UT Austin 2004
Red light sensor

Edinburgh 2010
Red light sensor

Uppsala 2011
Biopigments
Light sensors

Paint By COLI
Light
RGB model

Pigment
RYB model

Input

Output
Light
RGB model

Pigment
CMYK model

Additive

Subtractive
LIGHT

RED  ——>  CYAN

GREEN  ——>  MAGENTA

BLUE  ——>  YELLOW
Light sensors → Pigment producers → output colony

- Cyan
- Magenta
- Yellow
Light sensors: Red, Green, and Blue
Pigment producers: Cyan, Magenta, and Yellow
Output colony

Cyan and Magenta are marked with an 'X' to indicate they are not used.
Light sensors → Pigment producers →output colony

- Cyan
- Magenta (not selected)
- Yellow

Pigment producers: Cyan, Magenta, Yellow
Light sensors

Pigment producers

cyan

magenta

yellow

output colony
Light sensors → Pigment producers

- Cyan sensor
- Magenta sensor
- Yellow sensor

Output colony
**NO LIGHT**

- Cph8
- Cph1
- EnvZ
- OmpR

OmpR is phosphorylated

OmpR binds to its promoter...

... and the cyan pigment is synthesised

Cyan pigment

**RED LIGHT**

- Cph1
- EnvZ
- OmpR

OmpR is NOT phosphorylated

OmpR cannot bind to its promoter...

... so the cyan pigment is NOT synthesised

Cyan pigment
NO LIGHT

Cph8

Cph1

EnvZ

OmpR

OmpR is phosphorylated

It binds to its promoter...

... and the cyan pigment is synthesised

Cyan pigment gene

Cyan pigment

RED LIGHT

Cph1

EnvZ

OmpR

OmpR is NOT phosphorylated

It can't bind to its promoter...

... so the cyan pigment is NOT synthesised

Cyan pigment gene

Cyan pigment

LIGHT

PIGMENT

RED

CYAN
In no light conditions:

- FixJ is phosphorylated.
- FixJ binds to its promoter, leading to the synthesis of the yellow pigment gene.
- The yellow pigment is synthesized.

In blue light conditions:

- FixJ is not phosphorylated.
- FixJ cannot bind to its promoter.
- The yellow pigment is not synthesized.

Light 
BLUE 

PIGMENT 
YELLOW
GREEN LIGHT

CcaS

CcaR is phosphorylated

CcaR

P

It binds to the promoter...

... and the cl repressor protein is made.

cl repressor protein

Magenta pigment gene

... meaning the magenta pigment is NOT synthesised.

Magenta pigment

NO LIGHT

CcaS

CcaR

CcaR is NOT phosphorylated

The cl repressor protein is not made.

cl repressor protein

Magenta pigment gene

The lack of a cl repressor protein means the magenta pigment can be synthesised.

Magenta pigment

LIGHT

GREEN

PIGMENT MAGENTA.
Modelling

Stochastic simulation of tri-chromatic light regulated gene expression
Sensor activation rate

\[ \text{Rates}(\lambda) = \int_{\text{visible}} \text{Spec}(\lambda) \cdot \text{Incident}(\lambda) \cdot d\lambda \]
Stochastic simulation: Kappa

$A(x,y,z), B(x,y,z) \rightarrow A(x!1,y,z), B(x!1,y,z) @ \text{Rate}$
Absorption spectrum

$$Absorption(\lambda, t) = \sum_{i} population(t) \cdot spectrum(\lambda) + Background(\lambda)$$
Results:
Results:
Future Development

Update: With experimental data

Develop: Models for multiple cells

Simulate: Biological systems before synthesis
Green light sensor to NOT-magenta
Red light sensor to NOT-cyan
Blue light sensor to NOT-yellow

Synthesized by DNA 2.0
Output bricks

- IDT’s G-blocks
- Digest with BamHI and BglII

Digest with BamHI and BglII  
GFP expression
an introduction to
BACTERIAL PHOTOGRAPHY

21st September
3:30 - 5:00 pm
Bill Douglas Centre

An informal conference exploring the use of synthetic biology to create an innovative new photographic technique
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