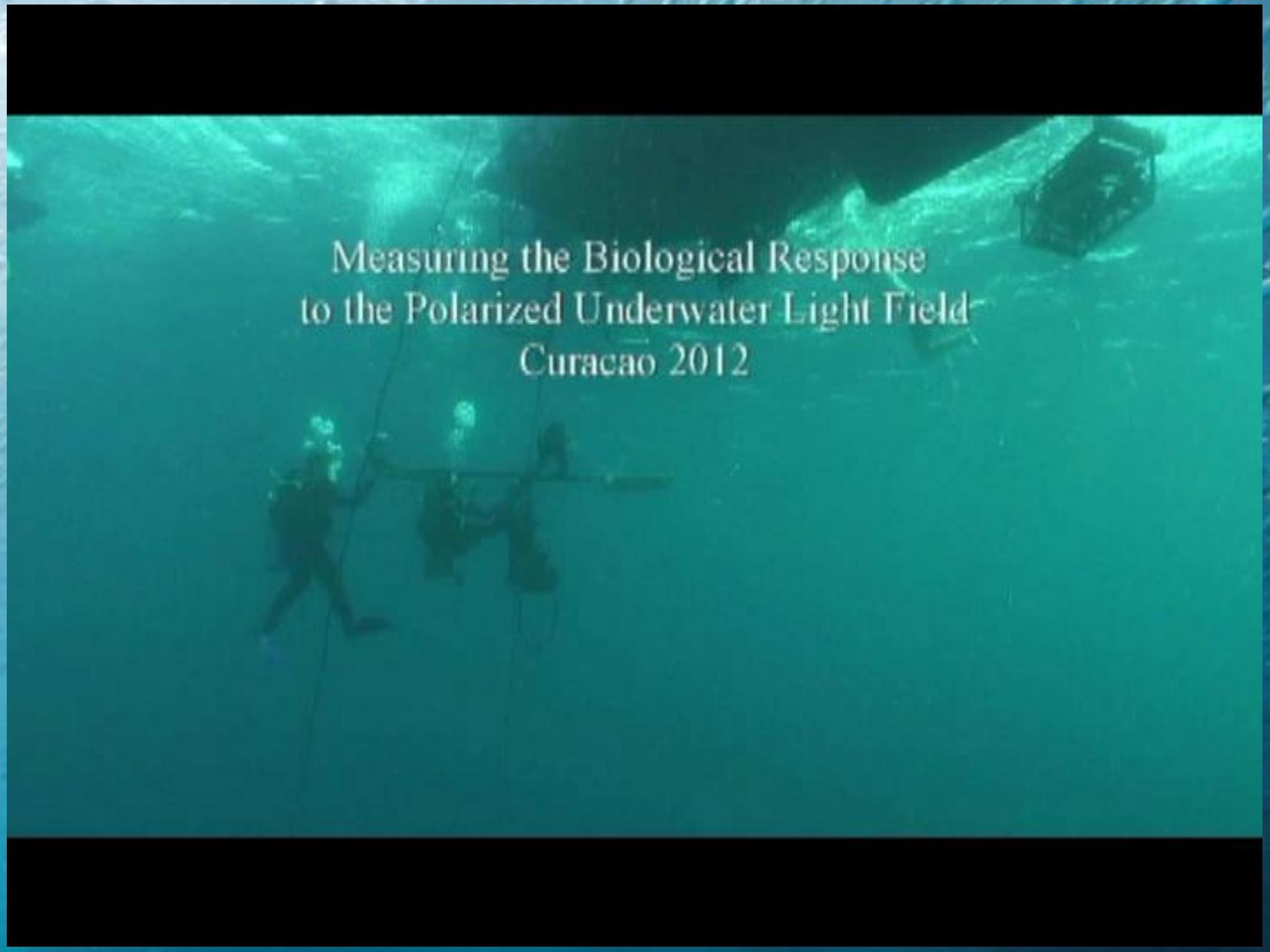

Reflective Mirror
Plexiglass Divider
Polarization Standard
750 Watt HPL Source 4 light
Porthole A
Plexiglass Divider
Video Polarimeter
Porthole B
Polarization Filter
750 Watt HPL Source 4 light

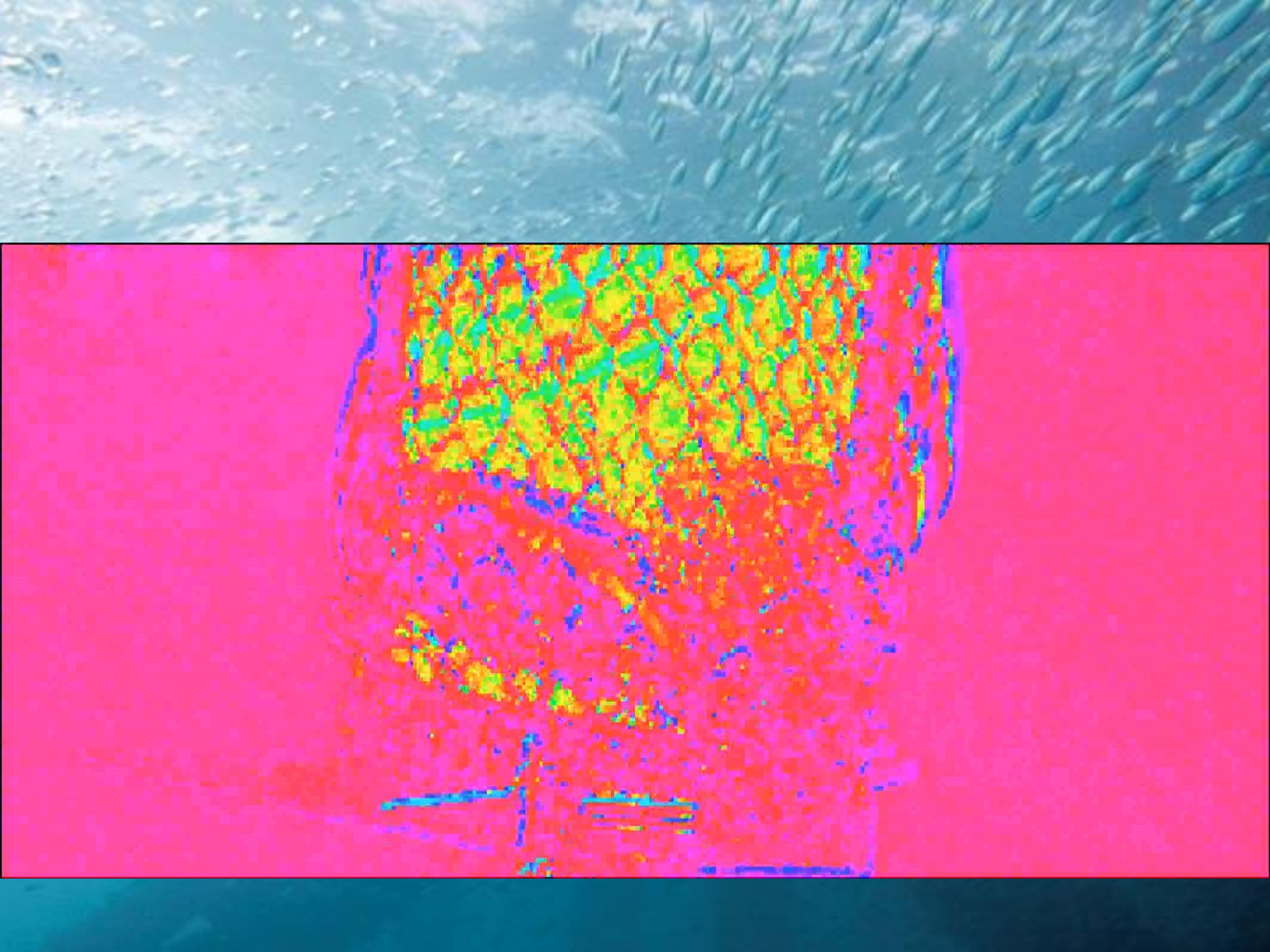


Mirror

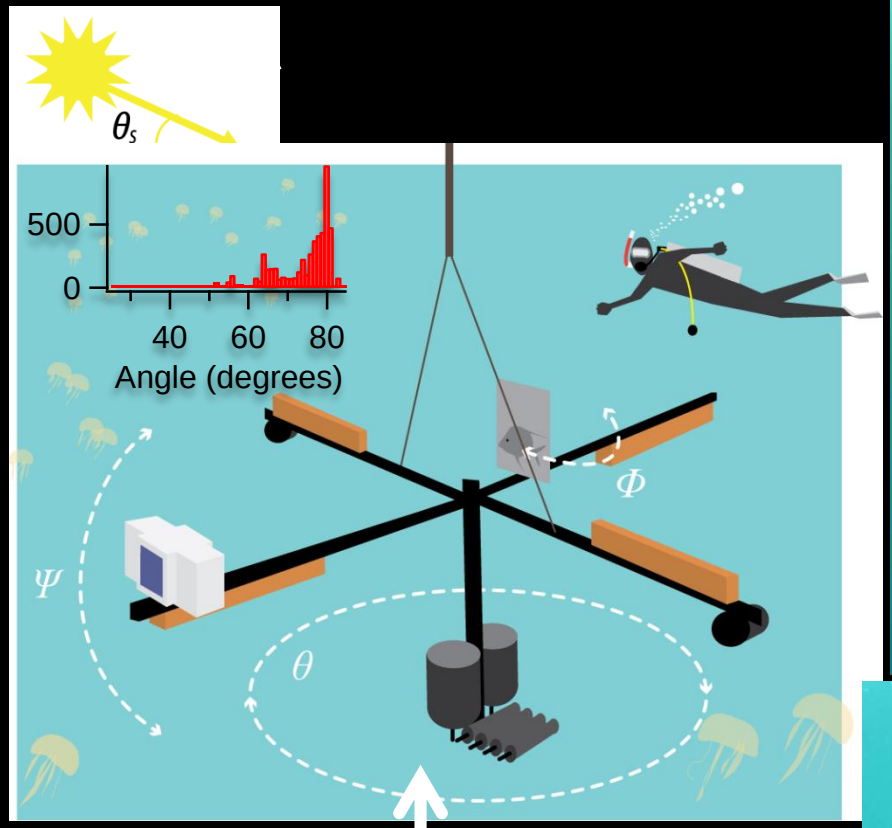
Lookdown

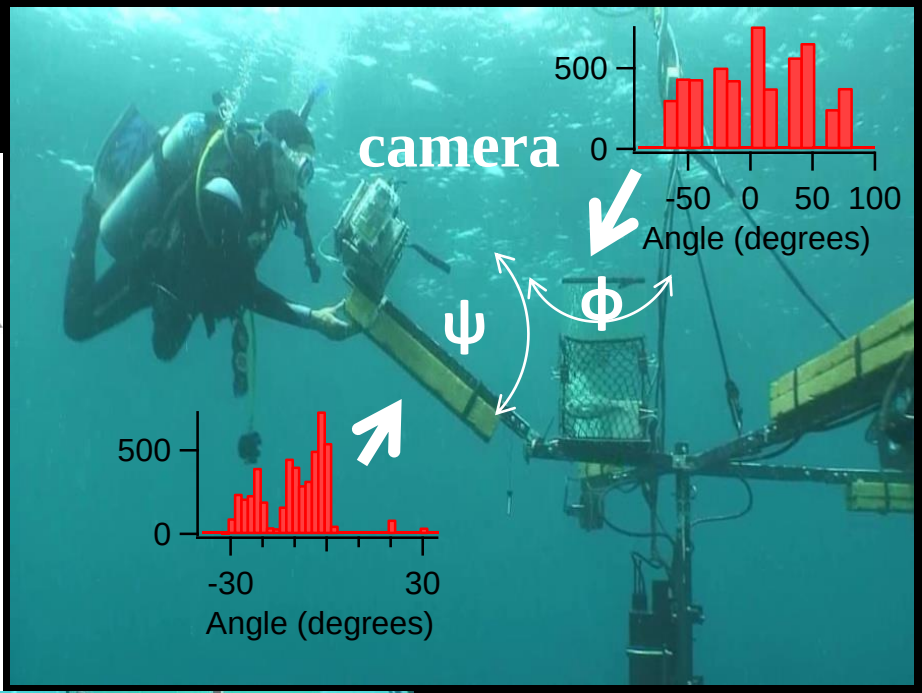
Field measurements in the Florida Keys and in Curaçao

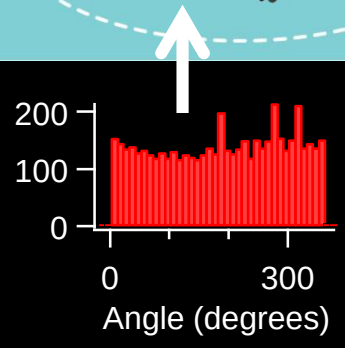

Measuring the Biological Response
to the Polarized Underwater Light Field
Curacao 2012

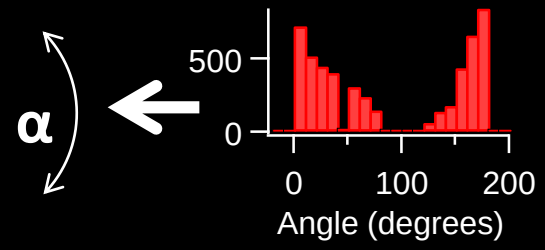


We took 1000s of measurements



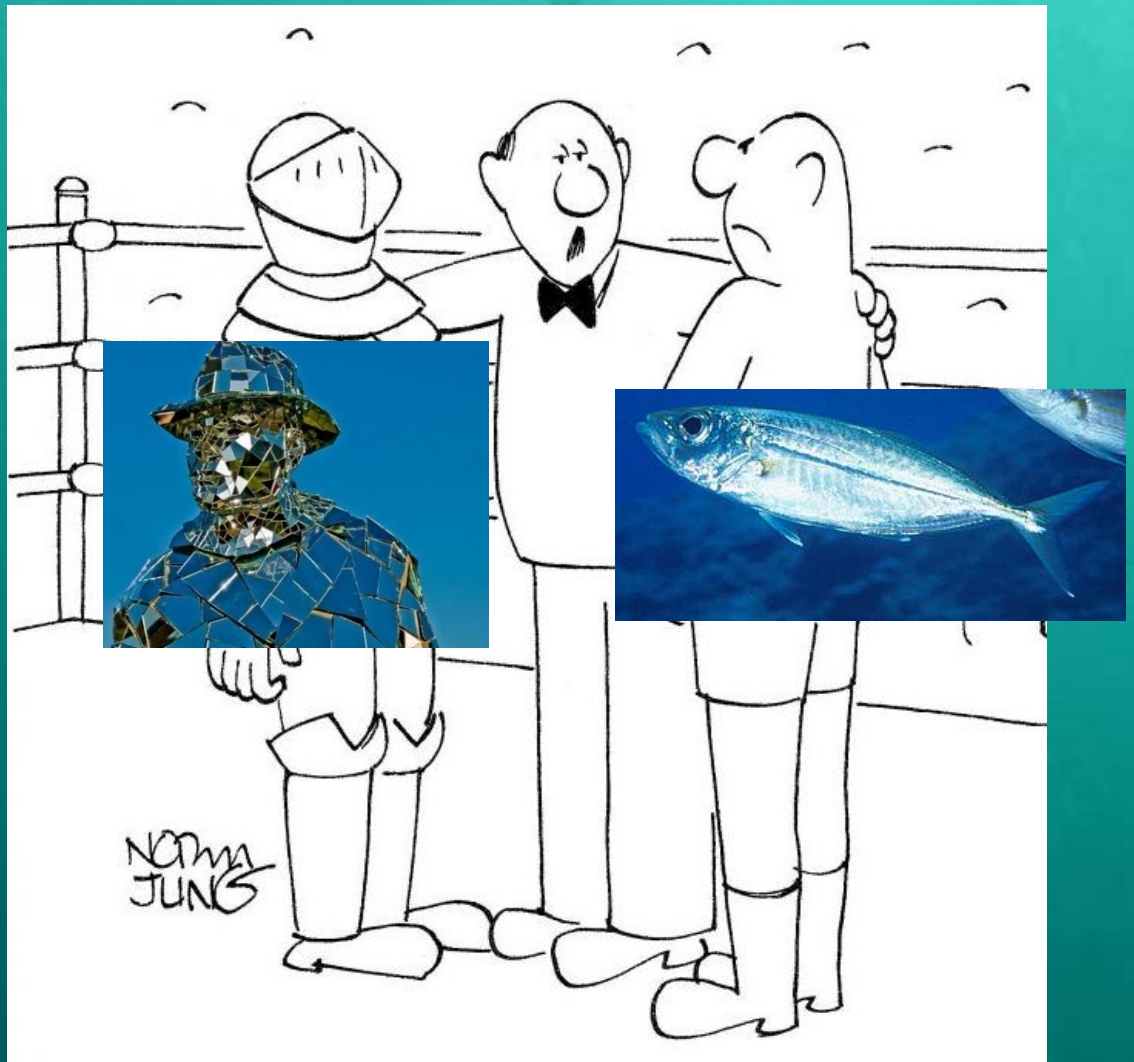






NATURAL SELECTION

Who is going to win the Camouflage Contest?
Mirror vs Fish



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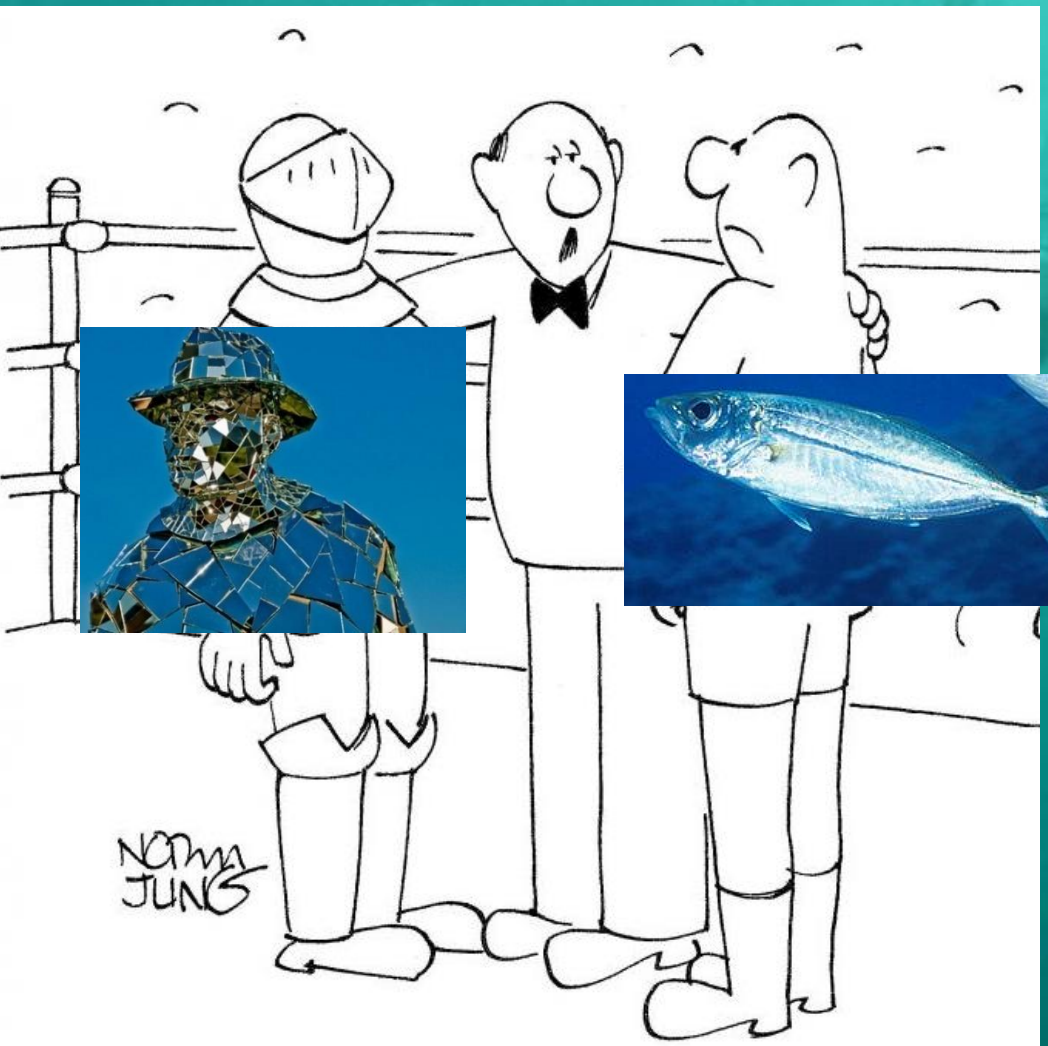
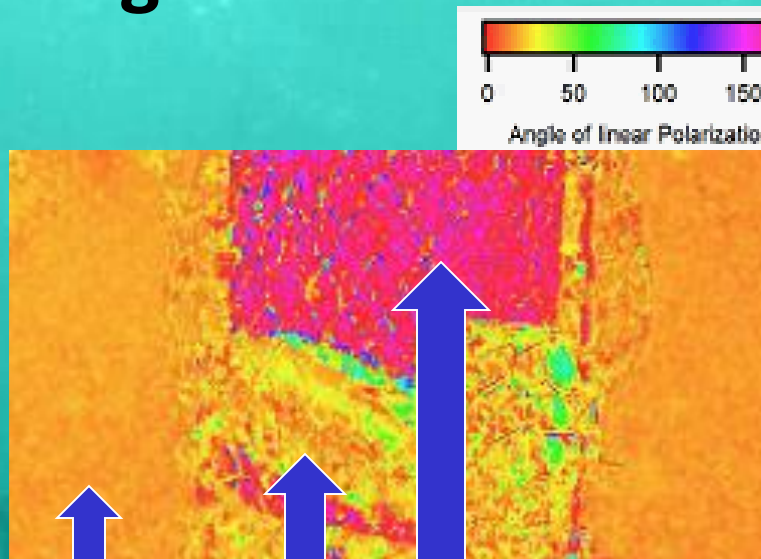
Mirror vs Fish





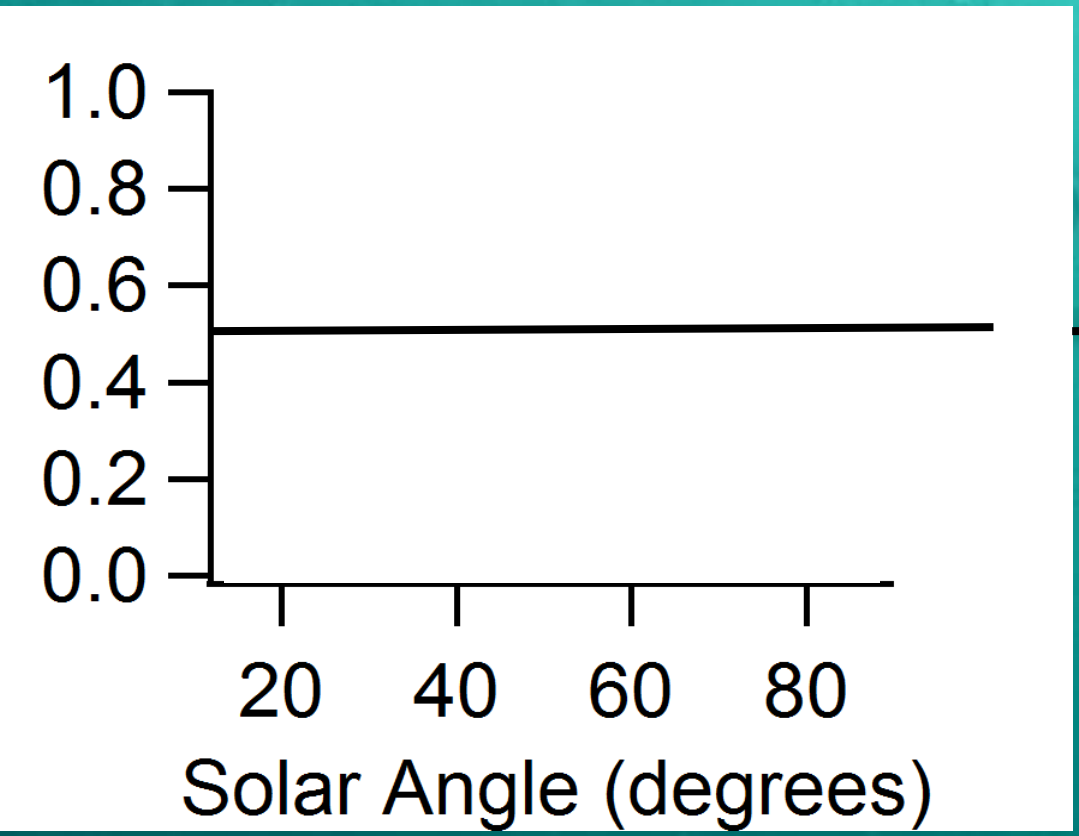
Fish

Mirror

Background

NATURAL SELECTION

Who is going to win the Camouflage Contest?
Fish vs Mirror



Fish WINS!

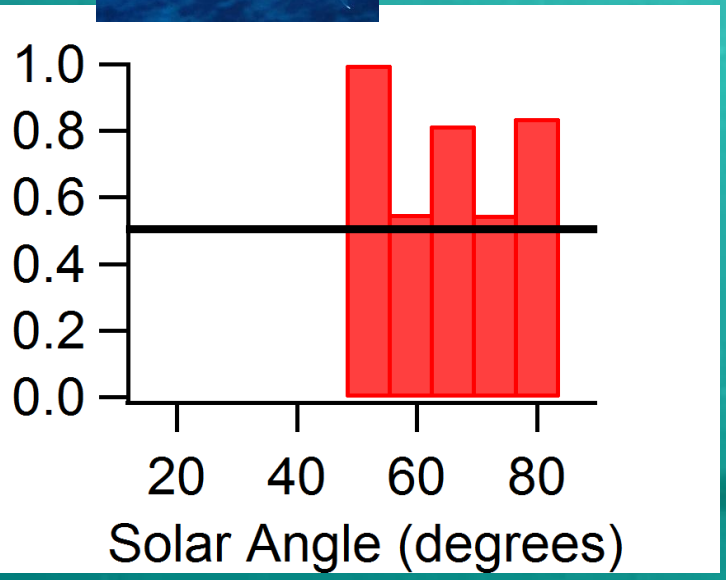
Mirror Man WINS!

NATURAL SELECTION

And the Winner is……

NATURAL SELECTION

And the Winner is..... The FISH!!!



Why the grand diversity in color?

- To communicate with Predators?

- To hide from Predators?

- To communicate to others of its own kind?

- Some combination of all three!


THANK YOU
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Dr. Molly Cummings

Molly Cummings is a professor at UT Austin. Her research examines how communication traits evolve in animals, using fieldwork and behavior experiments to discover what drives such communications. She has initiated studies examining how animals achieve crypsis in a dynamically changing aquatic environments at a molecular level, and with particular emphasis on the polarized light field. Her lab is also developing experimental techniques to characterize real-time dynamic camouflage in the lab and field as well as identify the internal coordination of the cells involved in orchestrating camouflage (melanophores, chromatophores and iridophores) along with the neutral color of their movements.