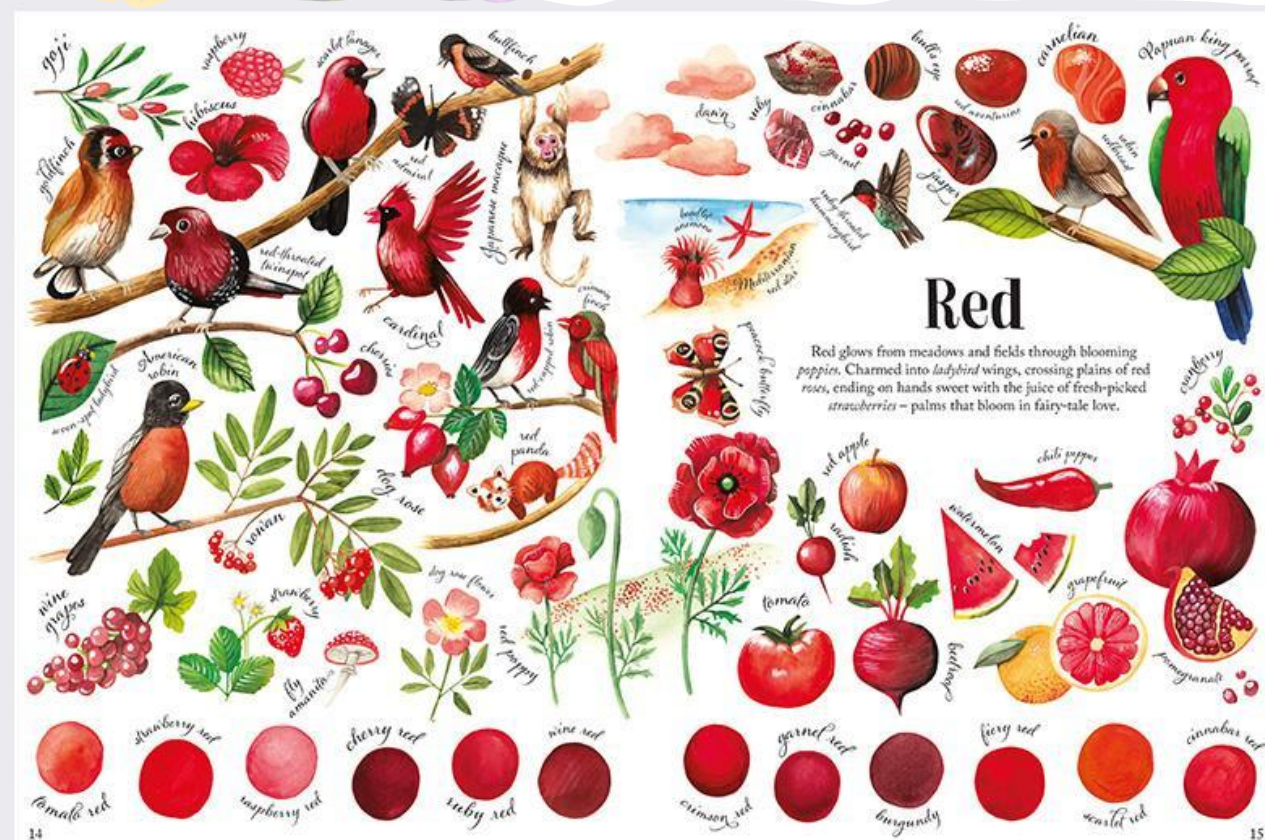


Colored Proteins for BIOART

Cholpisit (Ice) Kiattisewee
HTGAA Bootcamp
January 19th, 2026



Colors in Nature



Compounds or Structural



Chlorophyll

Xanthophyll

Carotene


Anthocyanin

Tannins

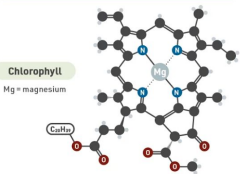
Compounds or Structural

The Chemistry of Autumn Leaf Colours

GI COMPOUND INTEREST




Chlorophyll



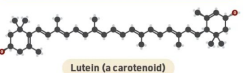
Chlorophyll
Mg = magnesium

KEY: ● Carbon ● Oxygen ● Nitrogen ● Hydrogen

Chlorophyll gives plant leaves their green colour. Plants require warm temperatures and sunlight to produce chlorophyll. In autumn, the amount produced begins to decrease and existing chlorophyll is slowly broken down, diminishing the green colour of the leaves.




Carotenoids and flavonoids




Lutein (a carotenoid)

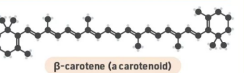
Carotenoids and flavonoid pigments are always present in leaves, but as chlorophyll is broken down in the autumn their colours come to the fore. Xanthophylls, a subclass of carotenoids, are responsible for the yellows of autumn leaves. A major xanthophyll, lutein, is also the compound that contributes towards the yellow colour of egg yolks.



Flavonol
Flavone
General structures shown

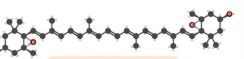


Carotenoids




β-carotene (a carotenoid)

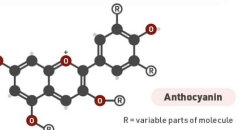
Carotenoids also contribute orange colours. Beta-carotene is one of the most common carotenoids in plants, and absorbs green and blue light strongly, reflecting red and yellow light and causing its orange appearance. It is also responsible for the colour of carrots. Carotenoids in leaves start degrading at the same time as chlorophyll, but they do so at a much slower rate. Some fallen leaves can still contain measurable amounts.



Violaxanthin (a carotenoid)

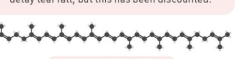


Anthocyanins & carotenoids



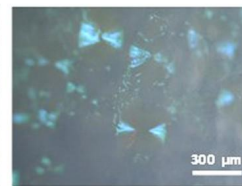
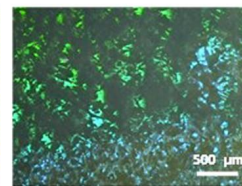
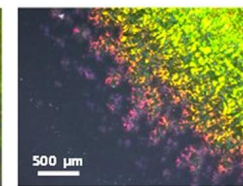
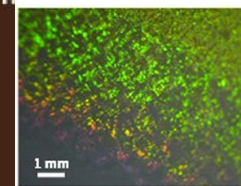
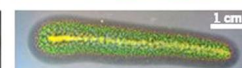
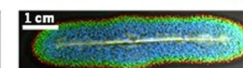
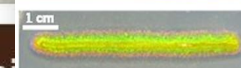
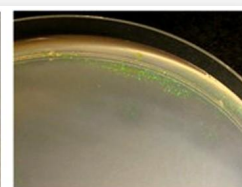
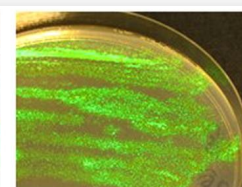
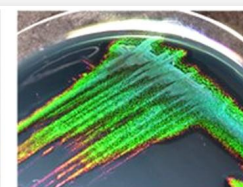
Anthocyanin
R = variable parts of molecule

Anthocyanin synthesis is kick-started by the onset of autumn. As sugar concentration in the leaves increases, sunlight initiates anthocyanin production. The purpose anthocyanins serve isn't clear, but it is suggested that they may play a light-protective role. It was thought they might delay leaf fall, but this has been discounted.



Lycopene (a carotenoid)

www.compoundchem.com © Andy Brunning/Compound Interest 2023 | Creative Commons Attribution-NonCommercial-NoDerivatives licence.



Chlorophyll

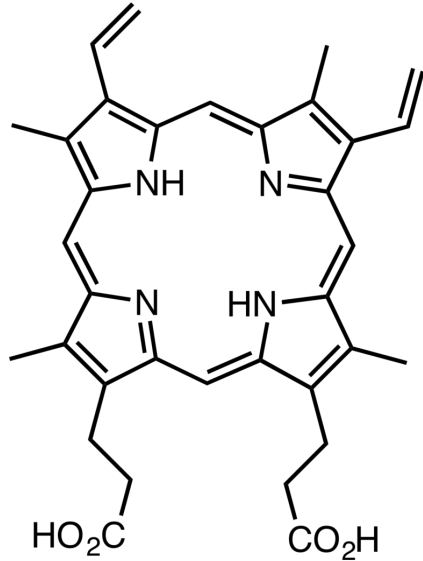
Xanthophyll

Carotene

Anthocyanin

Tannin

Pigments in Nature 1

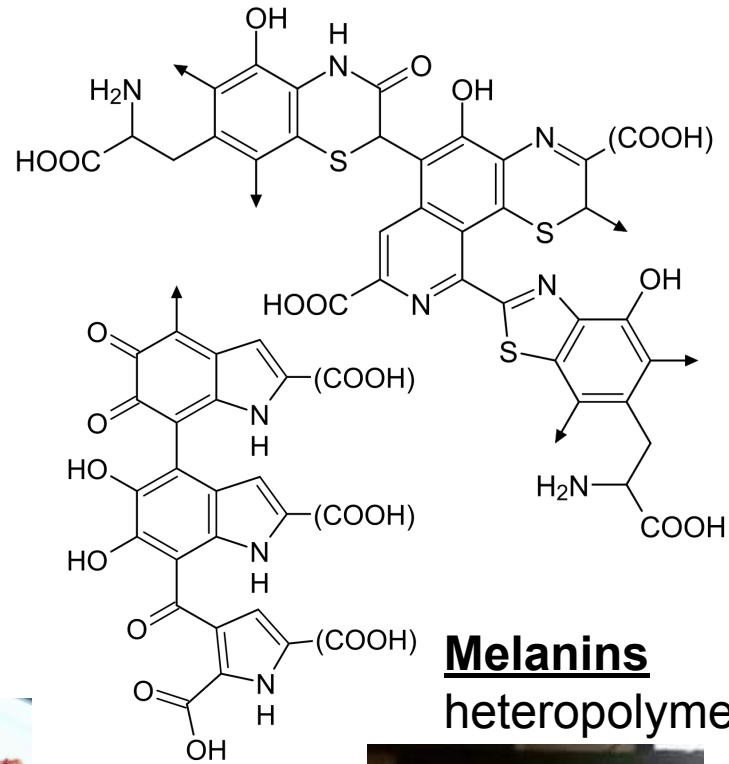


Porphyrin
core

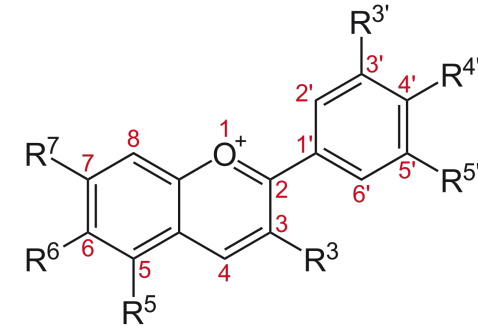


Mg^{2+}

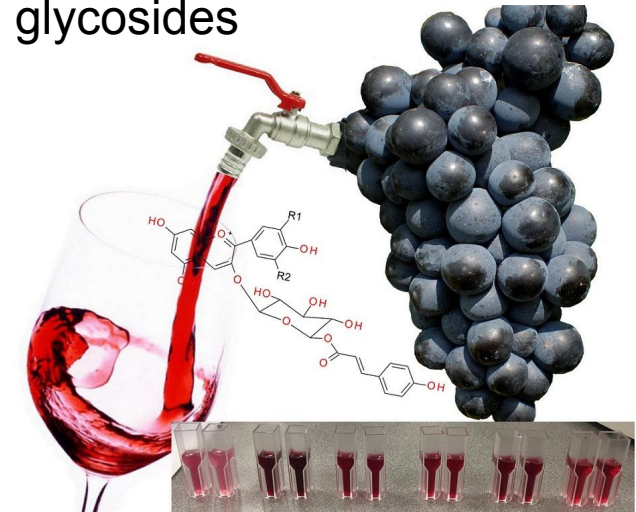
Fe^{2+}



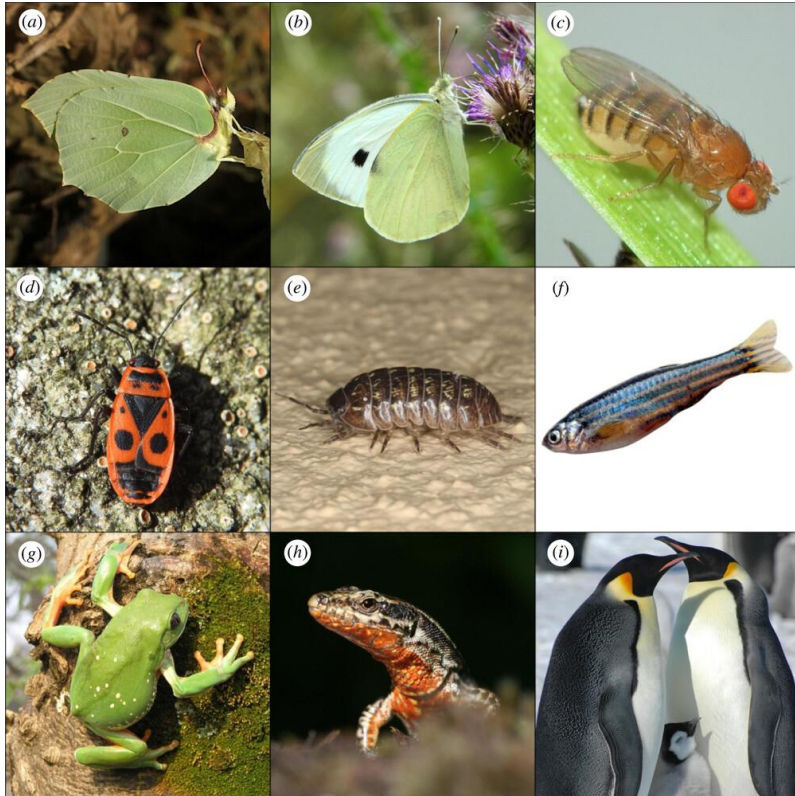
Melanins
heteropolymers



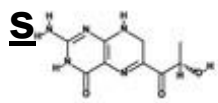
Anthocyanins
Flavonoids
glycosides



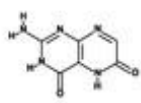
Pigments in Nature 2




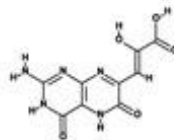
Pteridine




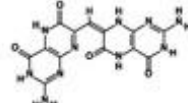
● **sepiapterin**



 xanthopterin



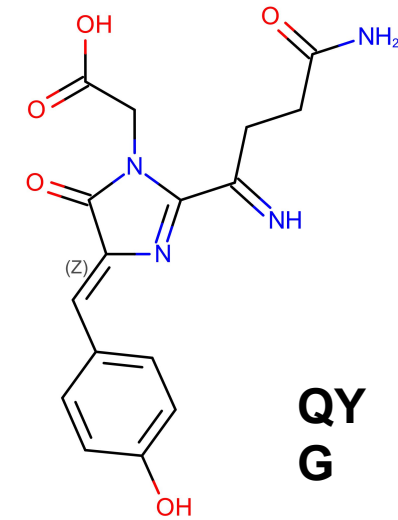
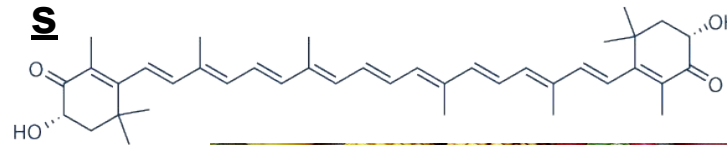
 erythropterin



● pterorhodin



Carotenoid



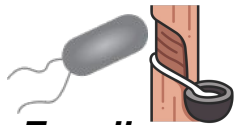
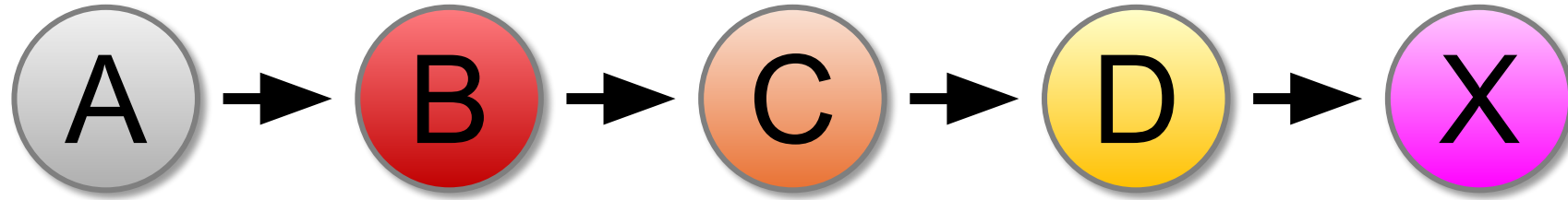
QY
G



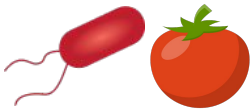
Stony coral
Acropora
millepora

RCSB PDB - CRQ

How Pigments were Synthesize



E. coli
+ *crtEB*
=
carotenoids



+ *crtL*
=
Lycopene



+ *crtY*
=
beta-Carotene



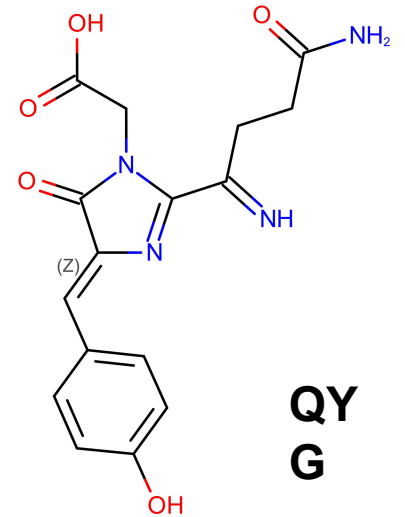
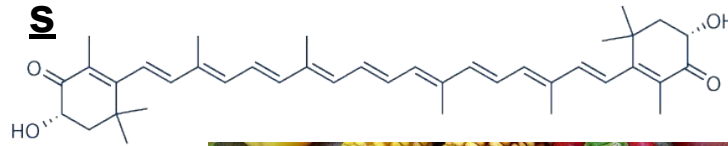
+ *crtZ*
=
Zeaxanthin



+ *crtW*
=
Astaxanthin



Carotenoid



QY
G



Stony coral
Acropora
millepora

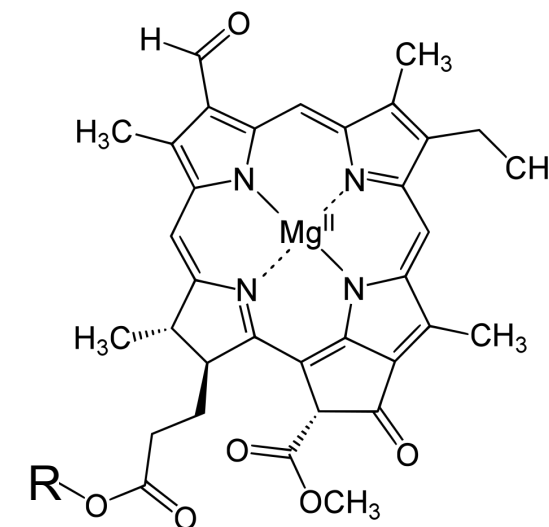
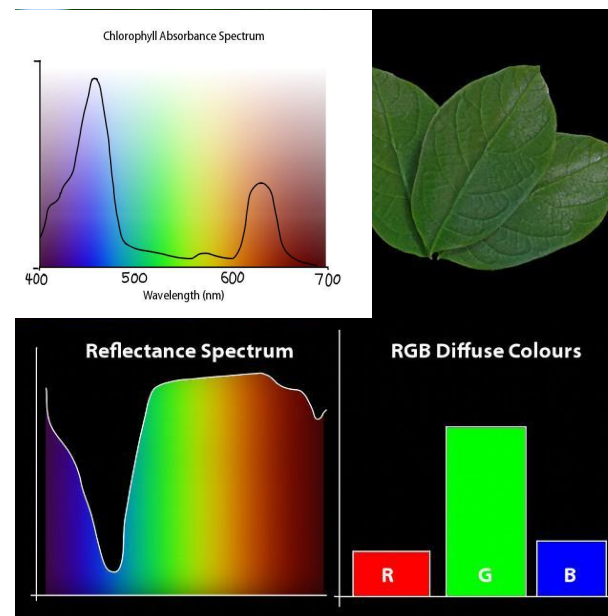
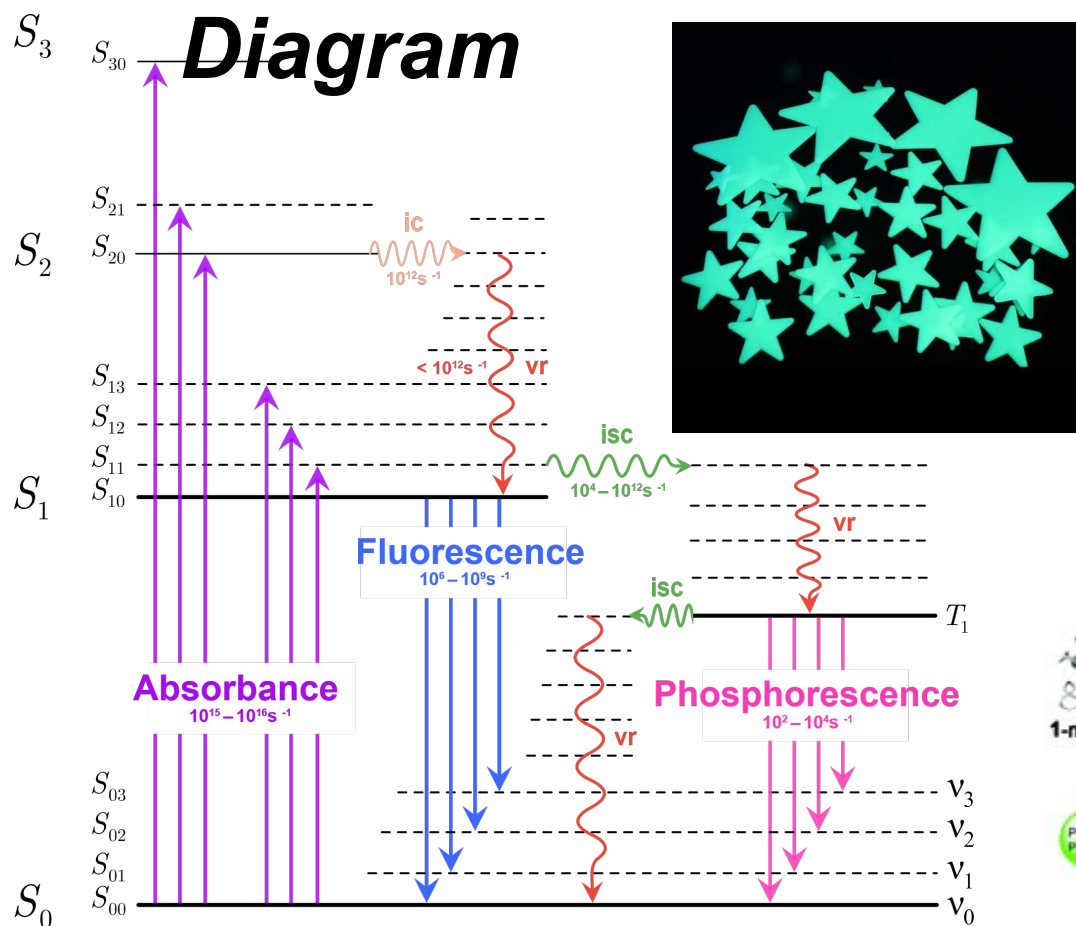
RCSB PDB - CRQ



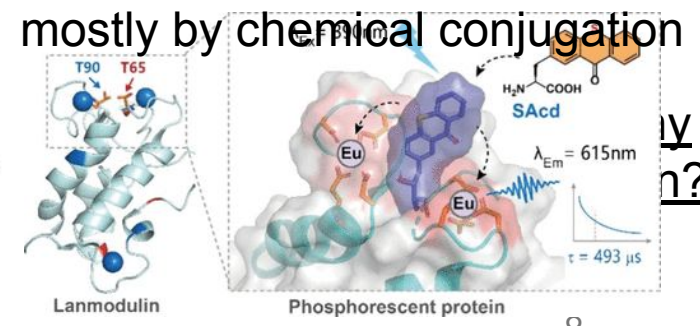
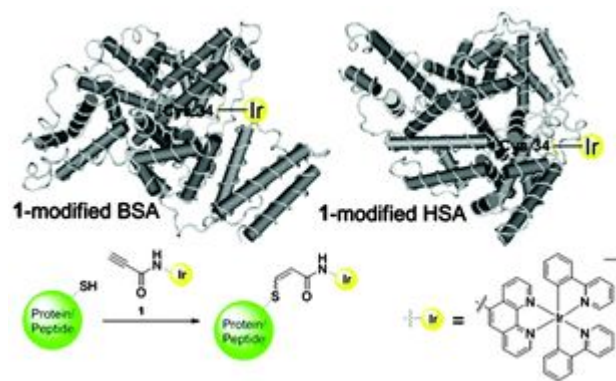
amilCP

Photochemistry and Colors

Jablonski Diagram



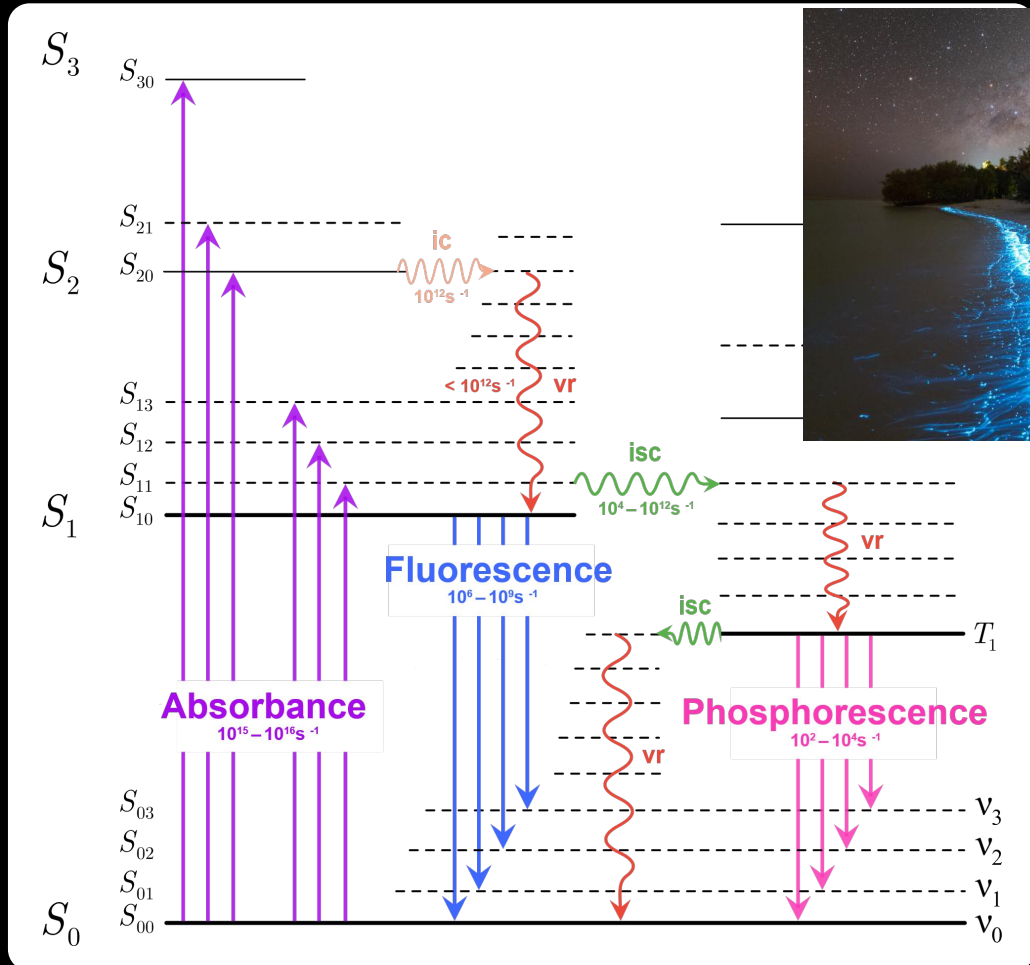
Reported Phosphorescent Proteins mostly by chemical conjugation



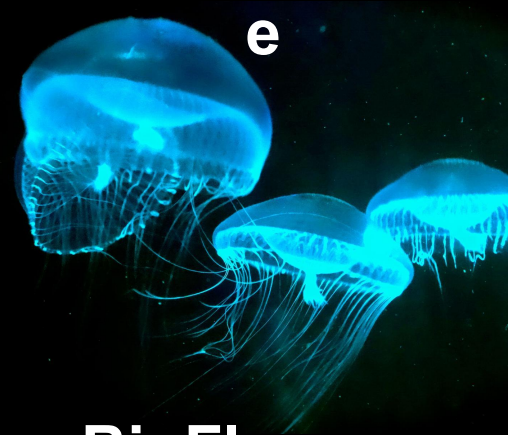
iv
n?

Photochemistry and Colors

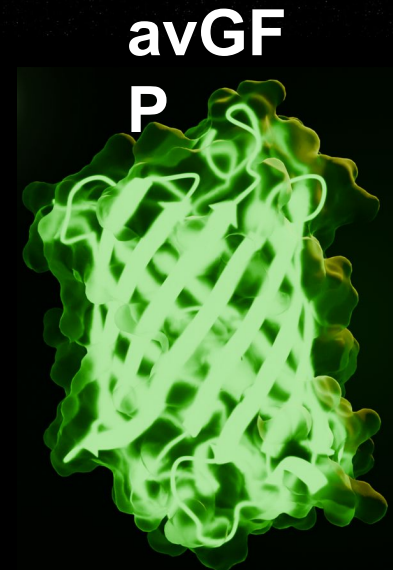
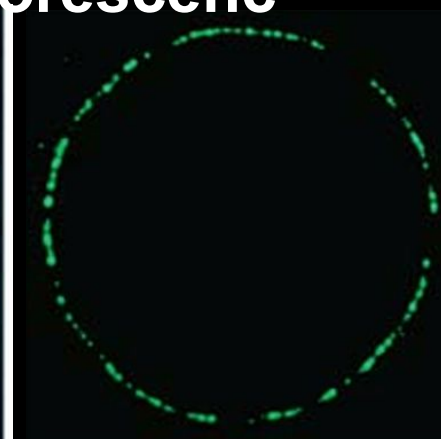
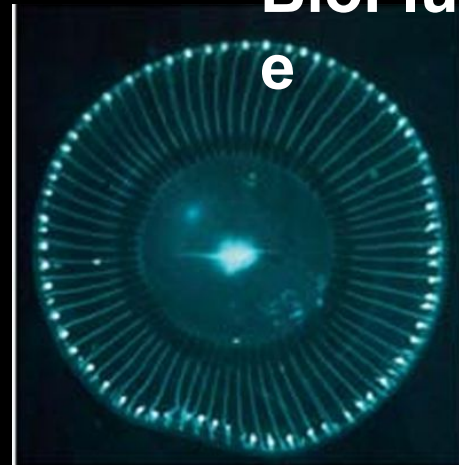
Jablonski



Bioluminescence

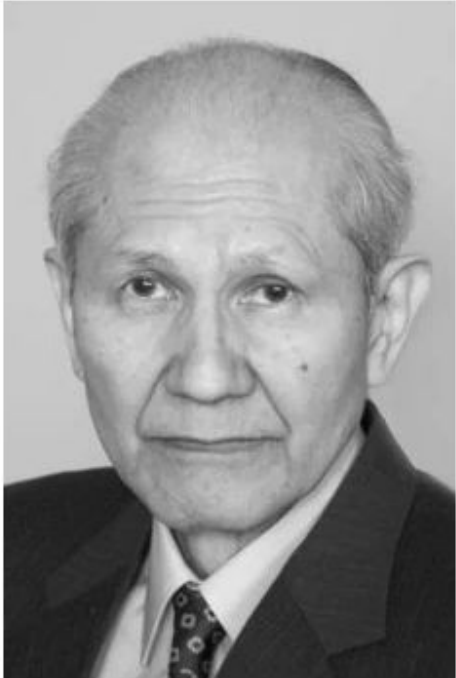


BioFluorescence



[Nobel Lecture by Osamu Shimomura](#)

Nobel Prize in Chemistry 2008



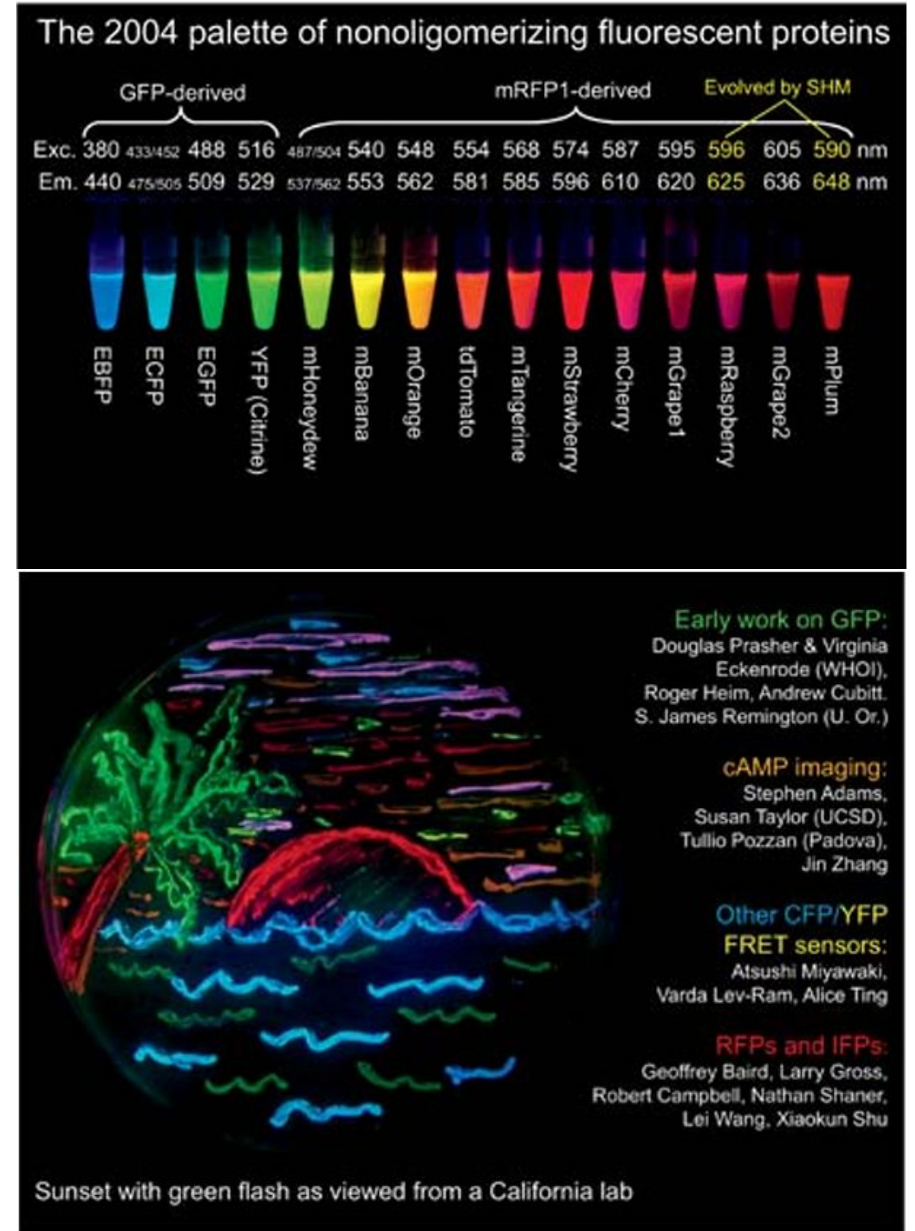
© The Nobel Foundation. Photo: U. Montan
Osamu Shimomura
 Prize share: 1/3



© The Nobel Foundation. Photo: U. Montan
Martin Chalfie
 Prize share: 1/3



© The Nobel Foundation. Photo: U. Montan
Roger Y. Tsien
 Prize share: 1/3



Structure of Green Fluorescent Protein

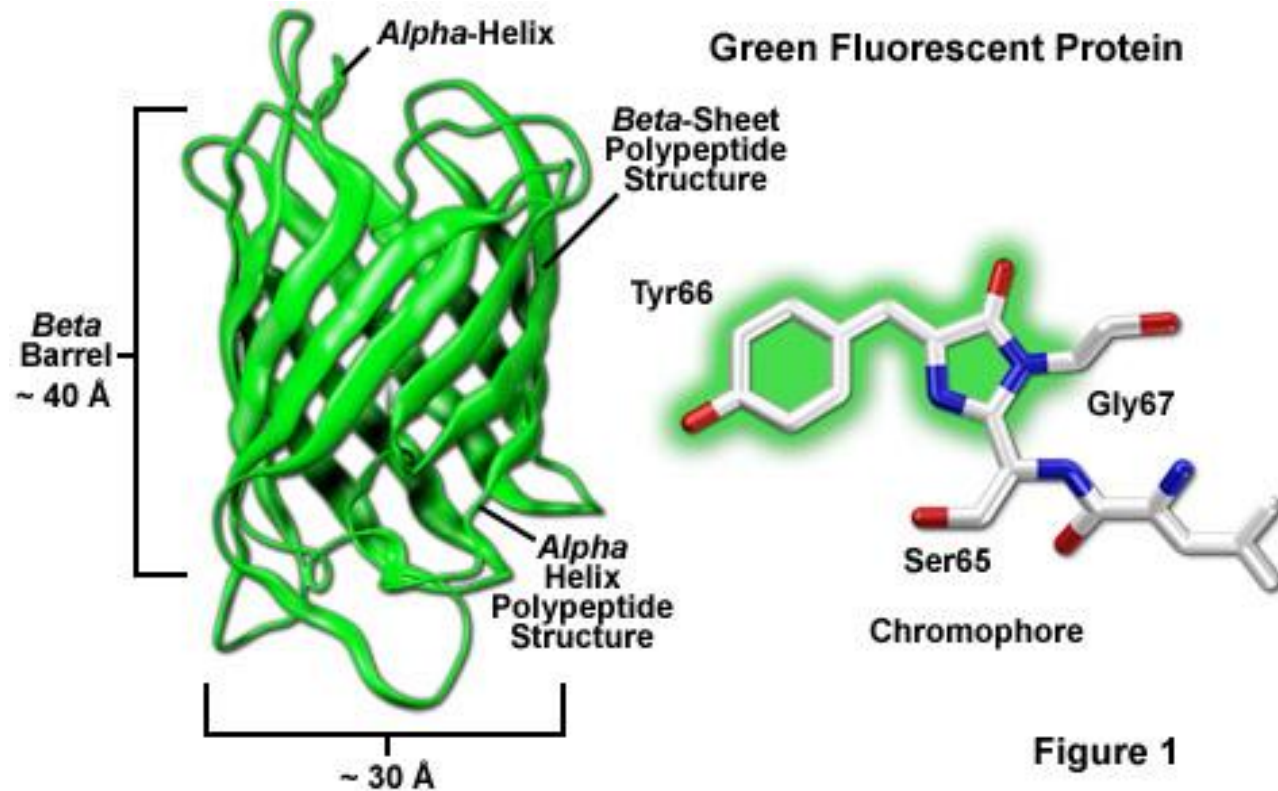


Figure 1

Maturation of the Enhanced Green Fluorescent Protein Chromophore

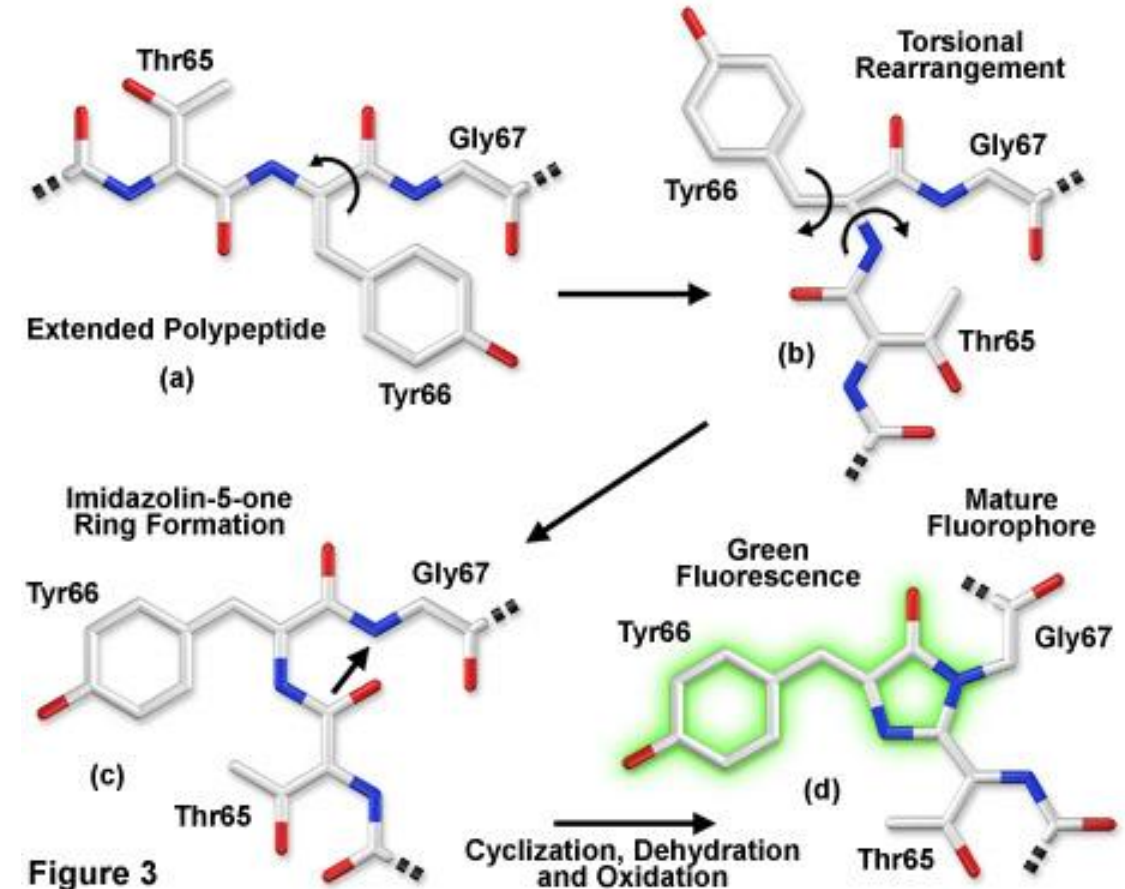
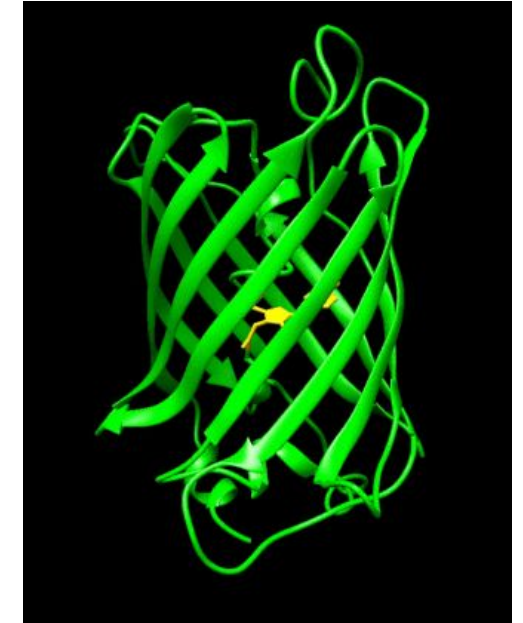
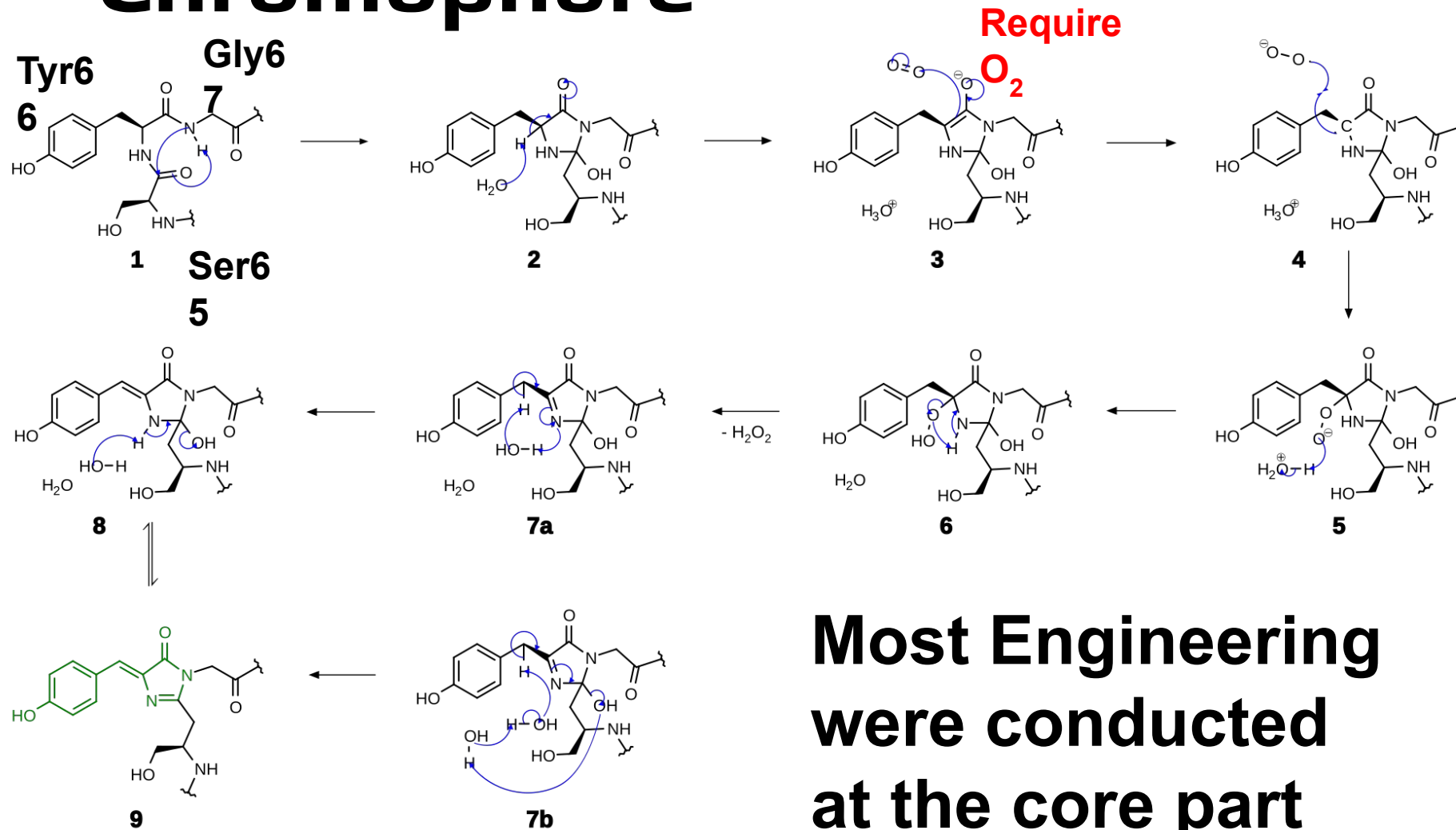


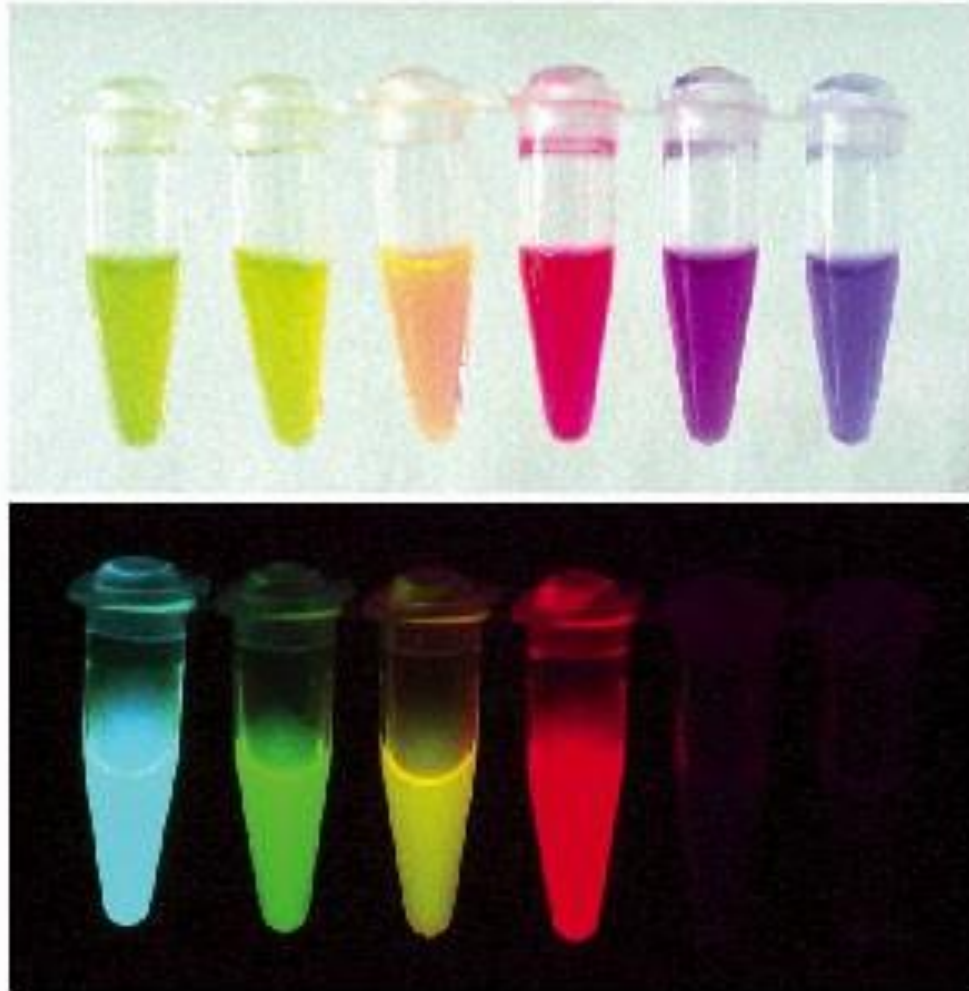
Figure 3

Autocatalysis to Generate Chromophore

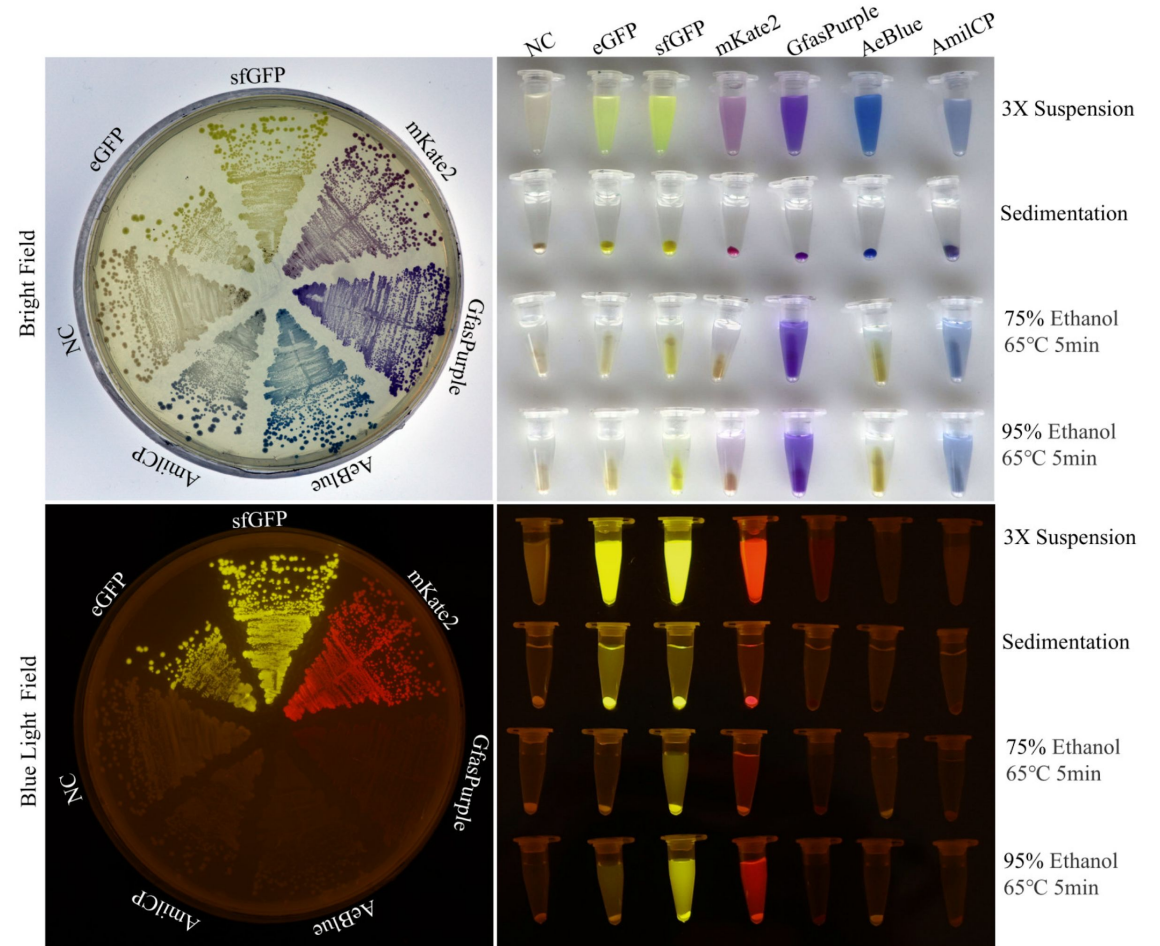


**Most Engineering
were conducted
at the core part**

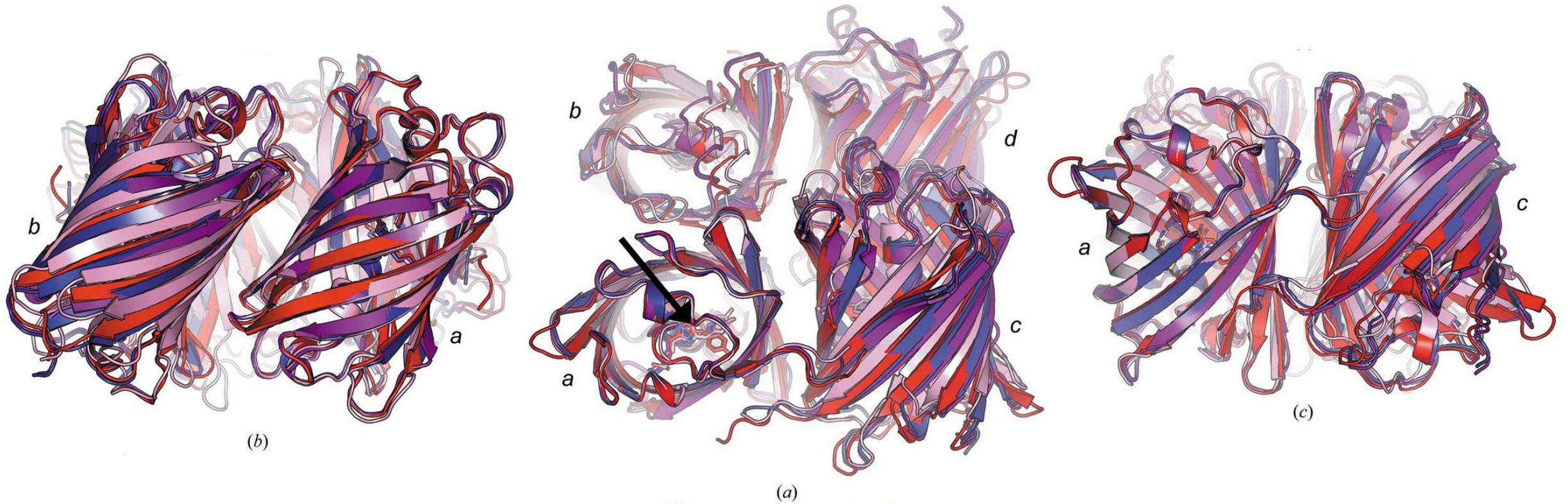
Fluorescent Proteins



Chromoproteins

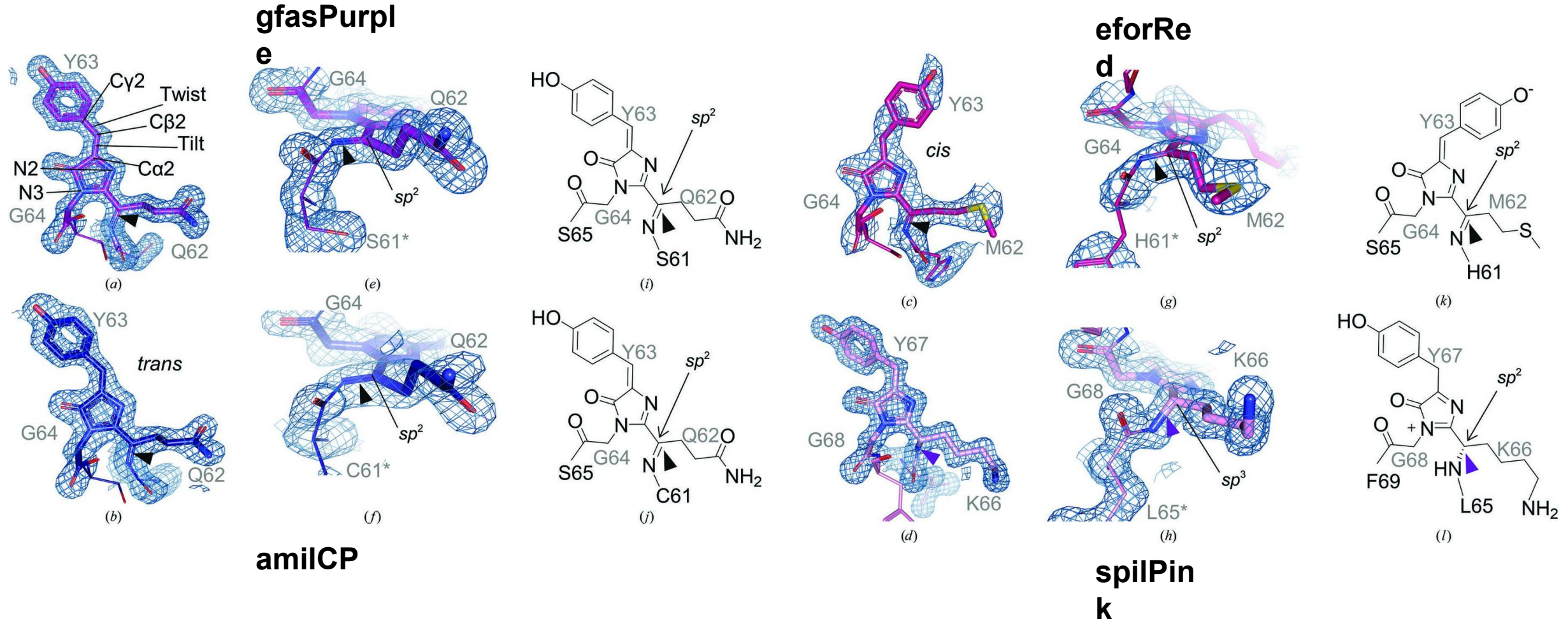


Structure Similarity | Overall Structure

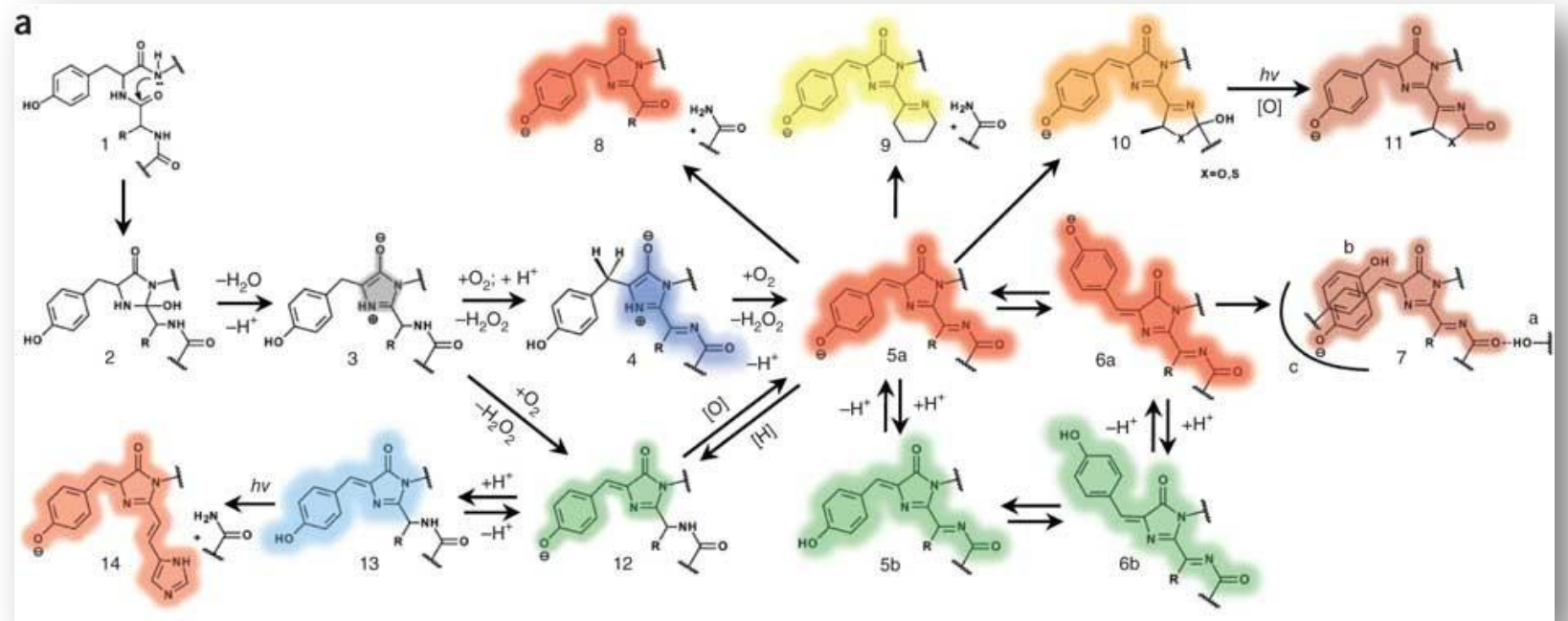
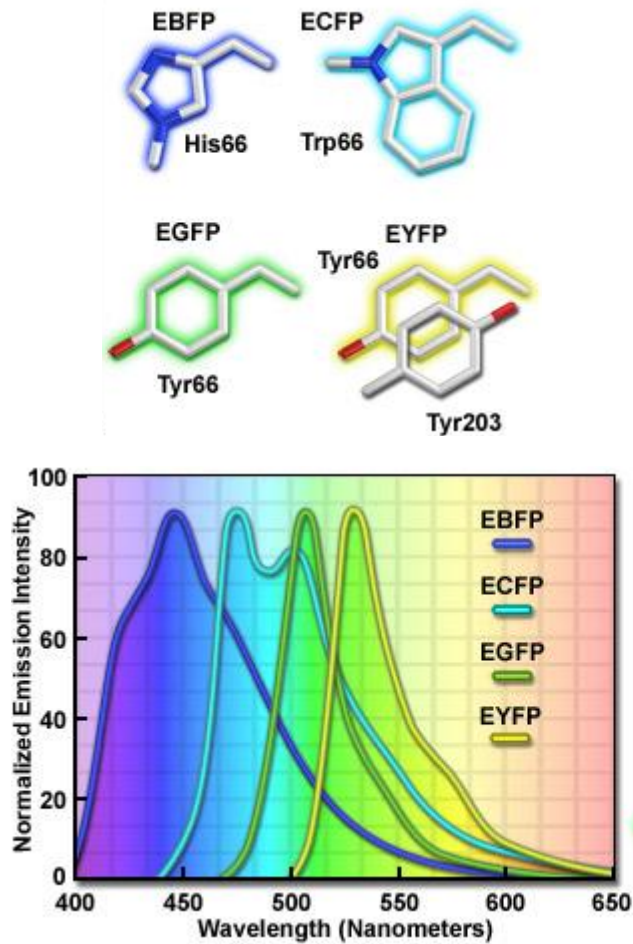


(IUCr) Over the rainbow: structural characterization of the chromoproteins gfasPurple, amilCP, spisPink and eforRed

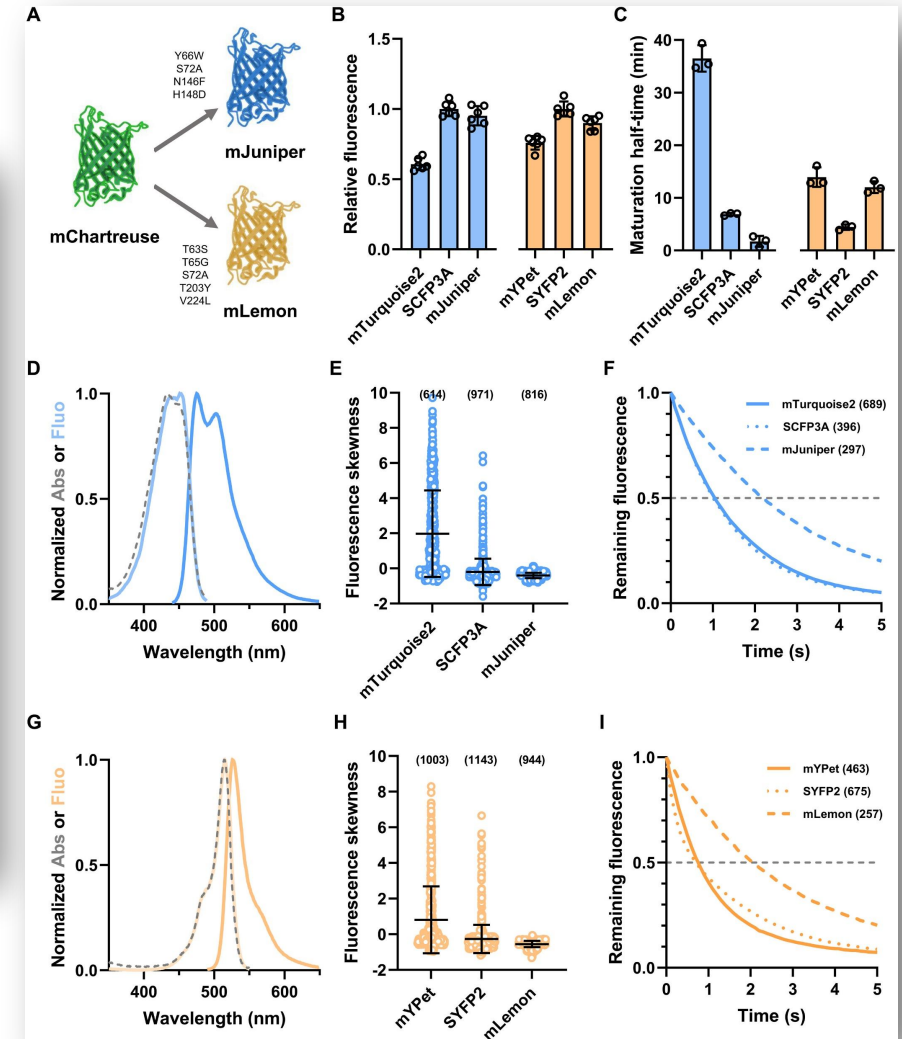
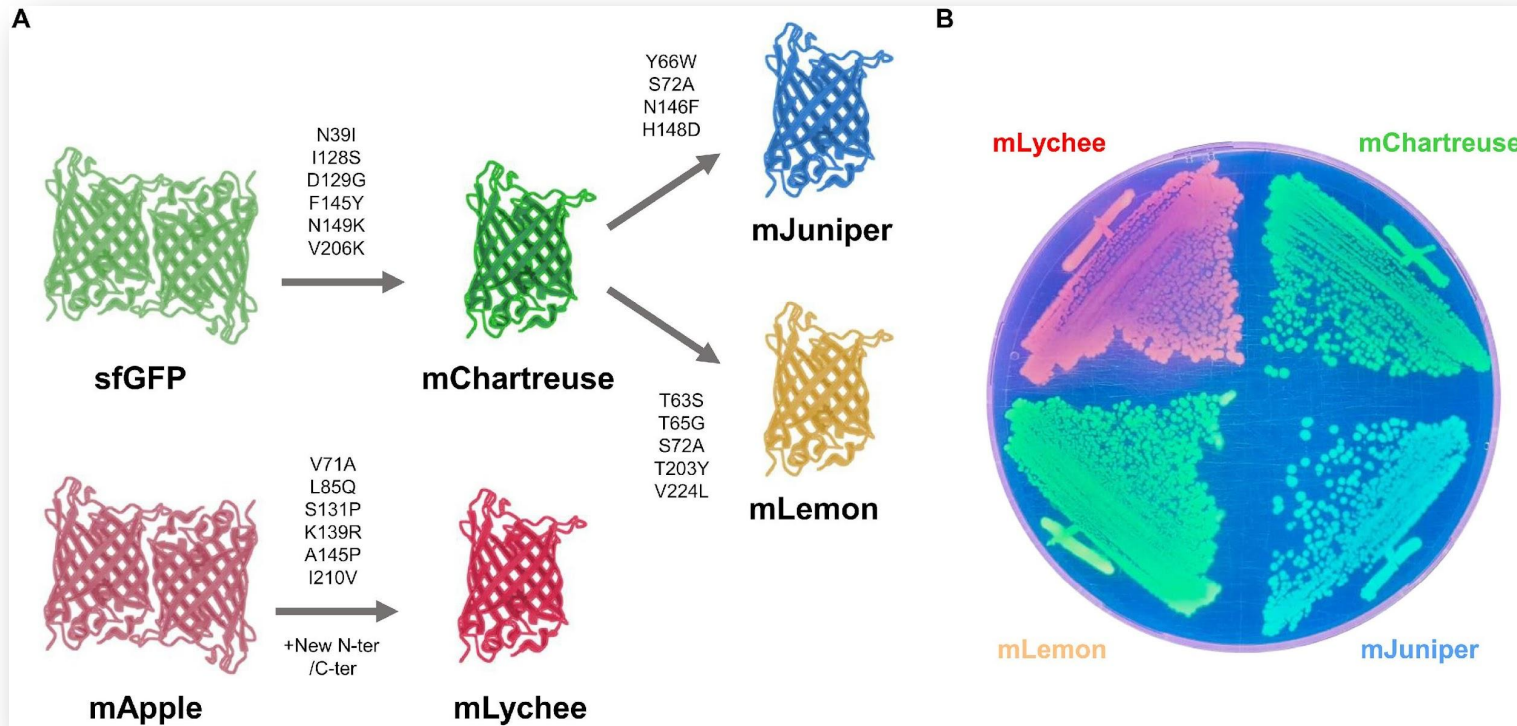
Structure Similarity | Core Chromophore



Core chromophore engineering



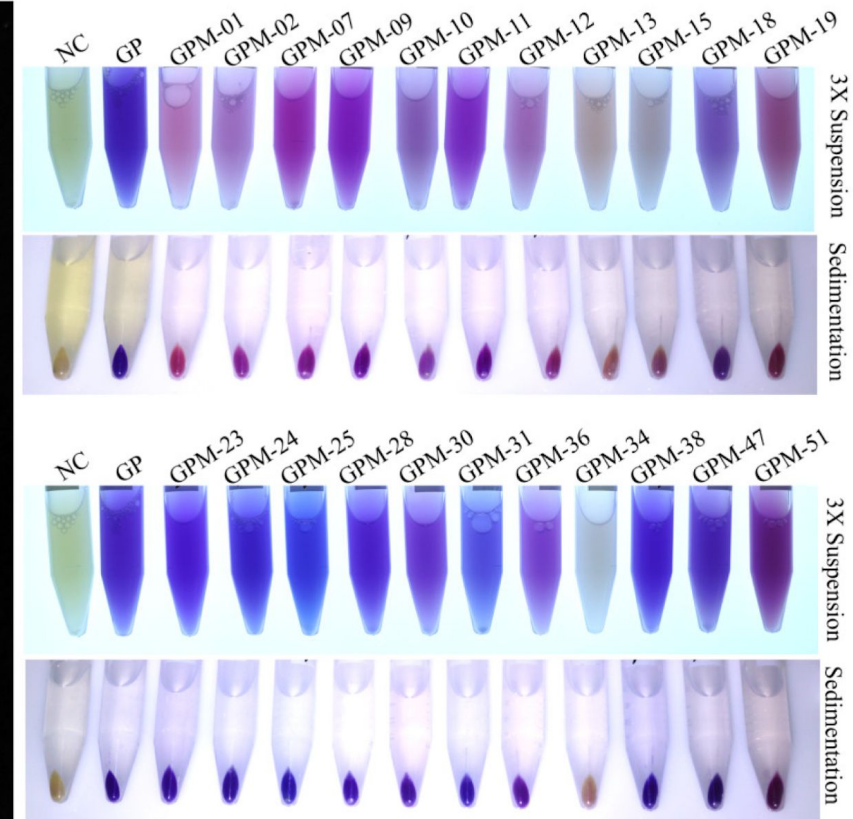
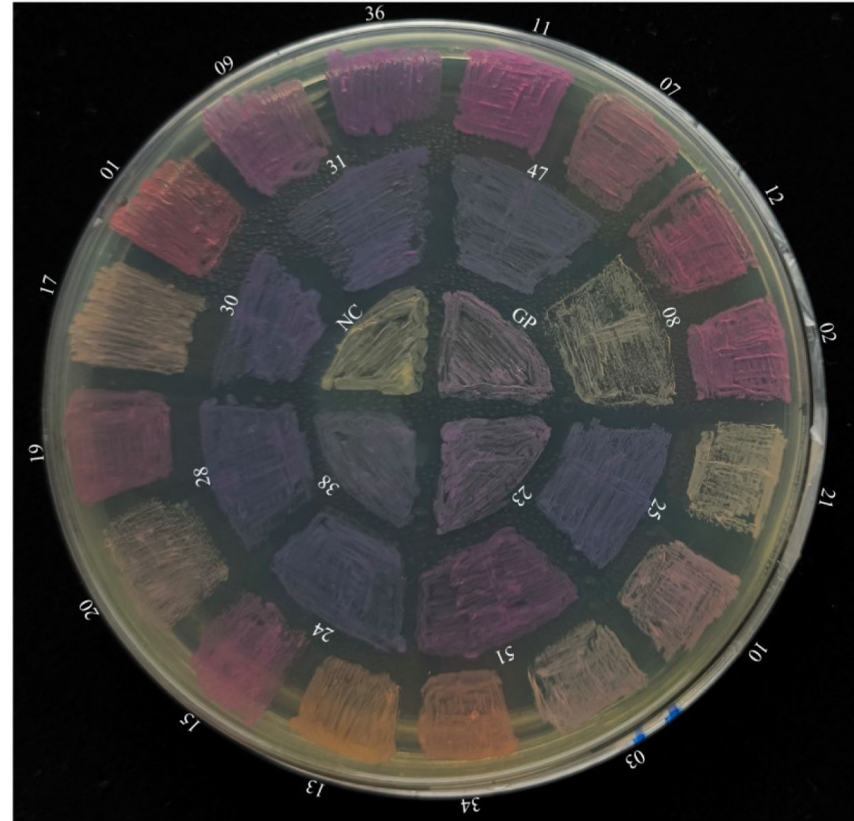
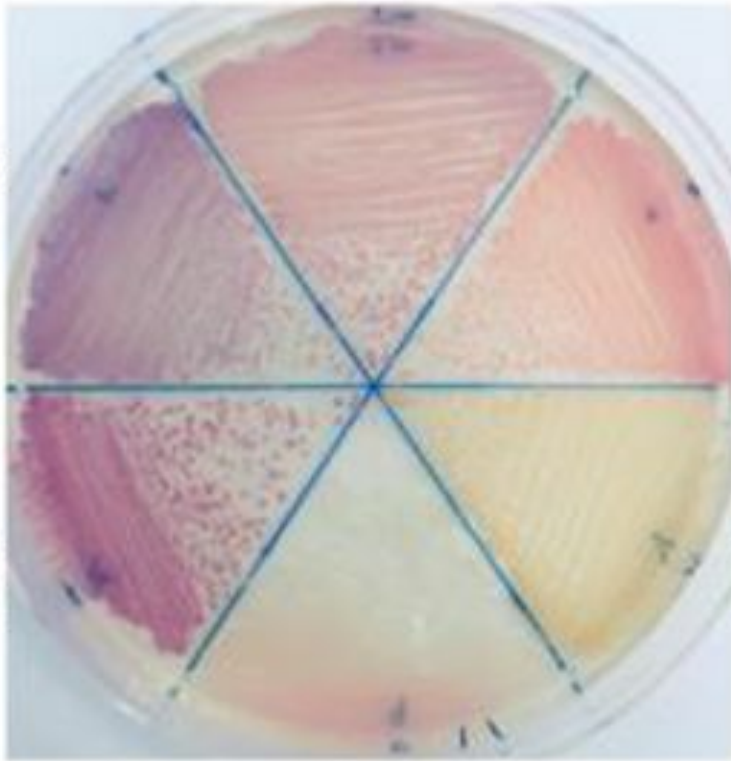
Engineering core protein structure beyond chromophore



A palette of bright and photostable monomeric fluorescent proteins for bacterial time-lapse imaging | Science Advances

ChromoProteins Engineering

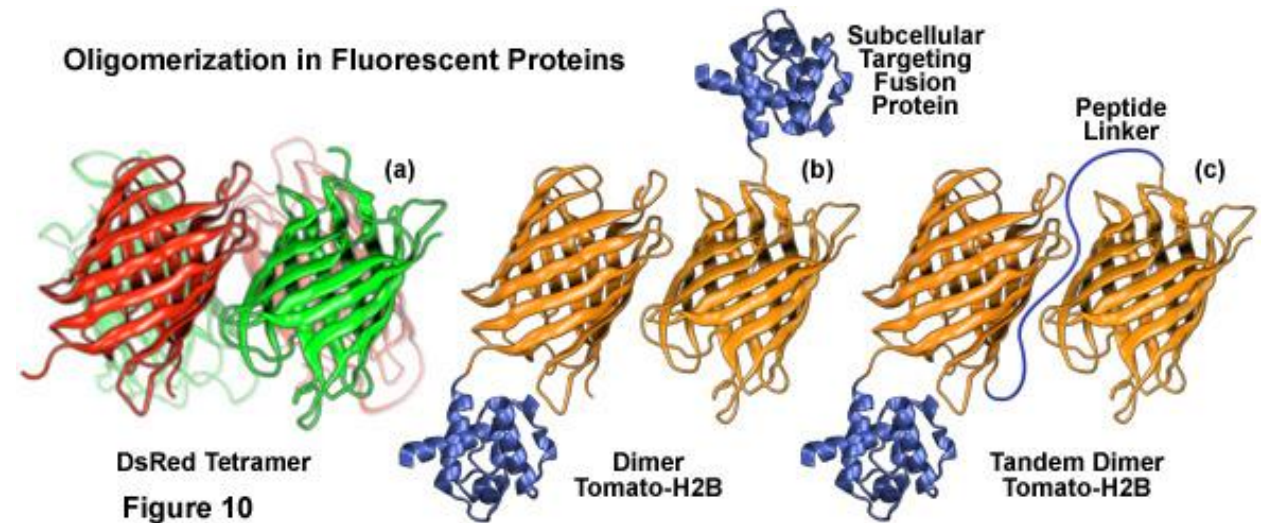
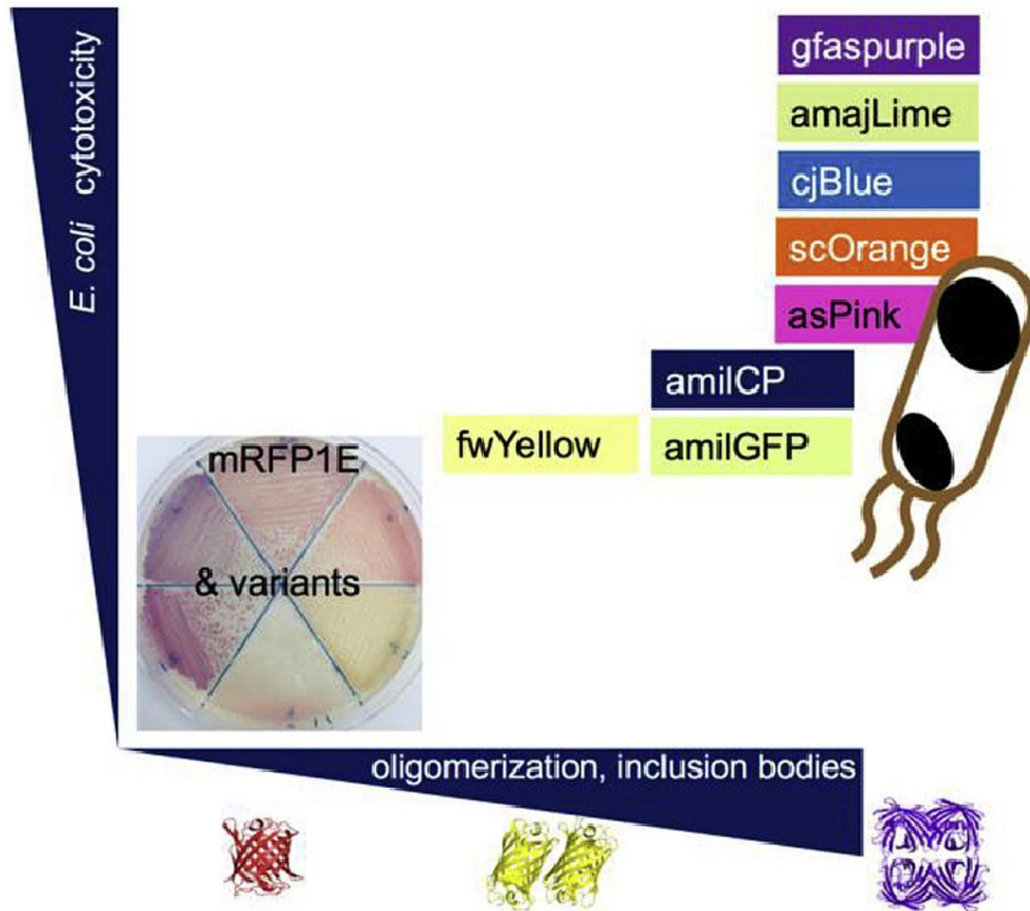
mRFP1 (FQ)



Overcoming chromoprotein limitations by engineering a red fluorescent protein - ScienceDirect

Colored Proteins Act as Biocolorants in Escherichia coli

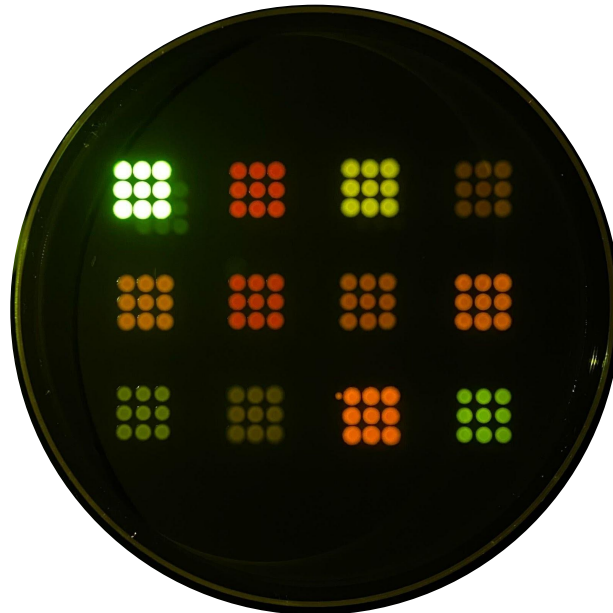
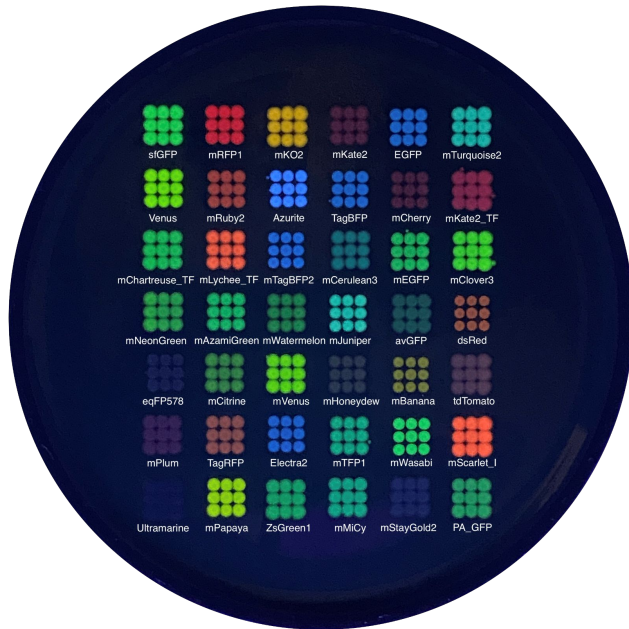
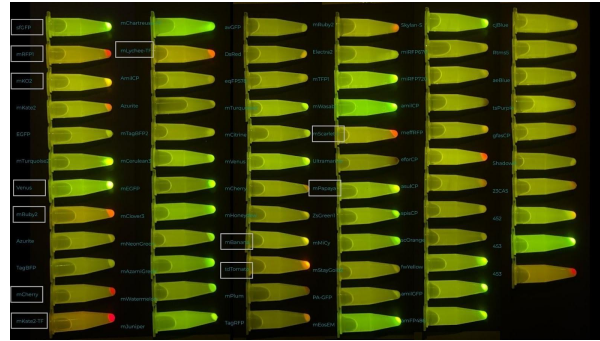
Engineering at Oligomerizability



- Toxicity Reduction
- Appropriate Localization

Overcoming chromoprotein limitations by engineering a red fluorescent protein -

A collection of fluorescent and chromoproteins curated by the HTGAA team



Mixing Colors



You can try mixing colors on your own; just follow these advanced recipes:

	$\times 7$	+		$\times 1$	+		$\times 1$	=		almond white
	$\times 2$	+		$\times 2$	+		$\times 1$	=		straw brown
	$\times 3$	+		$\times 2$	+		$\times 2$	=		apricot orange
	$\times 3$	+		$\times 2$	+		$\times 1$	=		lavender
	$\times 6$	+		$\times 3$	+		$\times 2$	=		turquoise
	$\times 3$	+		$\times 3$	+		$\times 1$	=		lime green
	$\times 7$	+		$\times 5$	+		$\times 2$	=		chestnut brown

Color Mixing

By adding the color white, you can make colors lighter...



HTGA
2026



Automation Art Interface



Gallery

Give it a try here~~~
<https://ginkgoartworks.com/>

Thanks to Ronan for the great
set-up!!!

Mode



Draw



Image

Bacteria



sfGFP

Coordinates



Automation Art Interface



Gallery



Publish



Erase All



Select

<https://example.com/image.gif>

Submit