# Introduction to Synthetic Biology

Topic 1 | Topic 2 | Topic 3 | Topic 4 | Topic 5

## Foundations for Synthetic Biology

Vincent Rouilly
Bioengineering Department
Imperial College London

# Introduction to Synthetic Biology

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**Abstraction** | **Standardisation** | **Quality Control**

## Foundations for Synthetic Biology

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**inter-operabilty** | **Re-usability** | **Rational Design** | **Predictive Properties**

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## Standard for Physical DNA Composition

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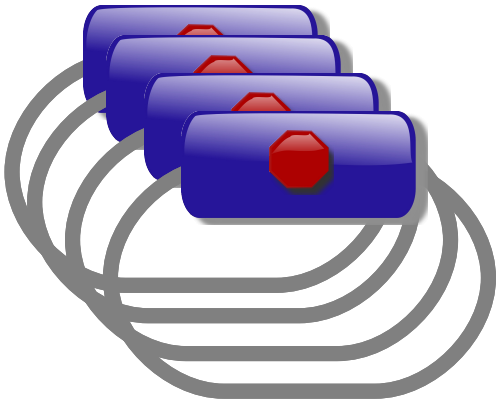
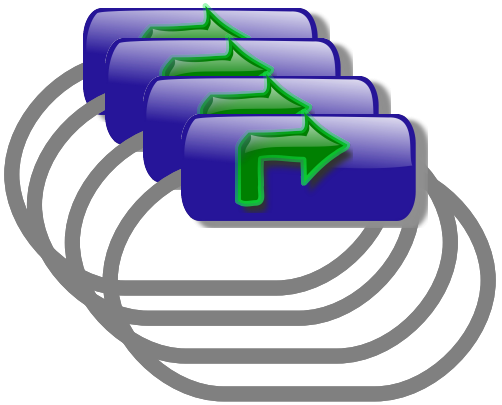
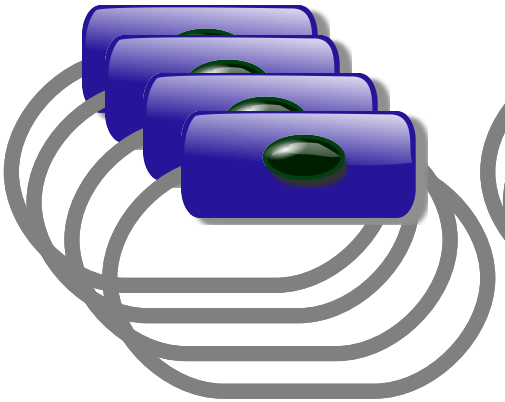
# DNA Physical Composition



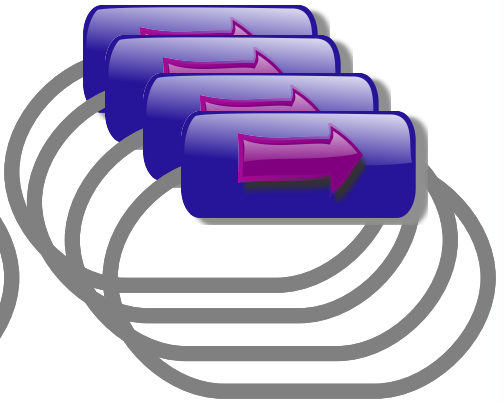
Terminators



Promoters

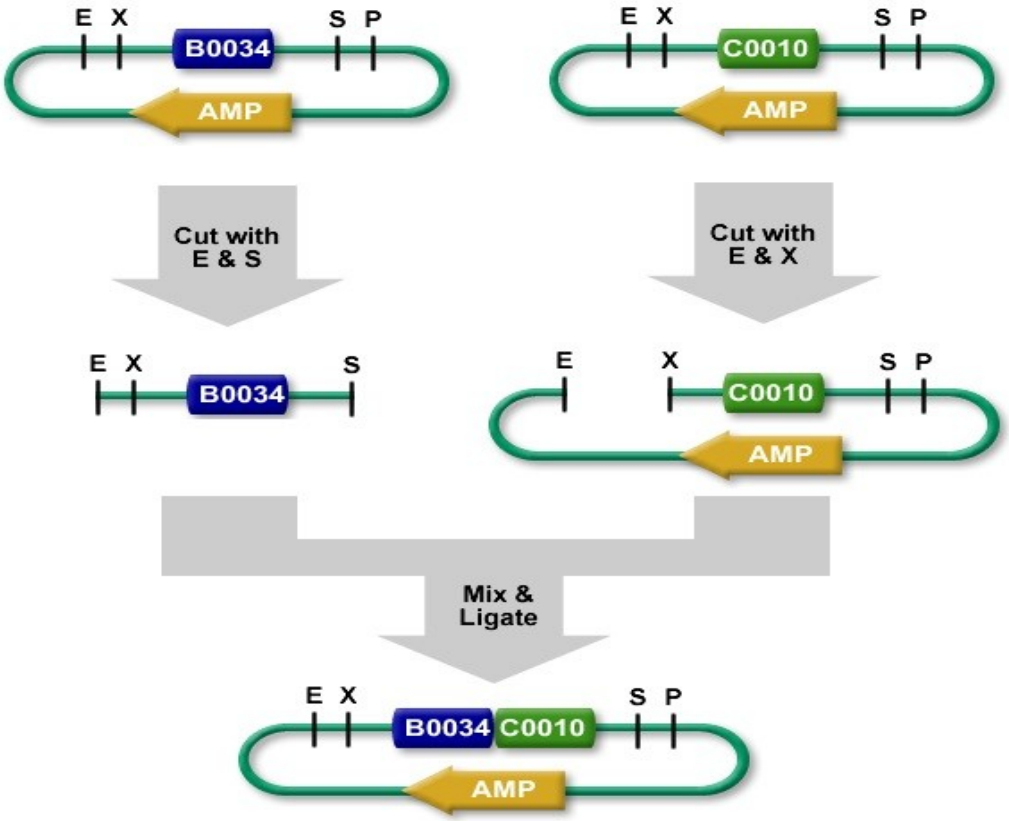


Ribosome Binding Site



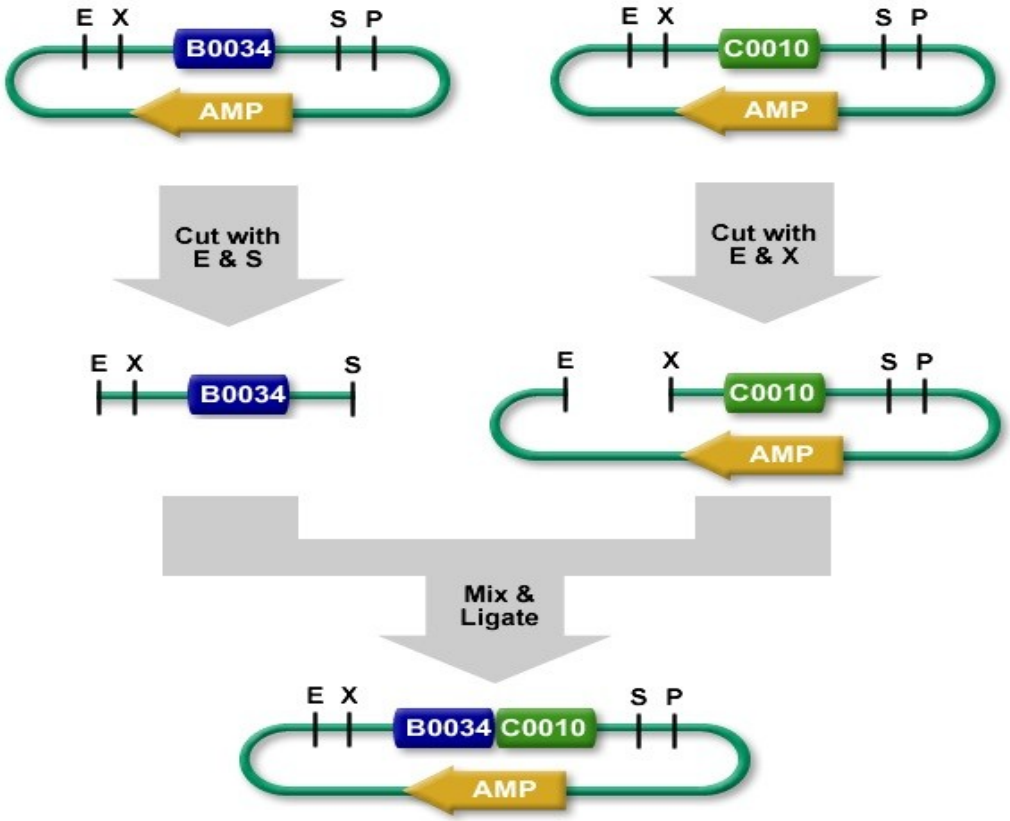
Coding Sequences

# DNA Physical Composition




**Standard Assembly**

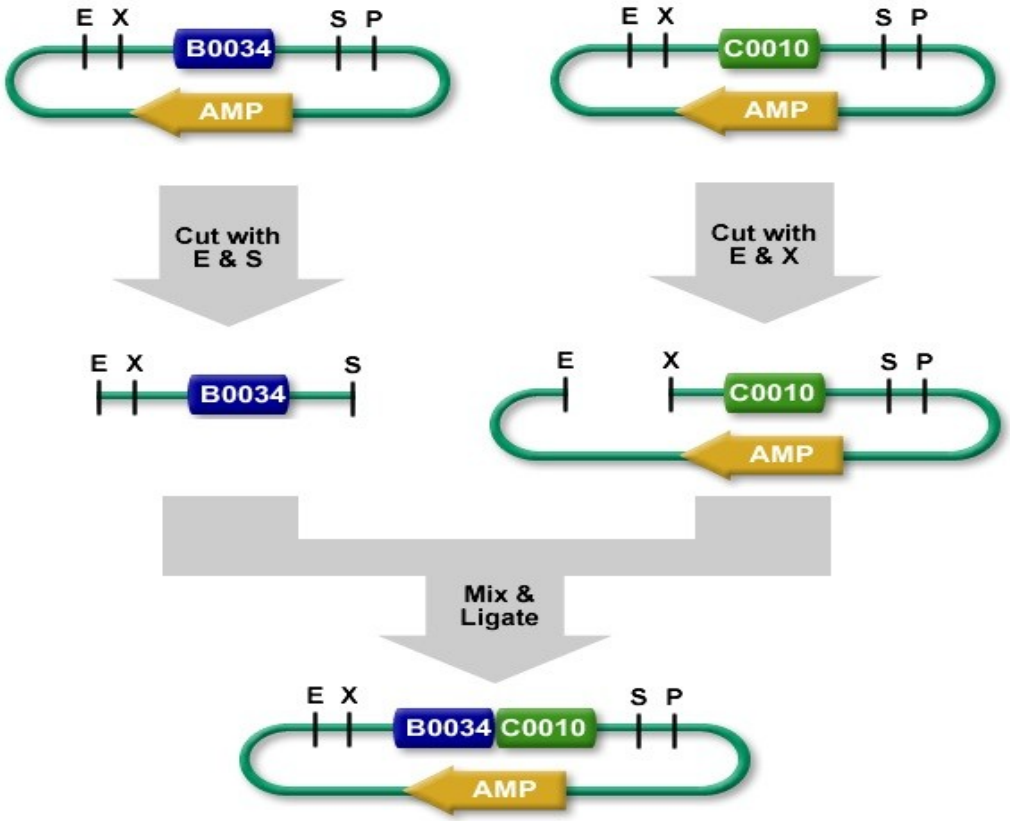
# DNA Physical Composition



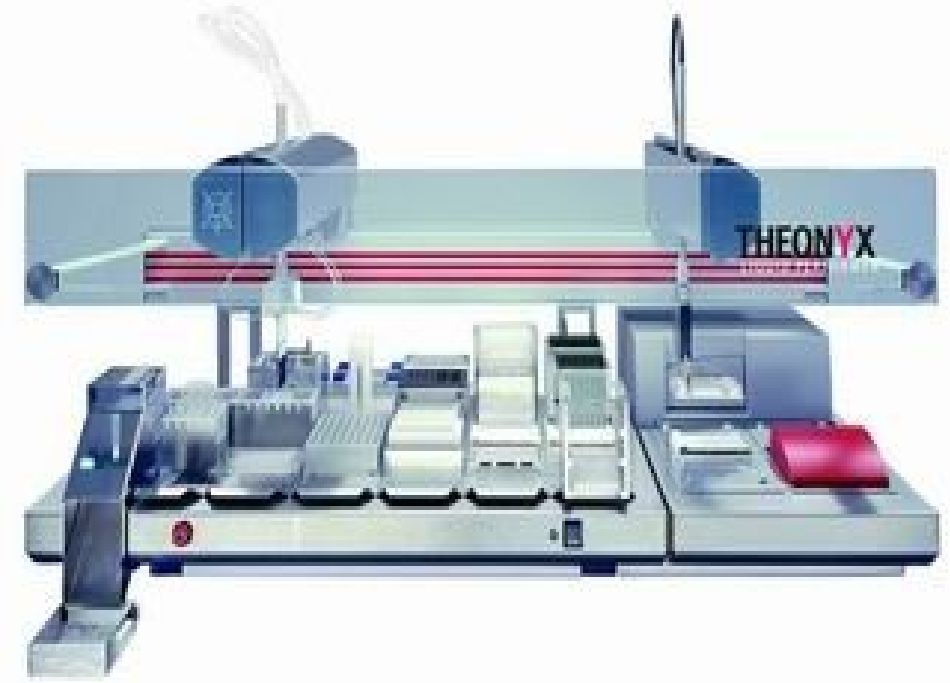

**Standard Assembly**

- Culture Bacteria with Parts
- Mini-prep Plasmid DNA
- Set-up Restriction Digest
- Run a Gel
- Gel extract parts
- Set-up ligation
- Transform bacteria
- Culture under Antibiotic
- Mini-Prep and Check DNA

# DNA Physical Composition

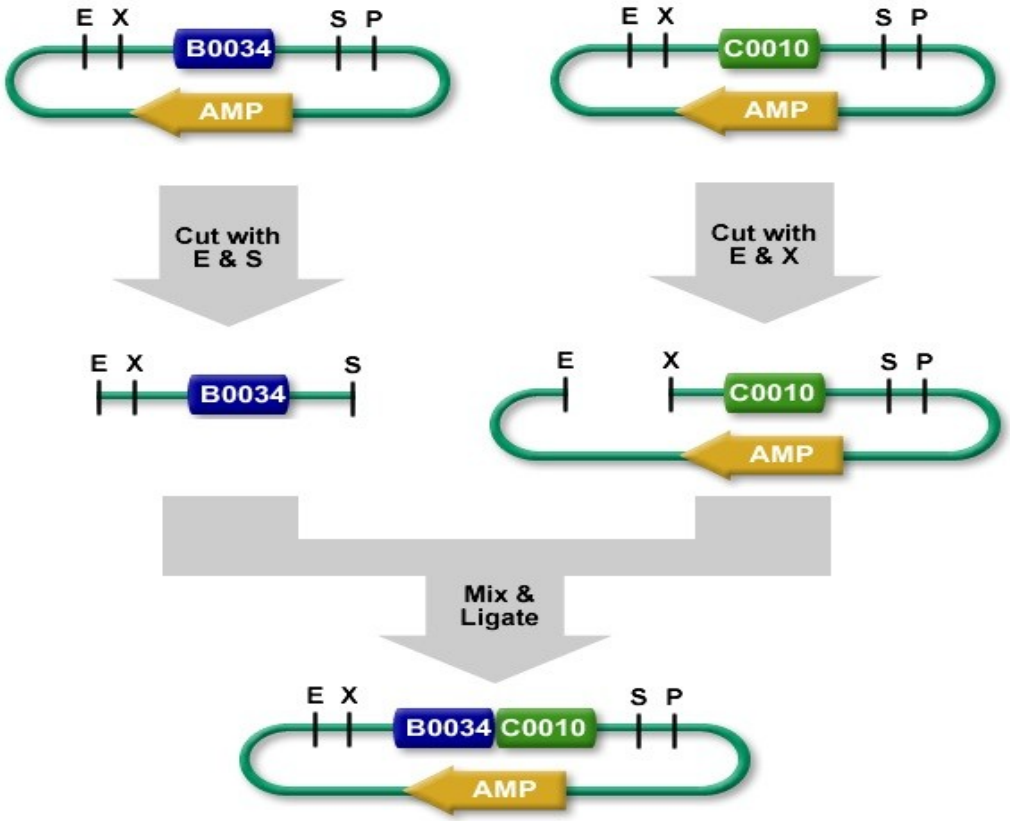



Standard Assembly




Automated Robotic Assembly
(Liquid Handling Robot)

# DNA Physical Composition




**Standard Assembly**

Registry 1 (UK)

Registry 2 (China)

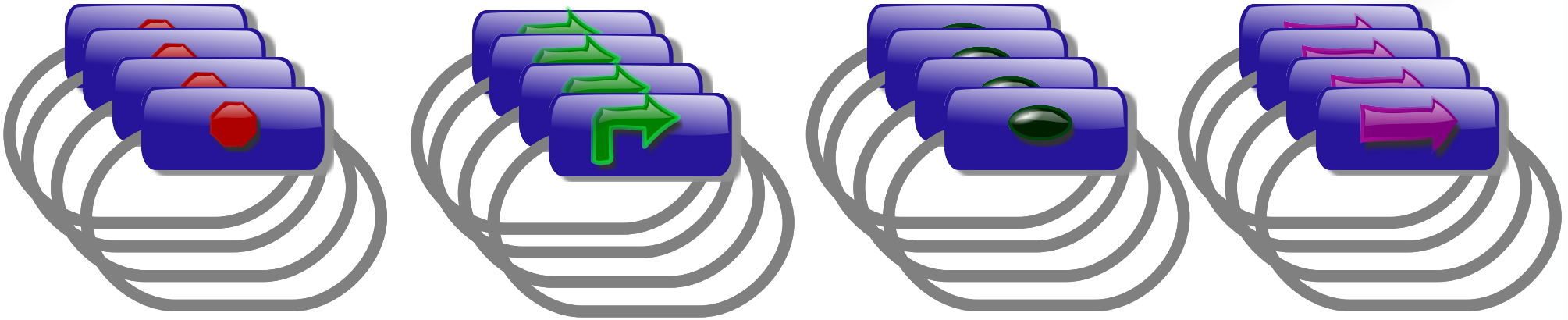
Registry 3 (lab next door)

Physical Composition

Compatibility

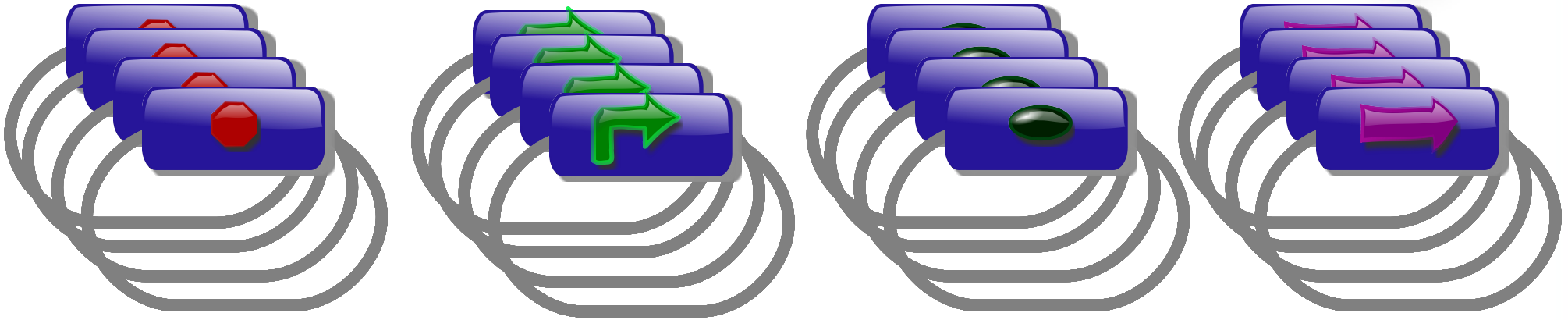
Standard Procedure

# DNA Physical Composition



The BioBrick Standard insures physical DNA composition

# Physical Composition and Function



The BioBrick Standard insures physical DNA composition

But does the assembly always make sense ?

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## Standards for Functional Composition

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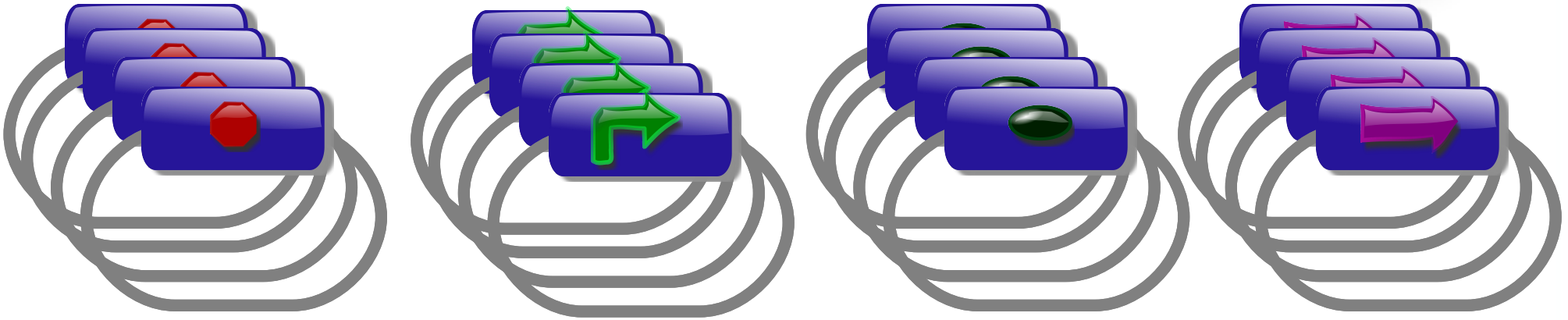
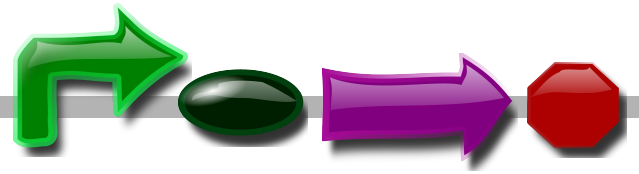
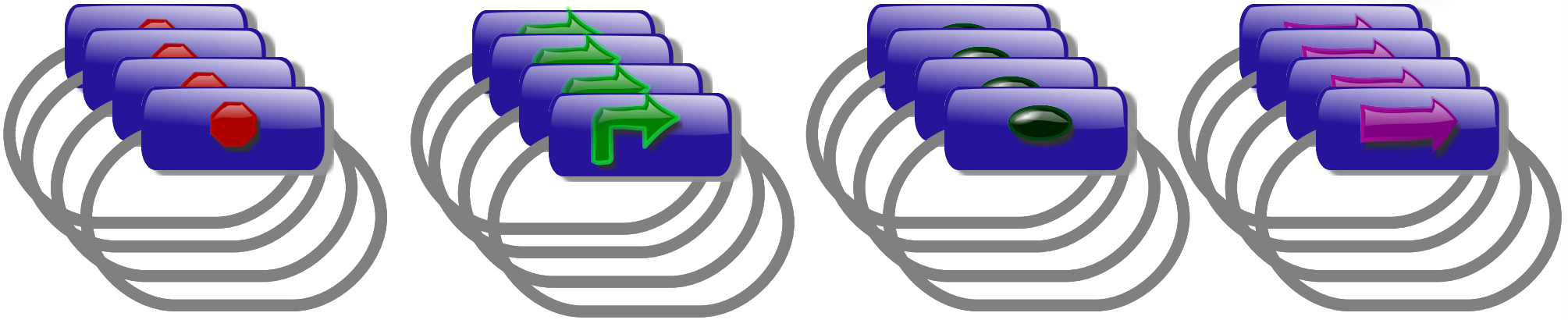
# Physical Composition and Function

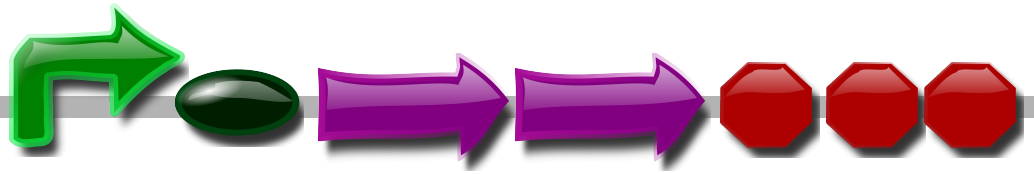




**Functional or Not Functional ?**

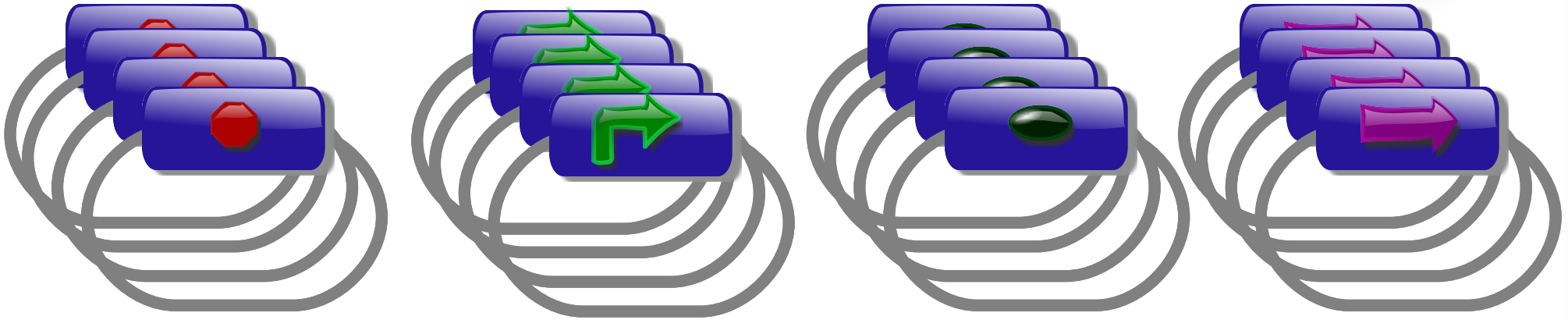
# Physical Composition and Function

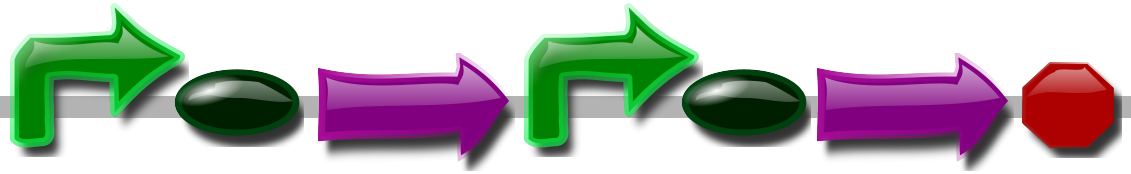




**Functional or Not Functional ?**

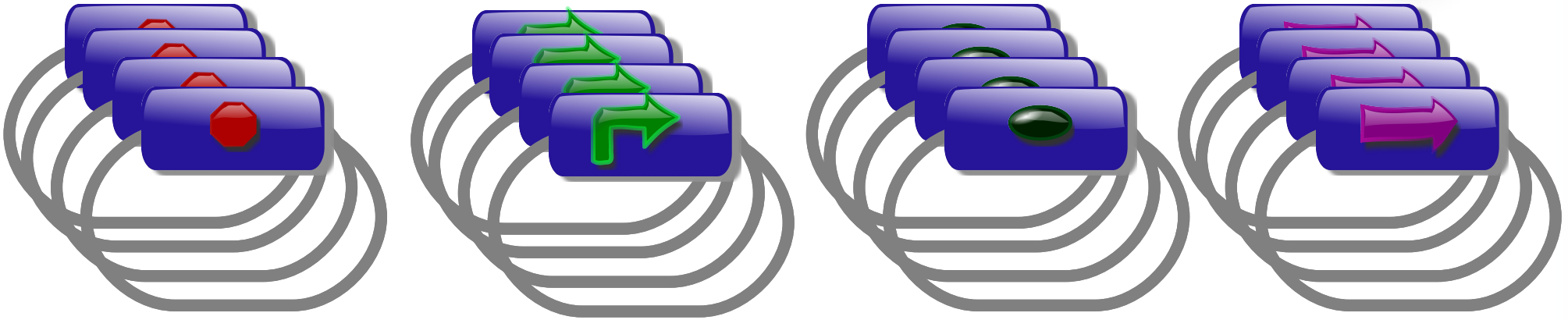
# Physical Composition and Function

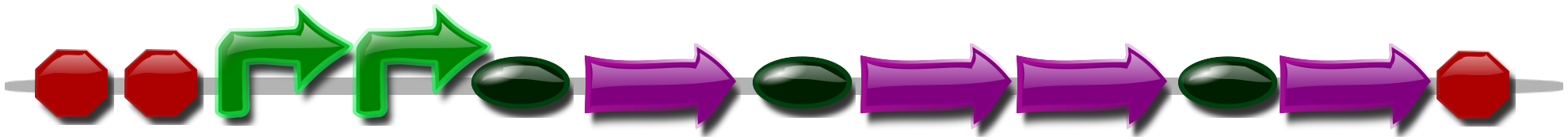




**Functional or Not Functional ?**

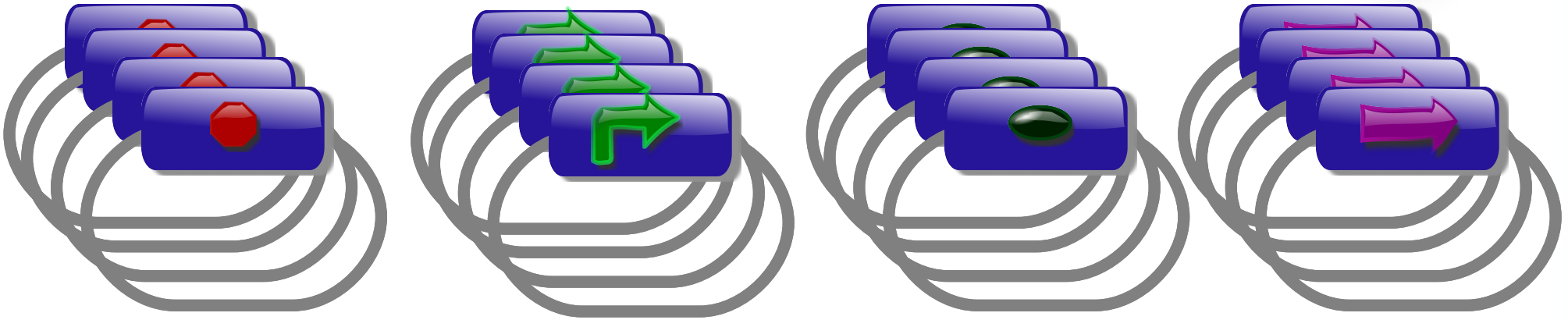
# Physical Composition and Function





**Functional or Not Functional ?**

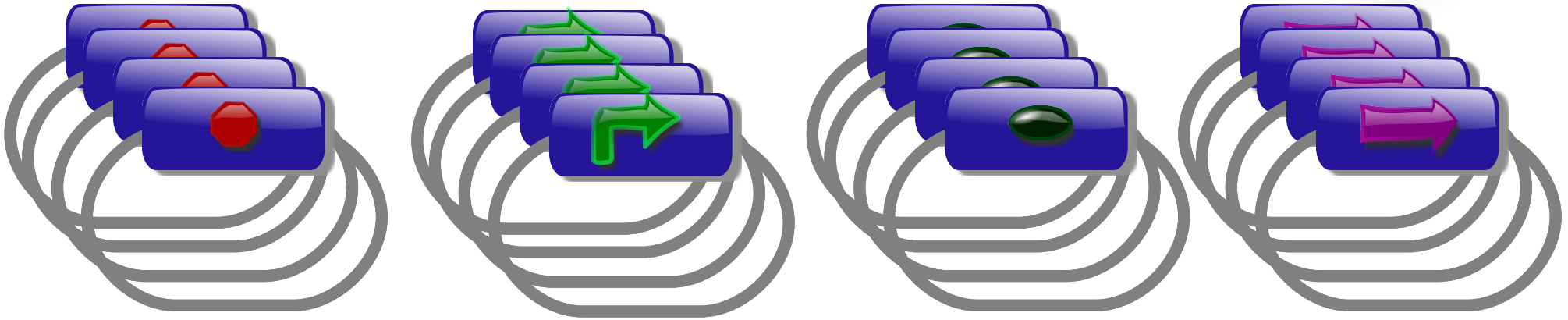
# Standard for Functional Composition



Can we find a set of **Design Rules** to promote:

1 - **Functional property** of the assembly
2 - **Modularity** of the device created
3 - **Re-usability** of the device/system

# Standard for Functional Composition



Can we find a set of **Design Rules** to insure:

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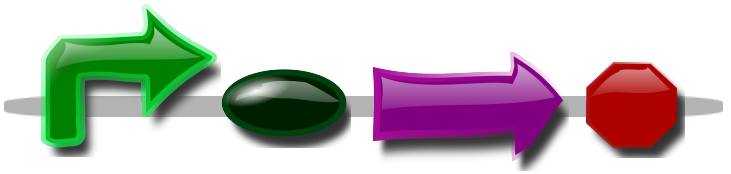
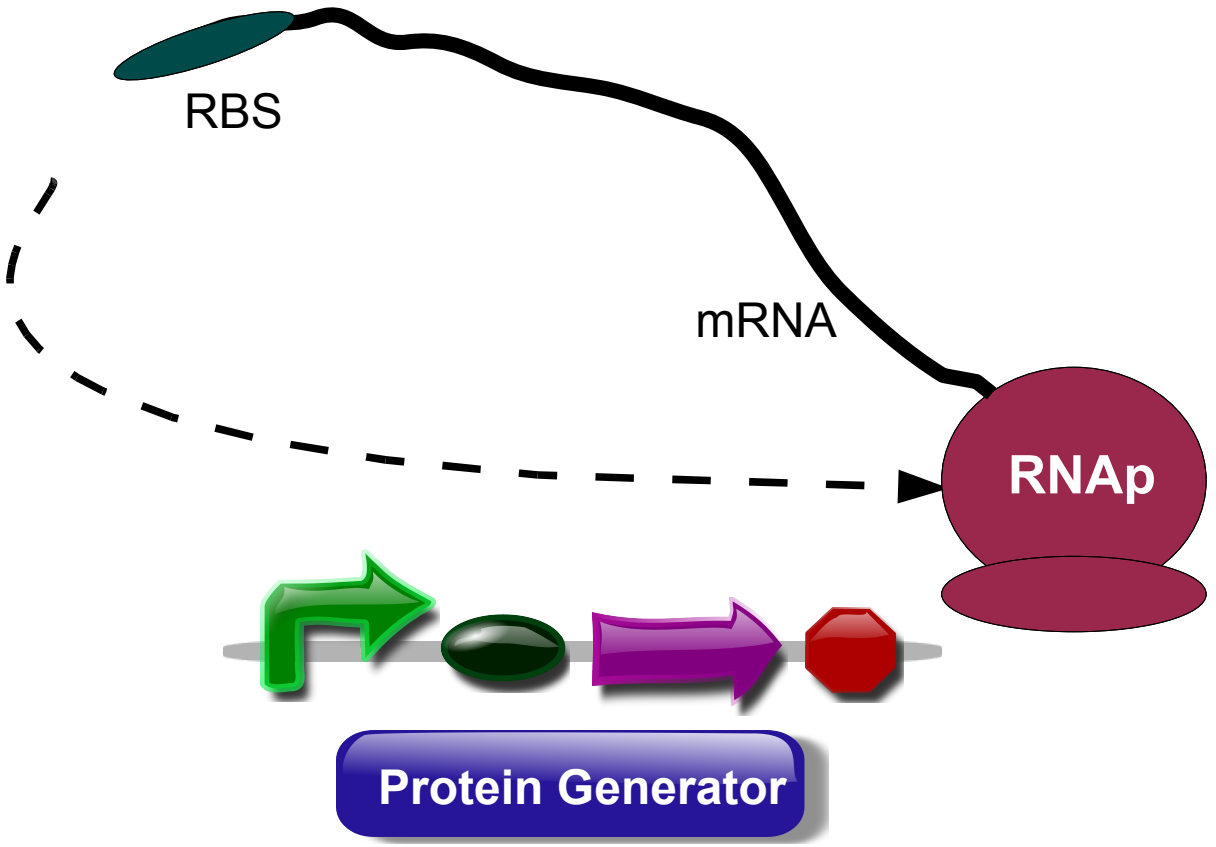
**Focus on Transcriptional Devices**

# Signal carrier in transcriptional devices

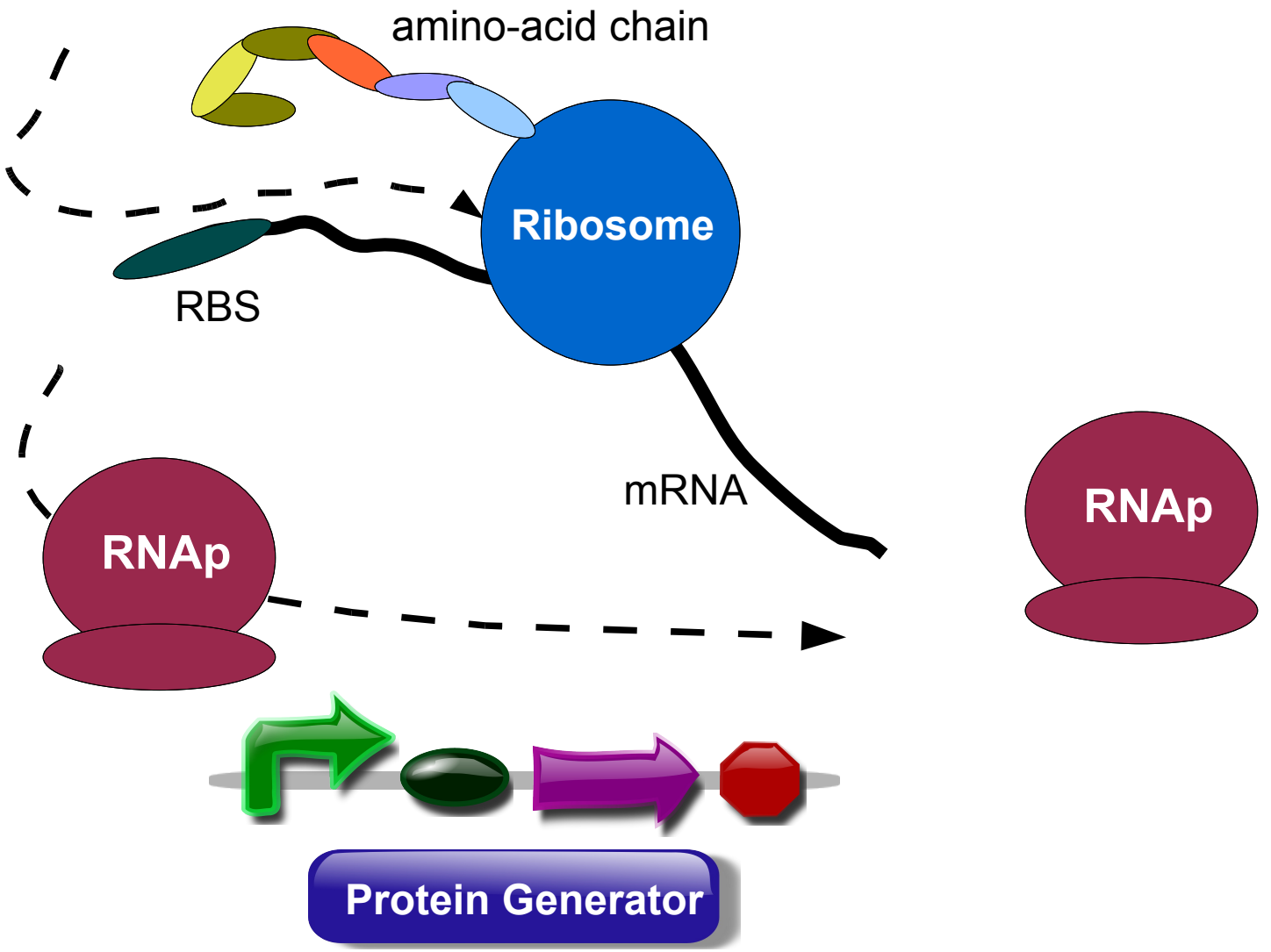


Protein Generator

# Signal carrier in transcriptional devices



# Signal carrier in transcriptional devices



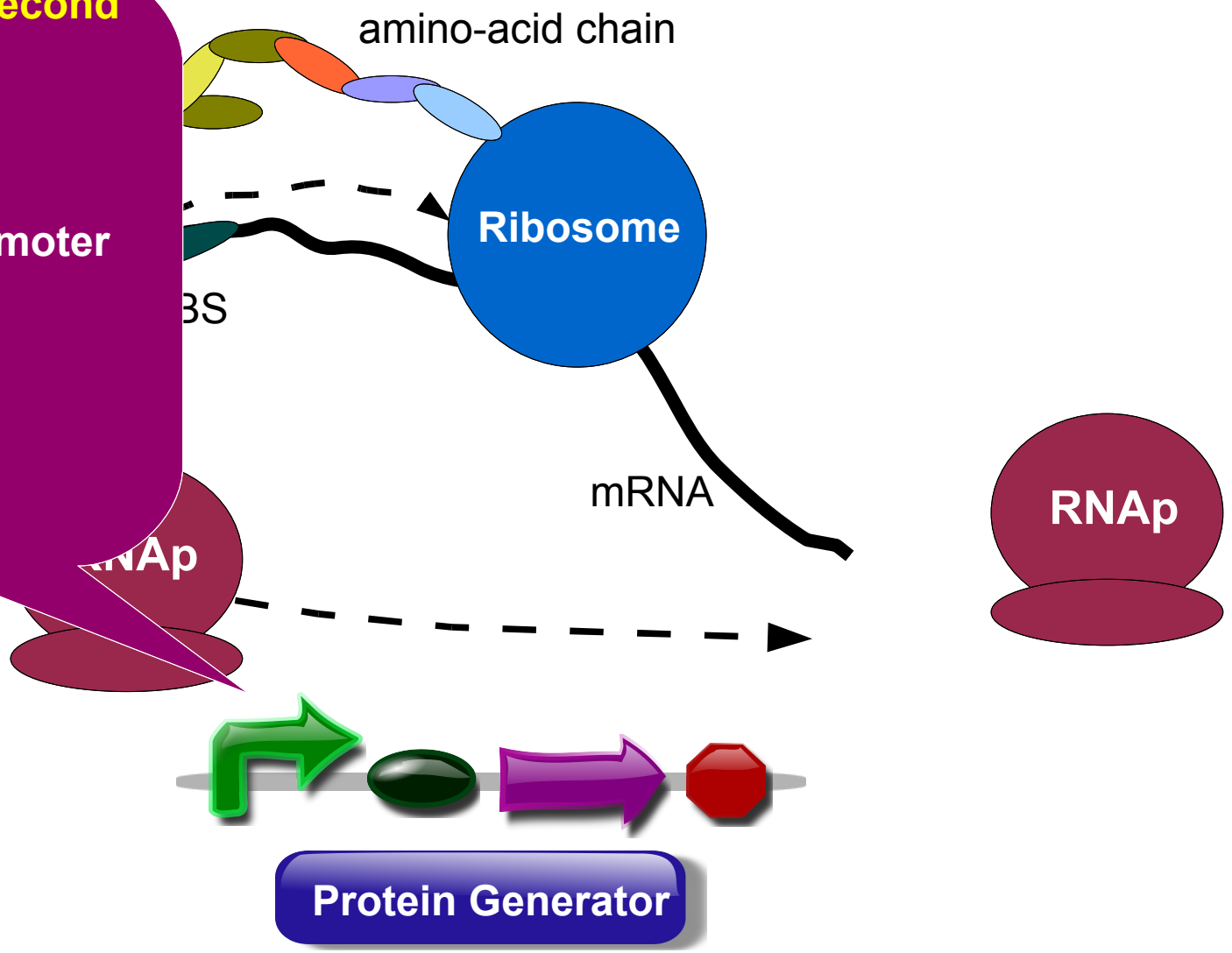
# Signal carrier in transcriptional devices

**Polymerases Per Second (PoPS)**

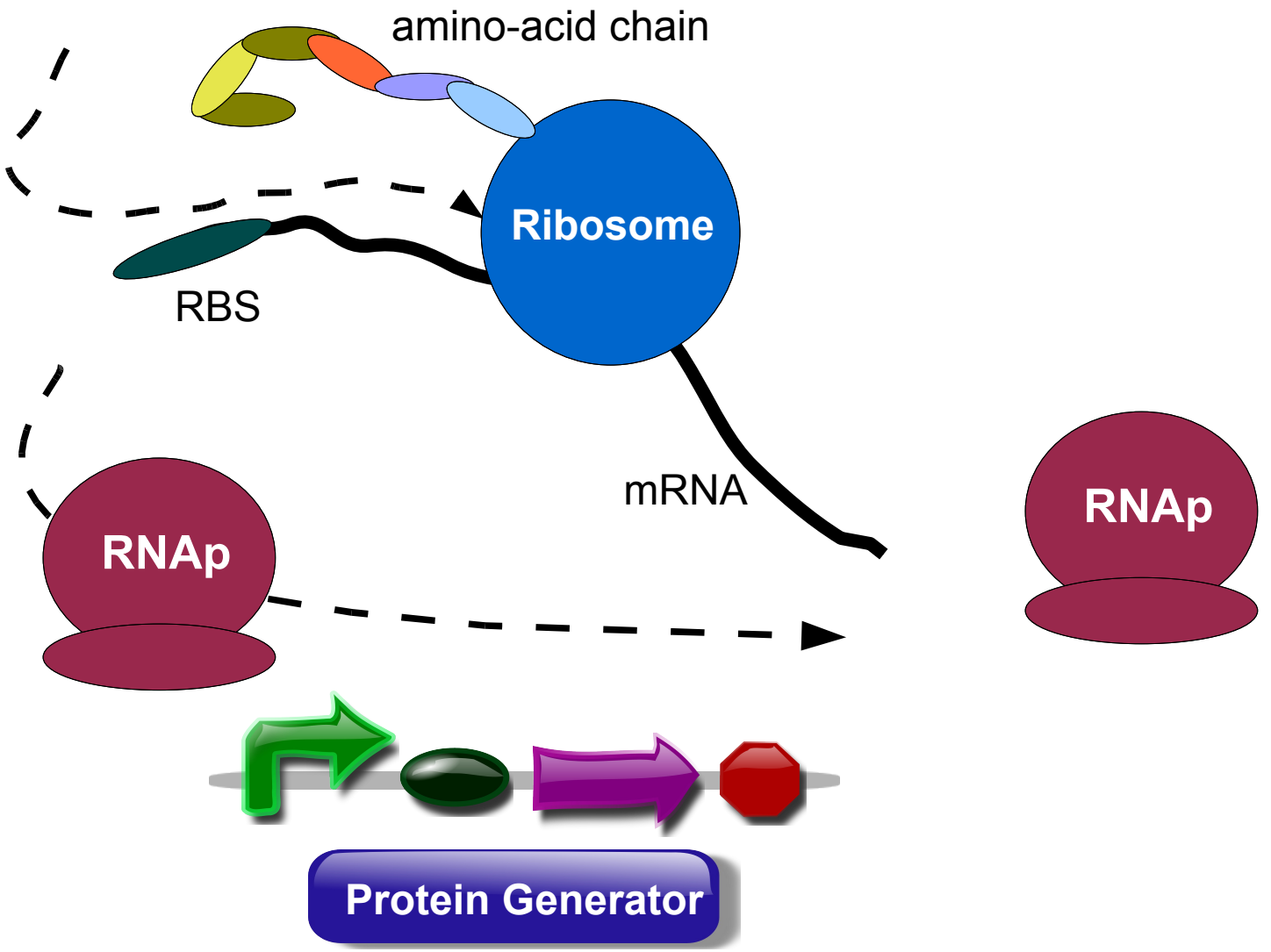
**depends on:**

**- strength of the promoter**

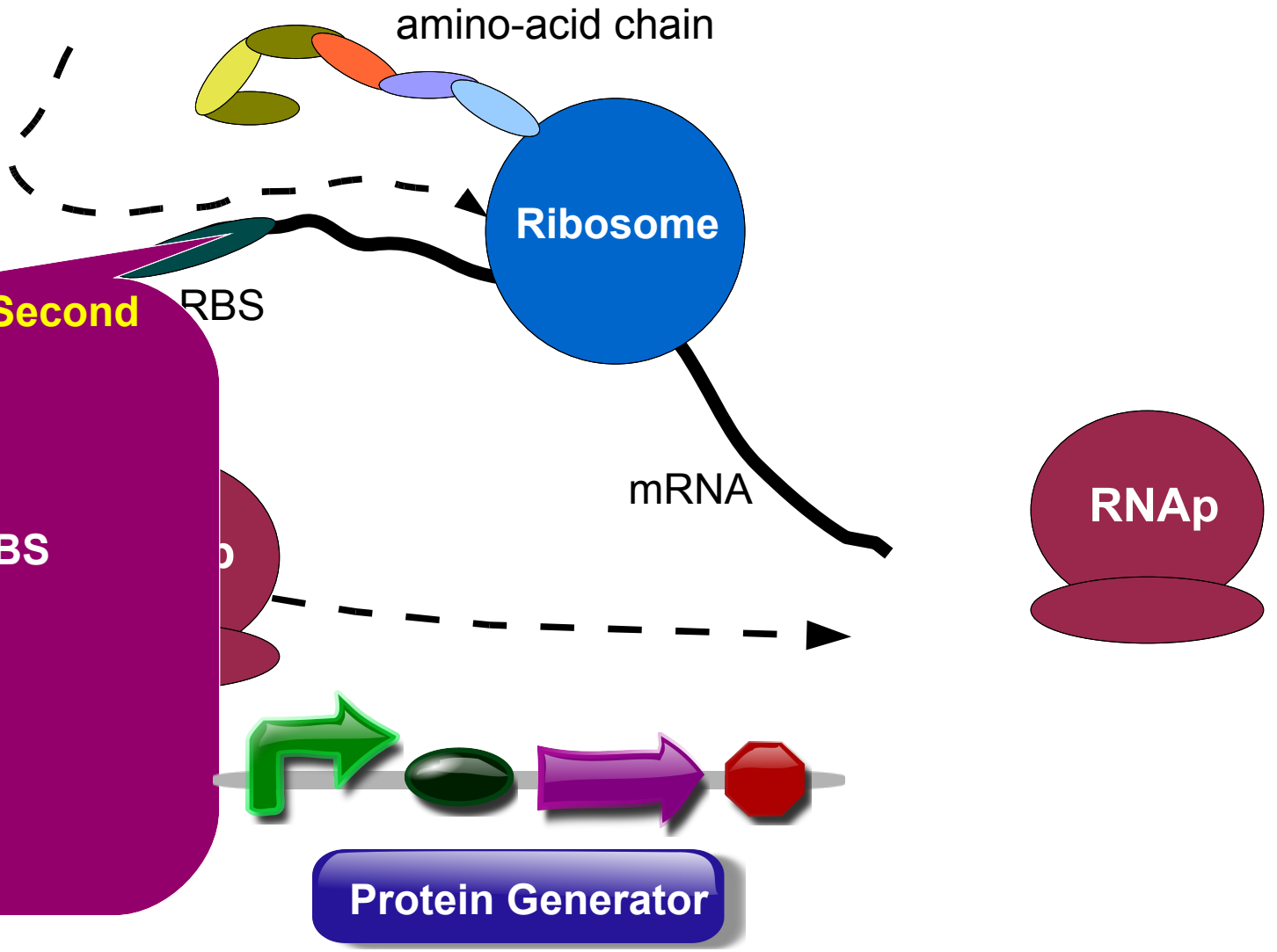
**- nb RNAps**
**- energy (ATP)**
**- cell Volume**
**- resources ...**



# Signal carrier in transcriptional devices



# Signal carrier in transcriptional devices



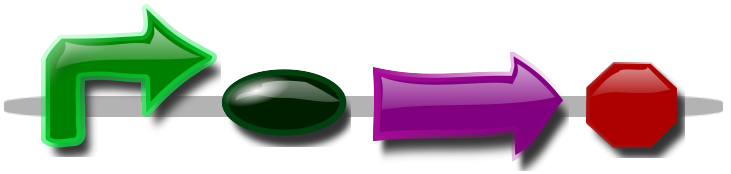

**Ribosomes Per Second (RiPS)**

**depends on:**

**- strength of the RBS**

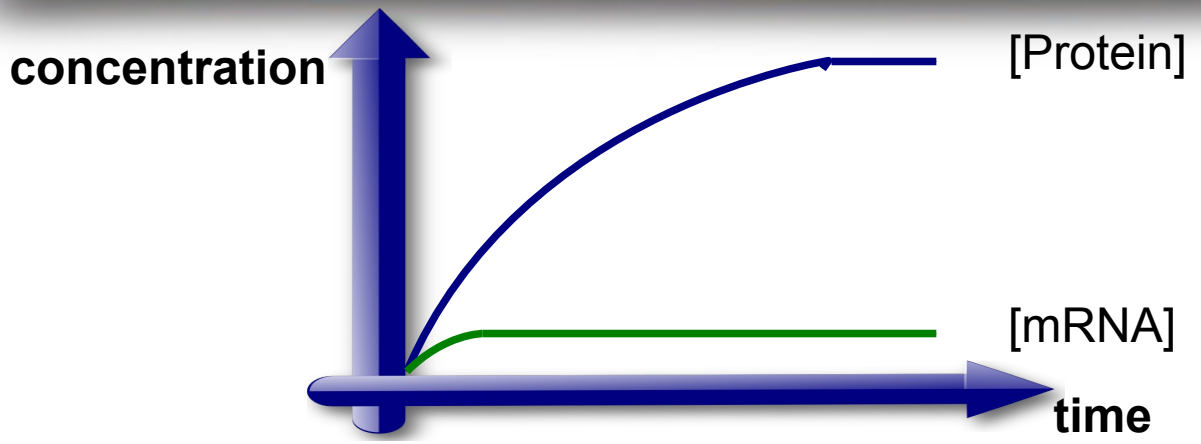
**- nb Ribosomes**
**- energy (ATP)**
**- cell volume**
**- tRNAs**
**- resources ...**

# Signal carrier in transcriptional devices



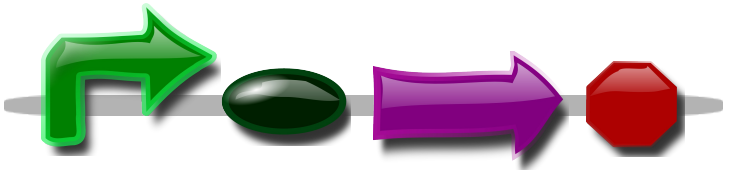
Protein Generator

# Signal carrier in transcriptional devices



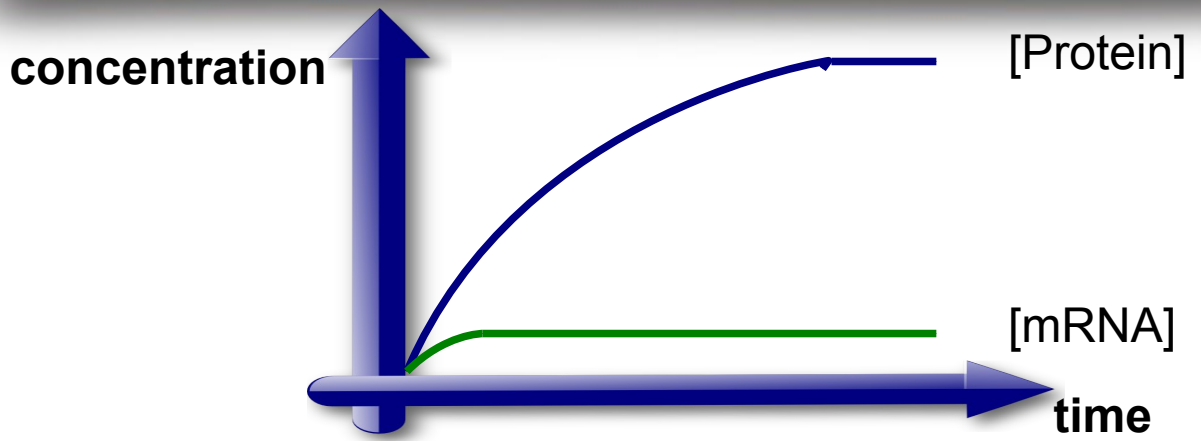

$$\frac{d[mRNA]}{dt} = k1 - d1[mRNA]$$

$$\frac{d[Protein]}{dt} = k2.[mRNA] - d2[Protein]$$



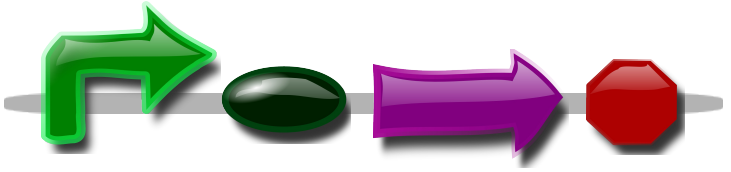
Protein Generator

# Signal carrier in transcriptional devices




$$\frac{d[mRNA]}{dt} = \text{  } - d1[mRNA]$$

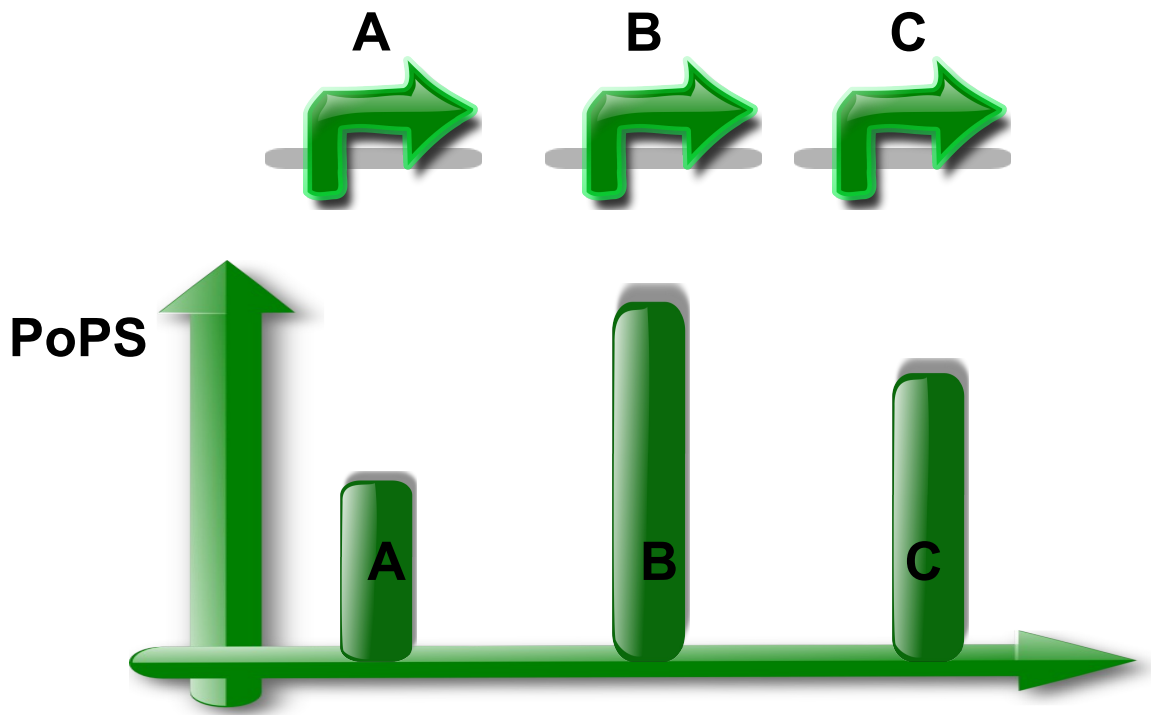
$$\frac{d[Protein]}{dt} = \text{  }[mRNA] - d2[Protein]$$



Protein Generator

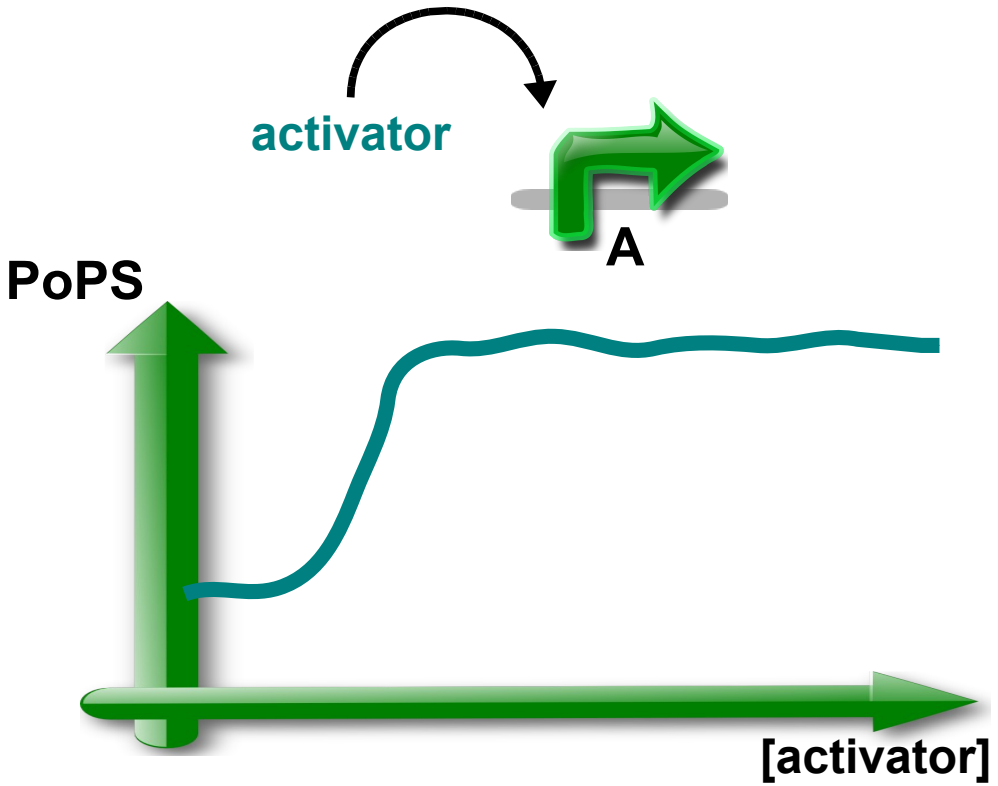
# PoPS Generators

# PoPS Characterisation



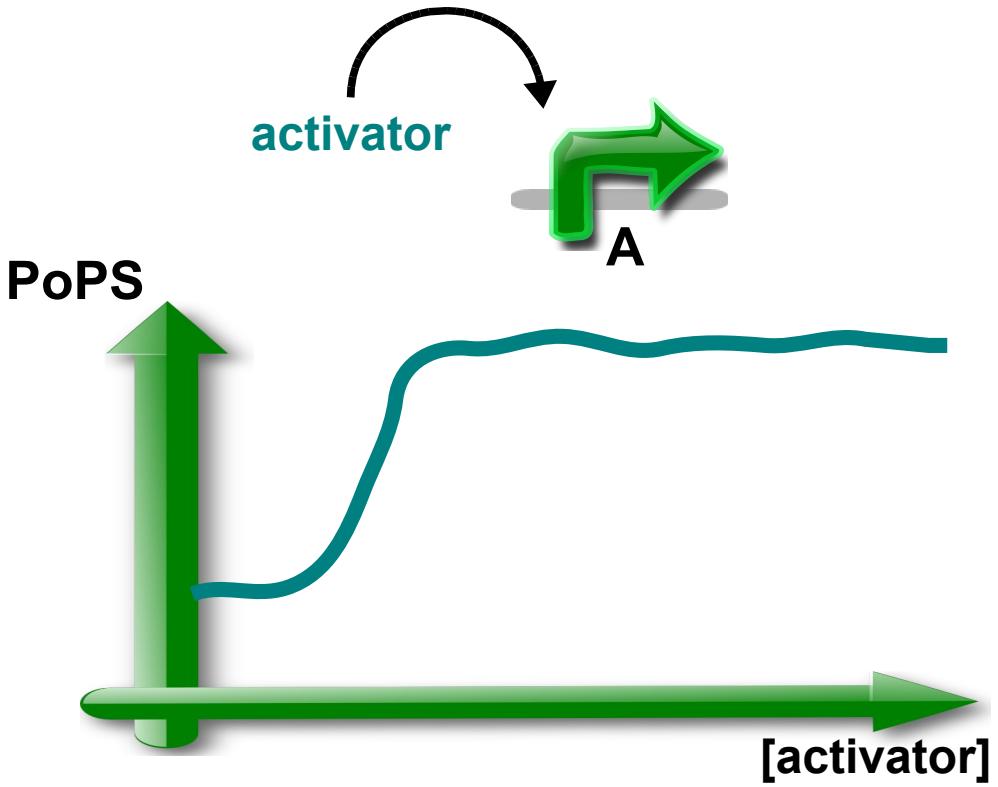

**Constitutive Promoters**

# Tuneable PoPS Generators

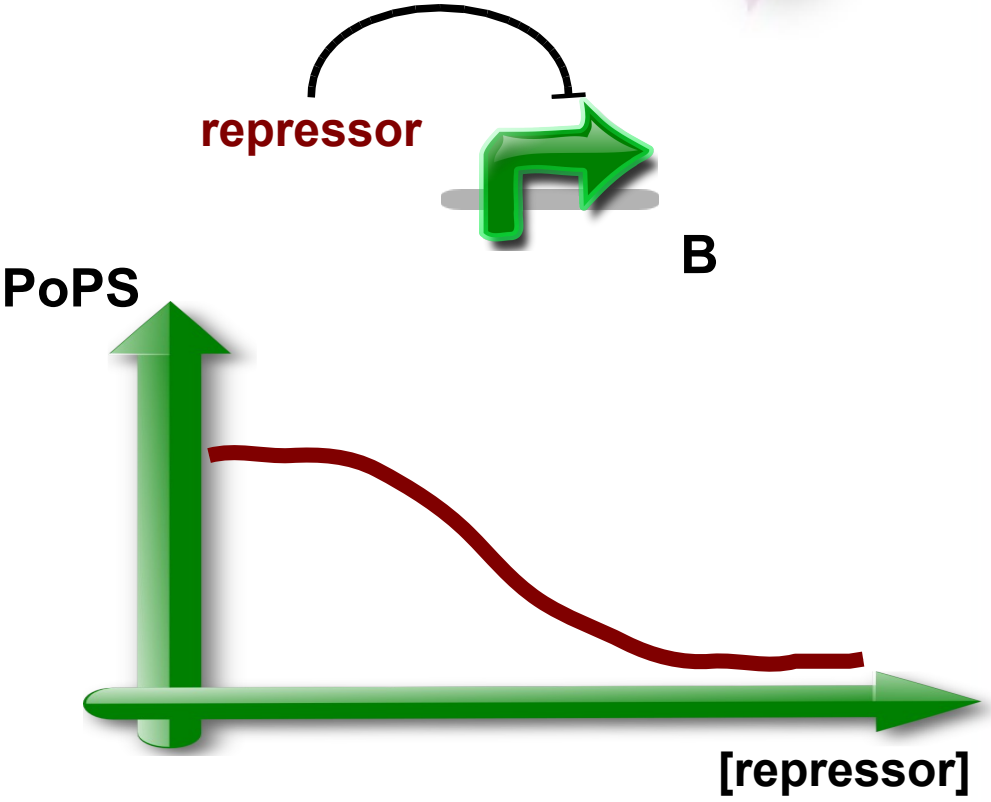



Activated Promoter

# Tuneable PoPS Generators




Activated Promoter




Repressed Promoter

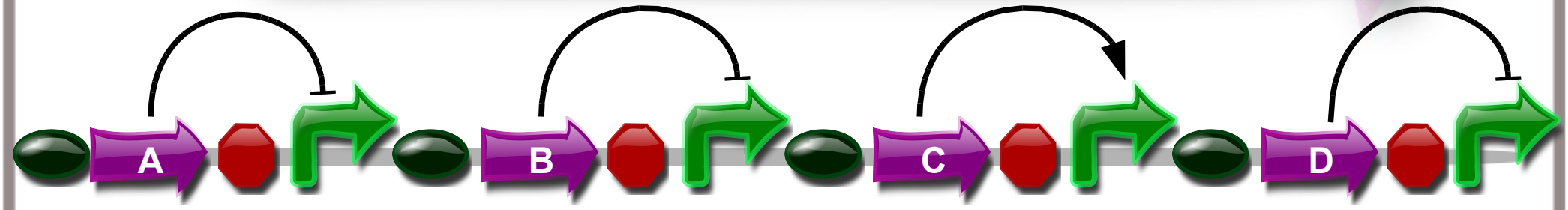
# RiPS Generators

**Are the same principles applicable to RBS parts ?**

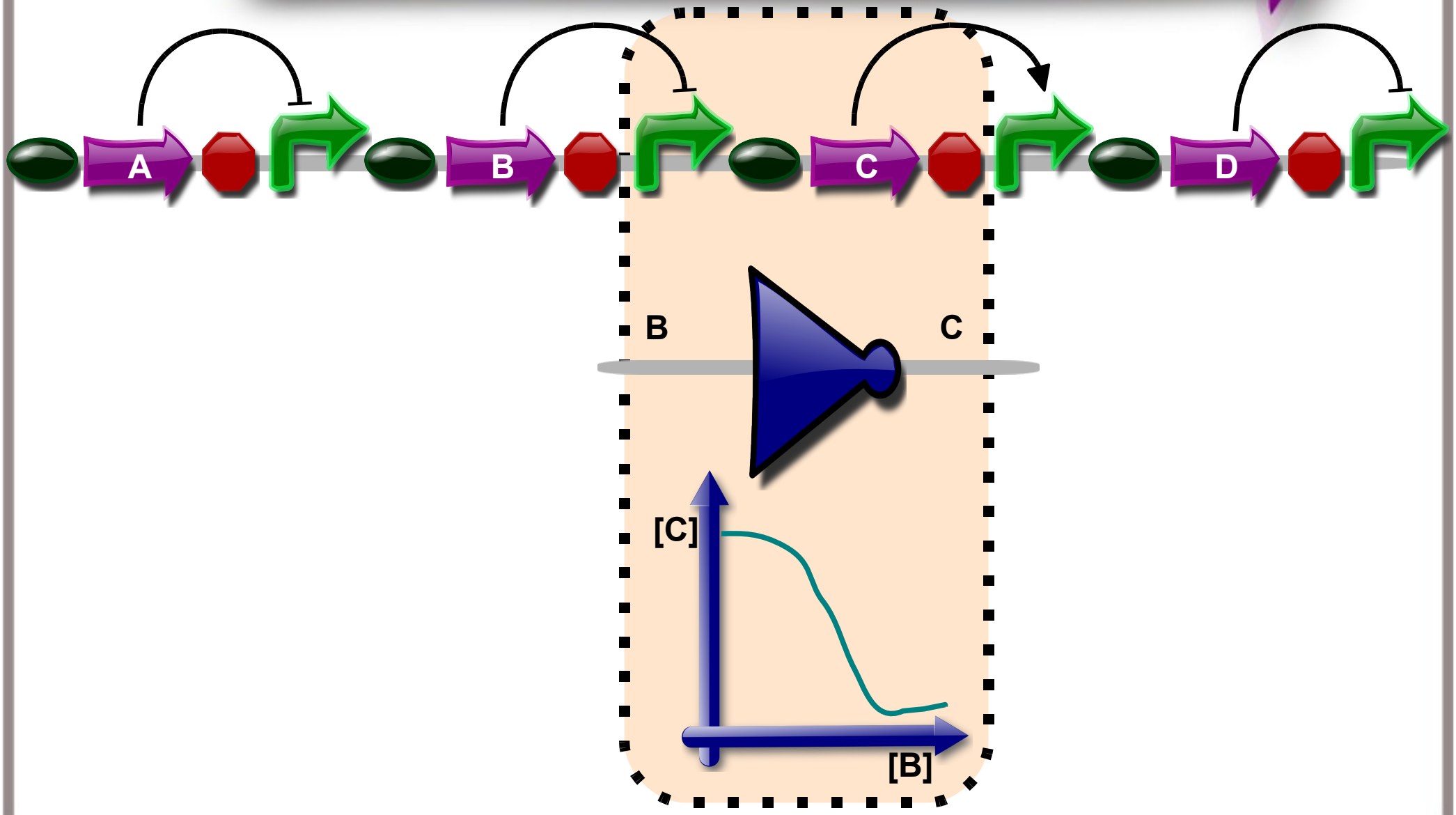
**give it a try ...**

**keywords**: riboswitches, miRNA ...

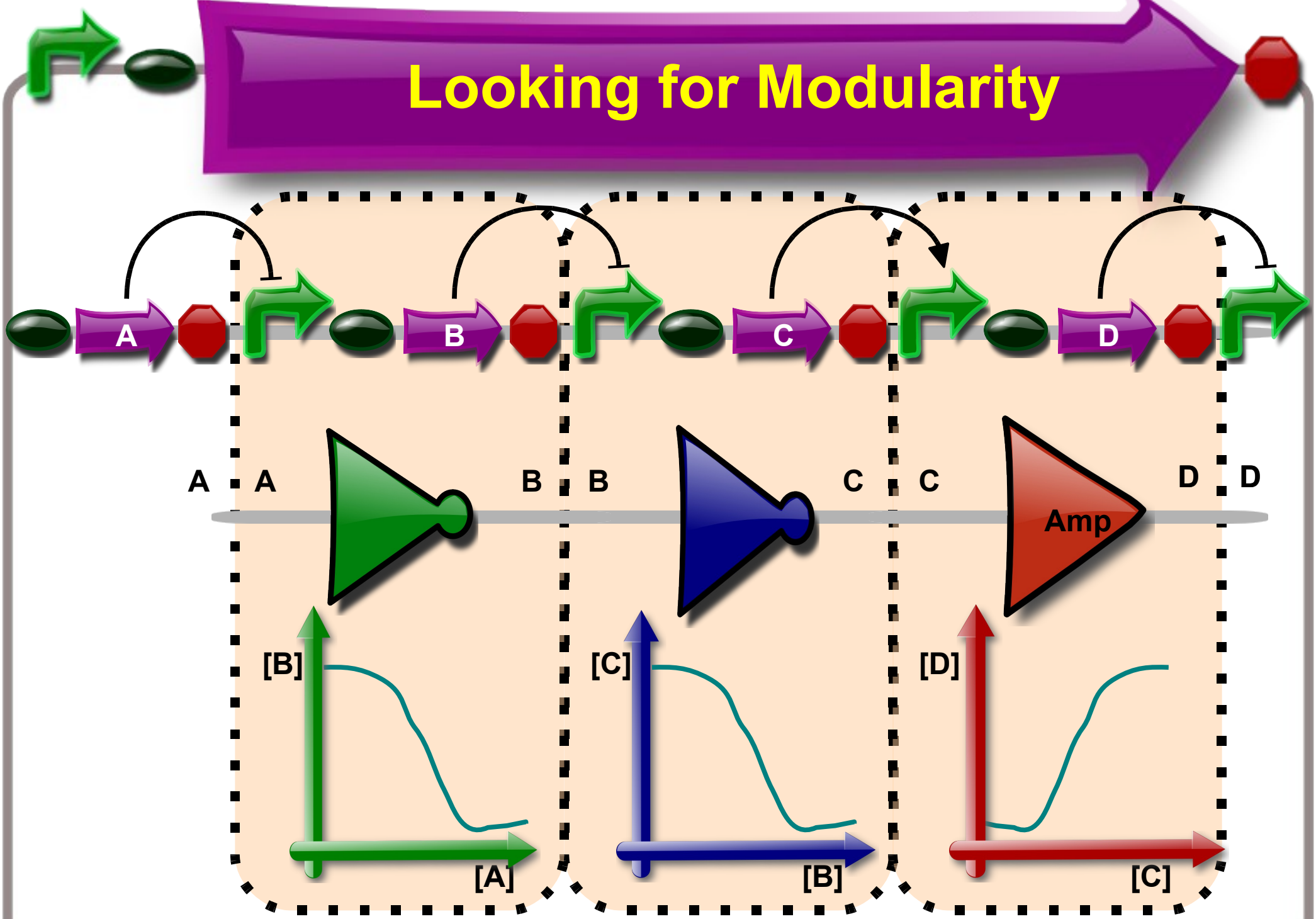
# Looking for Modularity



# Looking for Modularity



# Looking for Modularity



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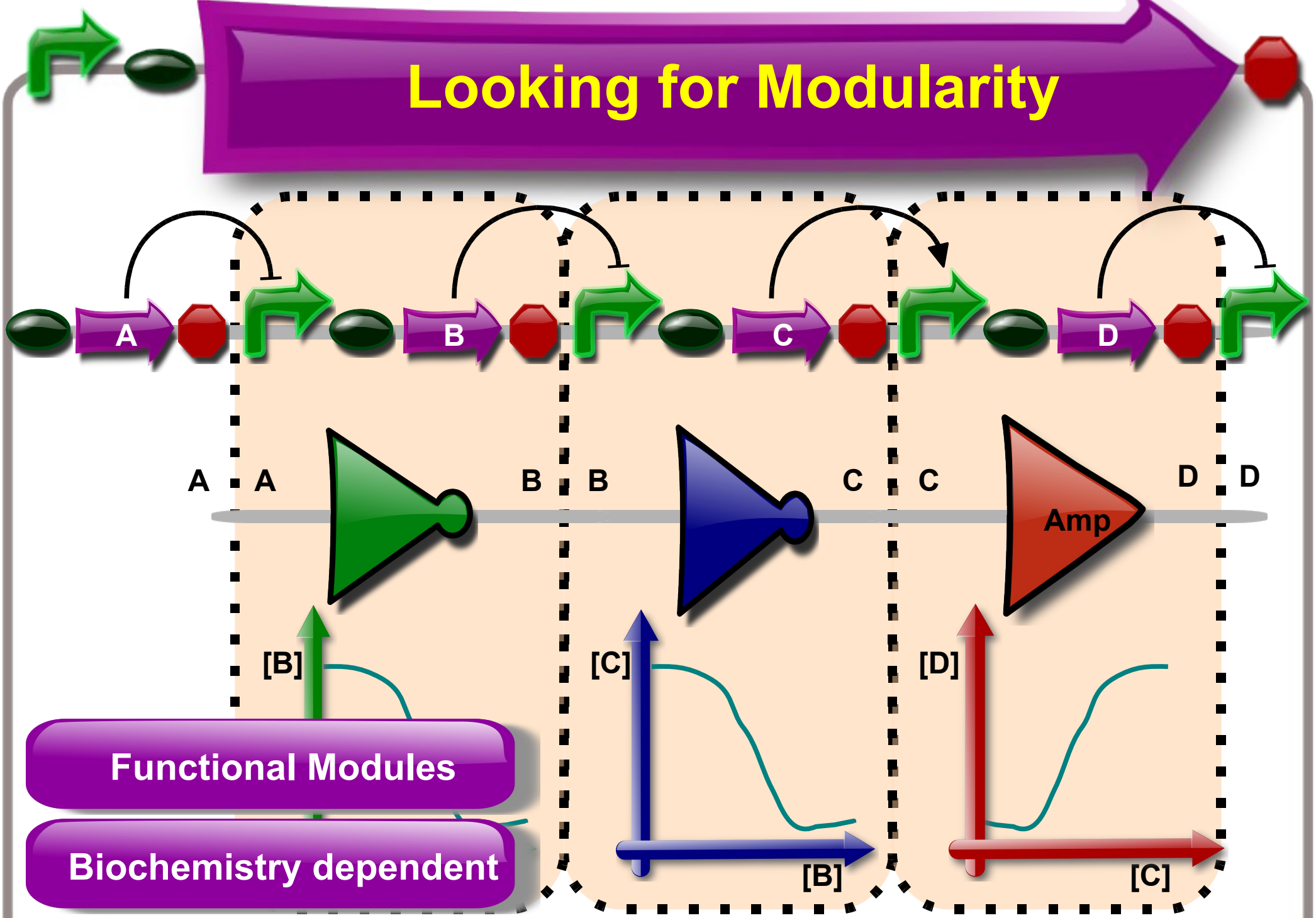
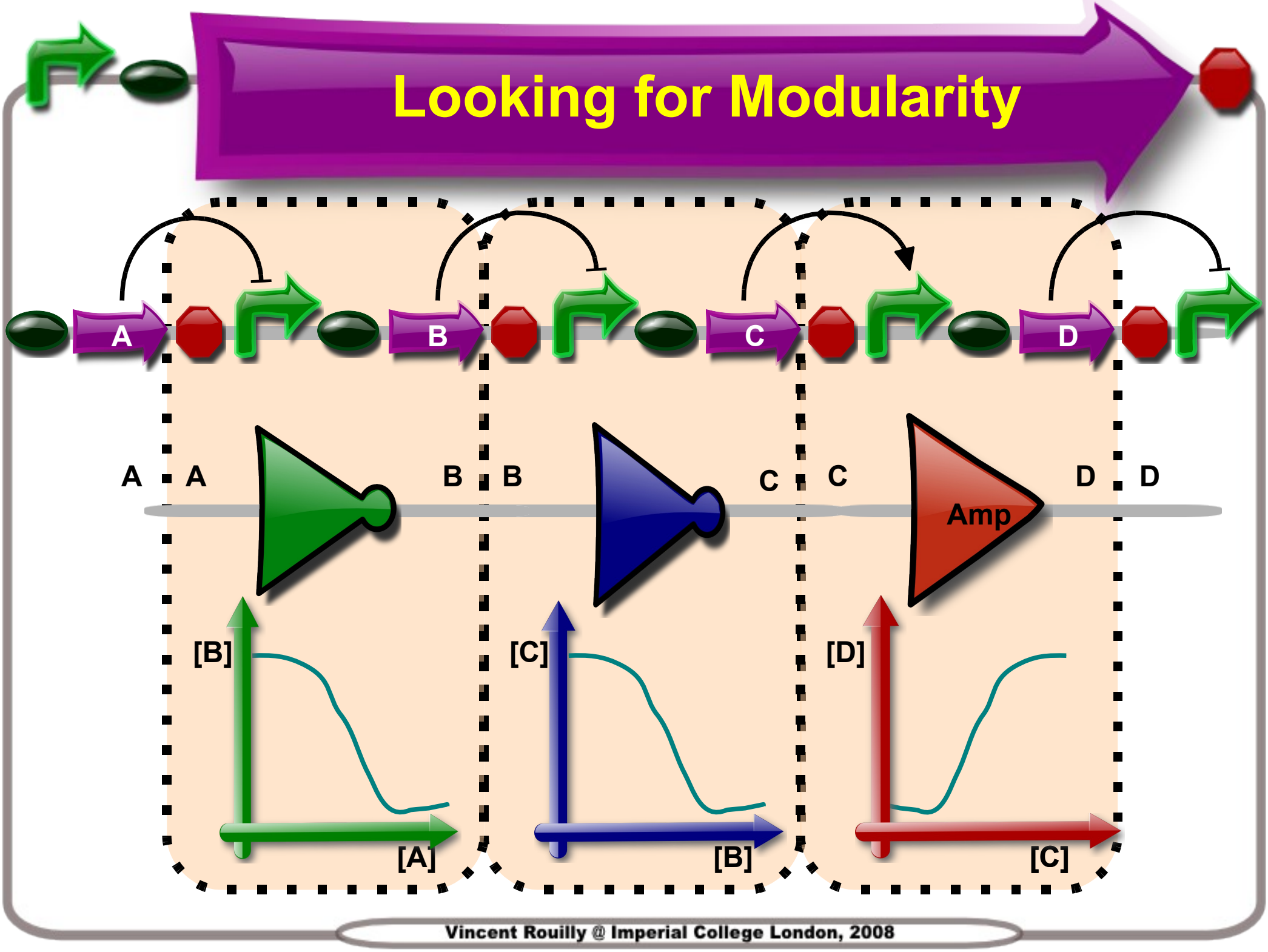



Functional Modules

Biochemistry dependent

# Looking for Modularity



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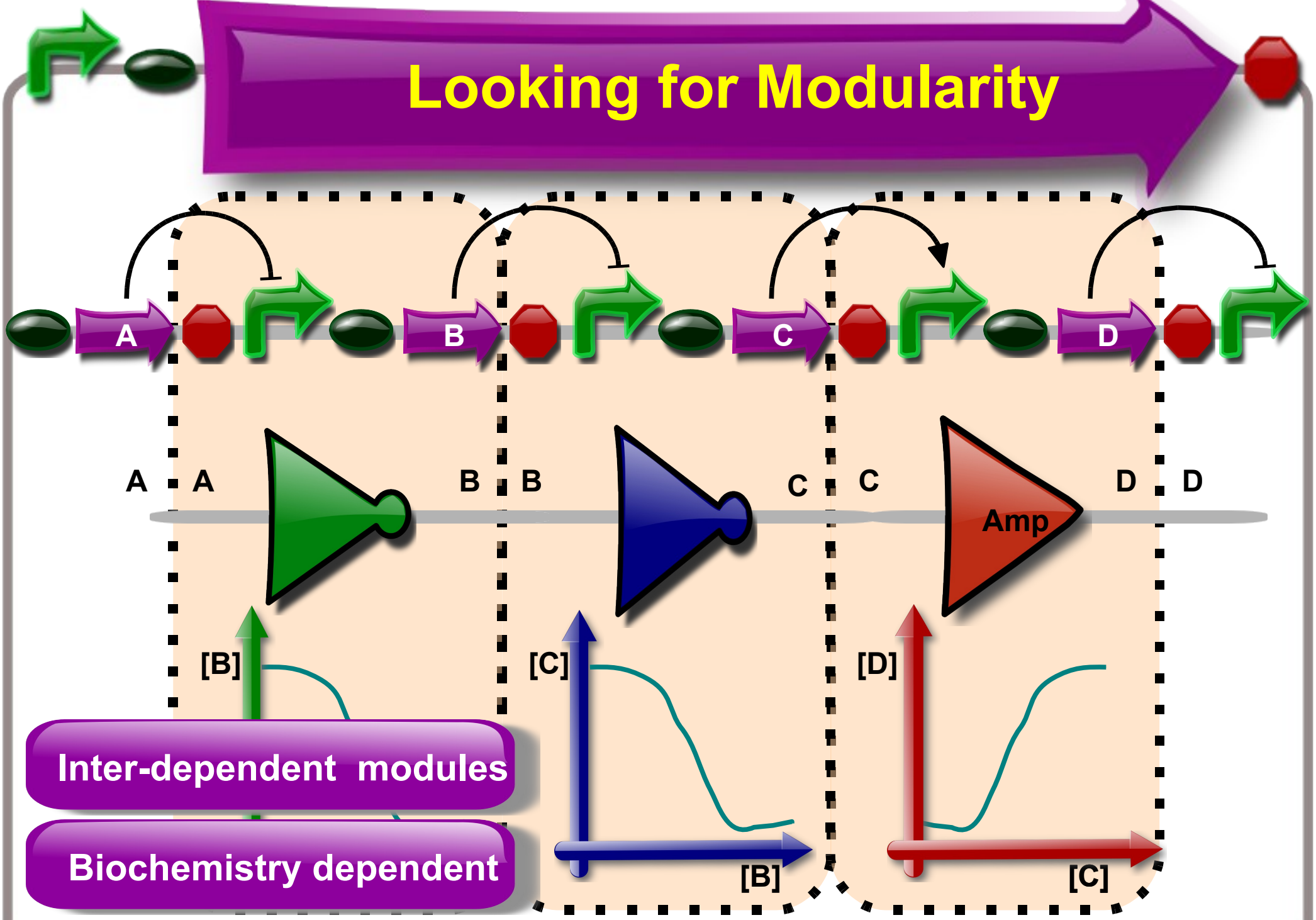

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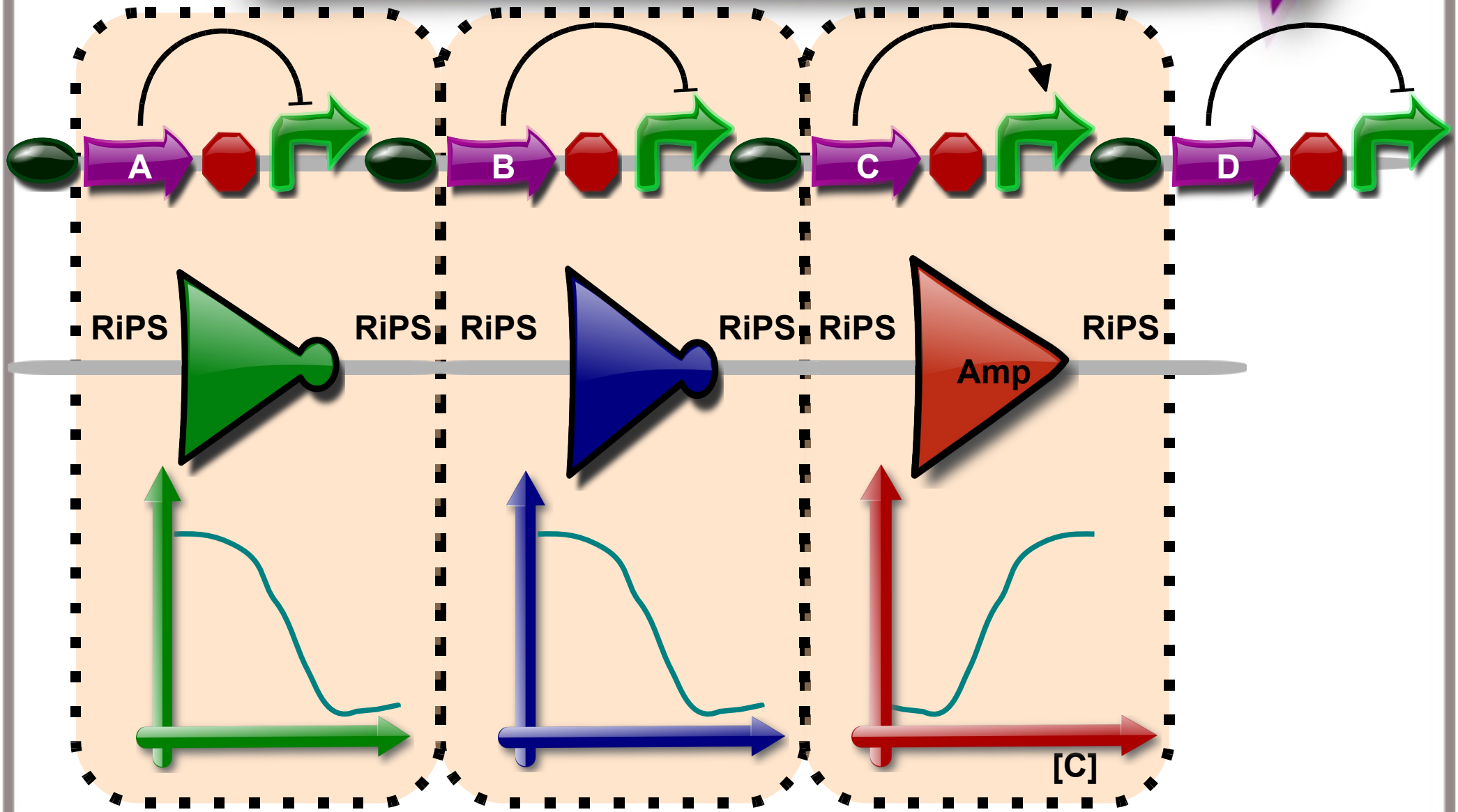
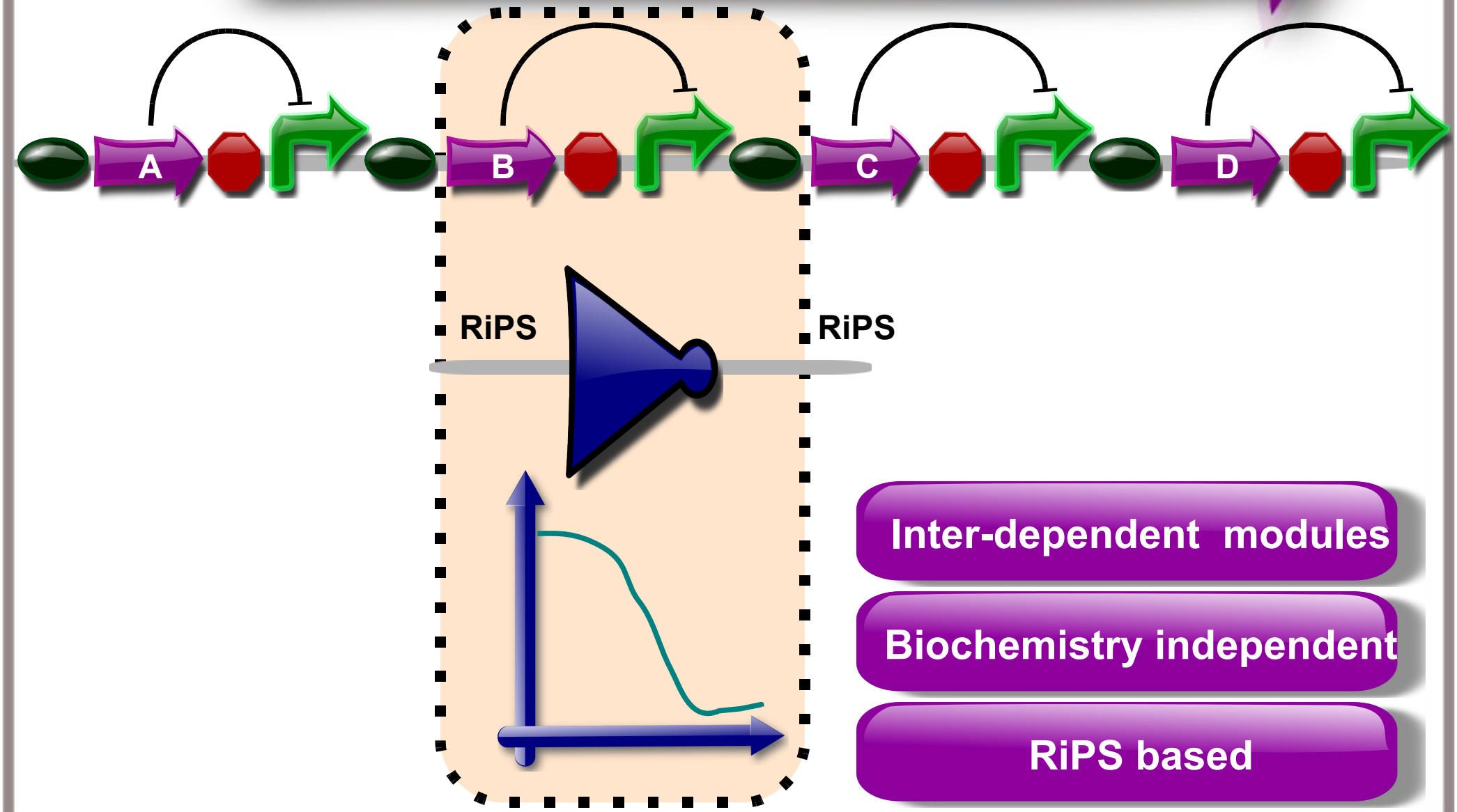
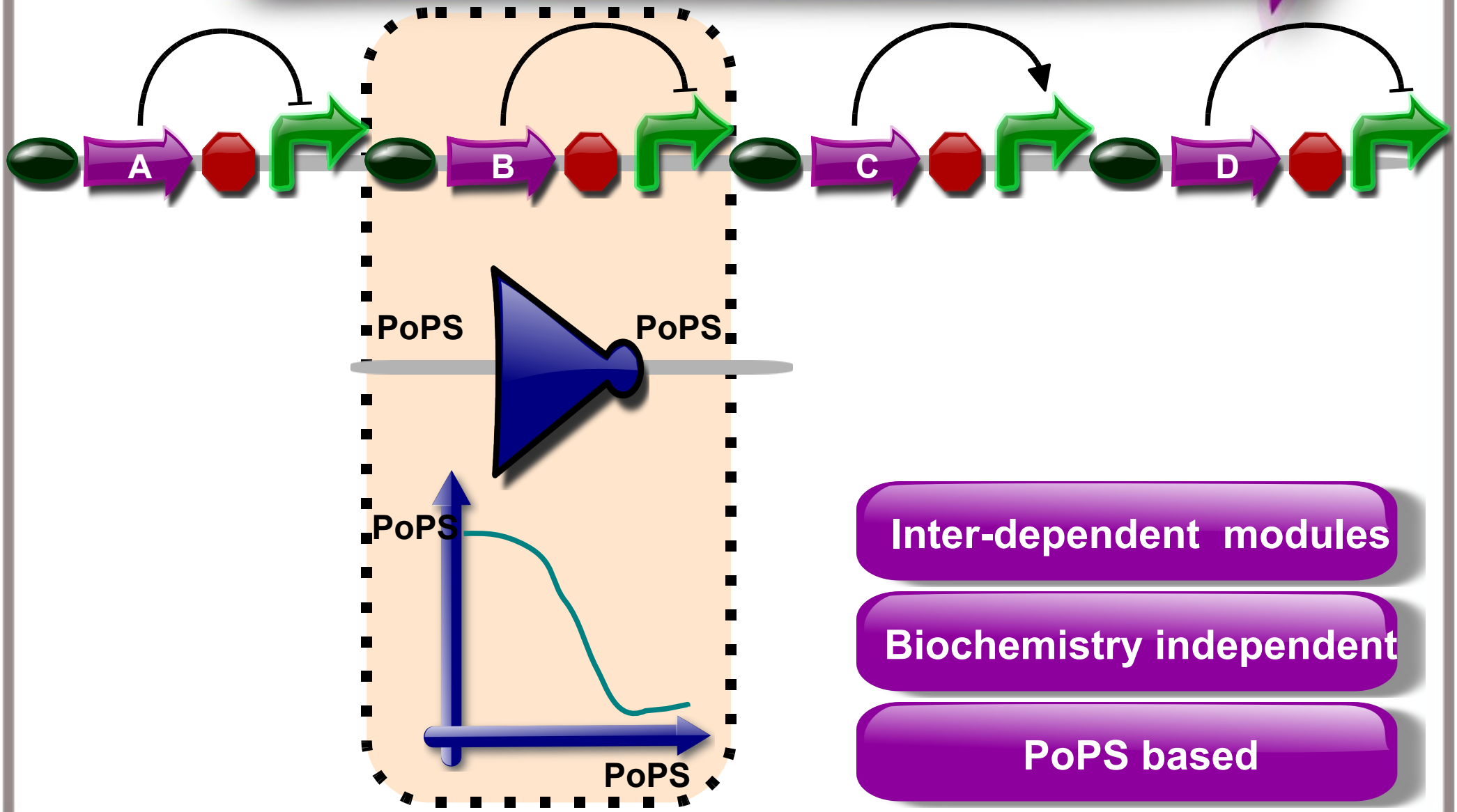


# Modular / Generic RiPS Inverter



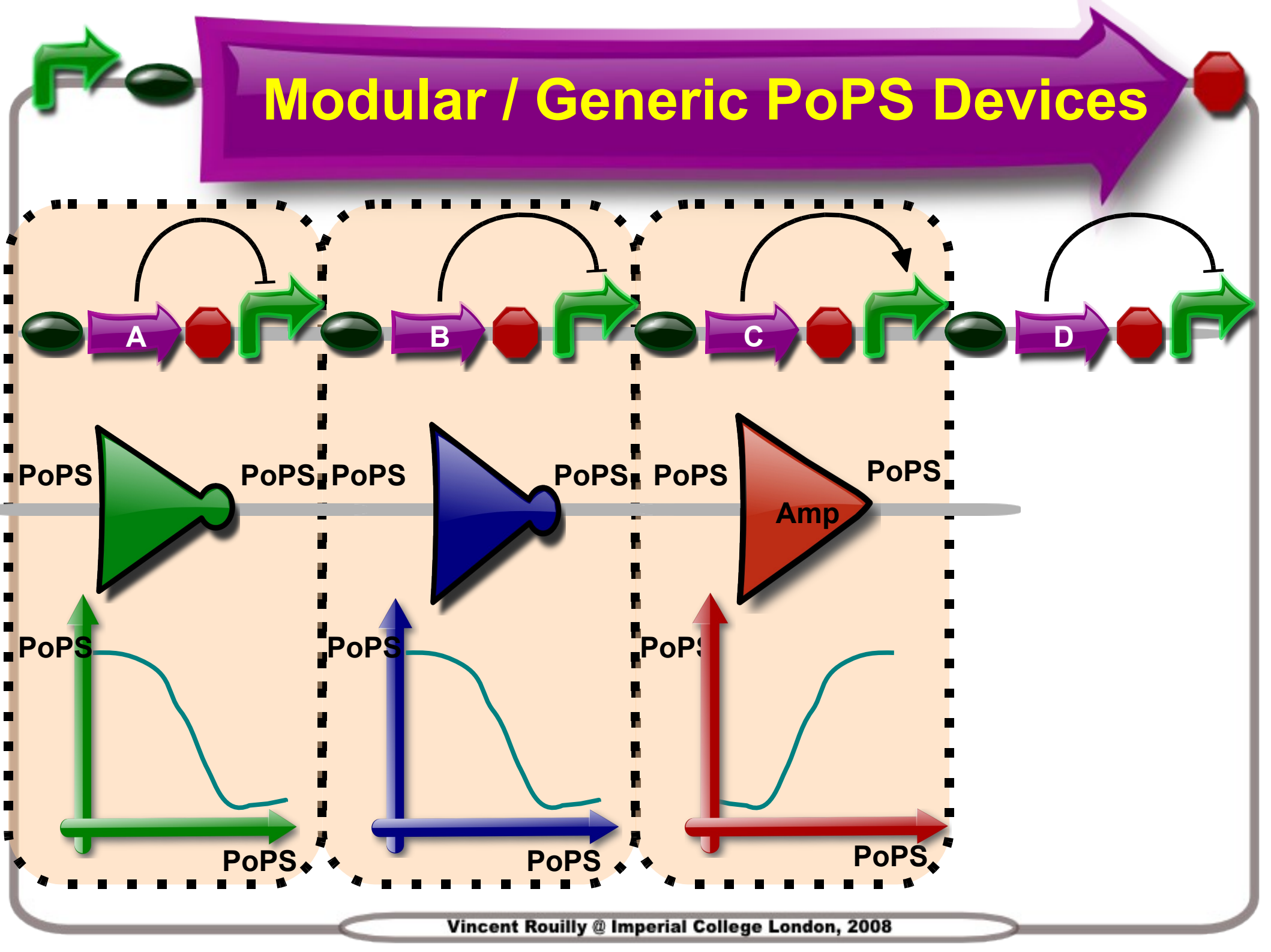

- Inter-dependent modules
- Biochemistry independent
- RiPS based

# Modular / Generic PoPS Inverter




- Inter-dependent modules
- Biochemistry independent
- PoPS based

# Modular / Generic PoPS Devices



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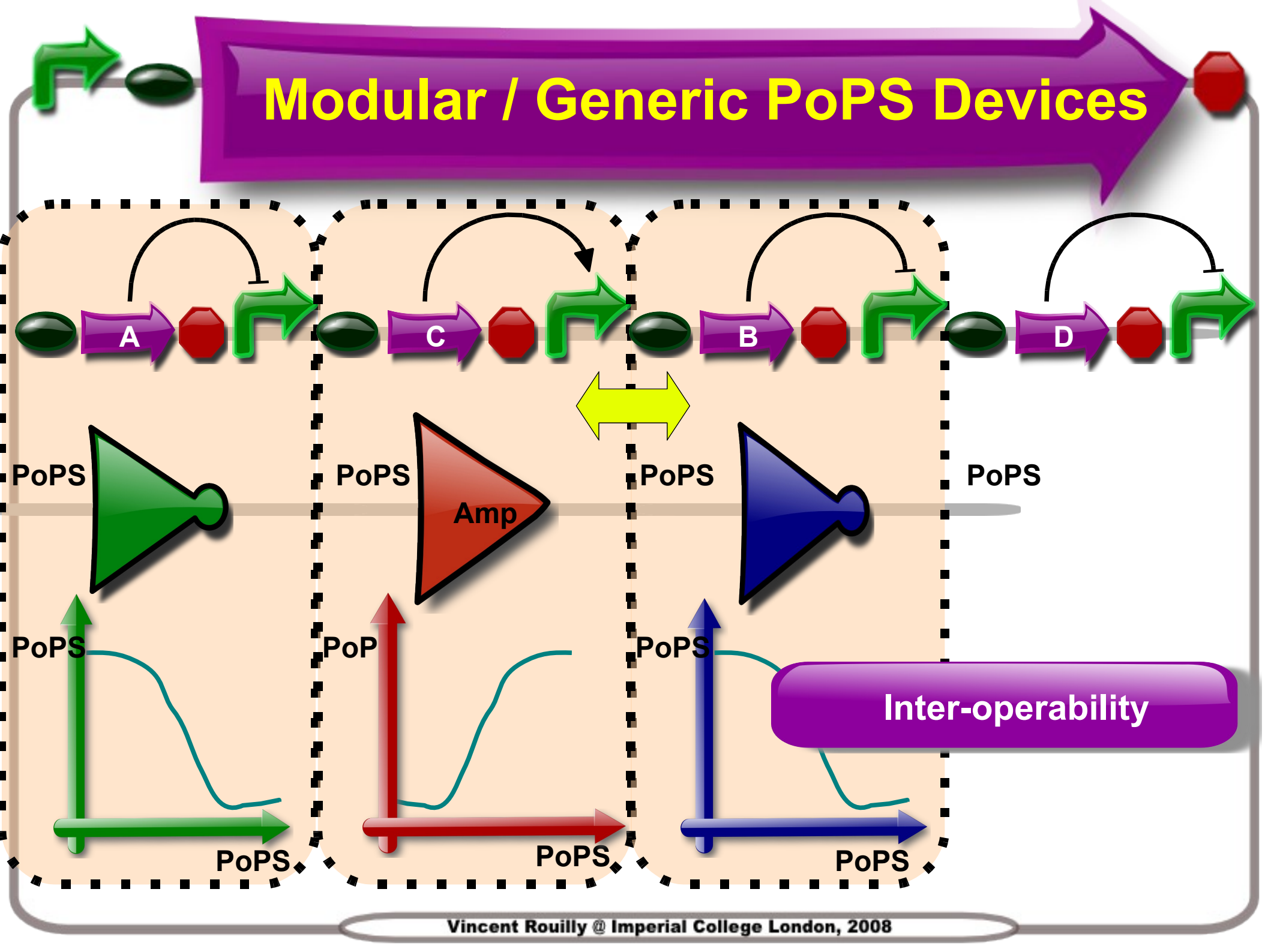

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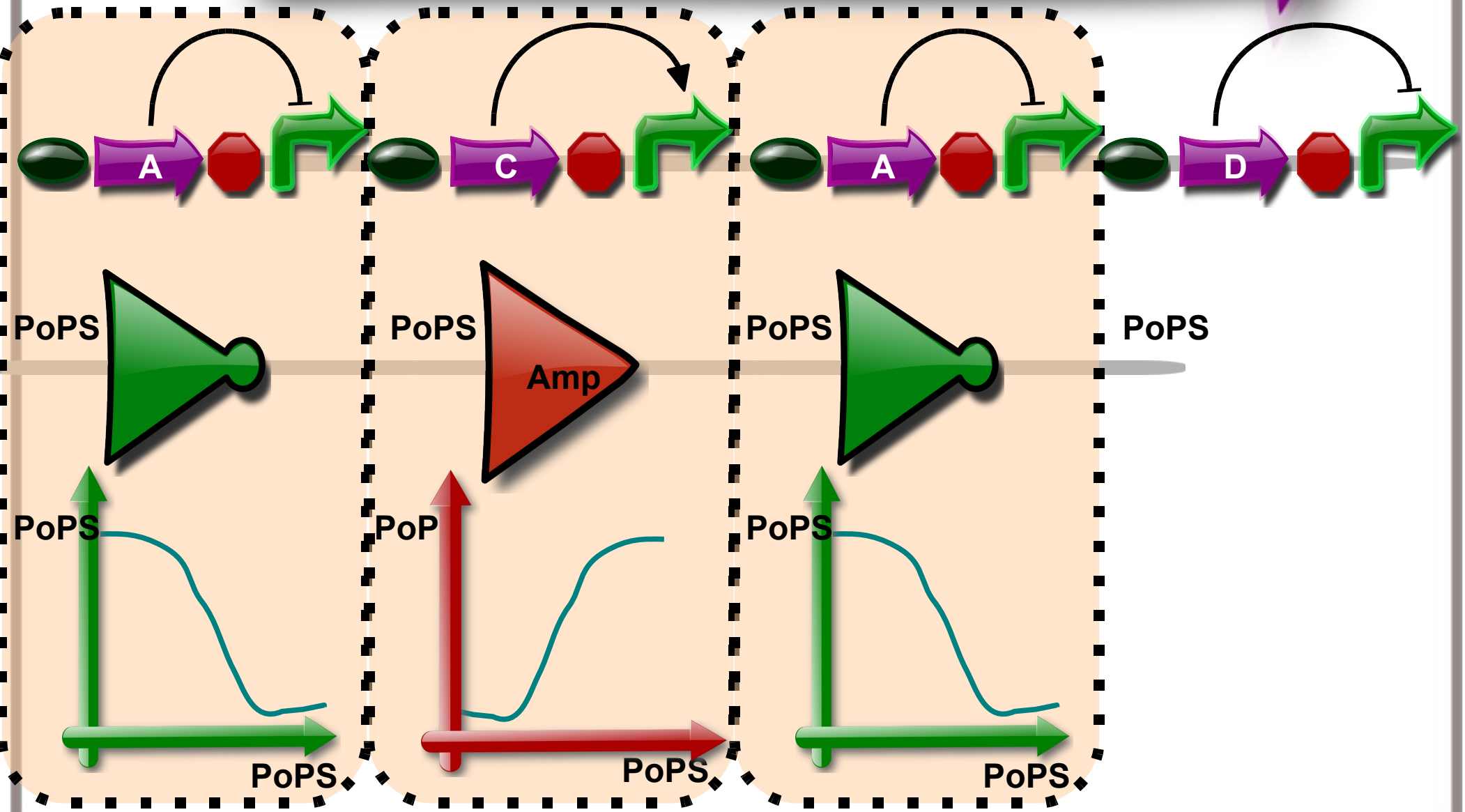
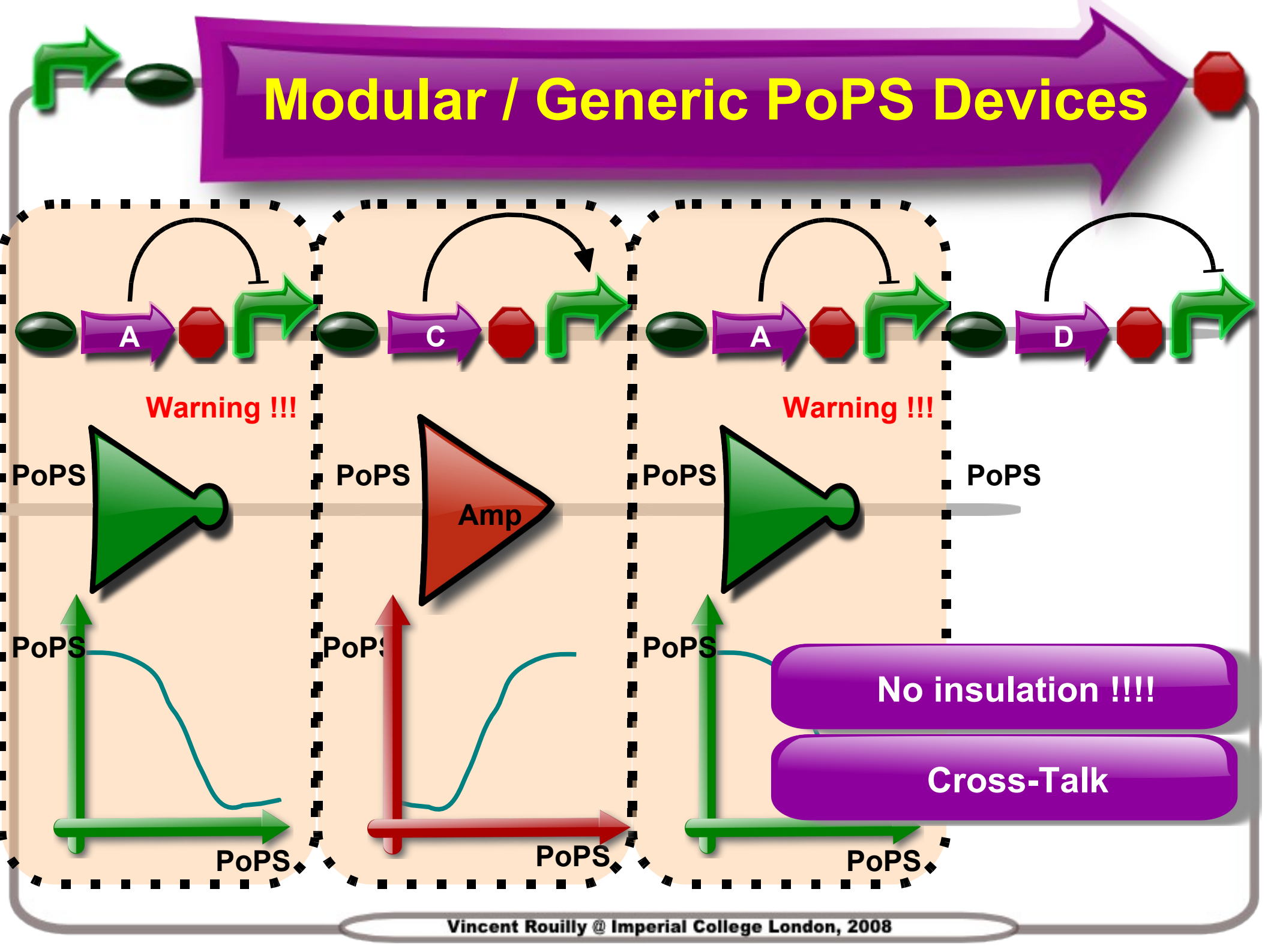


# Modular / Generic PoPS Devices



# What have we learnt so far ?

RiPS and PoPS are standard signal carrier for transcriptional device

RiPS and PoPS can promote modularity

RiPS and PoPS can promote re-usability

# What have we learnt so far ?

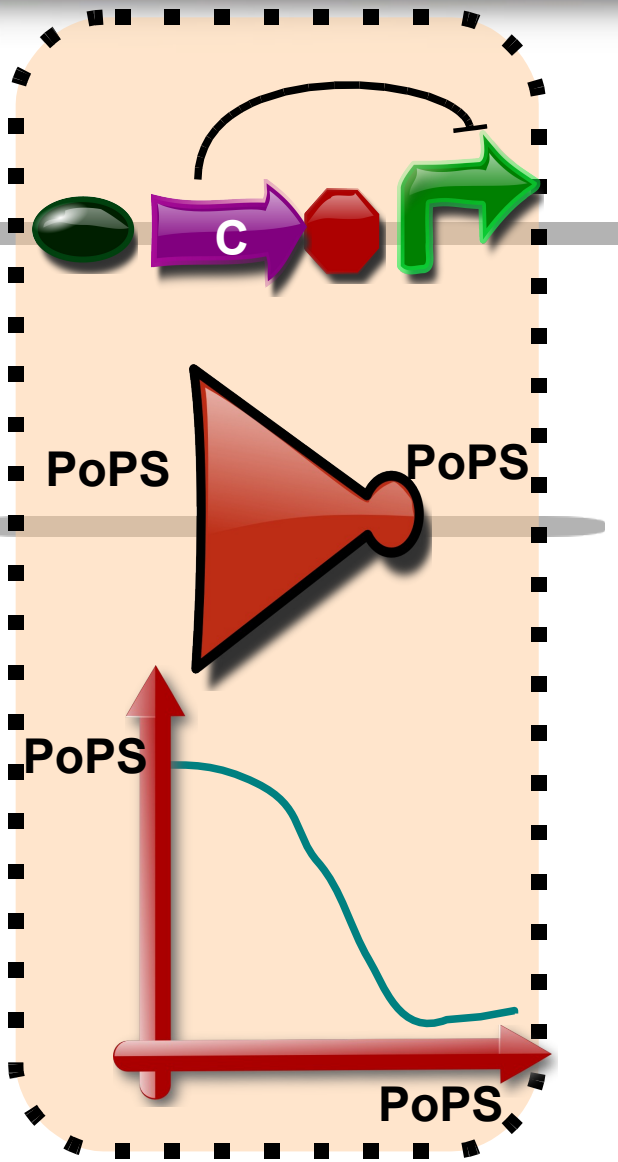
RiPS and PoPS are standard signal carrier for transcriptional device

RiPS and PoPS can promote modularity

RiPS and PoPS can promote re-usability

**Is it enough to insure that a device will function properly ?**

# Will it work as expected ?



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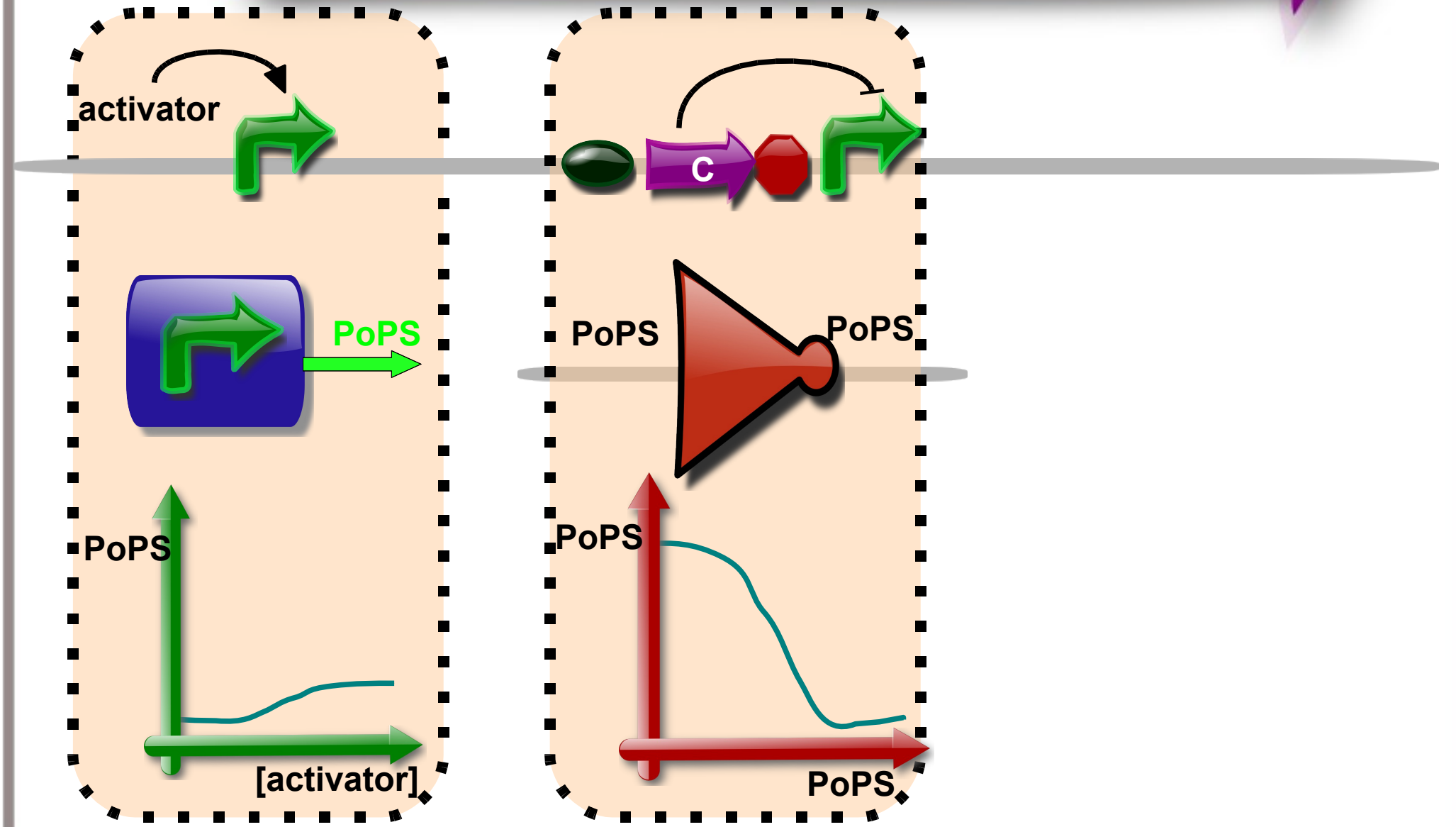
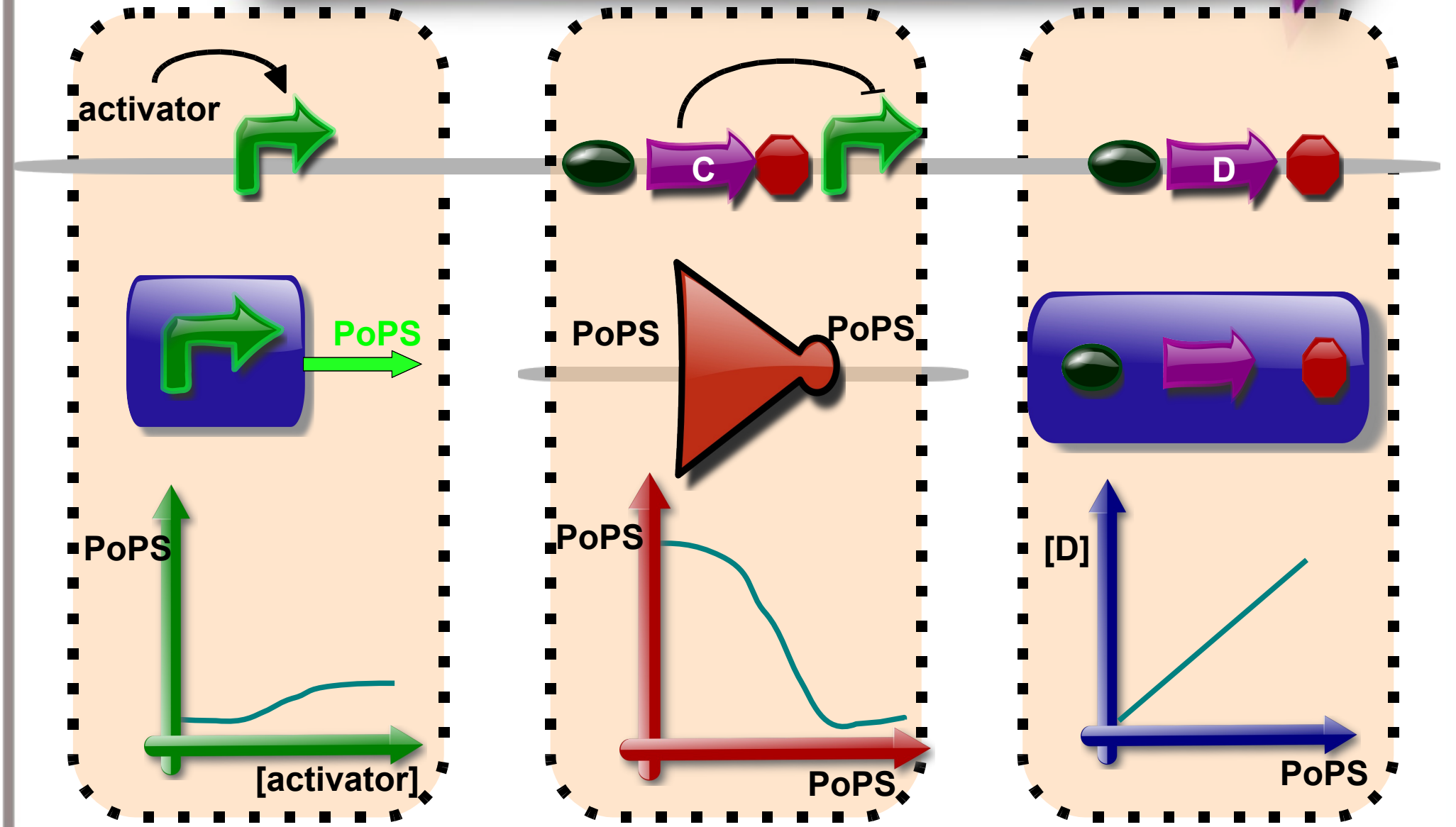
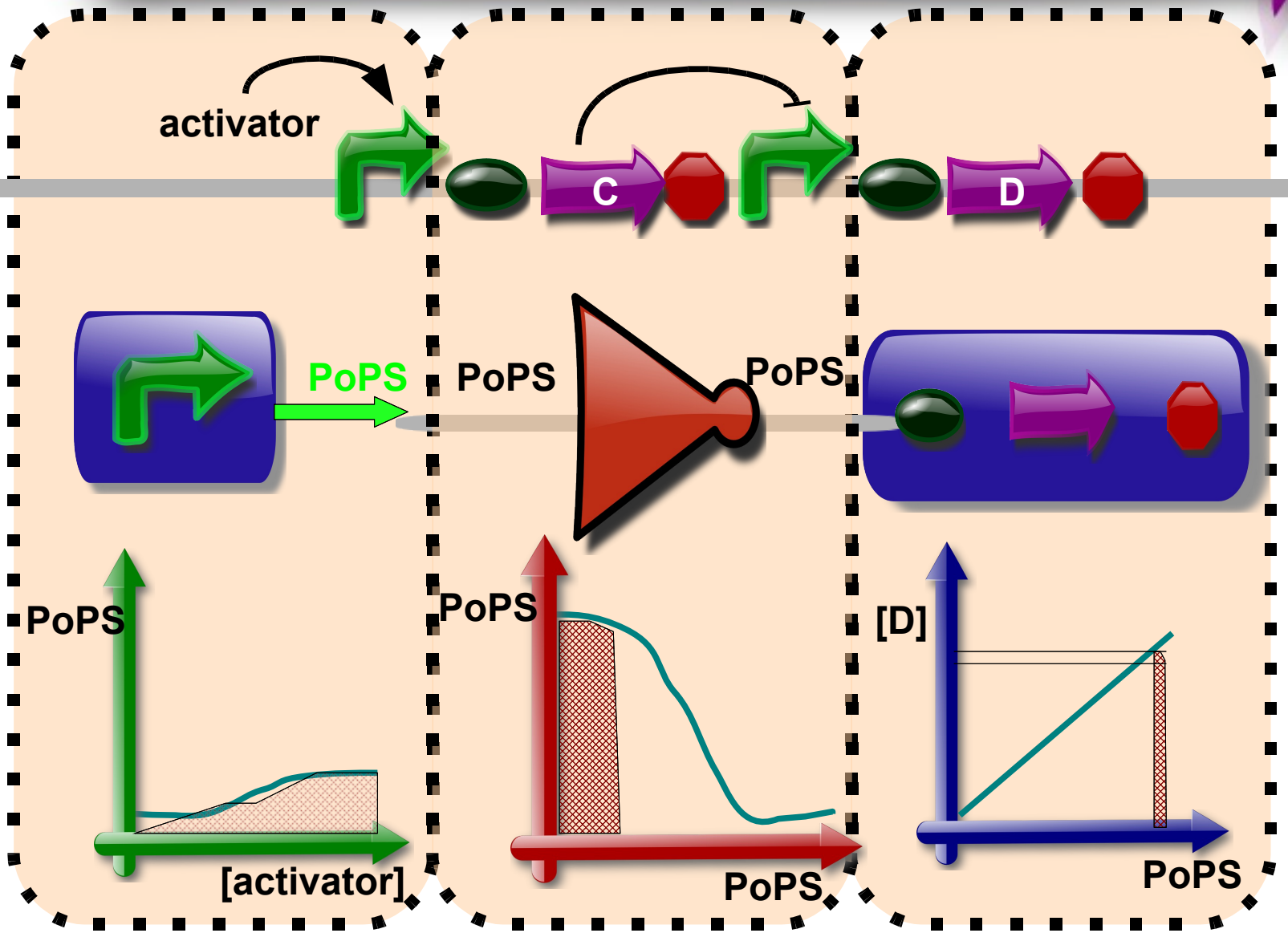


# Will it work as expected ?



# Will it work as expected ?



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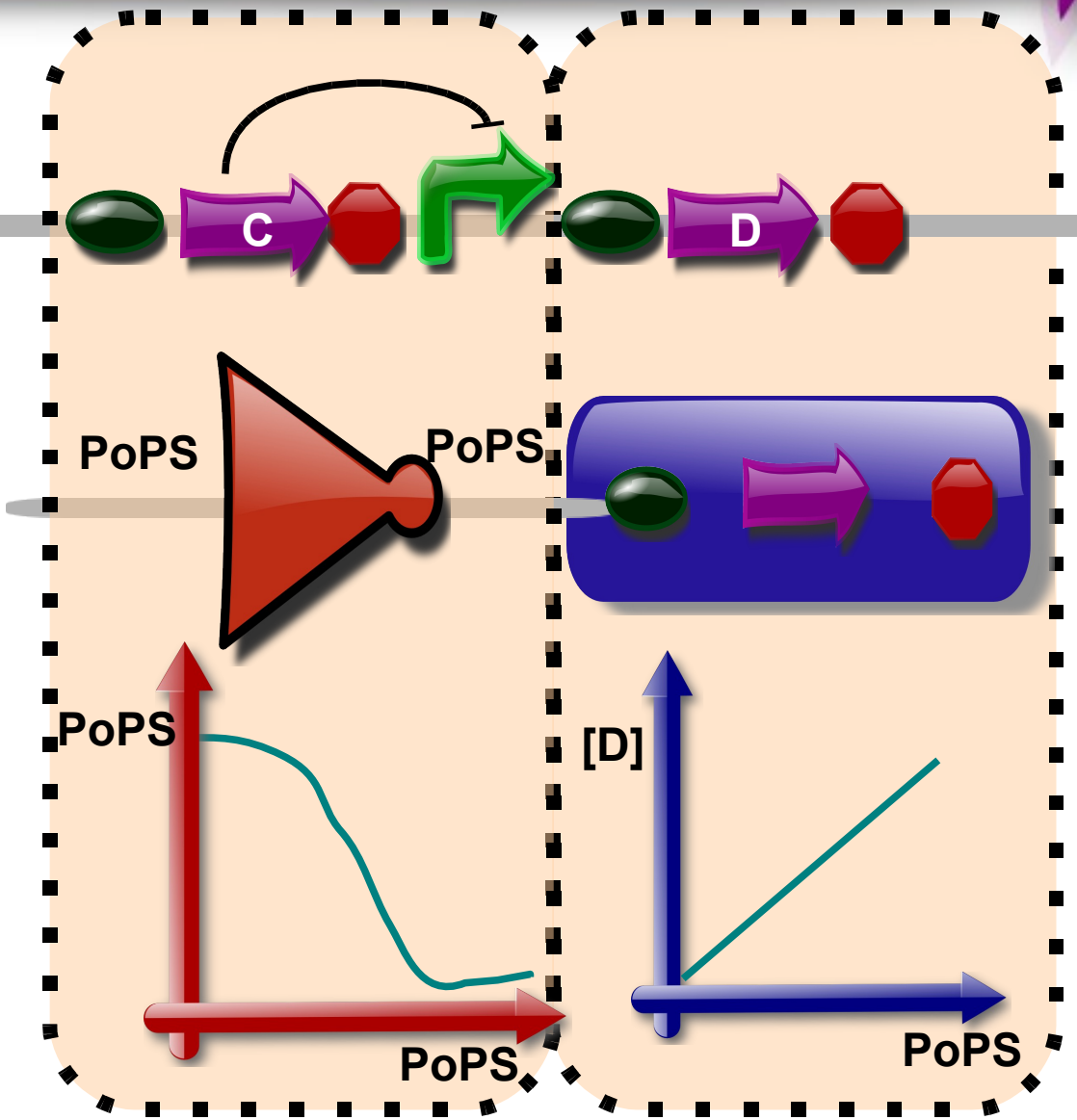
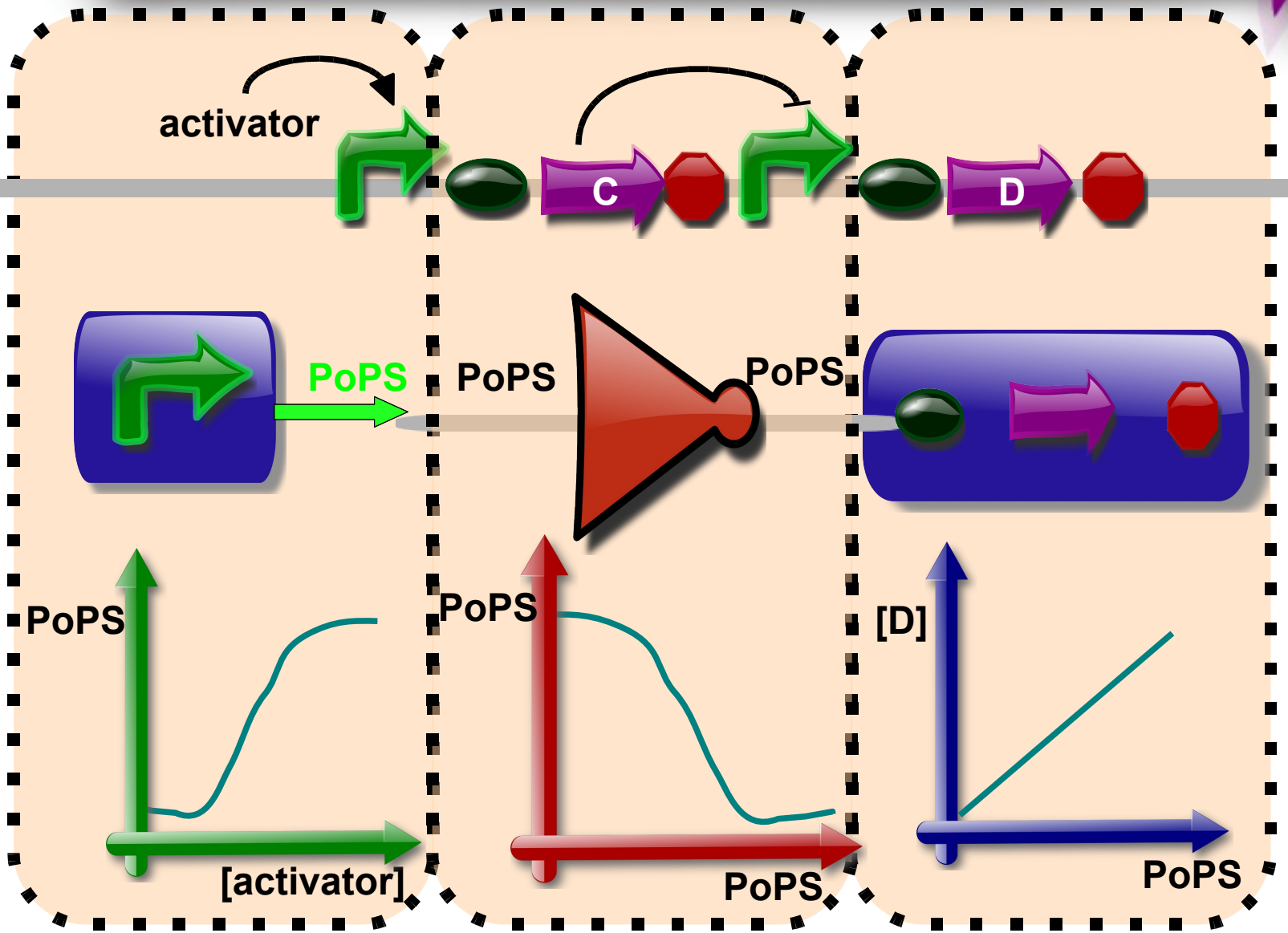
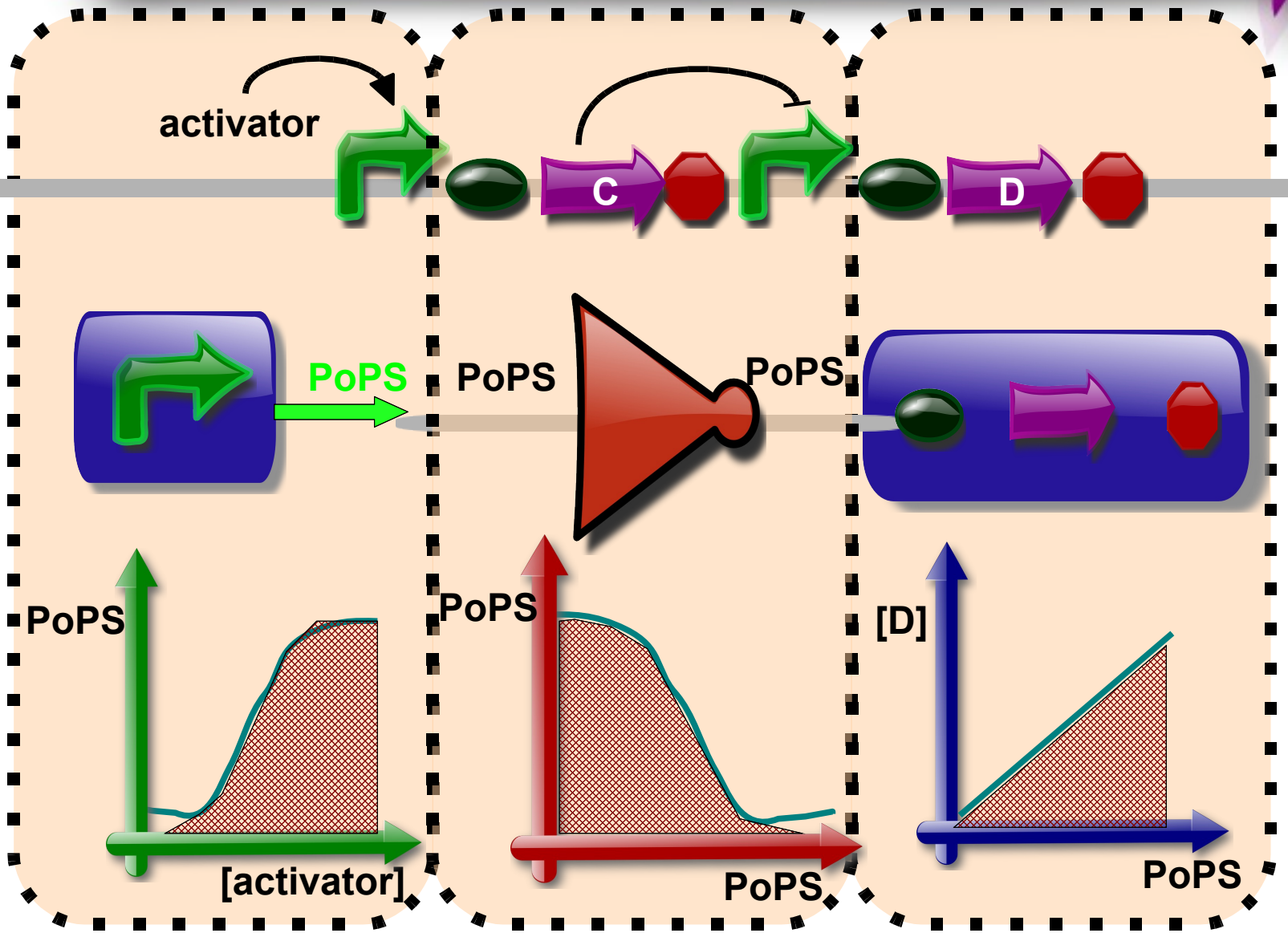


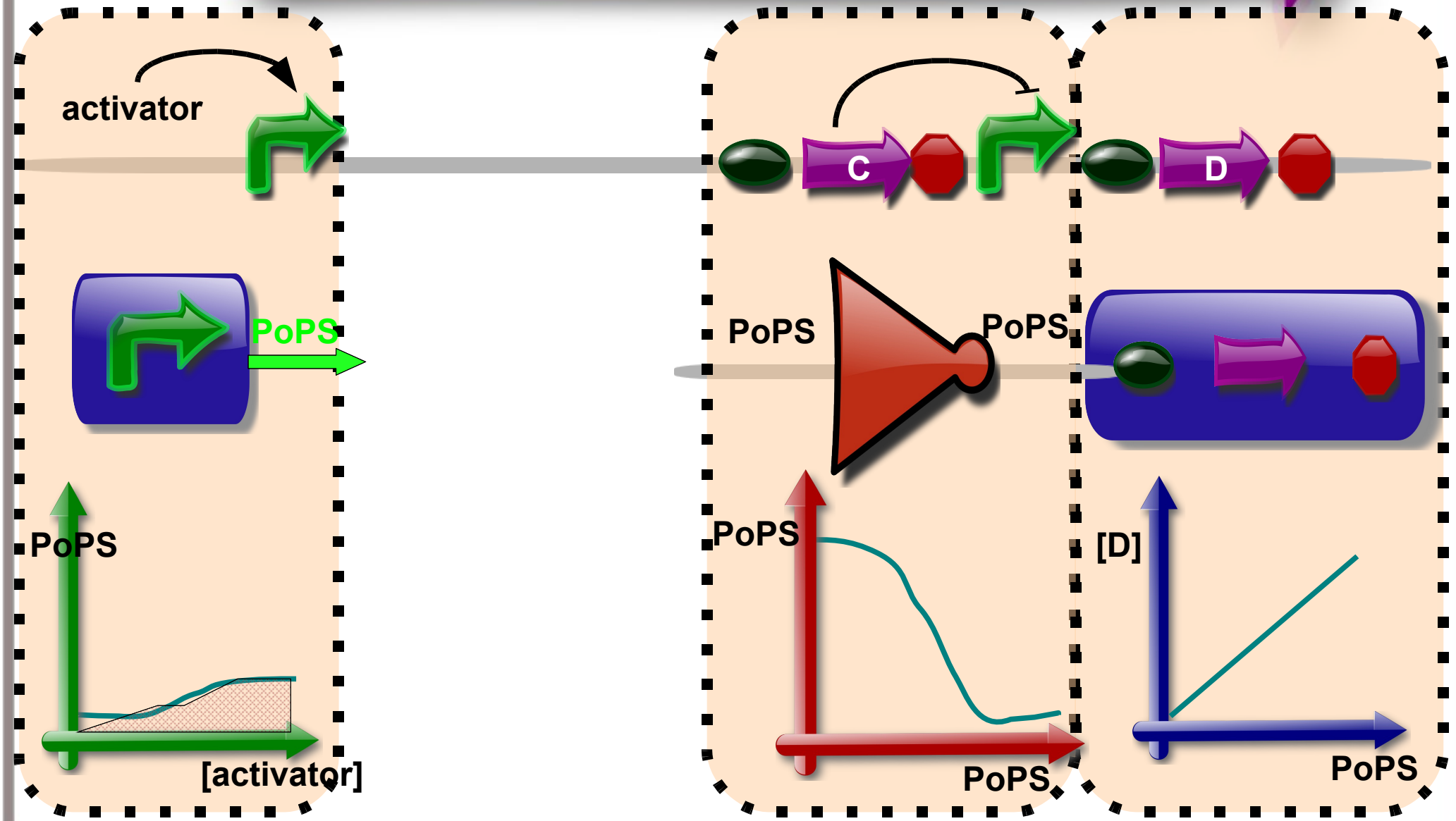
# Design for PoPs Matching



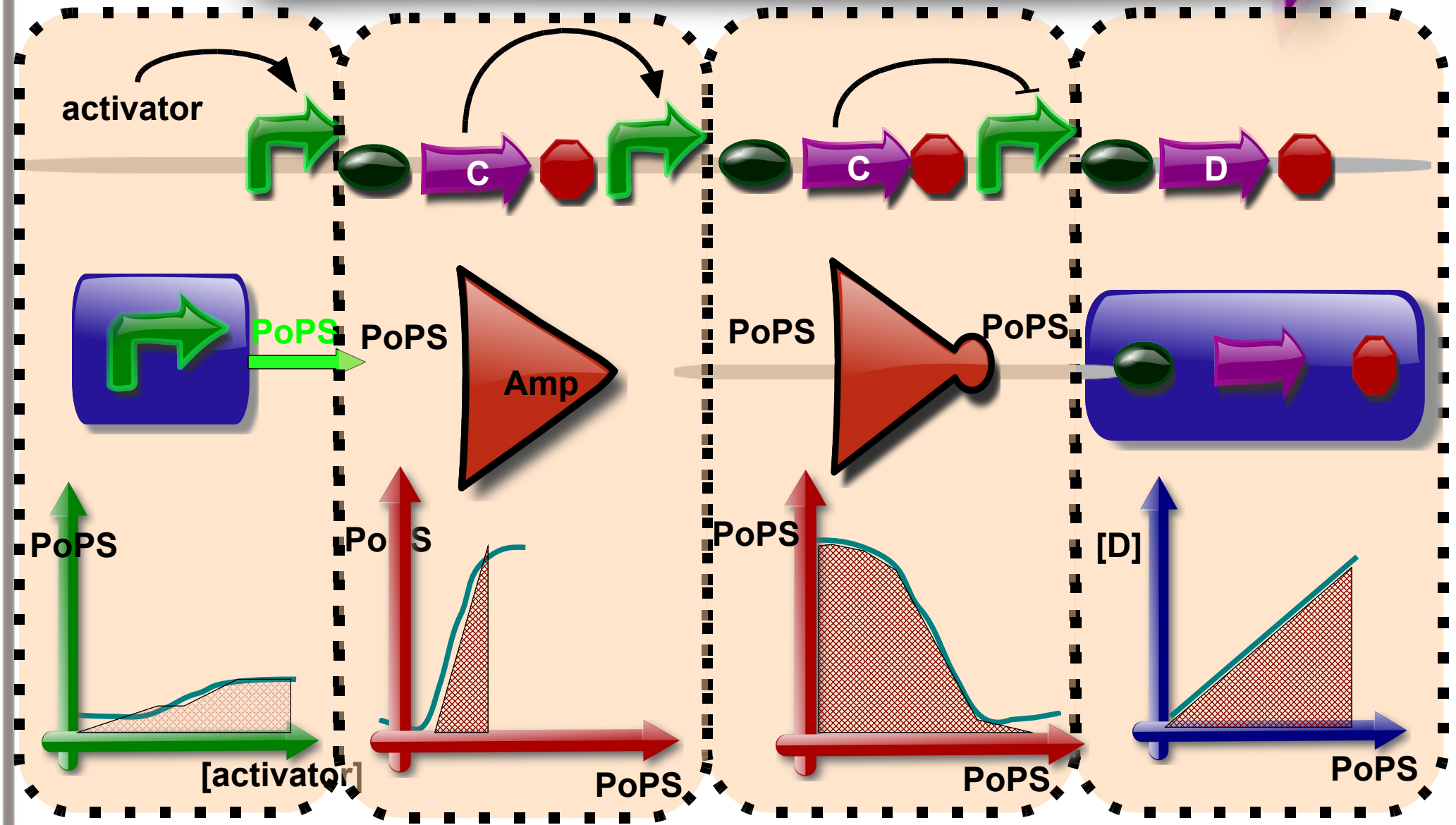
# Design for PoPs Matching



# Design for PoPs Matching



# Amplification for PoPs Matching



# What have we learnt so far ?

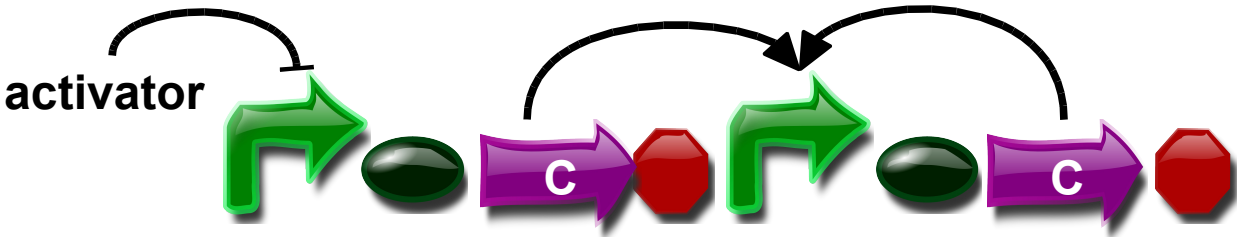
RiPS and PoPS are standard signal carrier for transcriptional device

RiPS and PoPS can promote modularity

RiPS and PoPS can promote re-usability

RiPS and PoPS matching between devices

# Transcriptional Device




**Question 1:**
**What does this system do ?**

**Question 2:**
**Extract a modular and re-usable device from this circuit.**

# References


> Drew Endy's Talks (on OWW)
> Austin Che Presentations
> OpenWetWare Folks
> iGEM Competition
> BioBricks Foundation