Vision and Change Introductory Biology Lecture and Lab

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Outline of Presentation

Why change my intro bio course now?

How is *ICB* different?

Hands-on activity #1 - constructing your own knowledge

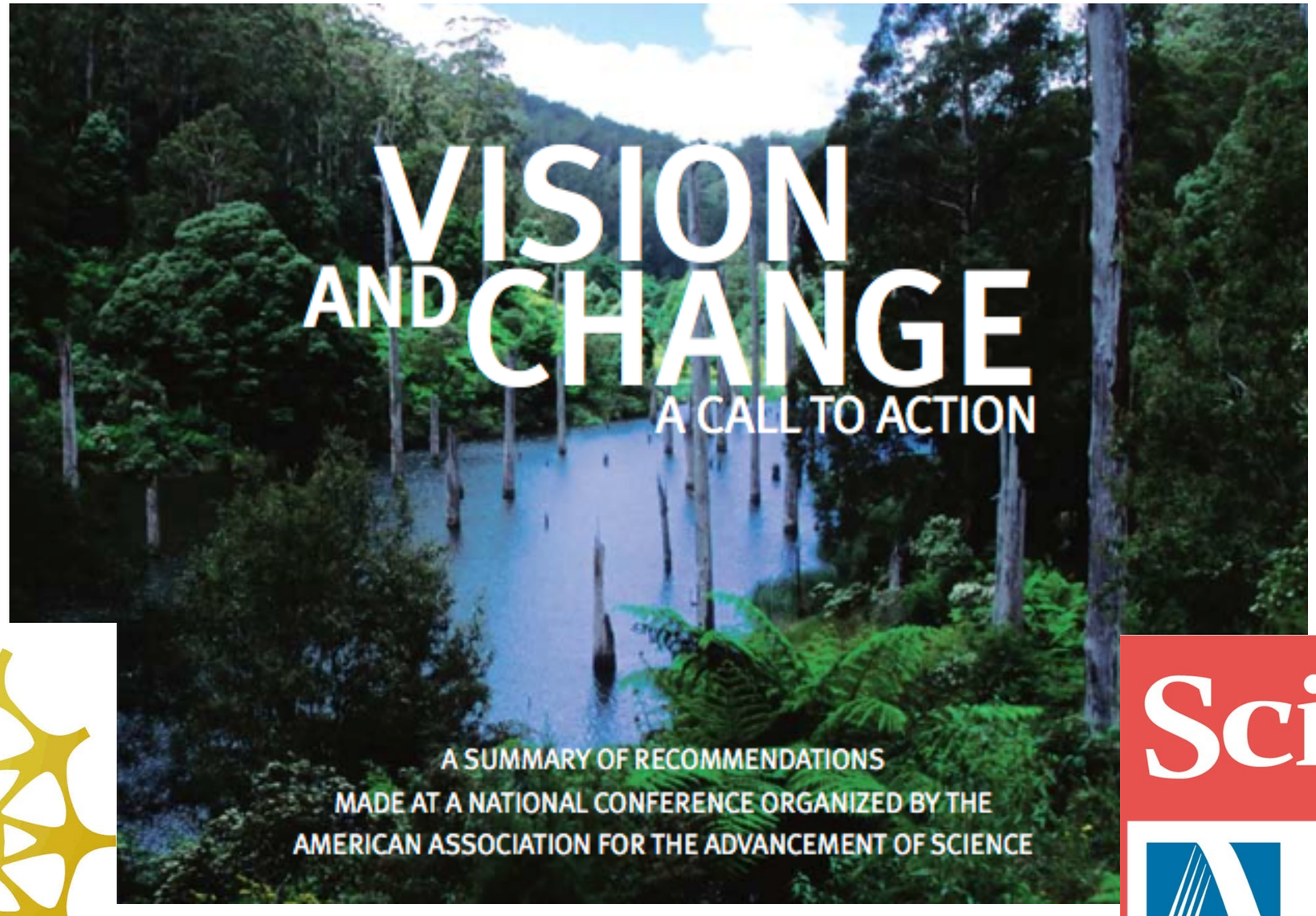
Did students meet learning objectives (content and attitude)?

Can intro labs be more authentic? Hands-on activity #2

pClone: real research by first year students

Closing remarks

National Recognition of Need to Change



NSF

Science

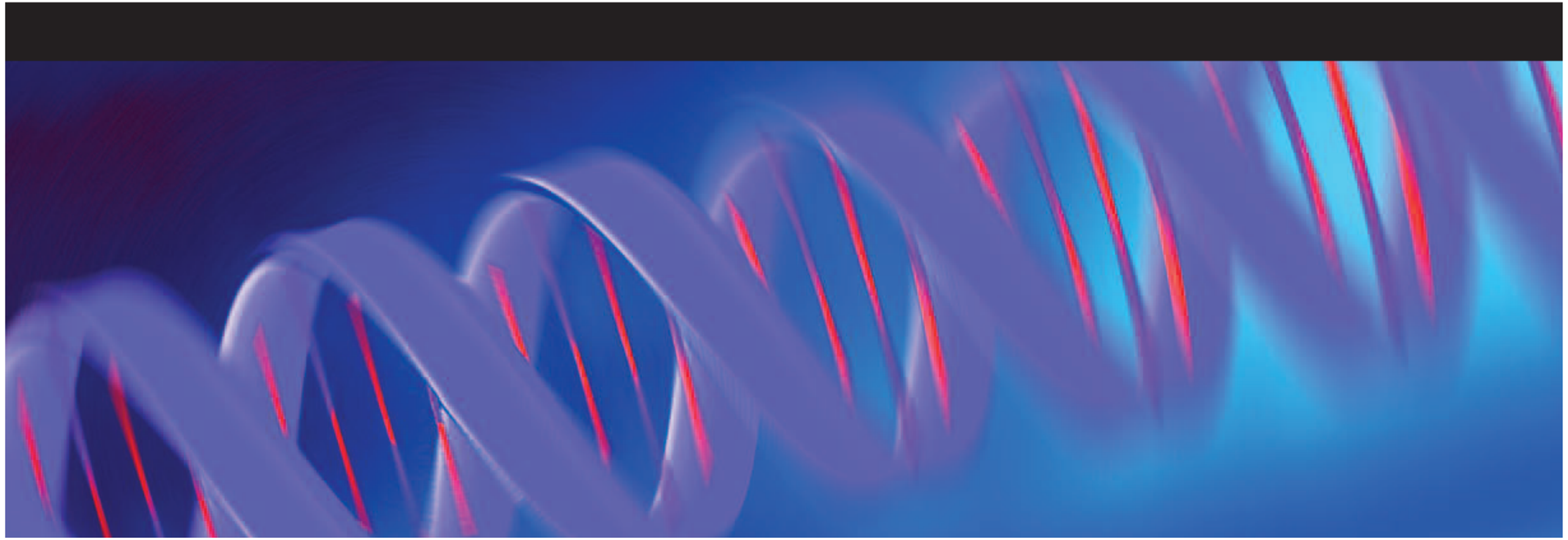
AAAS

AP Biology Redesign in Third year

AP® BIOLOGY

Curriculum Framework

2012–2013



GRE General Test

Verbal Reasoning: measures your ability to understand what you read and how you apply your reasoning skills.

Quantitative Reasoning: measures your ability to

- understand quantitative information
- interpret and analyze quantitative information
- solve problems using mathematical models
- apply basic mathematical skills and elementary mathematical concepts of arithmetic, algebra, geometry and data interpretation
- includes real-life scenarios

Analytical Writing: provide focused responses to prompts so you can demonstrate your ability to directly respond.

MCAT Redesigned Test

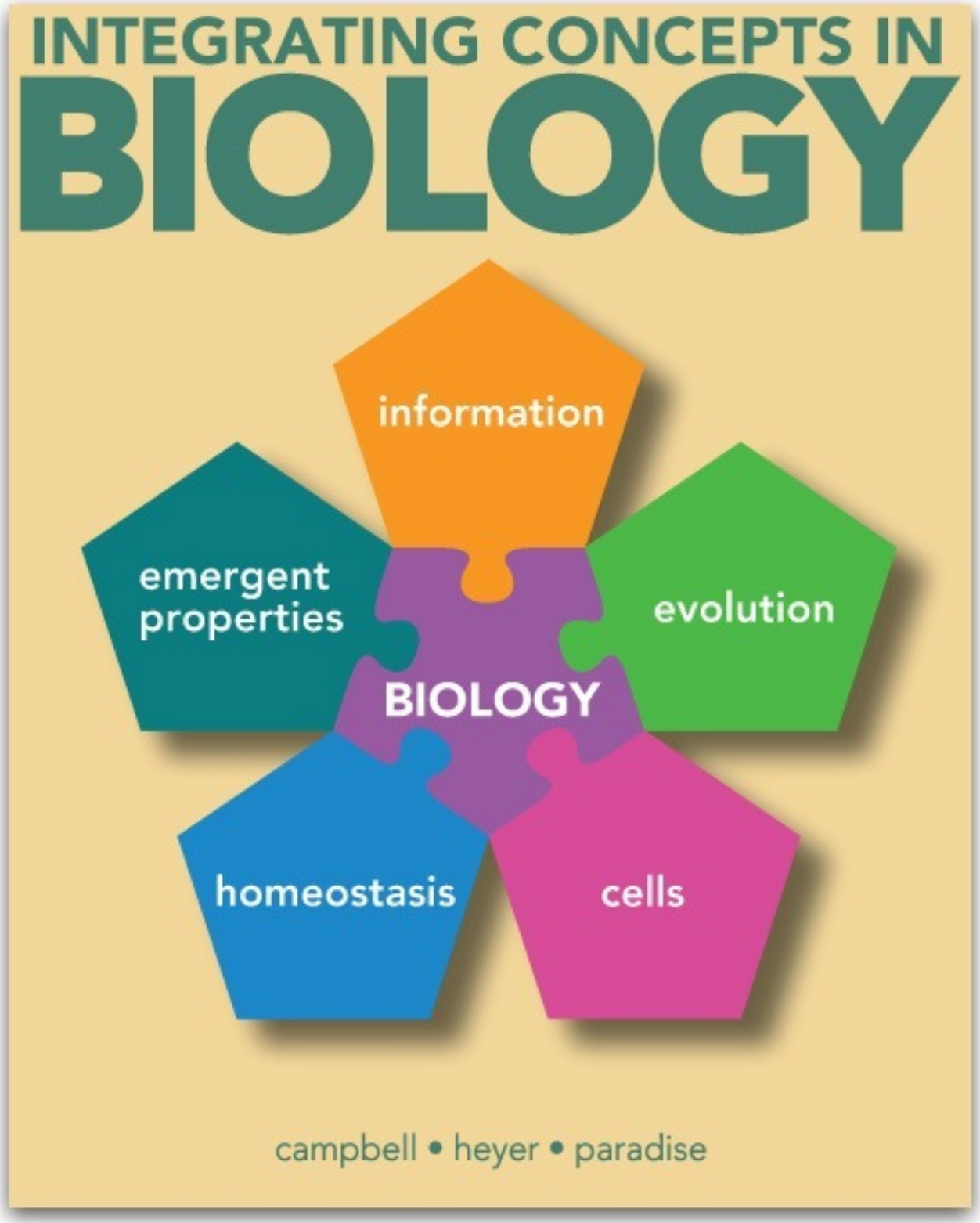
Critical Analysis and Reasoning Skills: analyze, evaluate, and apply information provided in passages

Natural Sciences: combine knowledge of natural science concepts with their scientific inquiry and reasoning skills to solve problems that demonstrate their readiness for medical school.

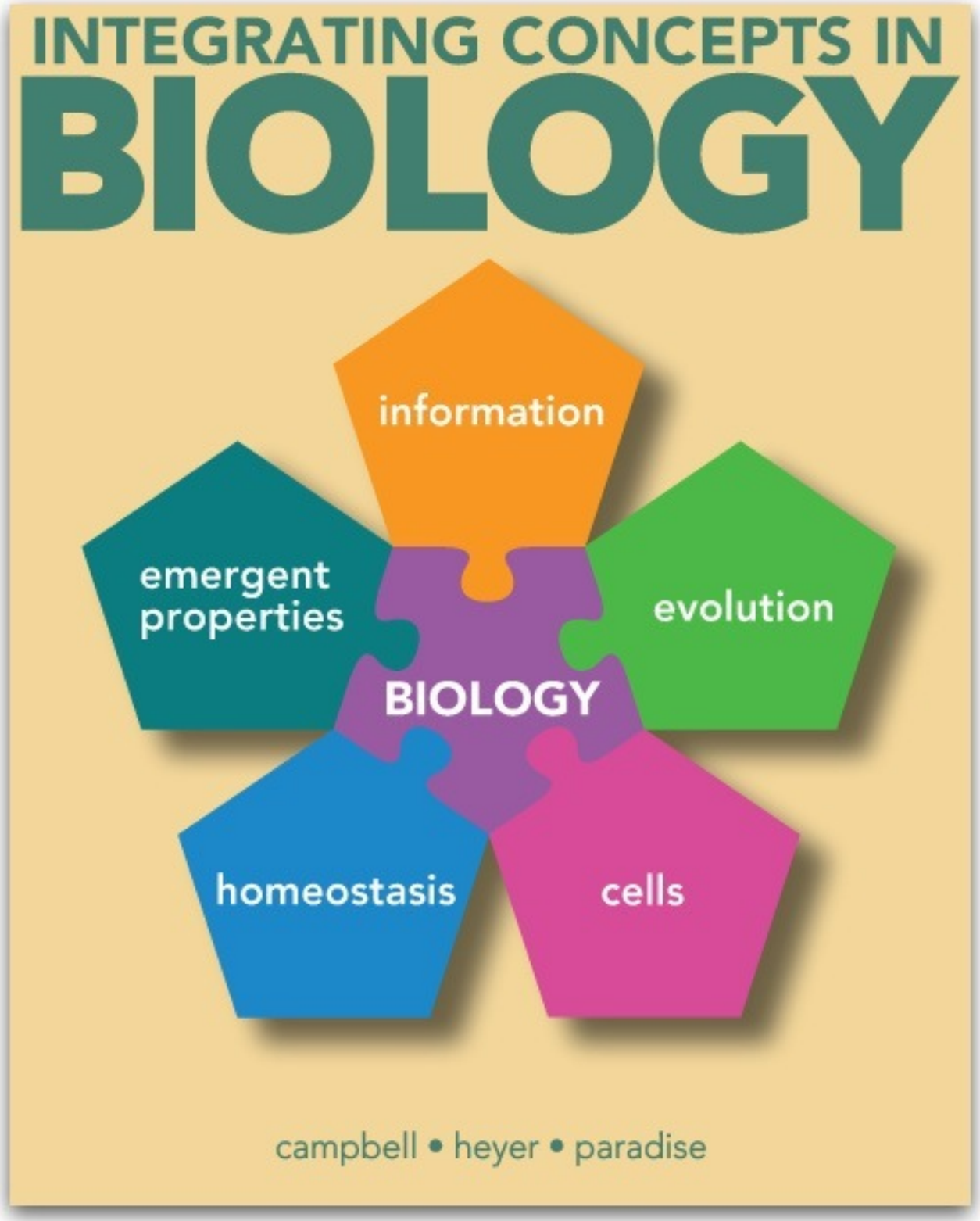
Psychological, Social, and Biological Foundations of Behavior

full disclosure

ICB is a commercial product



- 3 years to write, 4 years to publish
- traditional publishers rejected
- eBook hosted by Trunity
- David Botstein gift funded book
- Bruce Alberts wrote Foreword
- demonstrated learning gains
- adopt only chapters you use
- http://goo.gl/nRA0Od



Core Concepts = Big Ideas

Vision & Change

Evolution

Structure and Function

Information

Energy and Matter

Systems Biology

ICB

Evolution

Cells

Information

Homeostasis

Emergent Properties

AP Biology

Evolution

Information

Homeostasis

Emergent Properties

V&C Core Competencies

- Apply the process of science
- Use quantitative reasoning
- Use modeling and simulations
- Integrate different disciplines
- Communicate & collaborate
- Connect science & society

V&C Core Competencies (*ICB*)

- Apply the process of science (experimental design)
- Use quantitative reasoning (interpret raw data)
- Use modeling and simulations (work with models)
- Integrate different disciplines (chemistry, math, some physics)
- Communicate & collaborate (small group discussions, lab)
- Connect science & society (ELSI boxes)

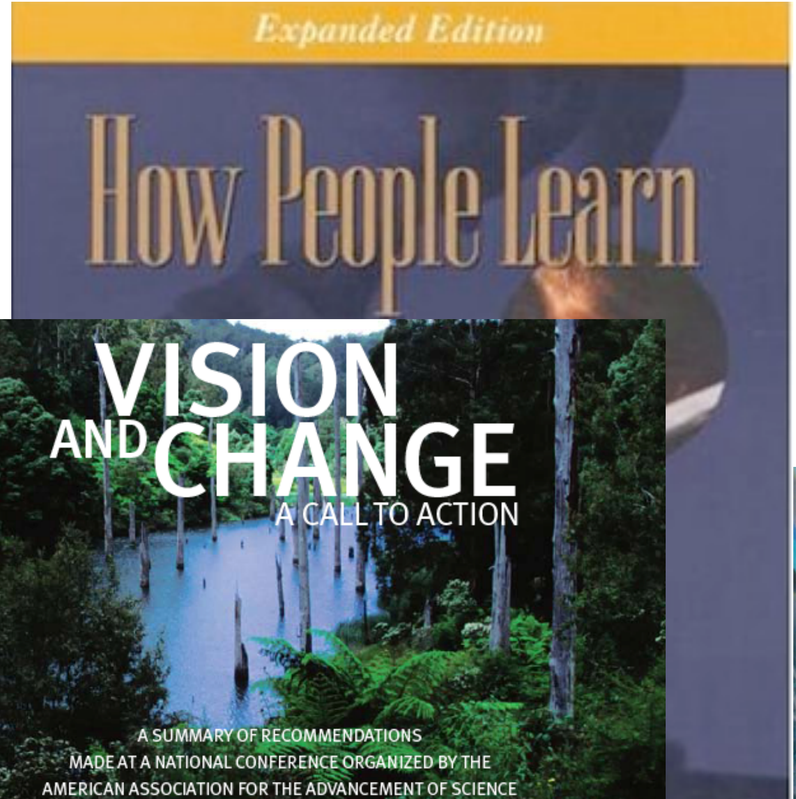
What's Wrong with Biology Education Now?

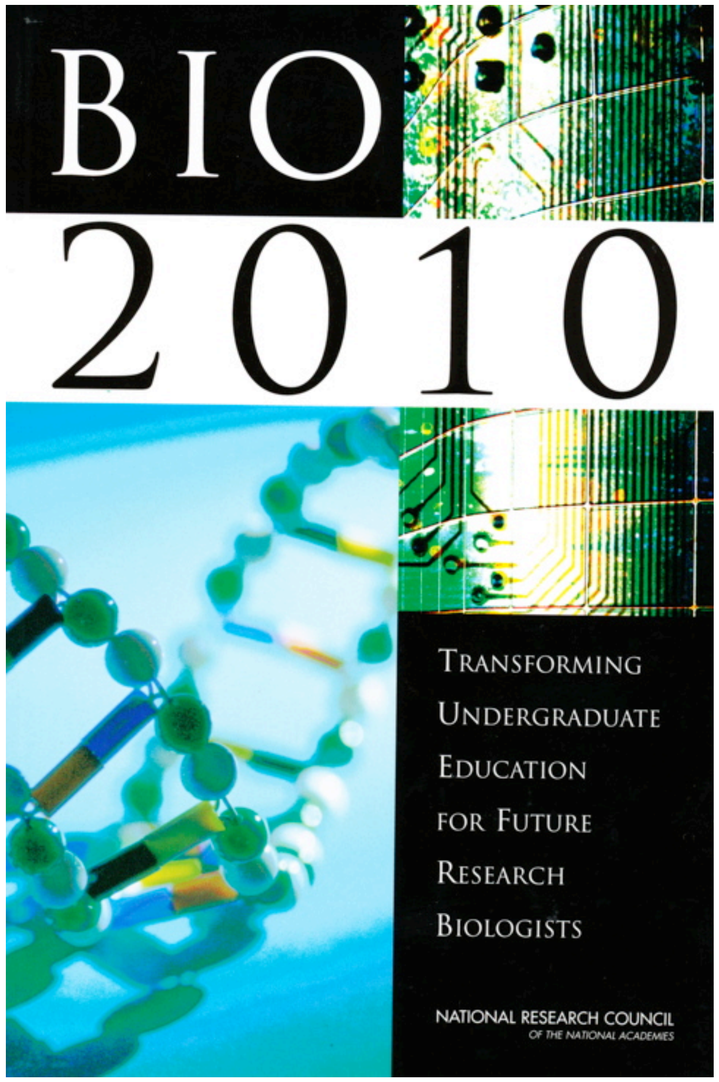
- **Vocabulary is emphasized (800-1000 vs 1400)**
- **Experimental approaches are minimized**
- **Math is absent**
- **Memorization is rewarded**
- **Critical thinking is discouraged**
- **Information is irrelevant to students**

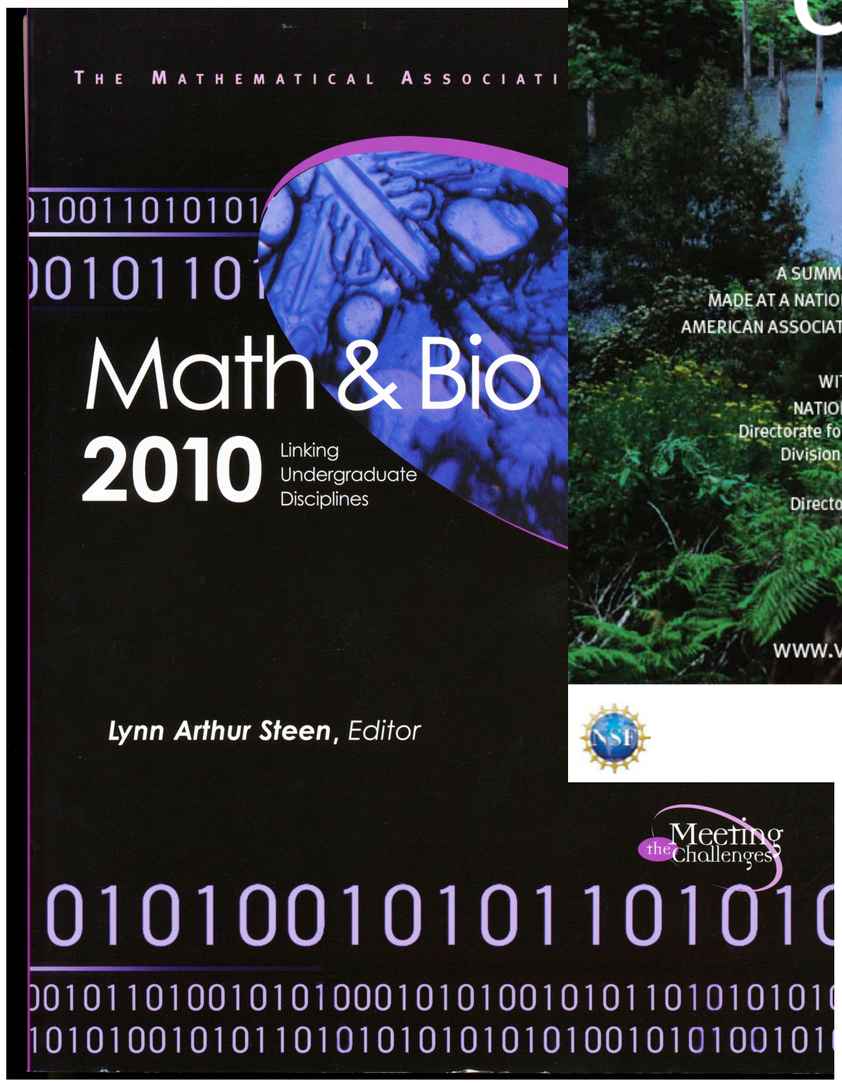
Present information and data…

… in the context of the big picture.

Start with the literature…







Artificial Divide within Biology

Small Biology

Big Biology

Five Levels of Organization

Molecular

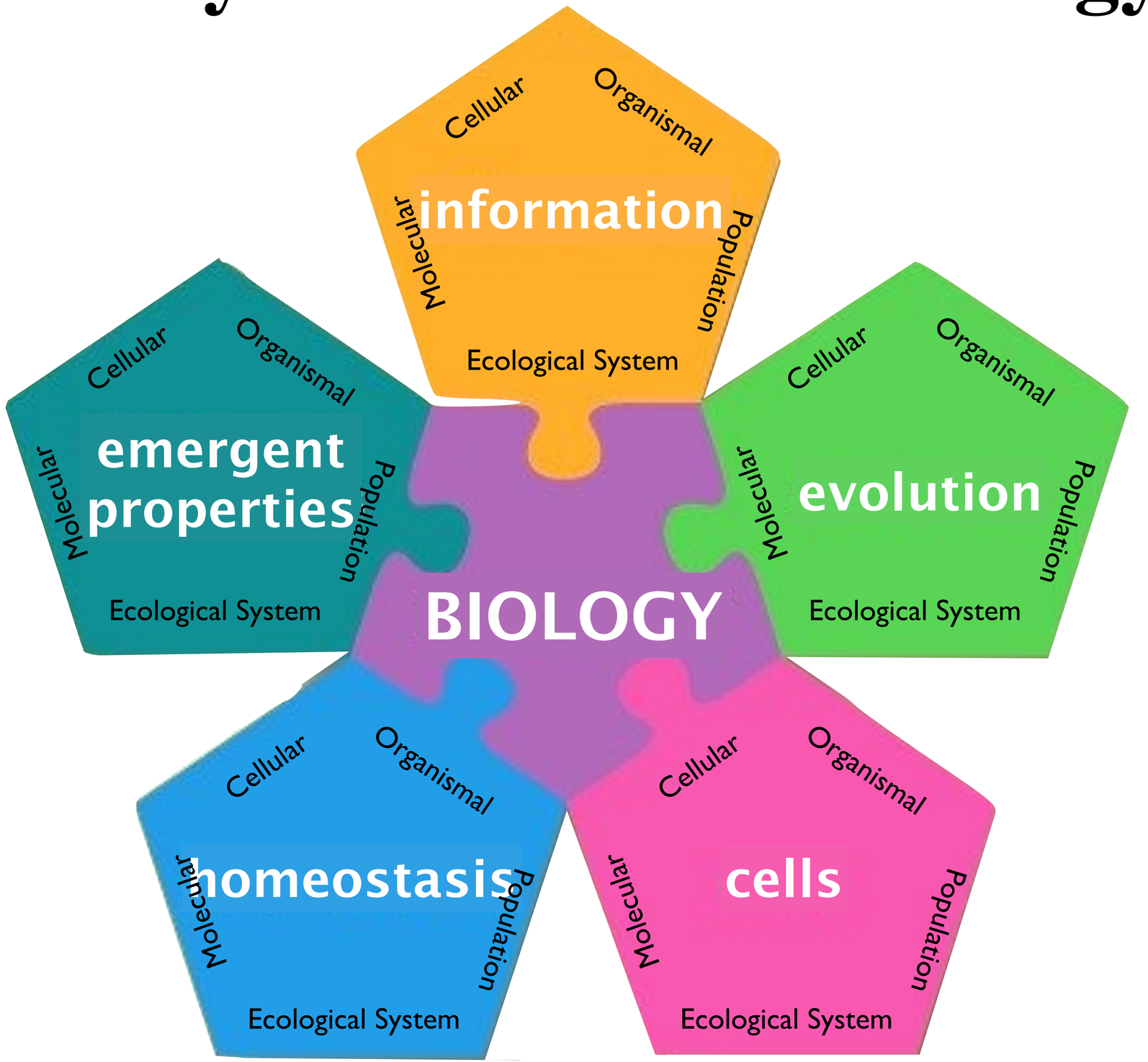
Cellular

Organismal

Population

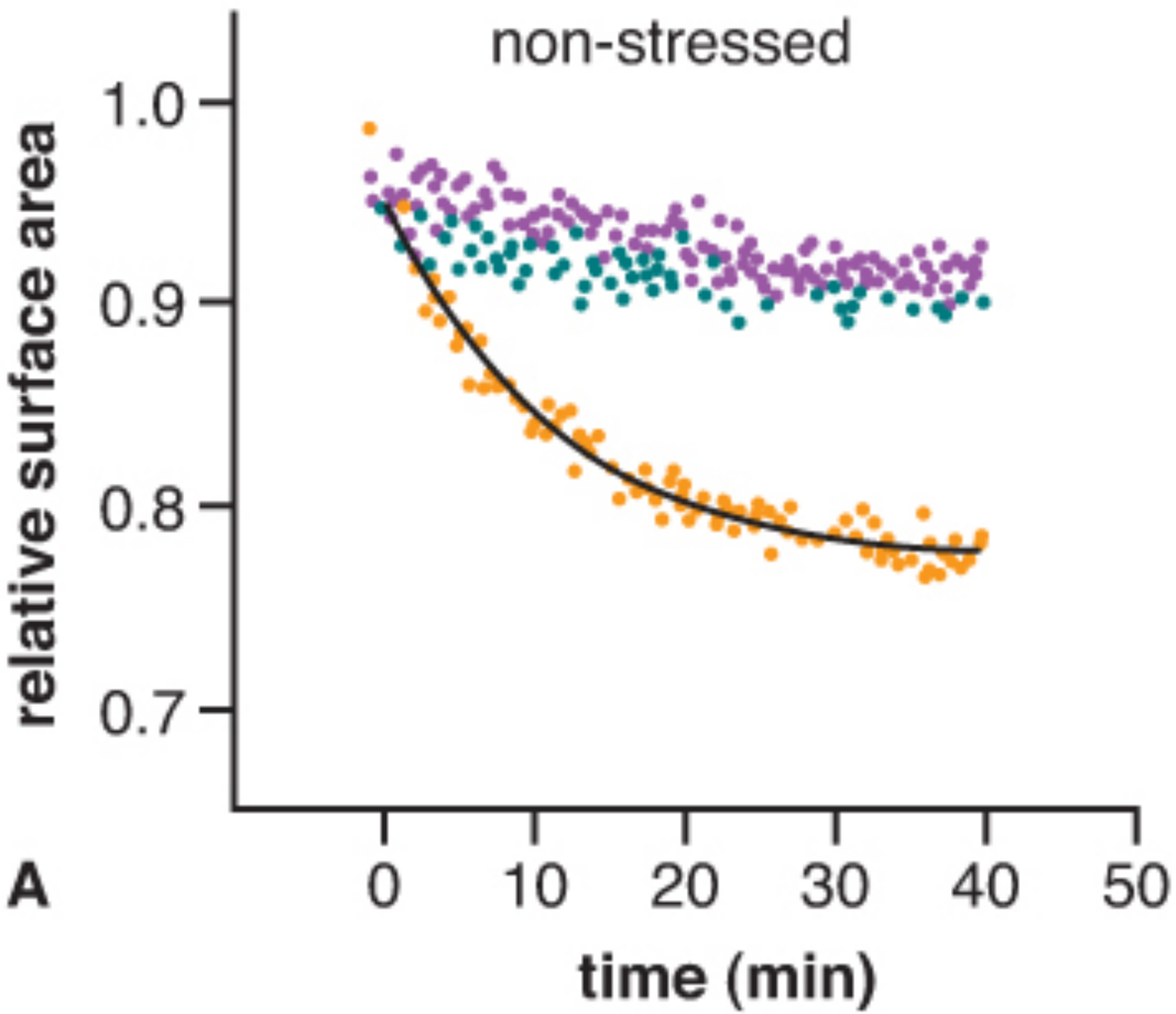
Ecological System

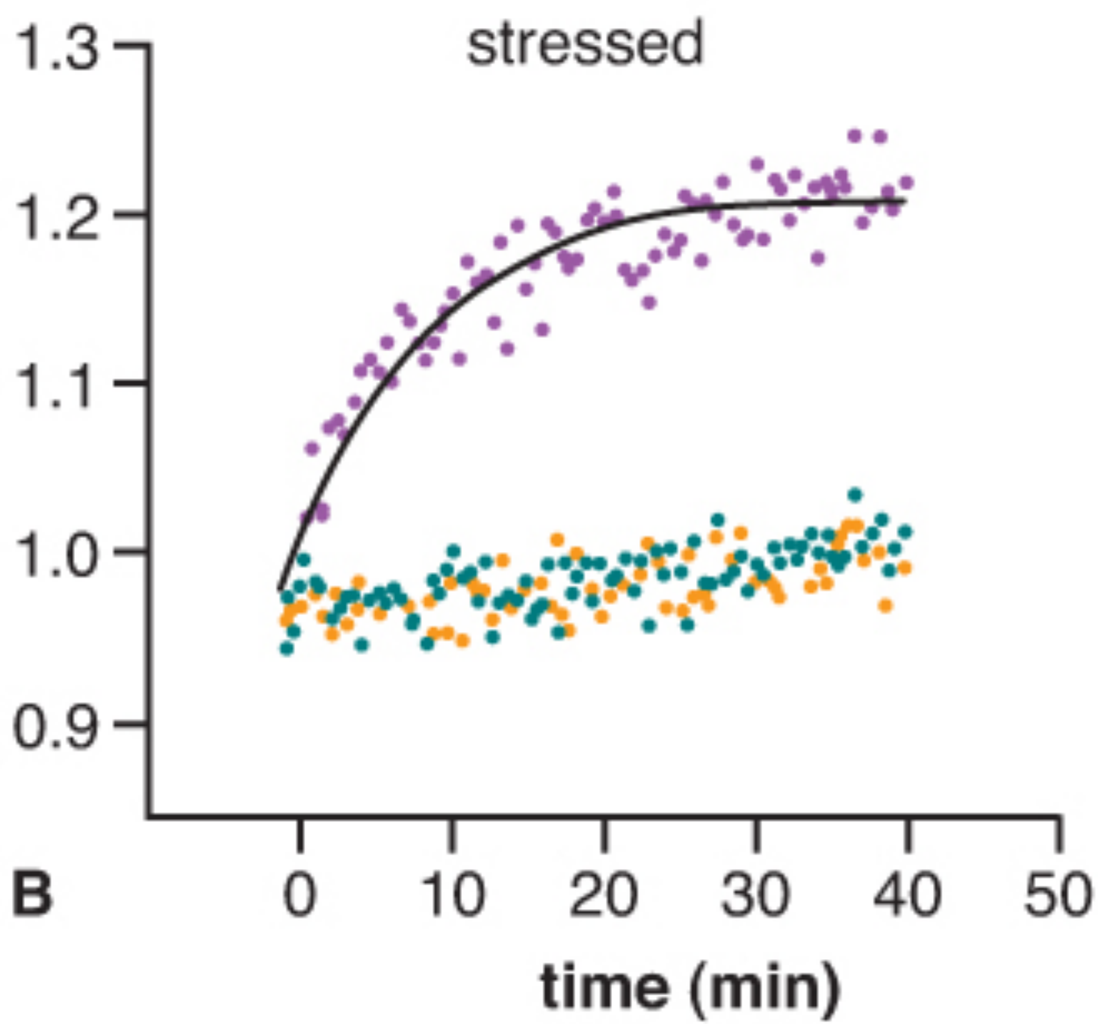
Five by Five Matrix of Biology



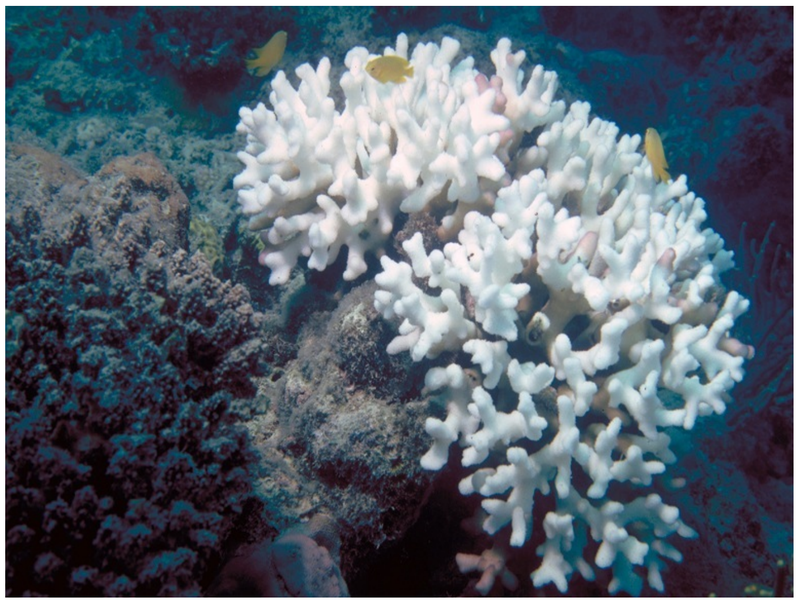
BioMath Exploration 4.2 (BME)

How fast is the vesicle size changing?





Ethical, Legal and Social Implications (ELSI)

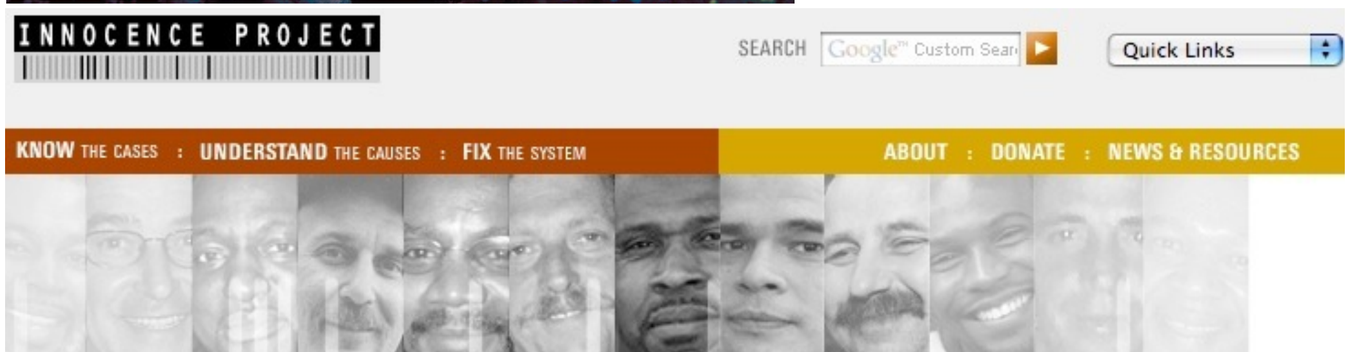


Are religion and evolution compatible?

Is science possible if you are uncertain about what is true?

Does basic biology have any impact on the real world?

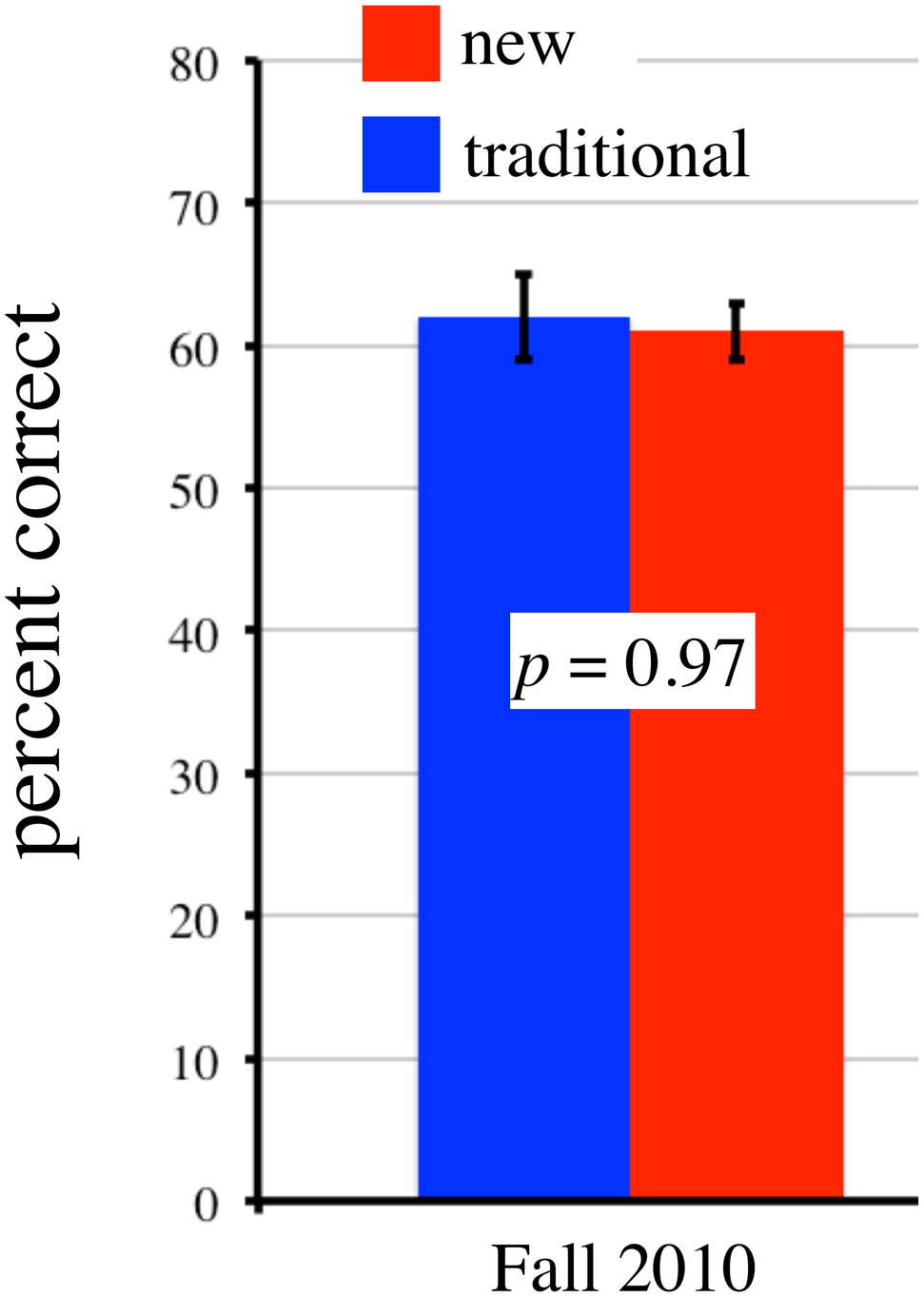
Who owns your DNA?



Hands-on Activity #1

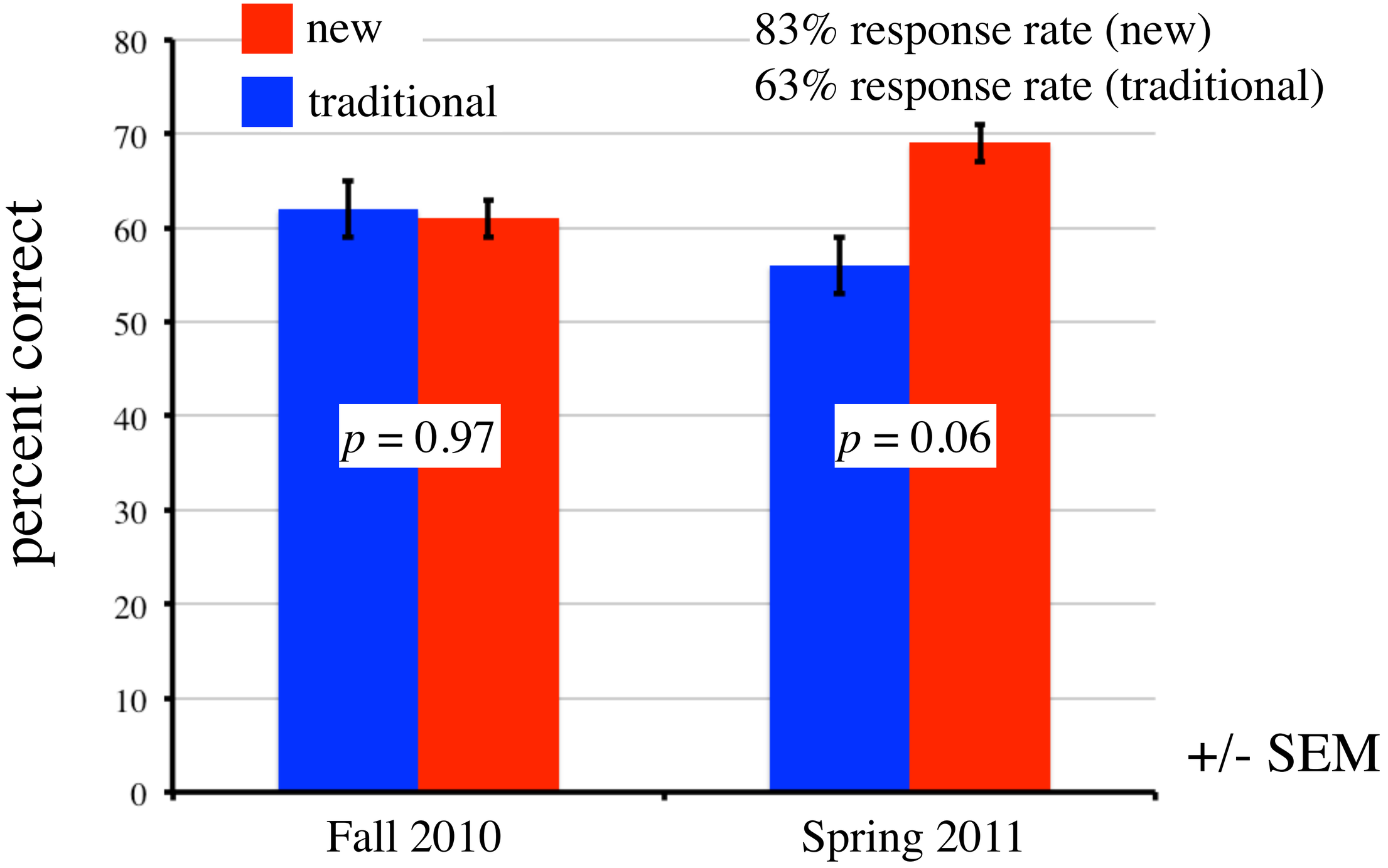
Did my students “learn less” content?

Core Concepts Assessment



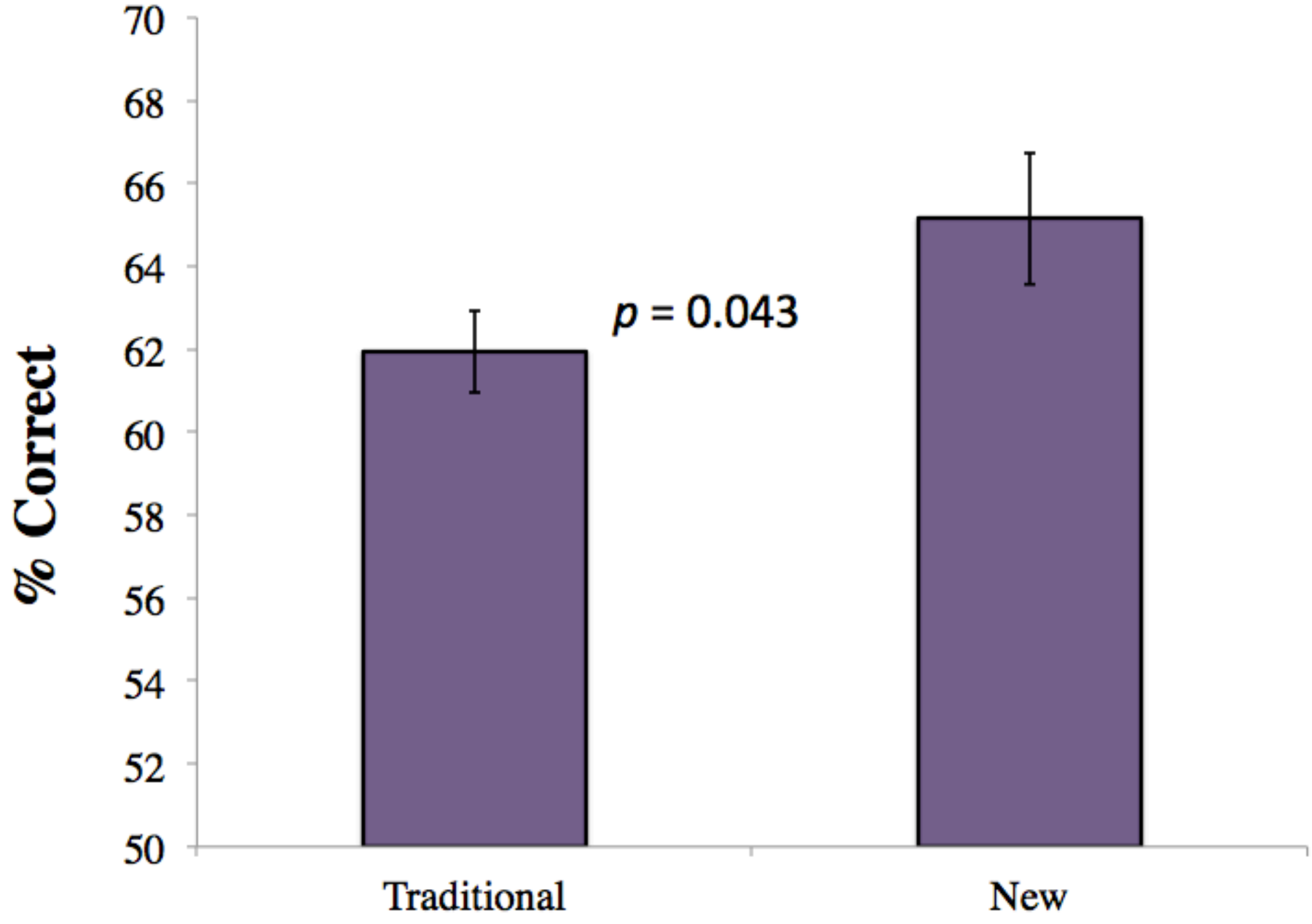
+/- SEM

Core Concepts Assessment

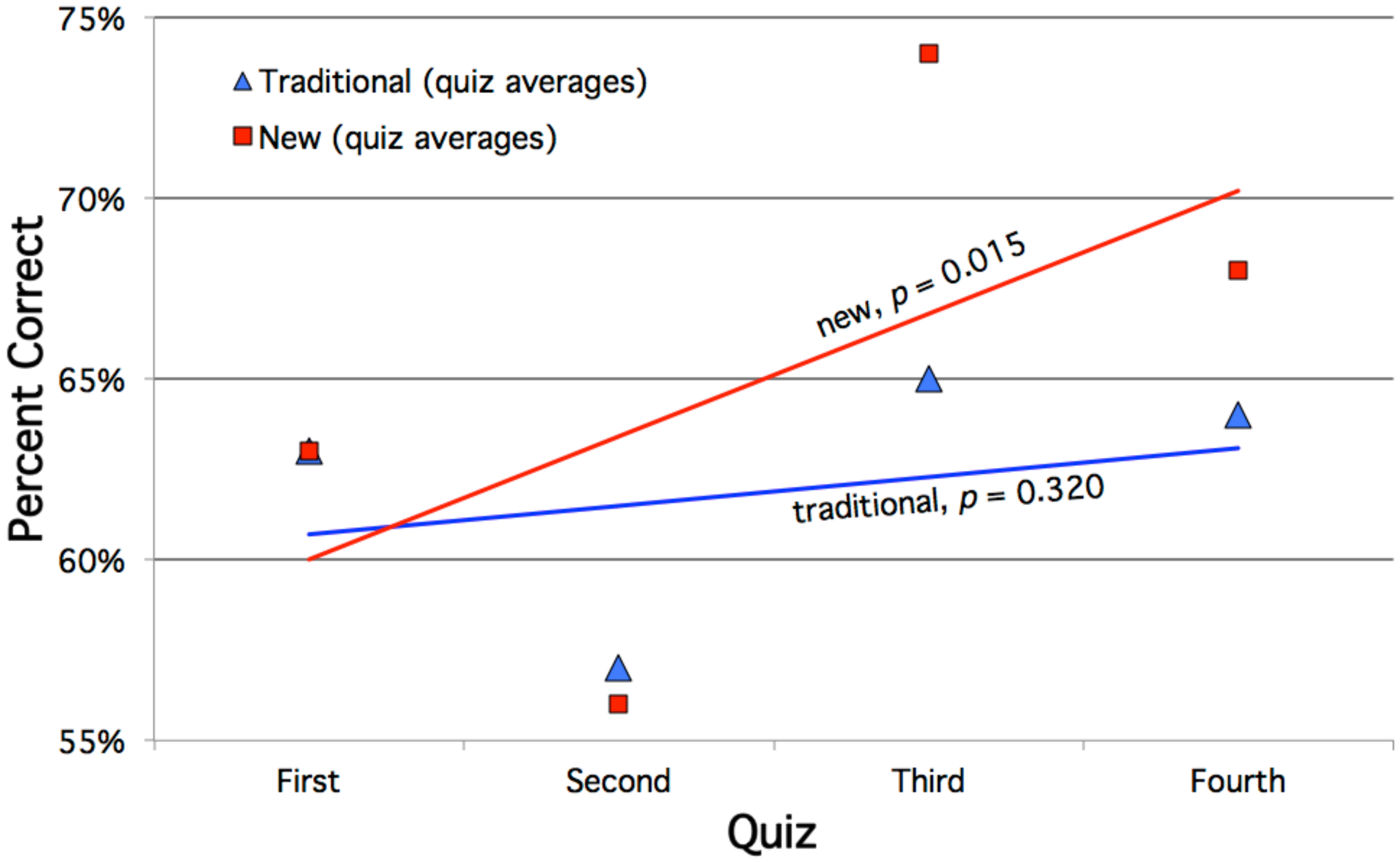


Can my students analyze data better?

Core Competency Assessment



Core Competency Assessment



Do *ICB* students see biology differently?

1-5 scale 5 = extremely accurate	Average at Start Fall	
	ICB	**Traditional**
biology is definitions & processes	2.86	2.61
big questions of biology already answered	1.71	1.50
big/small division of biology describes nature	3.15	3.02
1-5 scale 5 = extremely important		
memorization	3.96	3.64

* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06

no

Do *ICB* students see biology differently?

1-5 scale 5 = extremely accurate	Average at Start Fall		Δ in Average End of Fall	
	ICB	Traditional	ICB	Traditional
biology is definitions & processes	2.86	2.61	-0.58***	+0.50
big questions of biology already answered	1.71	1.50	-0.32*	+0.22
big/small division of biology describes nature	3.15	3.02	-1.08***	-0.06
1-5 scale 5 = extremely important				
memorization	3.96	3.64	-1.48***	-0.08

yes!

yes!

yes!

yes!

* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06

Do *ICB* students see biology differently?

1-5 scale 5 = extremely accurate	Average at Start Fall		Δ in Average End of Fall		Δ in Average End of Spring	
	ICB	Traditional	ICB	Traditional	ICB	Traditional
biology is definitions & processes	2.86	2.61	-0.58***	+0.50	-0.46***	+0.45
big questions of biology already answered	1.71	1.50	-0.32*	+0.22	-0.33^	0.00
big/small division of biology describes nature	3.15	3.02	-1.08***	-0.06	-0.75**	-0.10
1-5 scale 5 = extremely important						
memorization	3.96	3.64	-1.48***	-0.08	-1.27***	+0.23

yes!

yes?

yes!

yes!

* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06

Hands-on Activity #2

Can introductory biology labs be more authentic?

A common criticism I had gotten for 16 years was the lecture and lab were “disconnected” or were “unrelated.”

When you do research in lab:

1. Has someone prepared data collection tables for you?
2. Does someone hand you all the controls you will need for the day?
3. Does someone else do all the creative thinking for you and you merely pipet?
4. Do you only work on one project until it is completed?
5. Is your research completed in 3 hours?

My educational goals for Intro Bio Lab

1. Employ a **scientific approach** to answering biological questions and test hypotheses.
2. **Design experiments** to test hypotheses, answer questions.
3. **Analyze experimental data** and reach logical conclusions.
4. Organize an **oral presentation** for sharing scientific information with peers.
5. Prepare a **written summary** of experiments designed, performed and analyzed personally.
6. Work on three overlapping labs: **discover new promoter**, **why mammals evolved bitter taste receptors**, **and** **evolution of antibiotic resistant bacteria**.

Major Changes I Made to Intro Bio Lab

1. Minimal lab manual

Bio113 Week 4

Before you come to lab
1) At 5:30 pm on the Wednesday before your lab, one person from each lab group MUST COME TO Dr. C's research lab (Dana room 221). Make sure to bring your protocol from last week of how to prepare the oligos for boiling.

3) Answer each of these four questions in two sentences or less.
A) How will you ligate your new promoter into a plasmid for testing?

B) What will the plasmid need to contain if you want to determine if your promoter is working?

C) How is fluorescence of red fluorescent protein (RFP) measured?

D) How is a spectrophotometer used to measure cell density in a population of *E. coli*?

****

NOTE: At 5:30 pm on the Wednesday before your lab, one person from each lab group MUST COME TO Dr. C's research lab (Dana room 221). Please be on time. We need to boil the oligos so we can ligate them tomorrow. See page 2 for details.

****

Week 4

Before you come to lab
1) The afternoon before lab, one person has already boiled oligos and let cool slowly overnight.

Information: Design and Build a New Promoter (an 8 week project)

In Lab: **(Start lab at this point)**
2) Do appropriate dilution (step 9 of this protocol) of boiled and cooled oligos. You will ligate your promoter into receiving plasmid J119137.

3) You have been provided two tubes of a master mix for GGA. It already contains the receiving plasmid J119137, the BsaI and the ligase. The volume is 9 μL in each tube. You need one tube for your promoter (P) and one for a negative control (-). Add 1 μL of your freshly diluted promoter to the P tube and 1 μL water to the "-" tube. Label your tubes. Put them in the thermocycler. GGA is program name.

4) Transform cells (zippy competent JM109) with 3 different DNAs:
   a) experimental ligation DNA (with your promoter oligos added = P)
   b) ligation negative control DNA (water added, not promoter = -)
   c) transformation positive control DNA(+ tube; pLac promoter+RBS+RFP)

5) Plate each transformation on its own LB+amp plate.

6) Discuss as a group how to assay your promoter. How will test your promoter to know if it works the way you thought it would?

7) One person from each group will need to start the cells growing 4 pm next Wednesday the day before lab. Come to Dr. C's research lab on time.

Major Changes I Made to Intro Bio Lab

1. Minimal lab manual
2. Overlapping lab modules

9 weeks on promoters

8 weeks on taste receptor

7 weeks on antibiotic^{R}

Major Changes I Made to Intro Bio Lab

1. Minimal lab manual
2. Overlapping lab modules
3. CATME tool (CATME.org)

CATME
SMARTER Teamwork

Summary—Malcolm Campbell

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Show 10 entries Search:

Class	Activity (Section)	Start	End	% Comp.	
Bio113	Week 15 Lab	2014-12-04	Released	87%	View Results
Bio113	Week 15 Lab (A)	2014-12-04	Released	81%	View Results
Bio113	Week 15 Lab (B)	2014-12-04	Released	93%	View Results
Bio113	Week 13 Lab	2014-11-20	Released	71%	View Results
Bio113	Week 13 Lab (A)	2014-11-20	Released	75%	View Results
Bio113	Week 13 Lab (B)	2014-11-20	Released	68%	View Results
Bio113	Week 12 Lab	2014-11-13	Released	96%	View Results
Bio113	Week 12 Lab (A)	2014-11-13	Released	93%	View Results
Bio113	Week 12 Lab (B)	2014-11-13	Released	100%	View Results
Bio113	Week 11 Lab	2014-11-06	Released	93%	View Results

Showing 1 to 10 of 49 entries Previous Next

Promoter Research Using Golden Gate Assembly

Todd Eckdahl

MWSU

Eco RI

GAATTC
CTTAAG

palindrome

type II

Bsa I

GAGACC

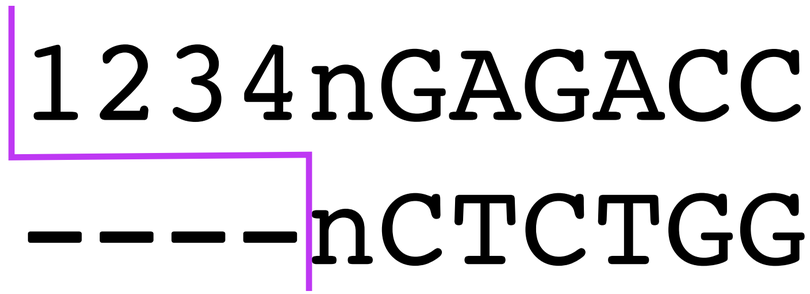
CTCTGG

G

not a palindrome

type IIs

Bsa I



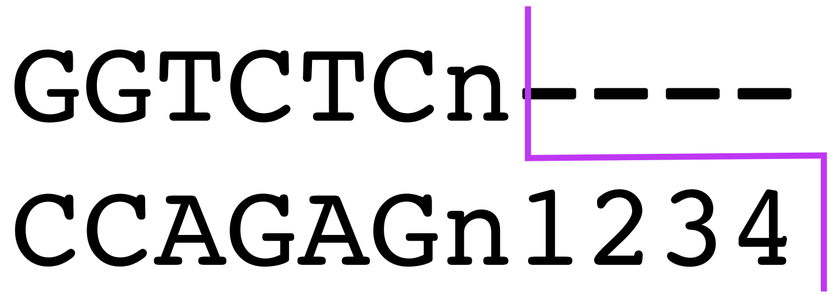
type IIs

Bsa I

```
1234nGAGACC
----        nCTCTGG
```

type IIs

Bsa I



type IIs

Bsa I

```
GGTCTCn                ----
CCAGAGn1234
```

type IIs

Bsa I

cuts left

1234nGAGACC

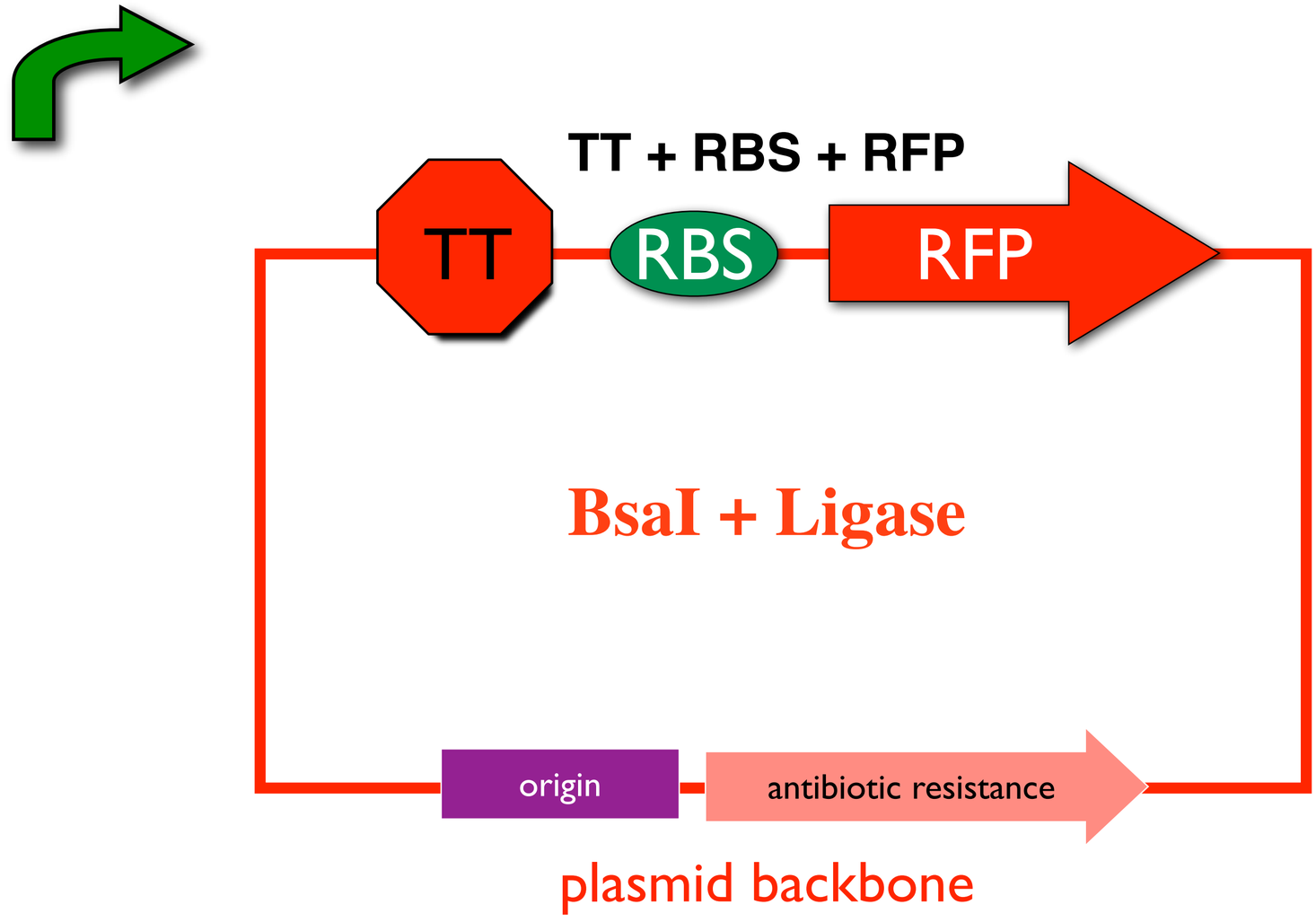
----nCTCTGG

GGTCTCn----

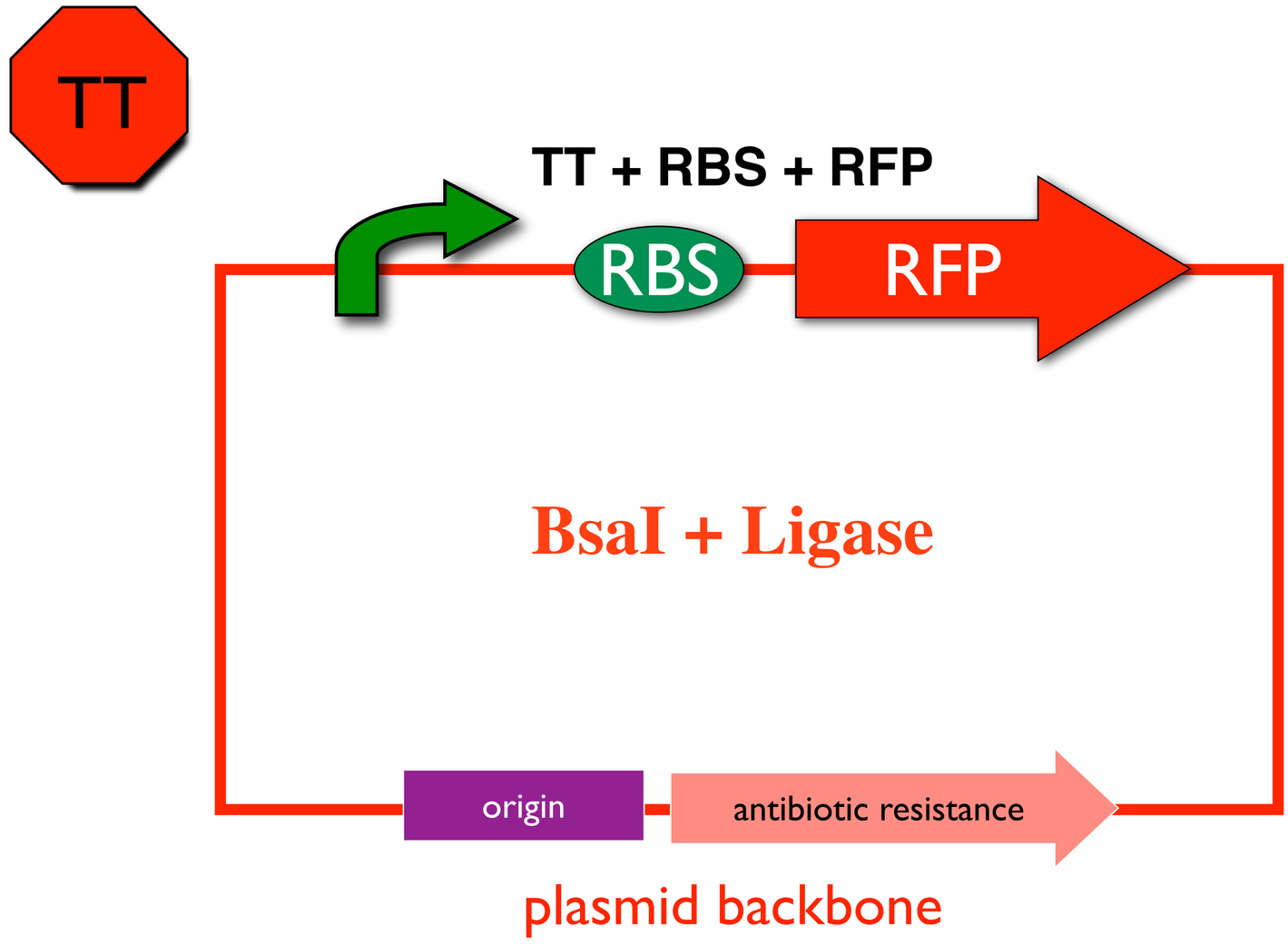
CCAGAGn1234

cuts right

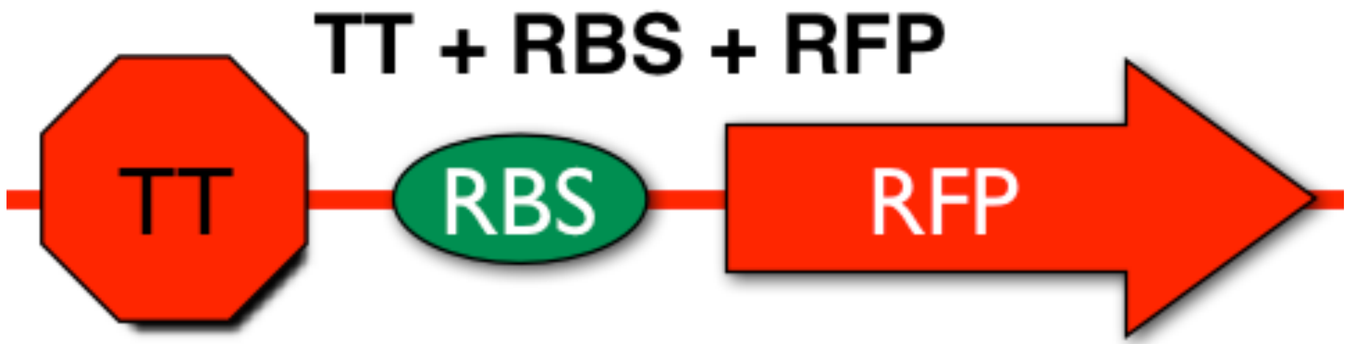
GGA Ligation Method - one step, one tube



GGA Ligation Method - one step, one tube



GGA Ligation Method - one step, one tube



GGA Ligation Method - one step, one tube

Bsa I

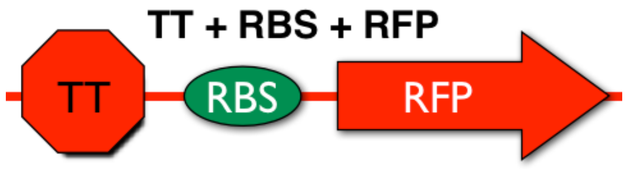
CGACtGAGACC(TT)GGTCTCa GCGG

GCTGaCTCTGG(TT)CCAGAGtCGCC

Bsa I

ligase

ligase



CGACt**GAGACC**(**TT**)**GGTCTCa**

aCTCTGG(**TT**)**CCAGAG**t**CGCC**

[redacted] **GCTG**

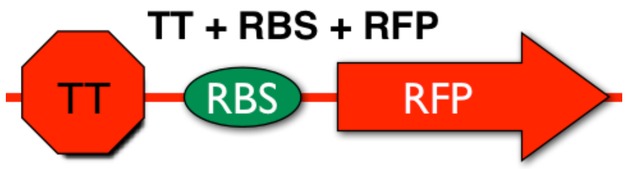
GCGG [redacted]

ligase

ligase

Bsa I

ligase Bsa I ligase



CGACtGAGACC(TT)GGTCTCa

aCTCTGG(TT)CCAGAGtCGCC

[redacted] GCTG

GCGG [redacted]

[redacted]

ligase

ligase

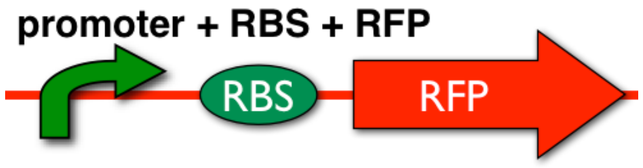
CGAC

CGAC

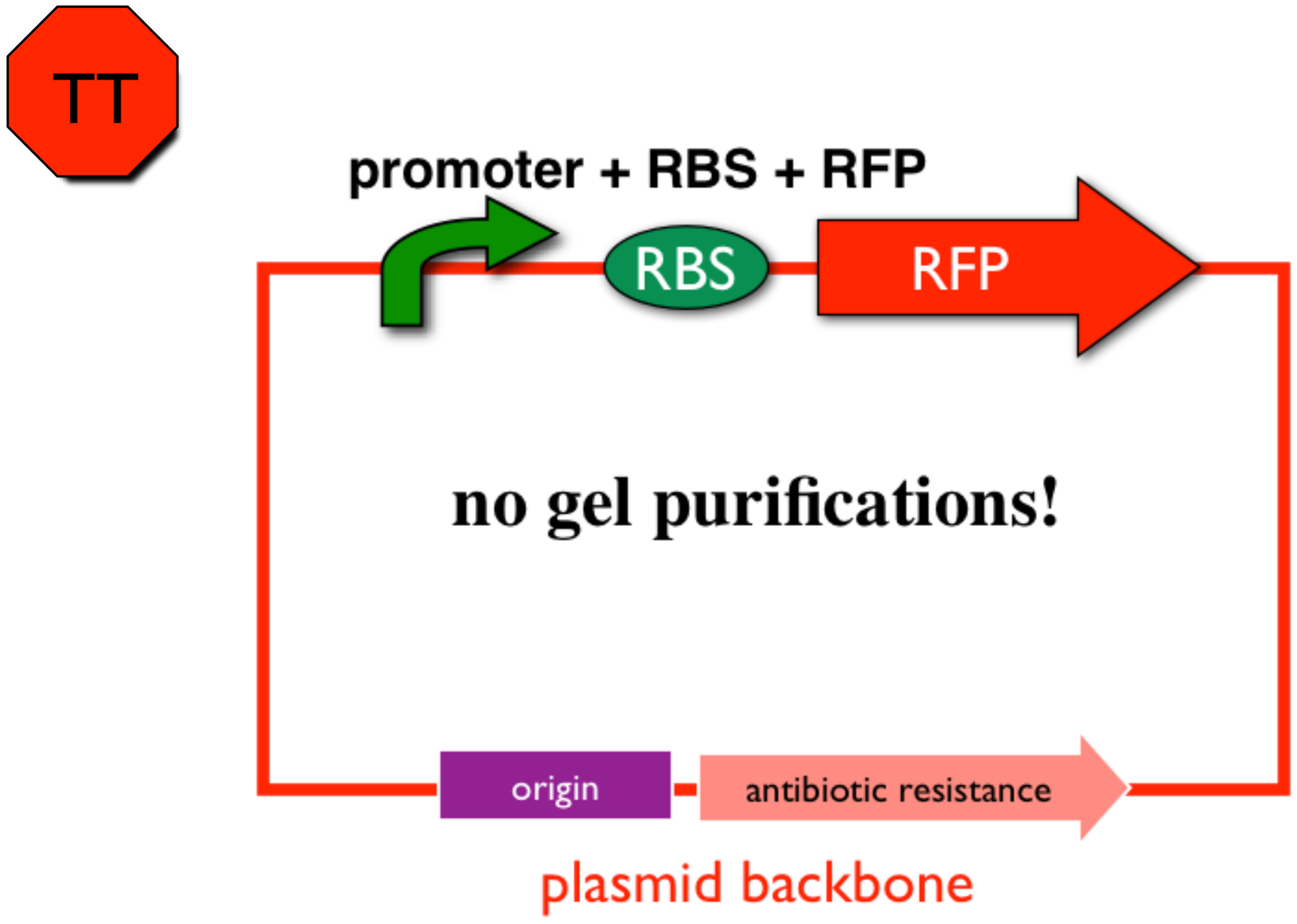
CGAC(promoter)GCGG

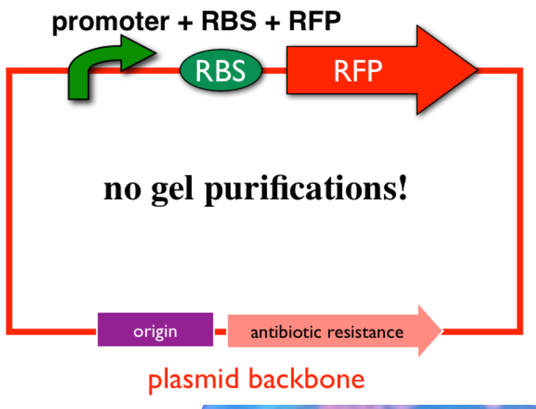
GCTG(promoter)CGCC

ligase ligase



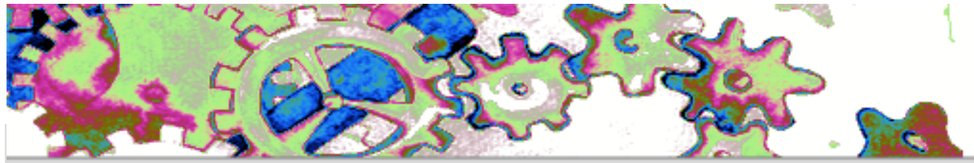
GGA Ligation Method - one step, one tube





50% ligation success rate

Student Sample, September 2012



Registry of Standard Biological Parts

		BBa_J100067	Regulatory	fadB promoter (long sequence)	Meredith Nakano	85
		BBa_J100068	Regulatory	fadB promoter (short sequence)	Meredith Nakano	61
		BBa_J100069	Reporter	Superfolder GFP	Rebecca Evans	770
		BBa_J100070	Coding	Superfolder GFP	Rebecca Evans	720
		BBa_J100071	Regulatory	cadA promoter	Ben Clarkson	334
		BBa_J100072	Regulatory	LcpxP promoter--Long cpxP promoter	Ben Clarkson	392
		BBa_J100073	Regulatory	ScpxP--Short cpxP promoter	Ben Clarkson	94
		BBa_J100074	Regulatory	Long pLux Promoter	Betsy Gammon	197
		BBa_J100075	Regulatory	CydAP1 Long Promoter	Betsy Gammon	158
		BBa_J100076	Regulatory	CydAP1 Short Promoter	Betsy Gammon	151
		BBa_J100077	Composite	J10068:K0903005	Meredith Nakano	793
		BBa_J100078	Composite	J100067:K0903005	Meredith Nakano	817
		BBa_J100079	Device	Riboswitch and GFP	Rebecca Evans	879
		BBa_J100080	Device	Riboswitch and GFP	Rebecca Evans	882
		BBa_J100081	Reporter	J100071+E0240	Ben Clarkson	334
		BBa_J100082	Reporter	J100072+E0240	Ben Clarkson	1276
		BBa_J100083	Composite	LuxI Long + RBS + GFP	Betsy Gammon	1081
		BBa_J100084	Composite	CydAP Long + RBS + GFP	Betsy Gammon	1042
		BBa_J100085	RNA	short CRISPR sequence with GFP target spacer	Caroline Vrana	240
		BBa_J100086	Composite	CydAP Short Promoter + RBS + GFP	Betsy Gammon	1035
		BBa_J100087	Reporter	J100073+E0240	Ben Clarkson	978
		BBa_J100088	Generator	J100071+J10063	Ben Clarkson	2965
		BBa_J100089	Generator	J100072+J10063 (LcpxP+LRE, Luciferase)	Ben Clarkson	3023
		BBa_J100090	Regulatory	CRISPR sequence with GFP and AmpR targets	Caroline Vrana	412
	W	BBa_J100092	Regulatory	Constitutive promoter for M1-162	Natalie Spach	50
	?	BBa_J100093	Regulatory	rrnB P1 promoter	Kayla McAvoy	60
	?	BBa_J100094	Regulatory	Lac promoter E. Coli	Cameron Bard	44
	?	BBa_J100095	Regulatory	malE1 Maltose induced promoter.	Pooja Potharaju	65
		BBa_J100096	Regulatory	PBAD Promoter from araE Gene	Elizabeth Brunner	27
	W	BBa_J100097	Regulatory	Anhydrotetracycline inducible promoter with BsaI sticky ends	Sarah Kim	55
		BBa_J100098	DNA	Promoter for the argF gene	Erin Nieusma	44
	W	BBa_J100099	Regulatory	A promoter (CydAB) activated by the FNR enzyme	Phoebe Parrish	64

Student Sample, September 2012

Registry of Standard Biological Parts

Go Search

page discussion view source history Log in / create account

BBa J100099 Main Page Part Design Physical DNA Hard Information Experience Tools

Part:BBa_J100099

Designed by Phoebe Parrish Group: Campbell_M_Lab (2012-09-13)

Regulatory

DNA Planning

Experience: Works

Get This Part

A promoter (CydAB) activated by the FNR enzyme

The promoter, CydAB, was found to be activated by the FNR enzyme, which is induced by the presence of (NH4)2Fe(SO4)2 and ascorbate. The oligo includes both CydAB, the FNR binding site, and the sticky ends needed for the Golden Gate Assembly method.

Sequence and Features

Format: Subparts | Ruler | **SS** | DS **Search:** **Length: 64 bp** **Context: Part only** Get selected sequence

```
      1          11         21         31         41         51         61         71         81         91
1     ggaattgata tttatcaatg tataagtctt ggaaatgggc atcaaaaaga gataaattgt tctc
```

FNR binding -35 -10

Assembly Compatibility: 10 12 21 23 25

Jeffrey Green. 1993. "Activation of FNR-dependent transcription by iron: An in vitro switch for FNR." FEMS Microbiology Letters 113 (1993) 219-222

[edit]

Student Sample, September 2012

Part:BBa_J100099:Experience

Regulatory

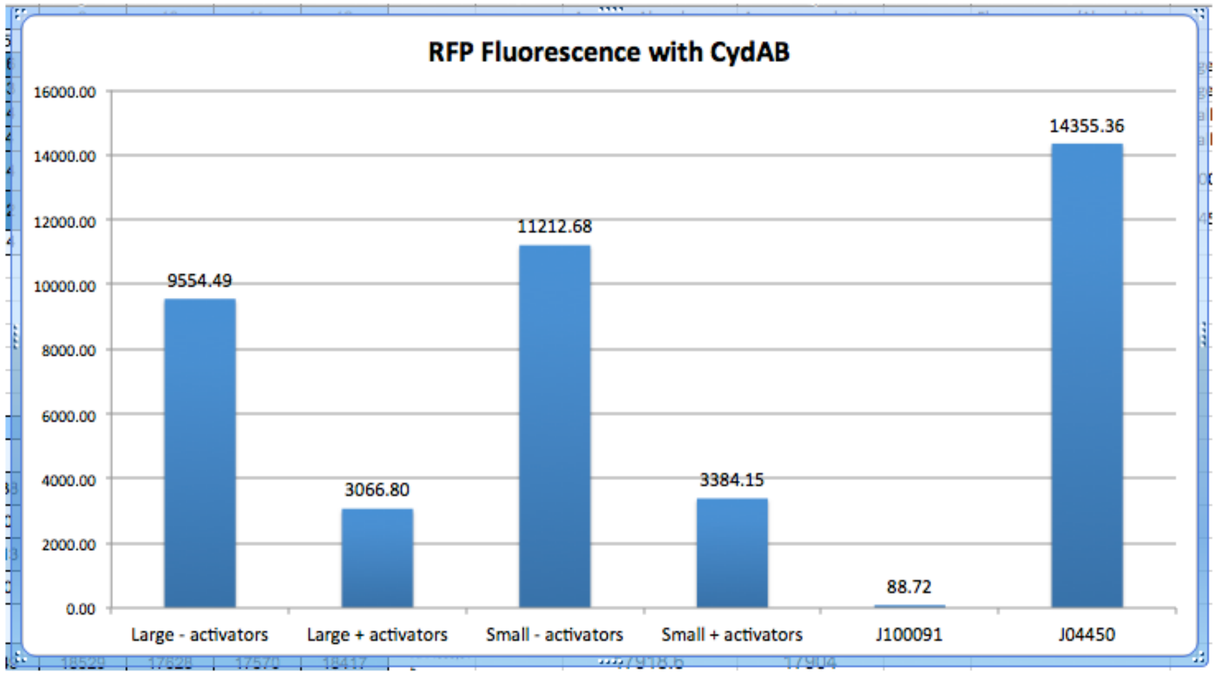
DNA Planning
Experience: Works
Get This Part

Designed by Phoebe Parrish Group: Campbell_M_Lab (2012-09-13)

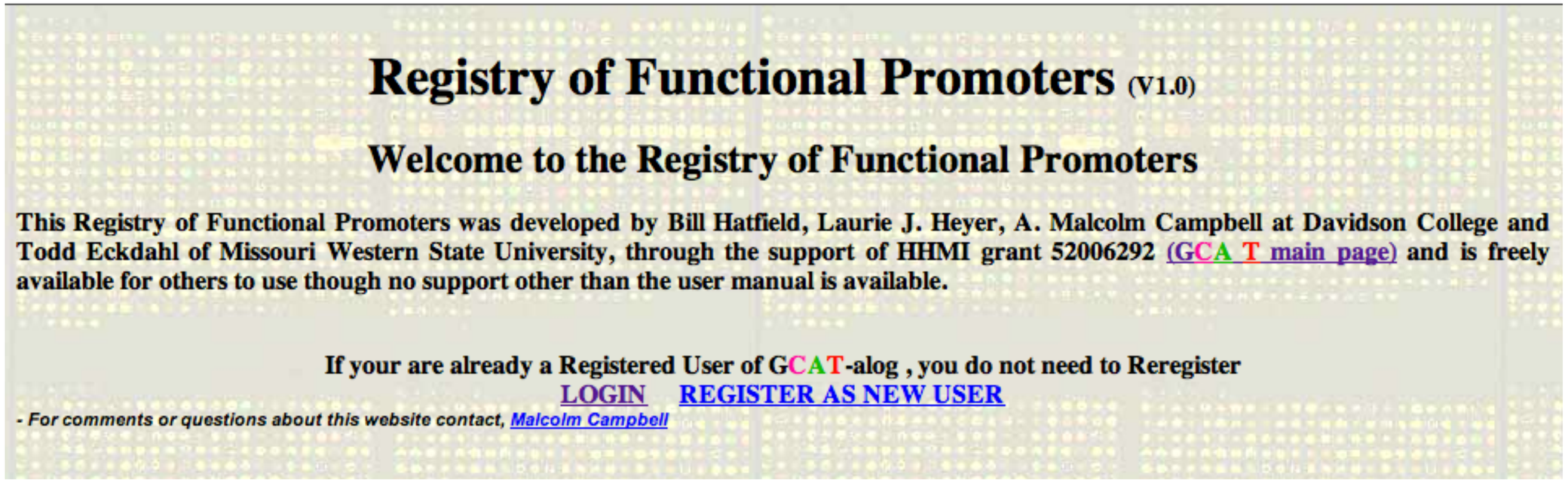
This experience page is provided so that any user may enter their experience using this part.
Please enter how you used this part and how it worked out.

Applications of BBa_J100099

We pipetted 200 microliters of one solution containing E coli cells from a small colony and the activators, one with cells from a small colony and no activators, one containing cells from a large colony and the activators, and one containing cells from a large colony and no activators. We also did a positive control with E coli cells containing a known promoter that causes red florescence (J04450) and a negative control with cells containing a the transcriptional terminator that does not cause red fluorescence (J100091). We tested both fluorescence of our samples using a fluorometer and the light absorbance using a spectrophotometer. We measured the fluorescence and absorbance of five samples of each solution, including a control solution that just contained the growth medium. We averaged the values for each solution and subtracted the average fluorescence/absorbance of the control. We then divided the average fluorescence by the average absorbance for each solution. These values are displayed on the accompanying graph.

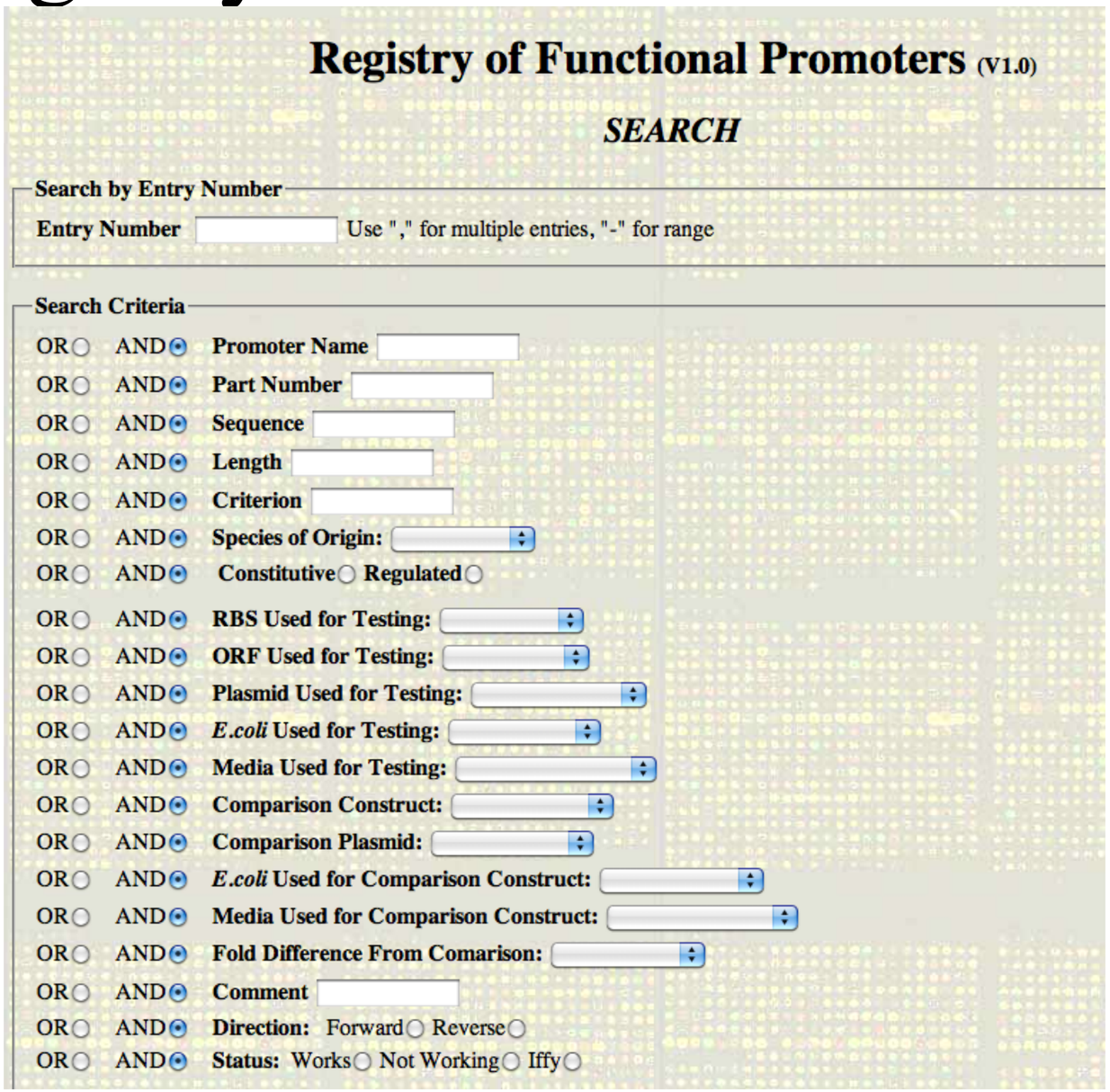


Registry of Functional Promoters (RFP)



gcat.davidson.edu/RFP/

Registry of Functional Promoters (RFP)



Registry of Functional Promoters (V1.0)

SEARCH

Search by Entry Number

Entry Number Use "," for multiple entries, "-" for range

Search Criteria

OR AND **Promoter Name**
OR AND **Part Number**
OR AND **Sequence**
OR AND **Length**
OR AND **Criterion**
OR AND **Species of Origin:**
OR AND **Constitutive** **Regulated**
OR AND **RBS Used for Testing:**
OR AND **ORF Used for Testing:**
OR AND **Plasmid Used for Testing:**
OR AND ***E.coli* Used for Testing:**
OR AND **Media Used for Testing:**
OR AND **Comparison Construct:**
OR AND **Comparison Plasmid:**
OR AND ***E.coli* Used for Comparison Construct:**
OR AND **Media Used for Comparison Construct:**
OR AND **Fold Difference From Comarison:**
OR AND **Comment**
OR AND **Direction:** Forward Reverse
OR AND **Status:** Works Not Working Iffy

gcat.davidson.edu/RFP/

Registry of Functional Promoters (RFP)

Registry of Functional Promoters (V1.0)

SEARCH PROMOTER RESULTS

Entry No.	Promoter Name	Part Number	Sequence	Length	Citation	Species of Interest	Constitutive/ Regulated	Inducible/ Repressible	Regulator	RBS Used for Testing	ORF Used for Testing	Pla Use Te
1	TetR Repressible Promoter	R0040	tccctatcagtgatagagattgacatccctatcagtgatagagatactgagcac	54			Regulated	Repressible	TetR			pSE
2	56 bp LacI Promoter	K091110	cgttgacaccatcgaatggcgcaaaacctttcgcggtatggcatgatagcgcccgg	56			Constitutive					
3	200 bp LacI Promoter	R0010	caatacgcaaaccgcctctccccgcgcgttggccgattcattaatgcagctggcac gacaggtttcccgactggaaagcgggcagtgagcgcaacgcaattaatgtgagtt agctcactcattaggcaccccaggctttacactttatgcttccggctcgtatgttgtgt ggaattgtgagcggataacaatttcacaca	200			Constitutive					
4	LuxR & HSL Regulated Lux promoter	R0062	acctgtaggatcgtacaggtttacgcaagaaaatggtttgttatagtcgaataaa	55			Regulated	Repressible				
5	Backwards 200 LacI Promoter (right to left)	J31013	tgtgtgaaattgttatccgctcacaattccacacaacatacgagccggaagcataaa gtgtaaagcctggggtgcctaatgagtgagctaactcacattaattgcgttgcgctc actgcccgctttccagtcgggaaacctgtcgtgccagctgcattaatgaatcggcca acgcgcggggagaggcggtttgcgtattg	200			Regulated	Repressible				
6	OmpC Promoter	K199017	tttacattttgaaacatctatagcgataaatgaaacatcttaaaagttttagtatcatattc gtgttggattattctgcatttttggggagaatggact	99			Constitutive					
7	23K series very strong constitutive Promoter	J23100	ttgacggctagctcagtcctaggtacagtgctagc	35			Constitutive					

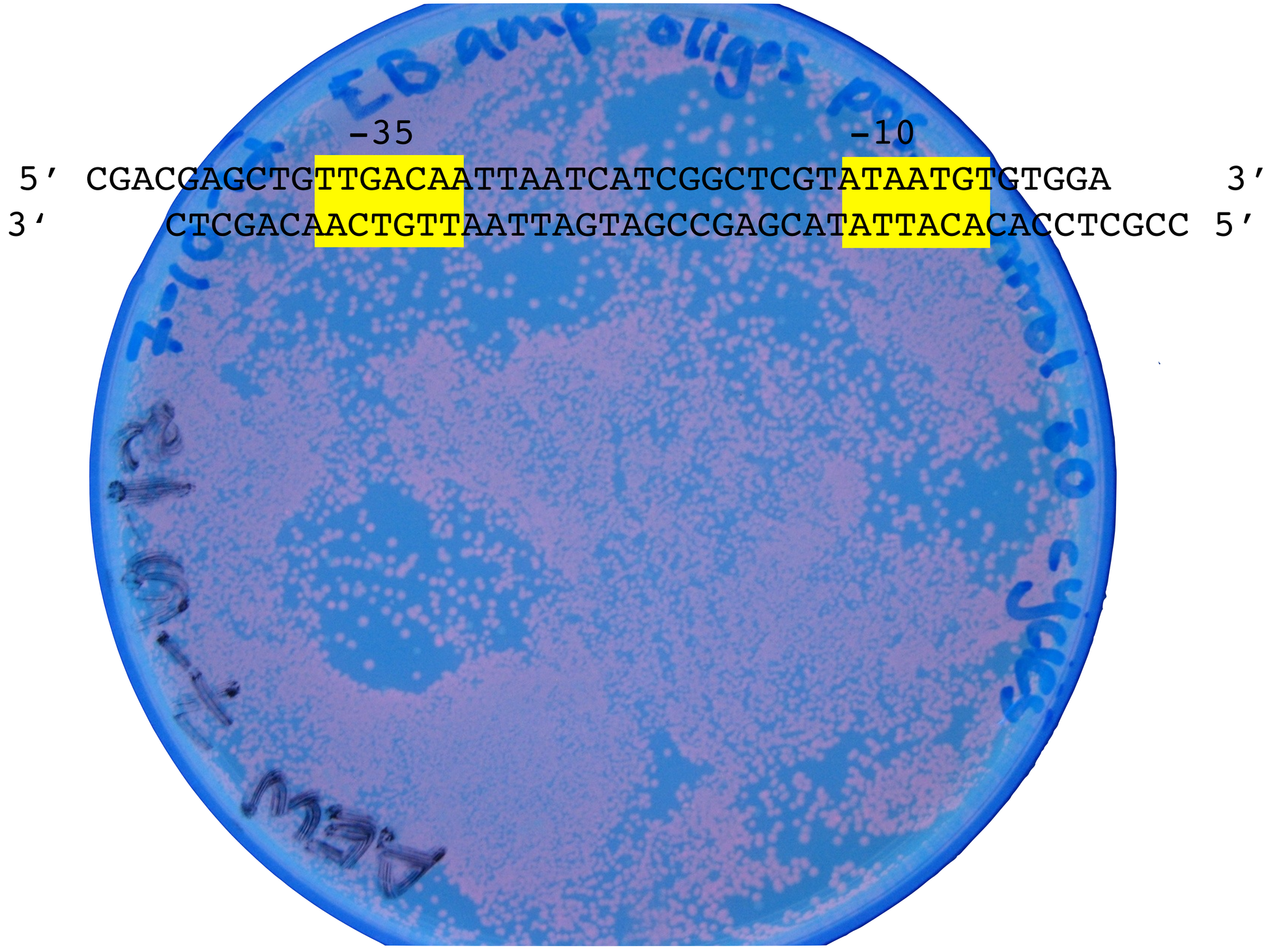
To Edit an Entry, Enter the Entry # and press "Edit Entry" [ ] Edit Entry

To Delete an Entry, Enter the Entry # and press "Delete Entry" [ ] Delete Entry

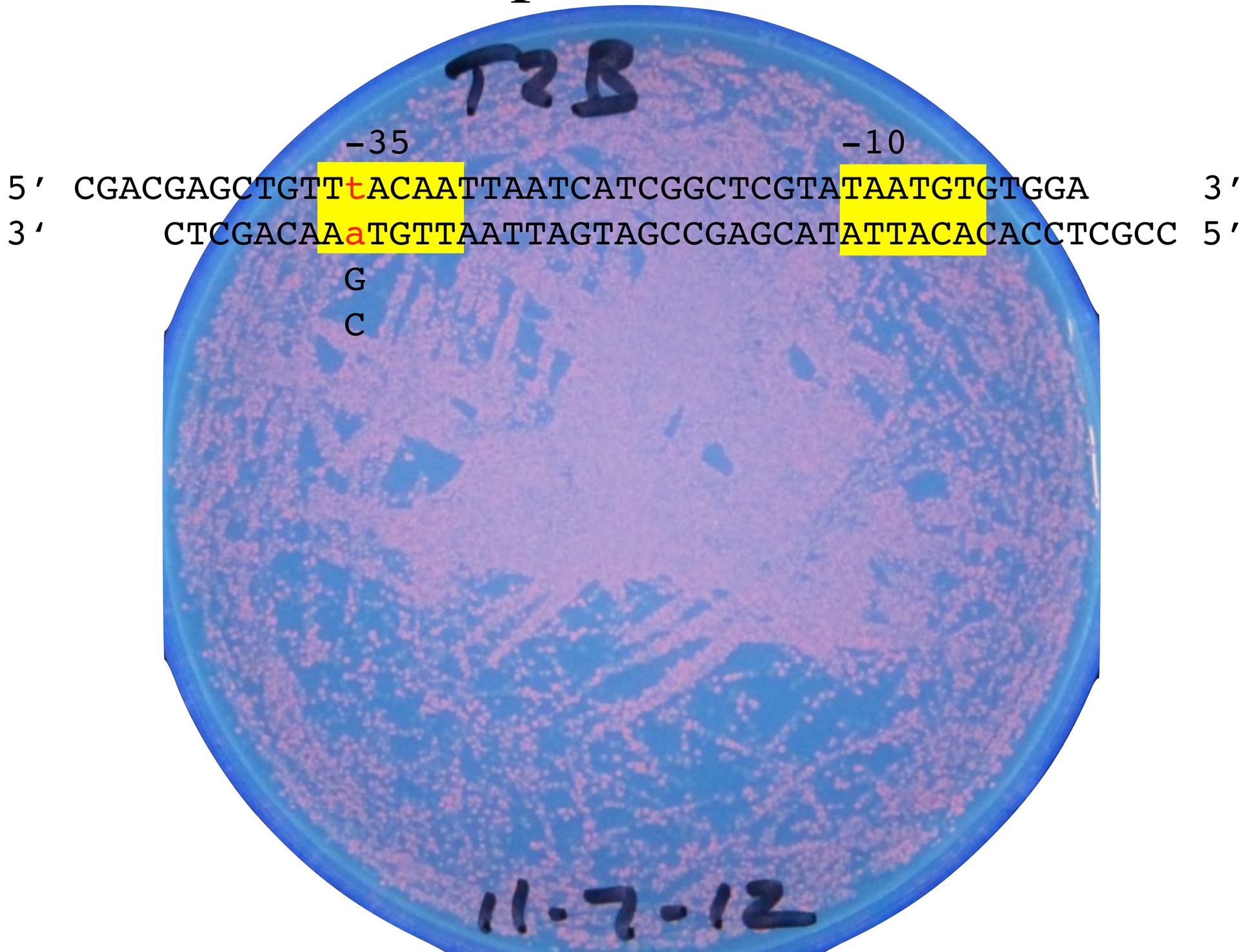
Search Again

gcat.davidson.edu/RFP/

Testing Known Promoters: Ptac

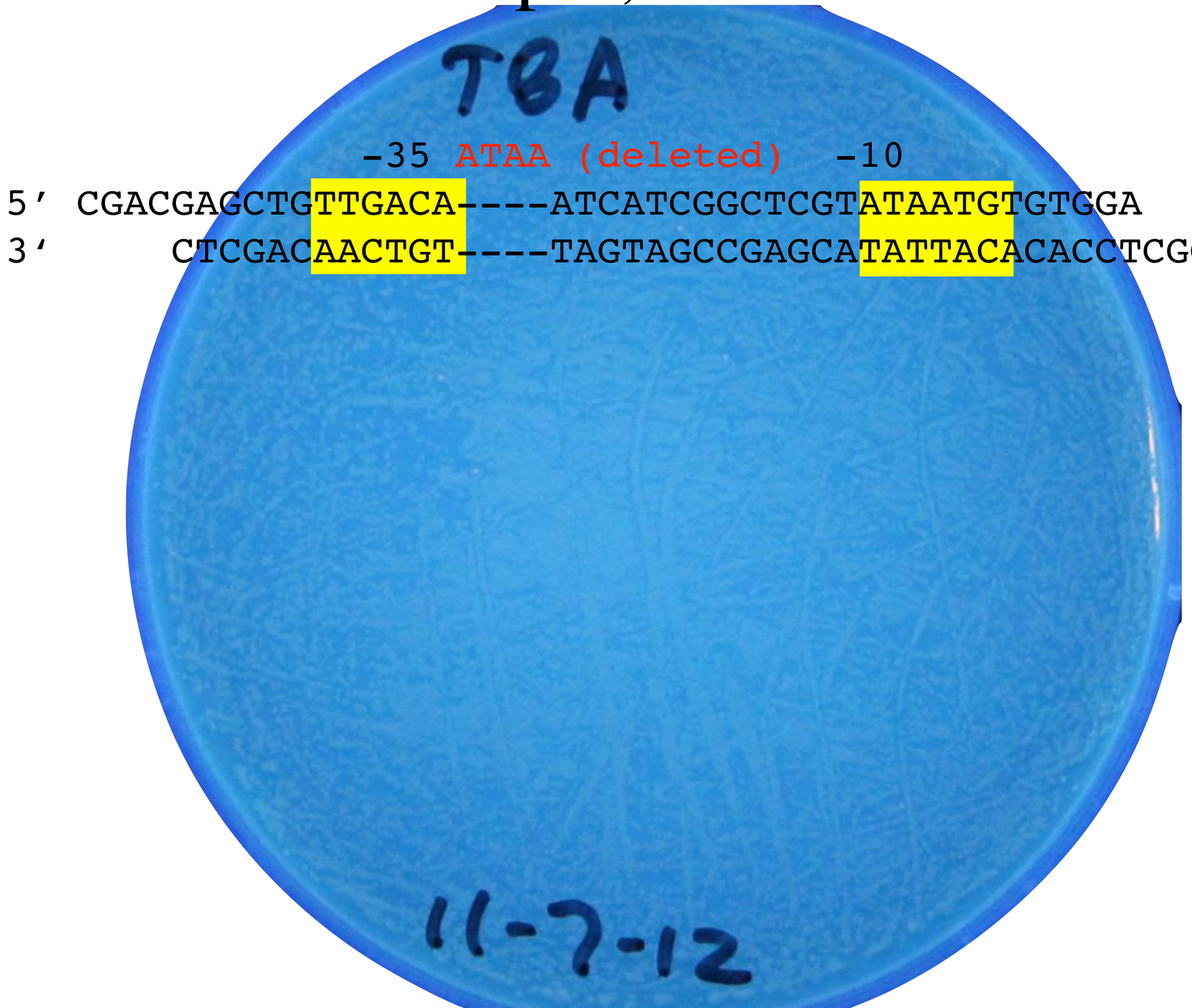


Student Sample, November 2012




```
                -35                    -10
5′ CGACGAGCTGTTtACAATTAATCATCGGCTCGTATAATGTGTGGA      3′
3′      CTCGACAAaTGTTAATTAGTAGCCGAGCATATTACACACCTCGCC 5′
                G
                C
```

Student Sample, November 2012



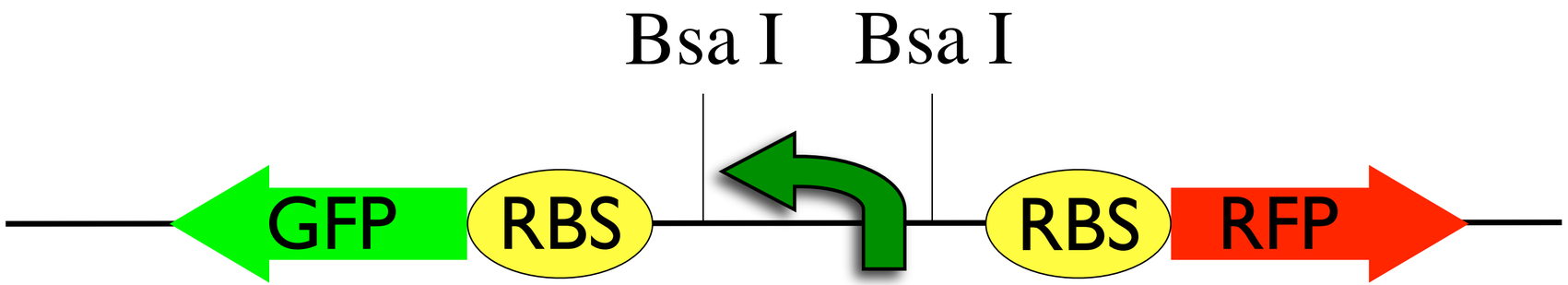
-35 ATAA (deleted) -10

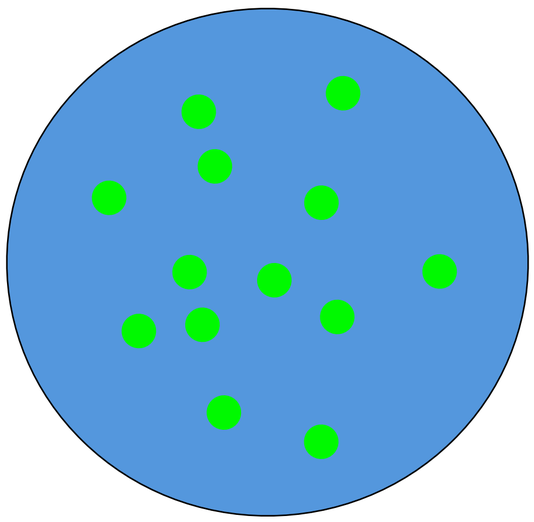
5′ CGACGAGCTGTTGACA----ATCATCGGCTCGTATAATGTGTGGA 3′

3′ CTCGACAACTGT----TAGTAGCCGAGCATATTACACACCTCGCC 5′

pClone Red

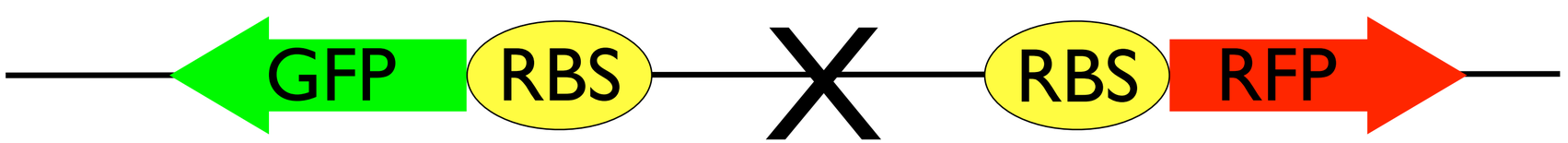
J119137

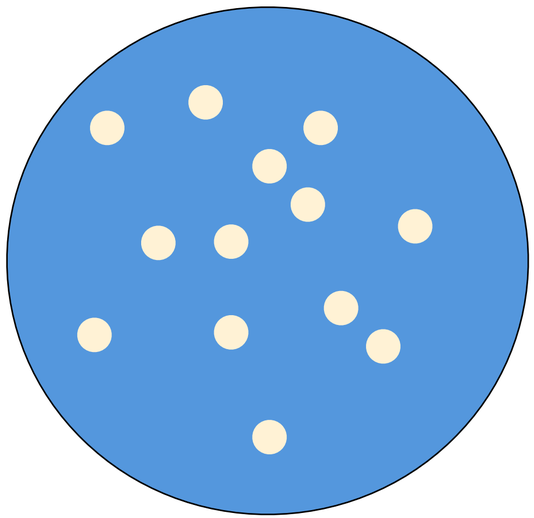




Remove Initial Promoter

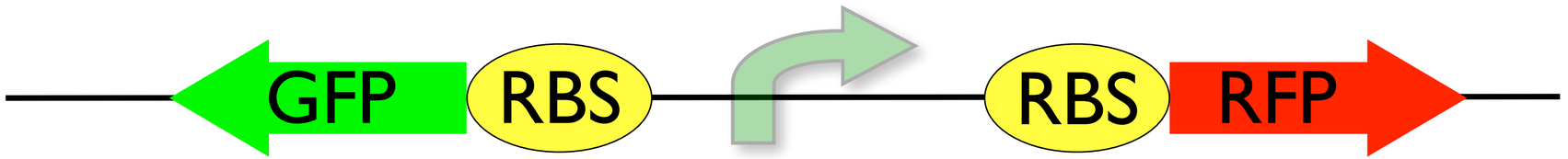
J119137

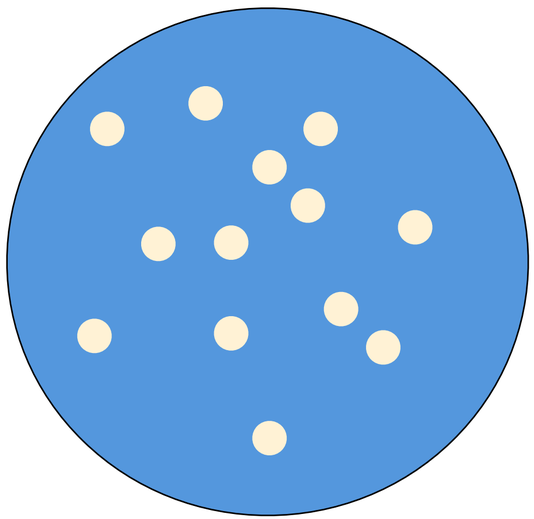




Insert Non-functional Promoter

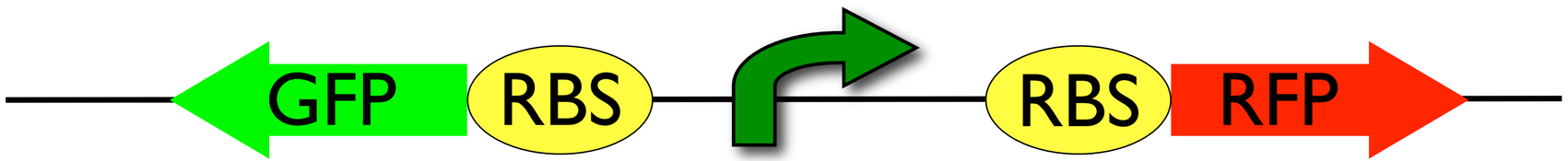
J119137

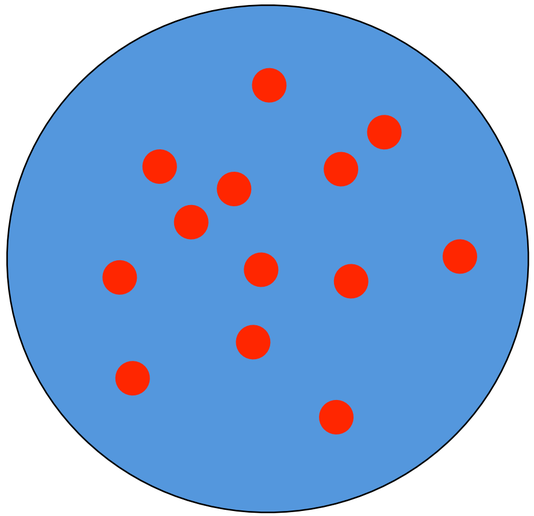




Insert Forward Promoter

J119137





Insert Bi-directional Promoter

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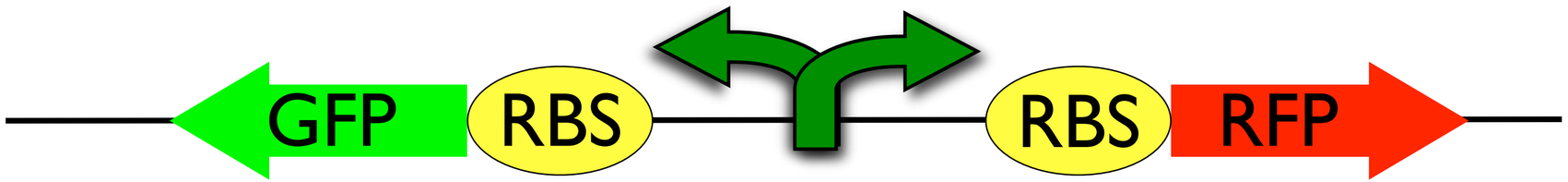

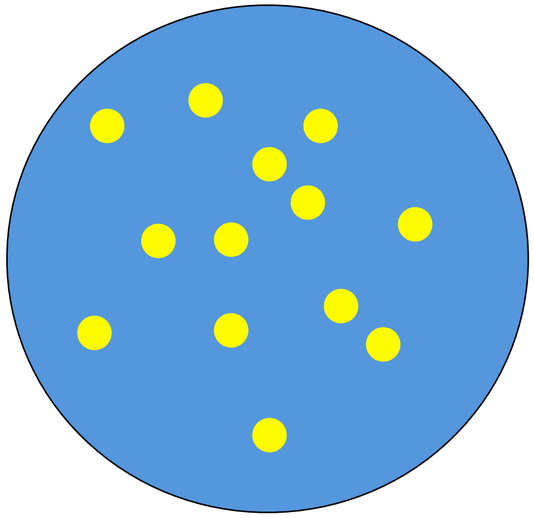

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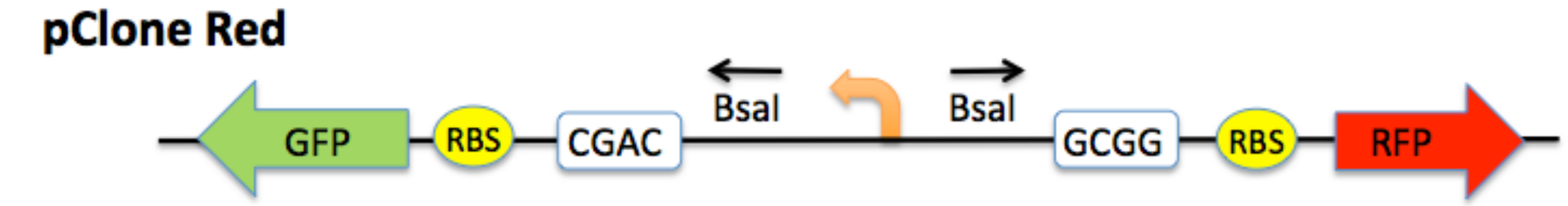
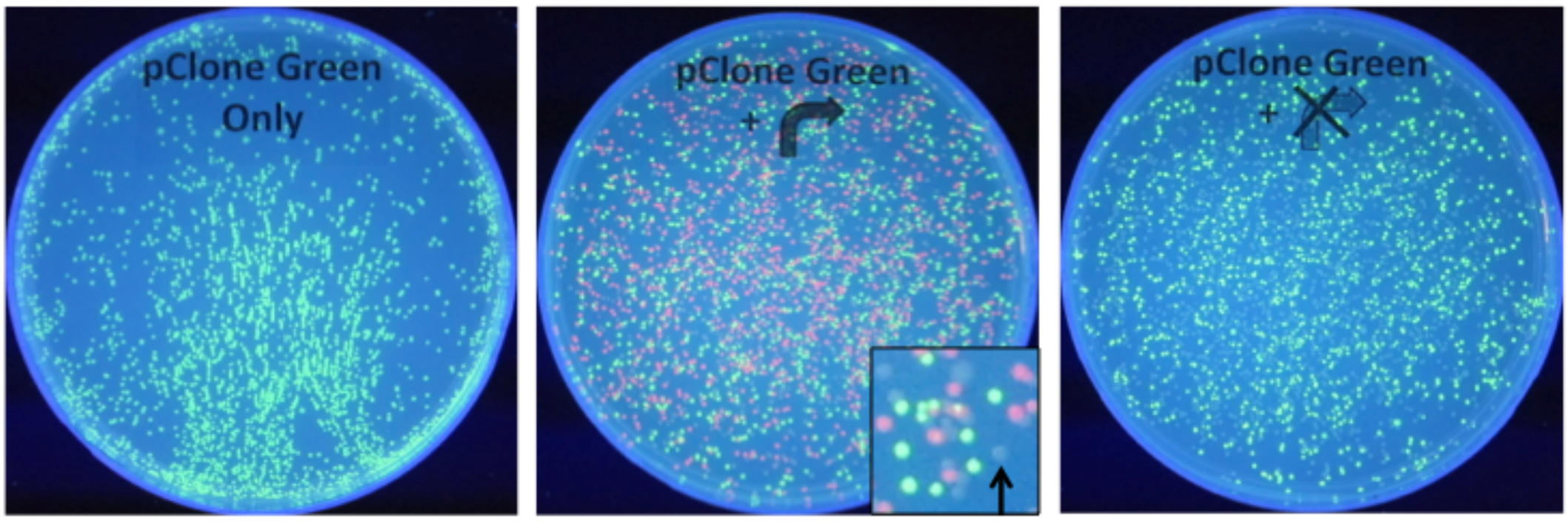
J119137

A



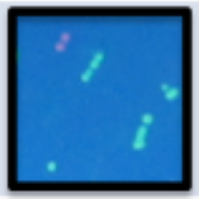
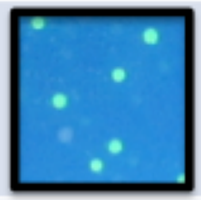
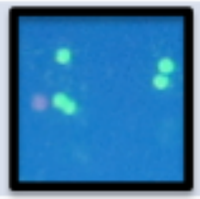
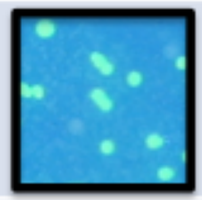
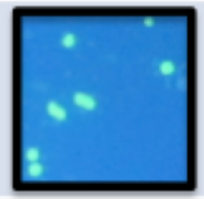
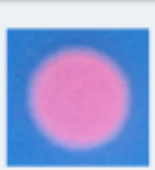
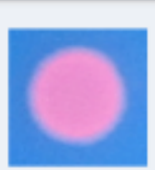
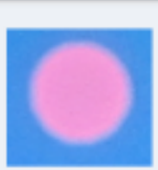
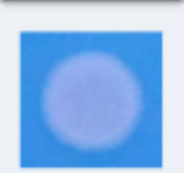
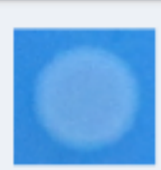
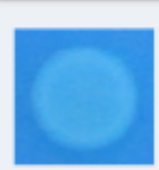
B



Campbell, *et al.* 2014. *CBE Life Sciences Education*. Vol. 13(2): 285 - 296.

Quantify with Phone and ImageJ

J119137

Mutant	J119319	J119320	J119321	J119322	J119323	J119324	J119325	J119326
pClone Green plate								
Isolated clones								
Expression Ratio	4.09	3.94	3.84	2.04	1.54	1.34	3.52	1.00

Campbell, *et al.* 2014. *CBE Life Sciences Education*. Vol. 13(2): 285 - 296.

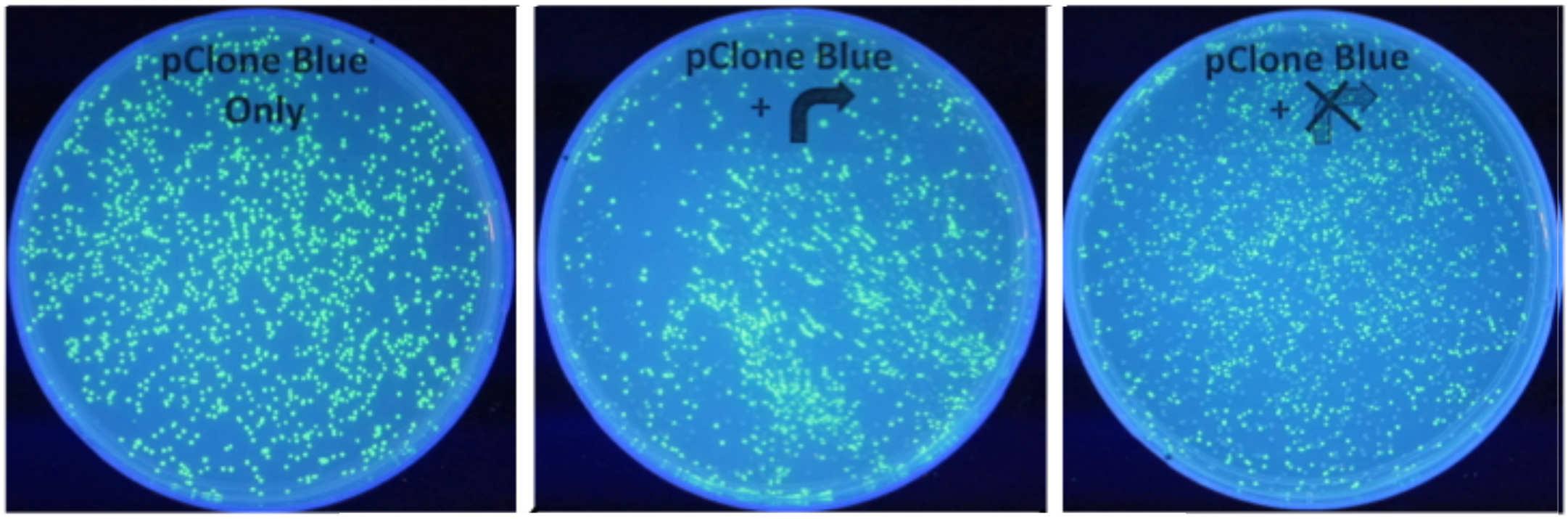
pClone Blue

J119313

A

pClone Blue

B



Campbell, *et al.* 2014. *CBE Life Sciences Education*. Vol. 13(2): 285 - 296.

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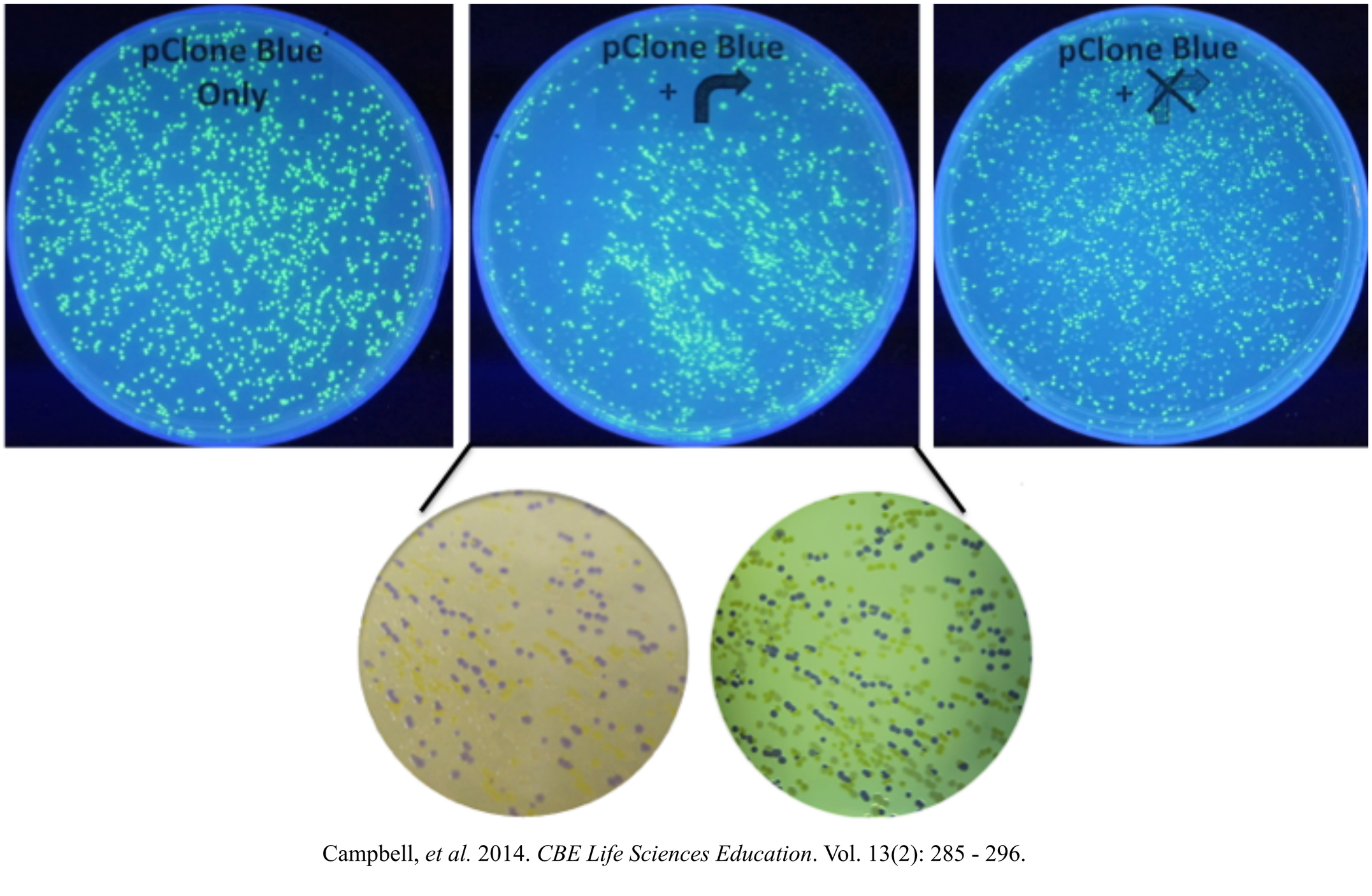
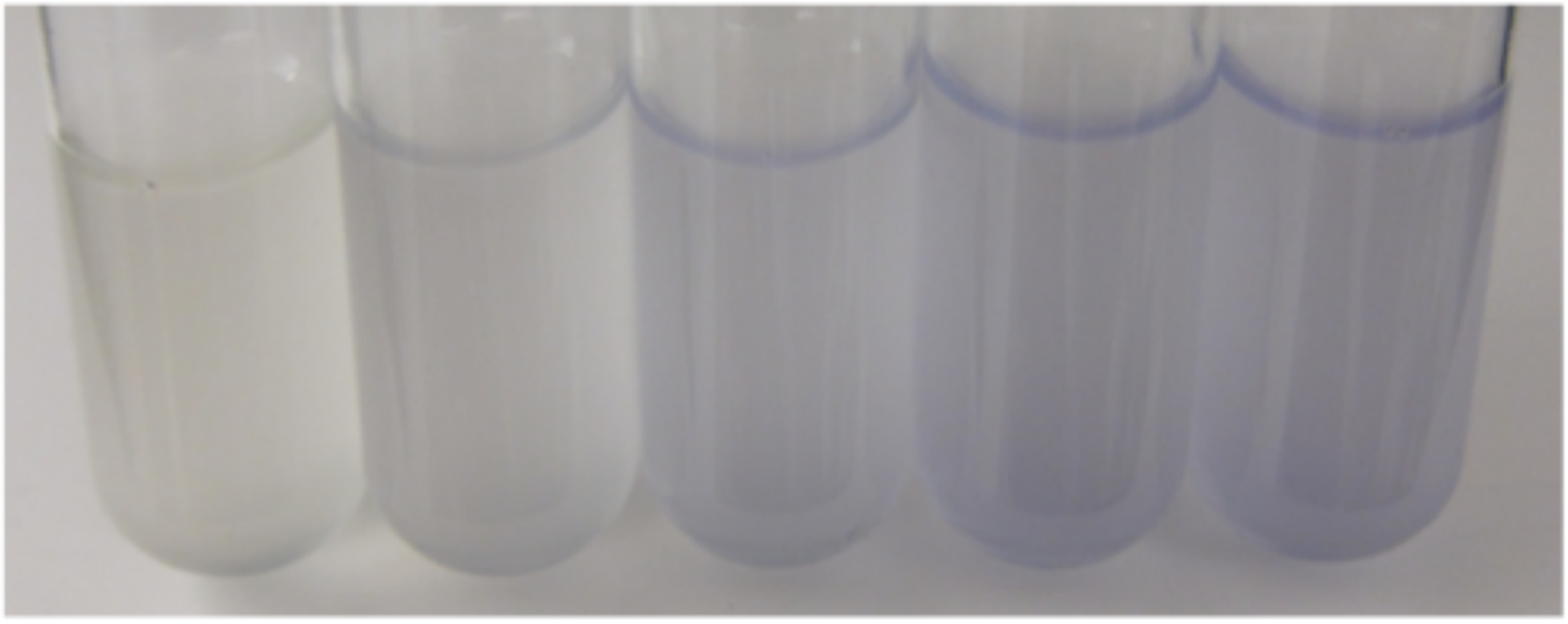


Campbell, *et al.* 2014. *CBE Life Sciences Education*. Vol. 13(2): 285 - 296.

Measure Promoter Qualitatively

J119313

A



Assessment Davidson Intro Bio

	Learning objective	Pretest experimental	Posttest experimental	Comparison course	$F(2,88)$	Effect size (η^2)	Conclusion
1	Function of promoter	43%	87%[a]	48%	8.008, $p = 0.001$	0.154	Large effect
2	Repressor diagram	23%	53%[a]	13%	7.206, $p = 0.001$	0.141	Large effect
3	Activator diagram	0%	41%[a]	0%	7.250, $p = 0.001$	0.167	Large effect
4	Experiment overview	0%	13%[a]	0%	4.538, $p = 0.013$	0.103	Moderate effect
5	Transformation method	0%	20%[a]	0%	7.374, $p = 0.001$	0.143	Large effect
6	Verify promoter cloned	50%	40%	48%	0.34, $p = 0.713$	0.008	No effect
7	Test promoter strength	43%	60%	39%	1.525, $p = 0.223$	0.034	No effect
8	Type IIs restriction enzymes	7%	50%	6%	1.873, $p = 0.16$	0.041	No effect
9	GGA method	10%	63%[a]	0%	31.929, $p < 0.001$	0.421	Large effect

[a]Significant improvement between pre- and posttest.

Assessment MWSU Genetics (soph)

	Learning objective	Pretest experimental	Posttest experimental	Control course (ecology)	$F(2252)$	Effect size (η^2)	Conclusion
1	Function of promoter	36%	59%[a]	20%	13.527, $p < 0.001$	0.097	Moderate effect
2	−10 and −35 sites	3%	70%[a]	0%	145.374, $p < 0.001$	0.536	Large effect
3	Mutational analysis	30%	75%[a]	33%	28.773, $p < 0.001$	0.186	Large effect
4	Student-designed mutation	0%	0%	0%	0, $p > 0.05$	0.000	No effect
5	Transformation method	11%	51%[a]	12%	30.731, $p < 0.001$	0.196	Large effect
6	Verify promoter cloned	19%	44%[a]	18%	10.264, $p < 0.001$	0.075	Moderate effect
7	Test promoter strength	17%	33%[a]	18%	4.421, $p = 0.013$	0.034	Moderate effect
8	Type IIs restriction enzymes	2%	29%[a]	4%	21.661, $p < 0.001$	0.147	Large effect
9	GGA method	14%	22%	14%	1.56, $p = 0.212$	0.012	No effect

[a]Significant improvement between pre- and posttest.

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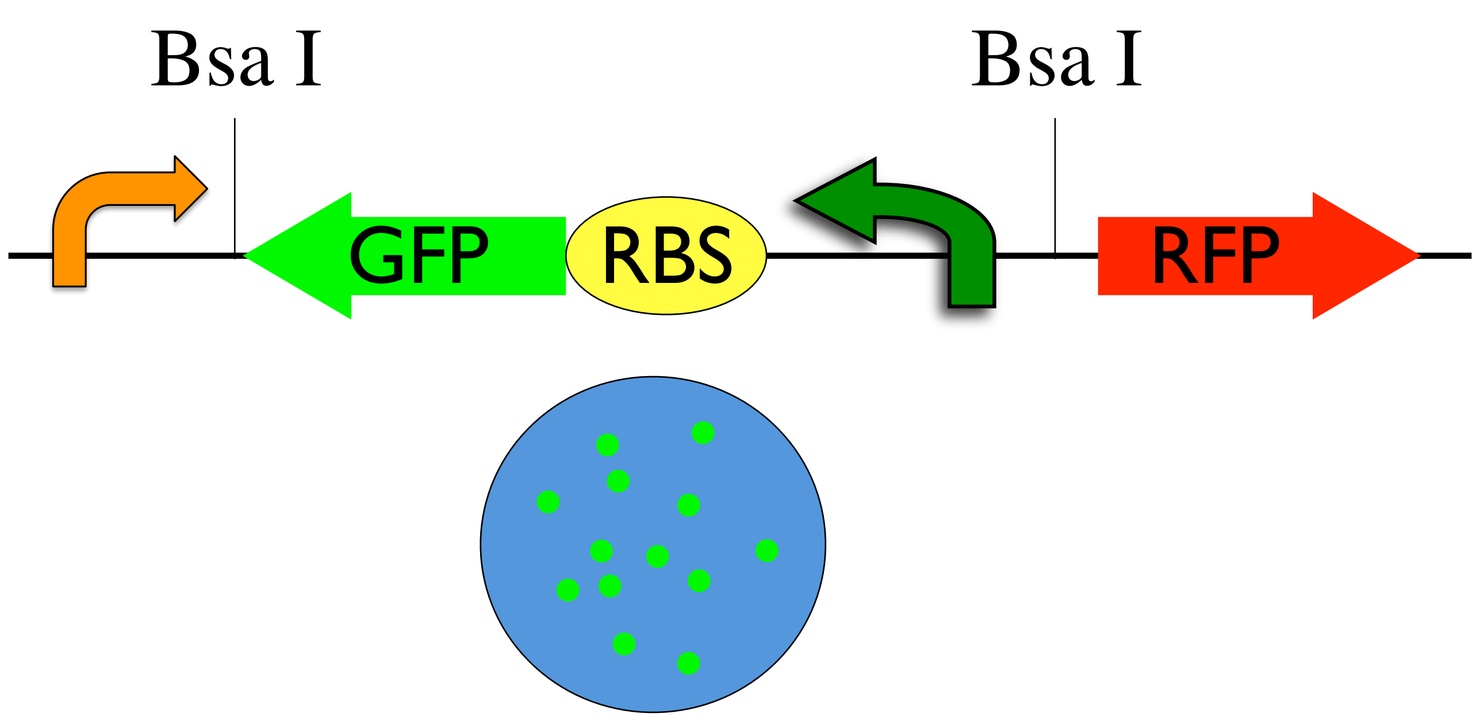
[a]Significant improvement between pre- and posttest.

rClone Red

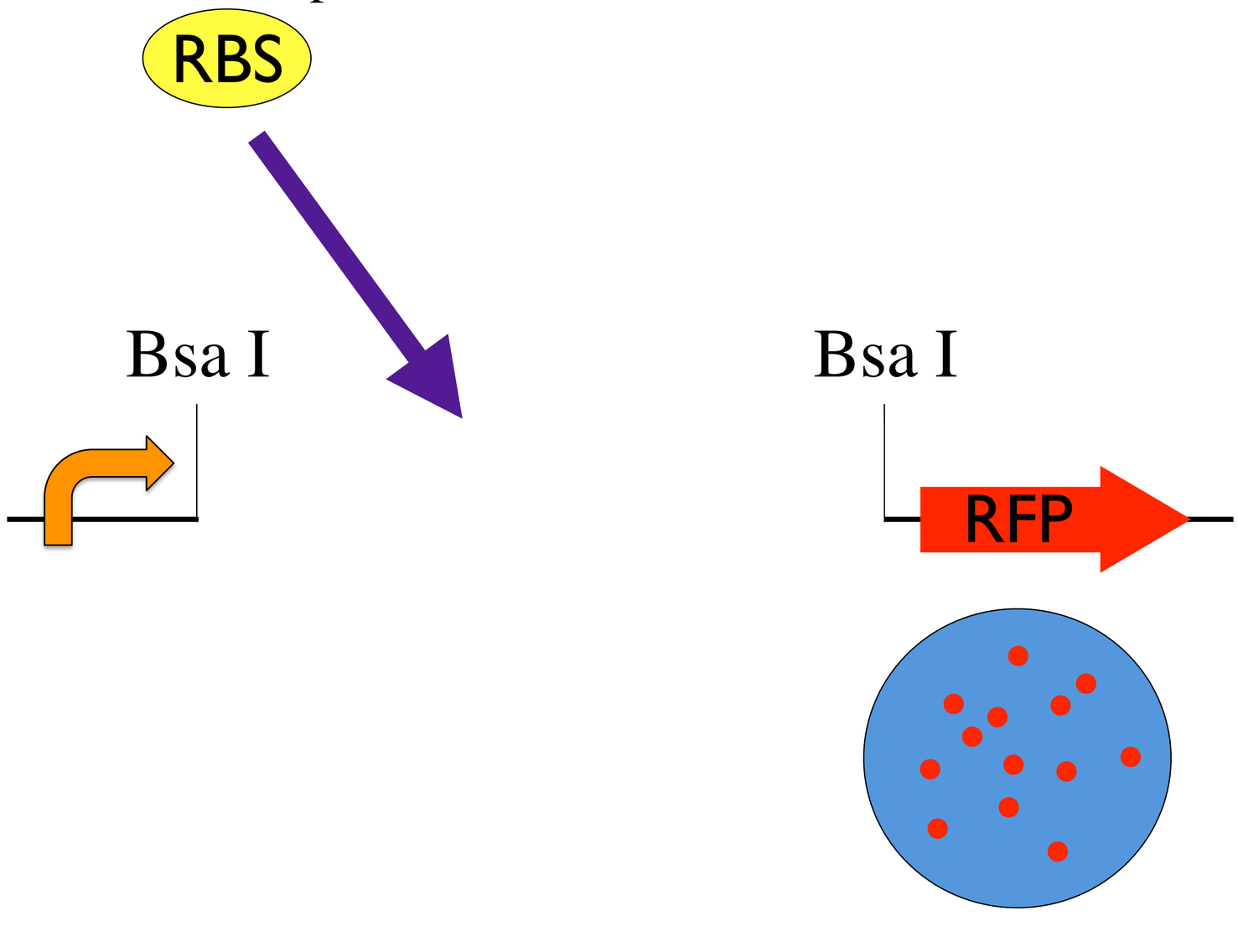
J119###



rClone Red

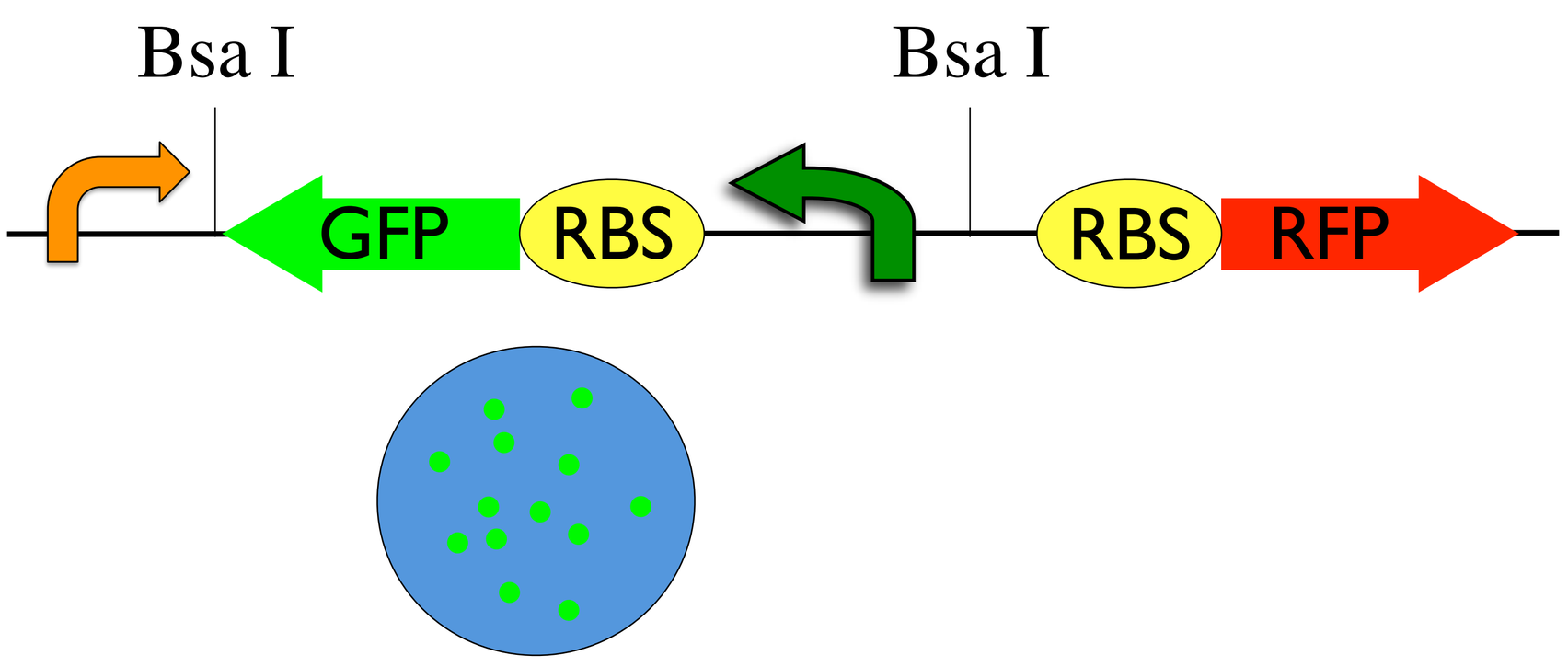
J119###

12 - 60 bp



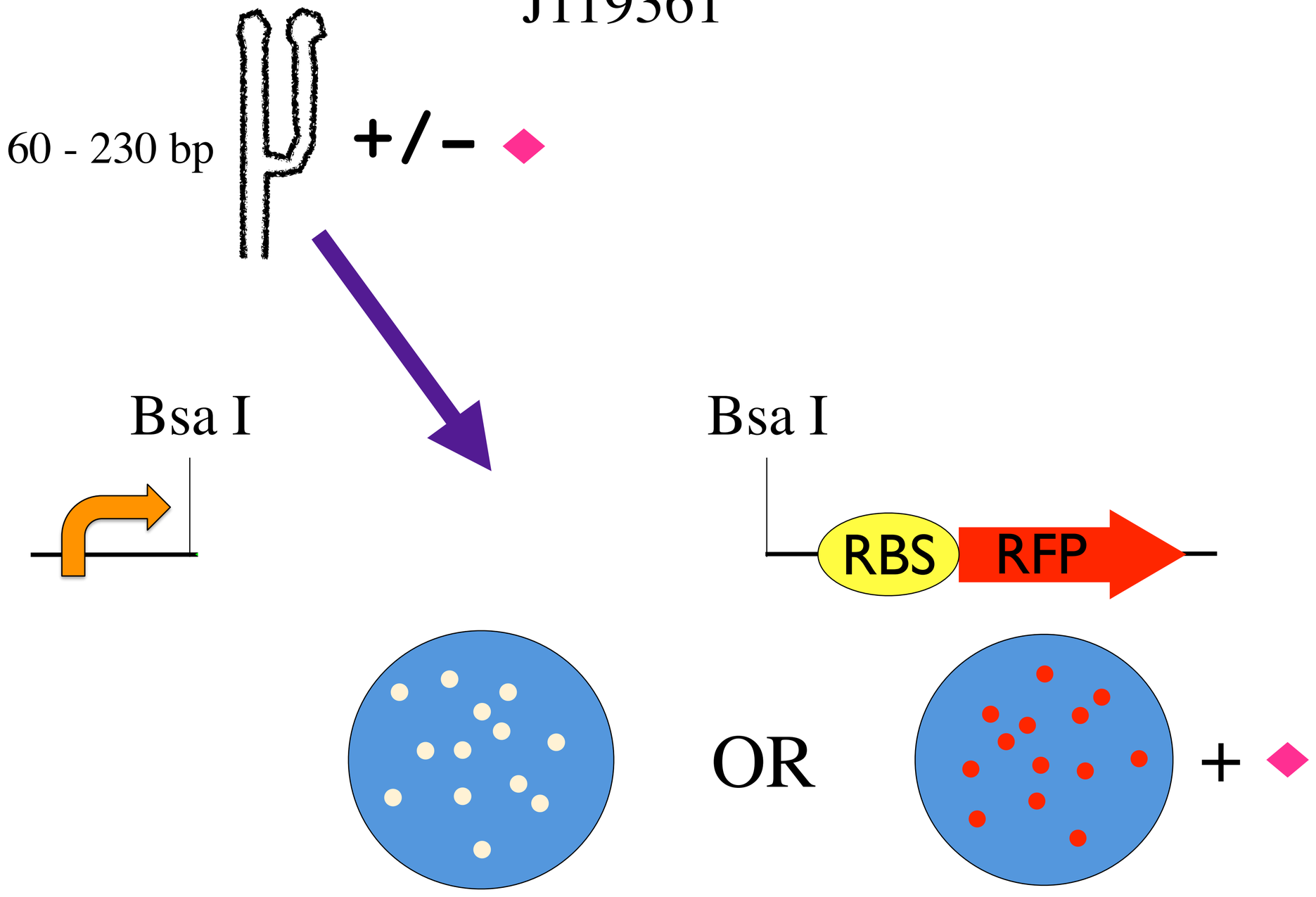
tClone Red

J119361



tClone Red

J119361



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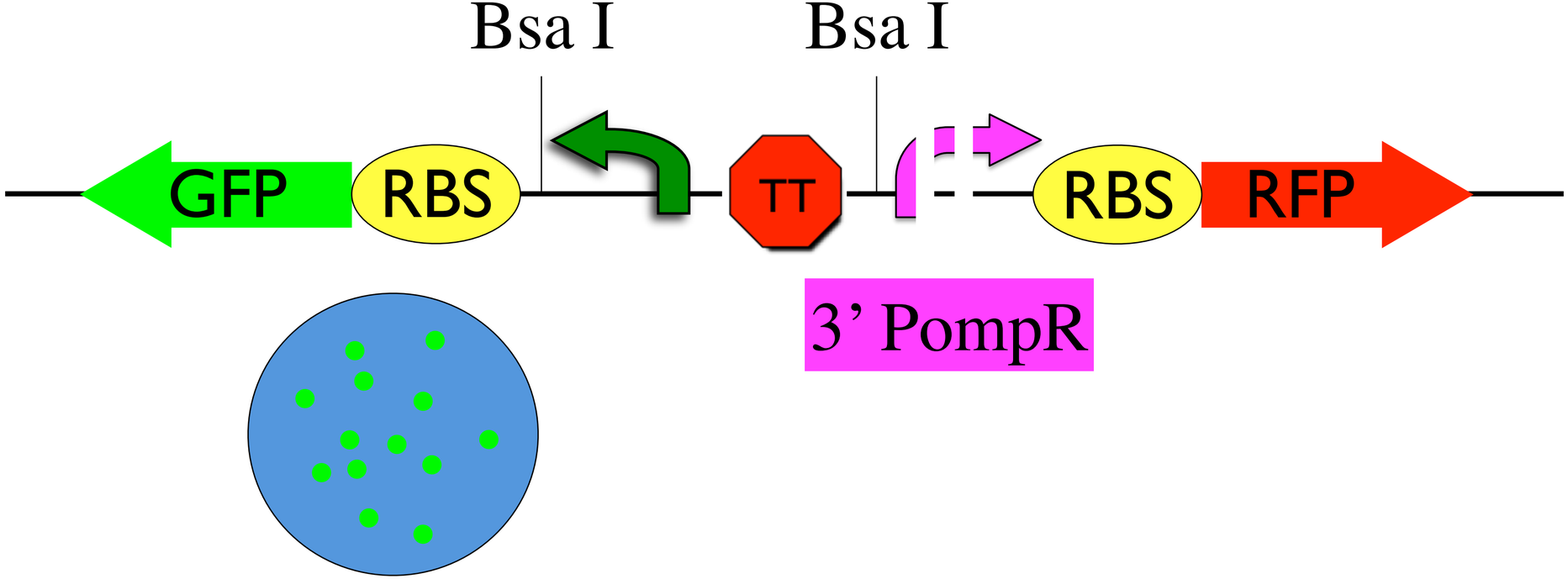

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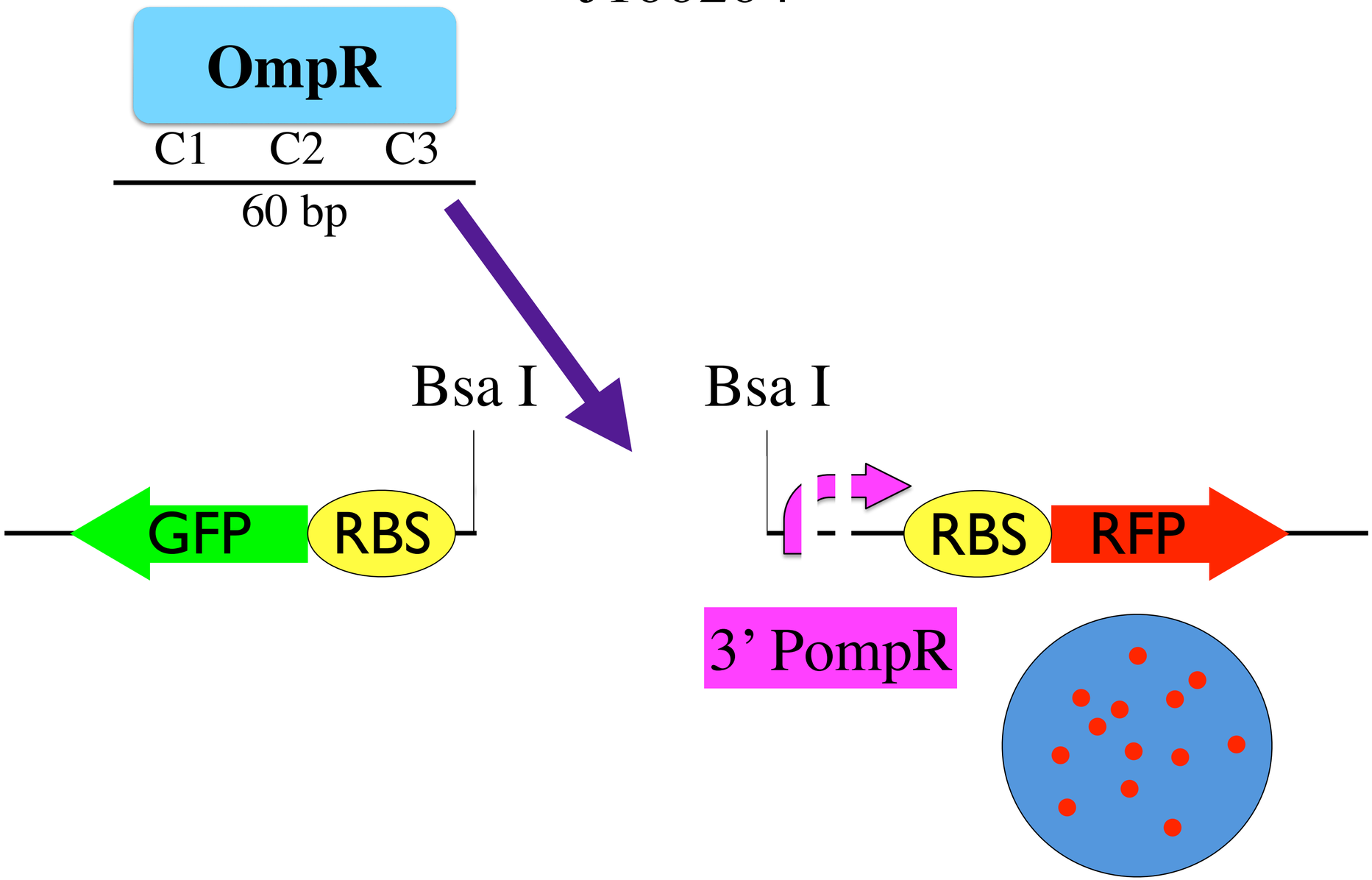
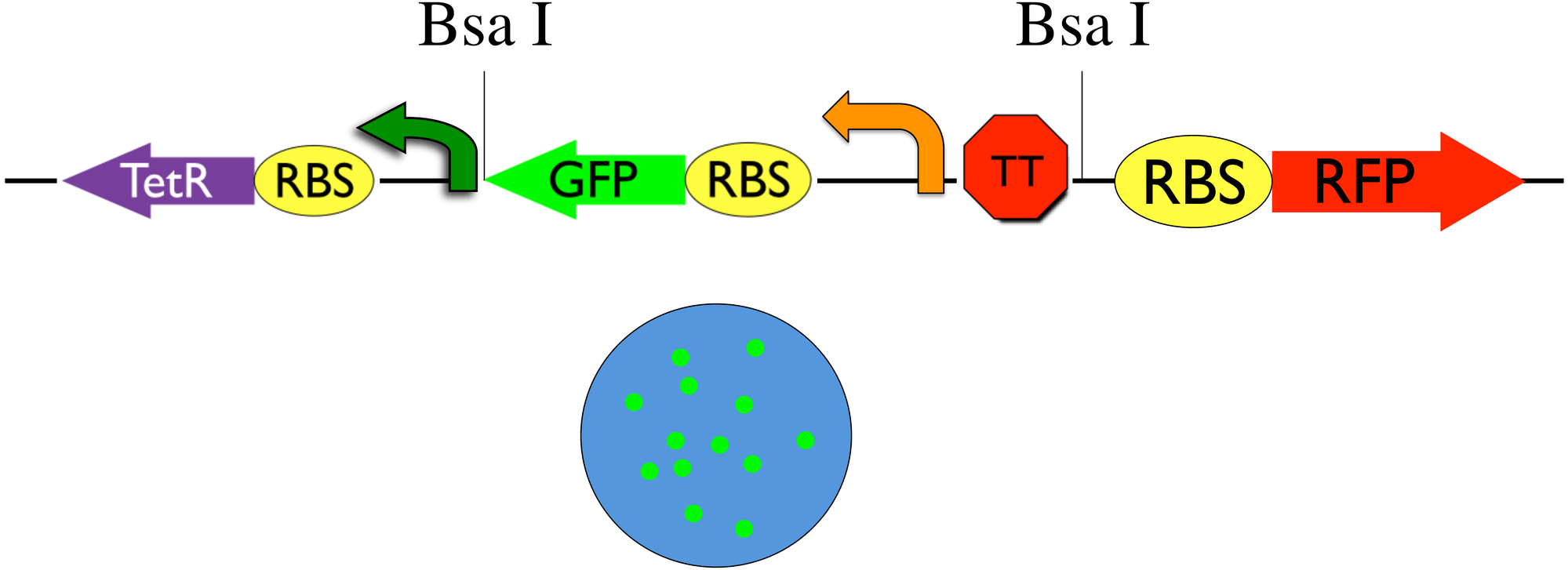


repClone Red

J100205



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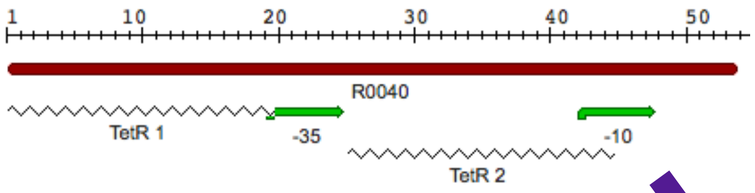
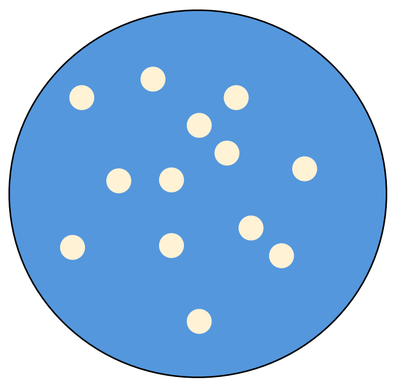
J100205

Ptet



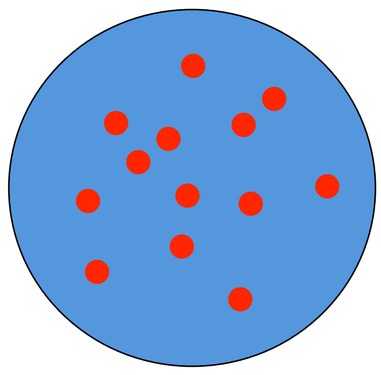
54 bp

Bsa I

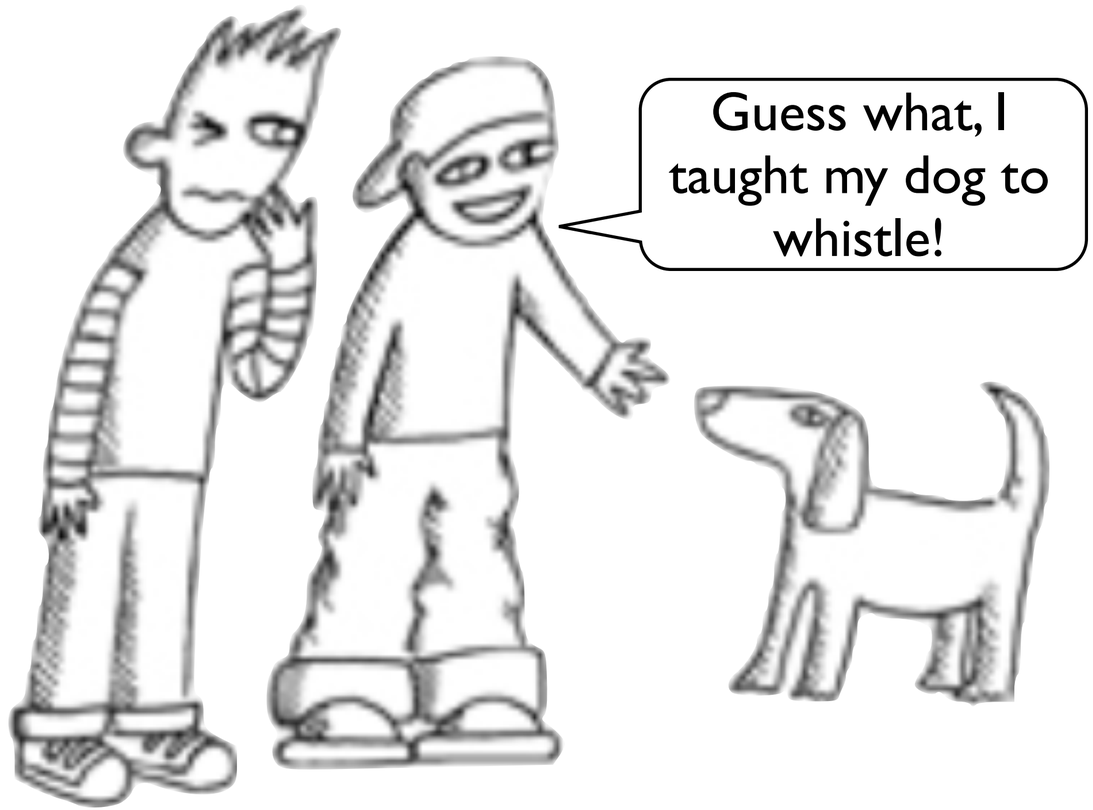


Bsa I

OR

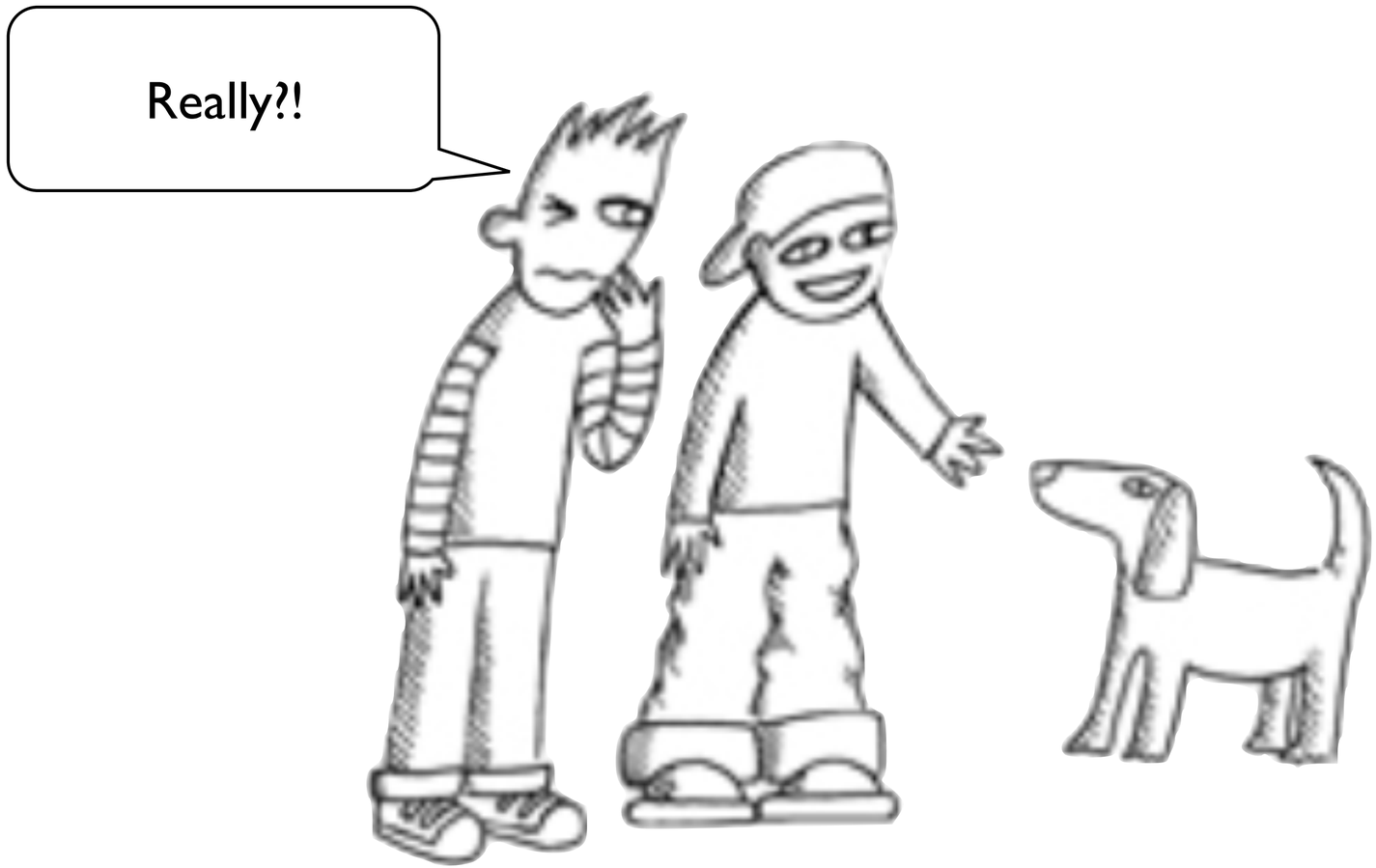


Teaching *vs* Learning

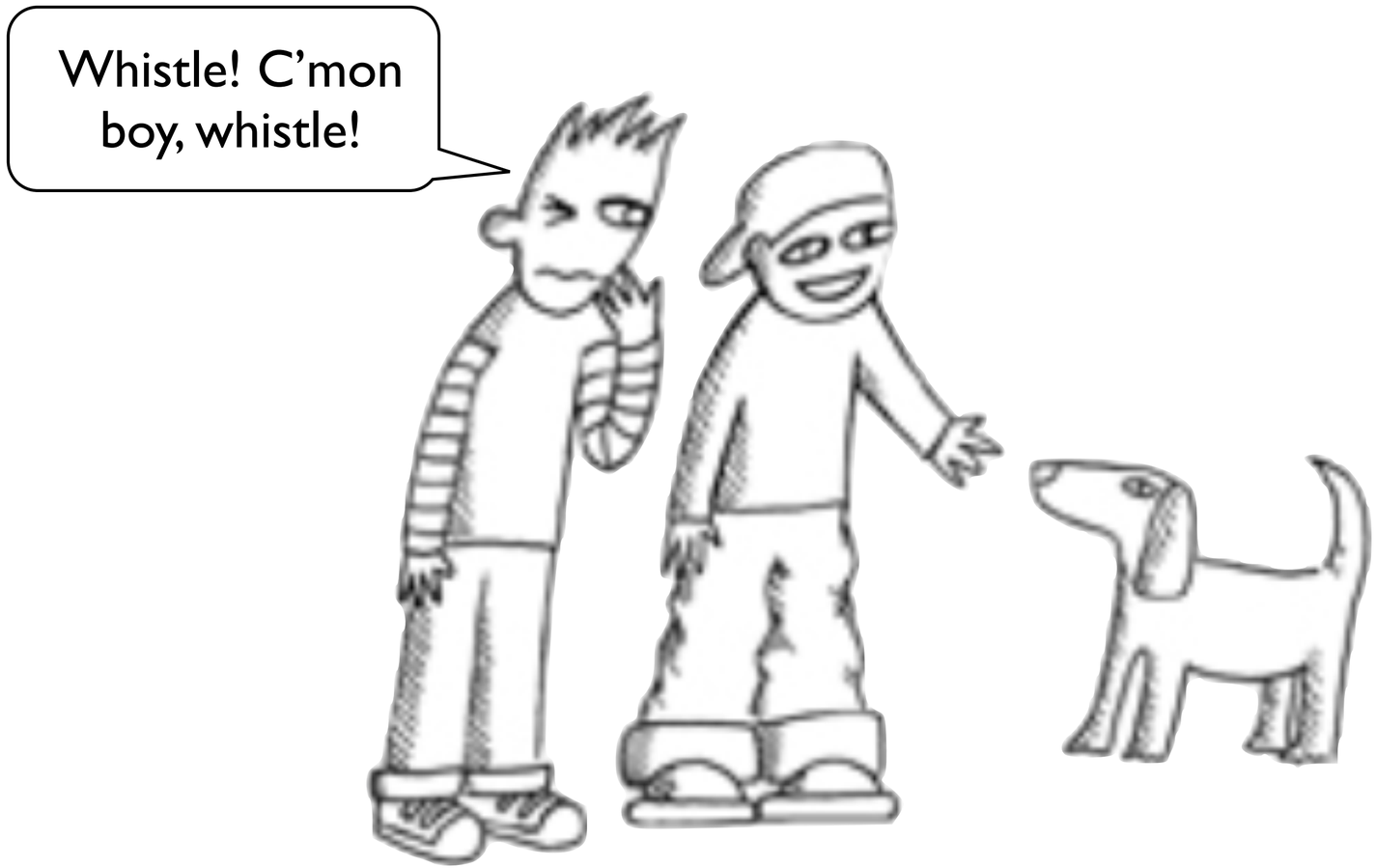


http://thegoodpeople.se/blog/?p=208

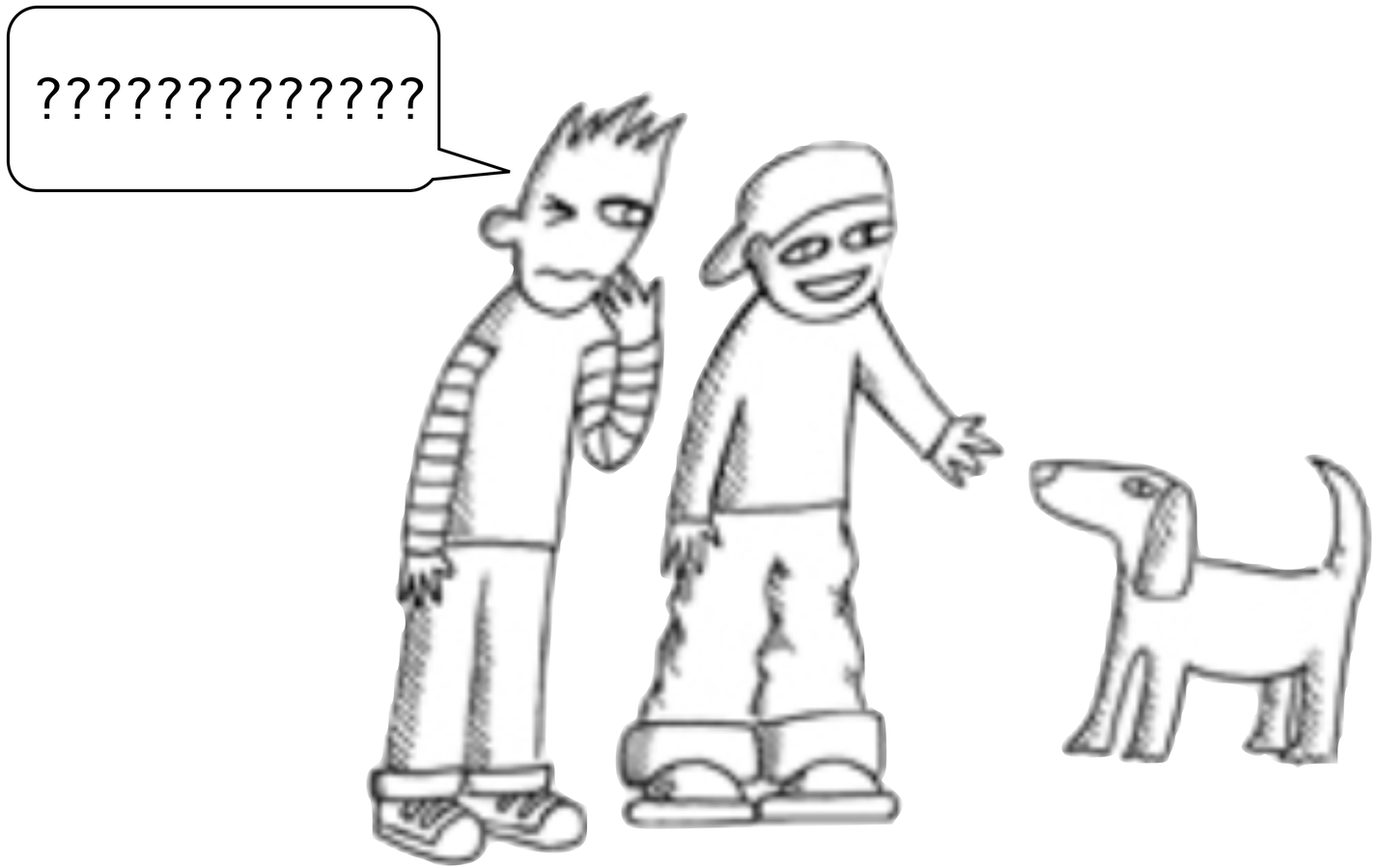
Teaching *vs* Learning



Teaching *vs* Learning



Teaching *vs* Learning



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Remember, teaching is supposed to be fun!