Integrating Concepts in Biology

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Winthrop College, ASBMB RCN
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Outline of Presentation

Why change my course now?

How is *ICB* different?

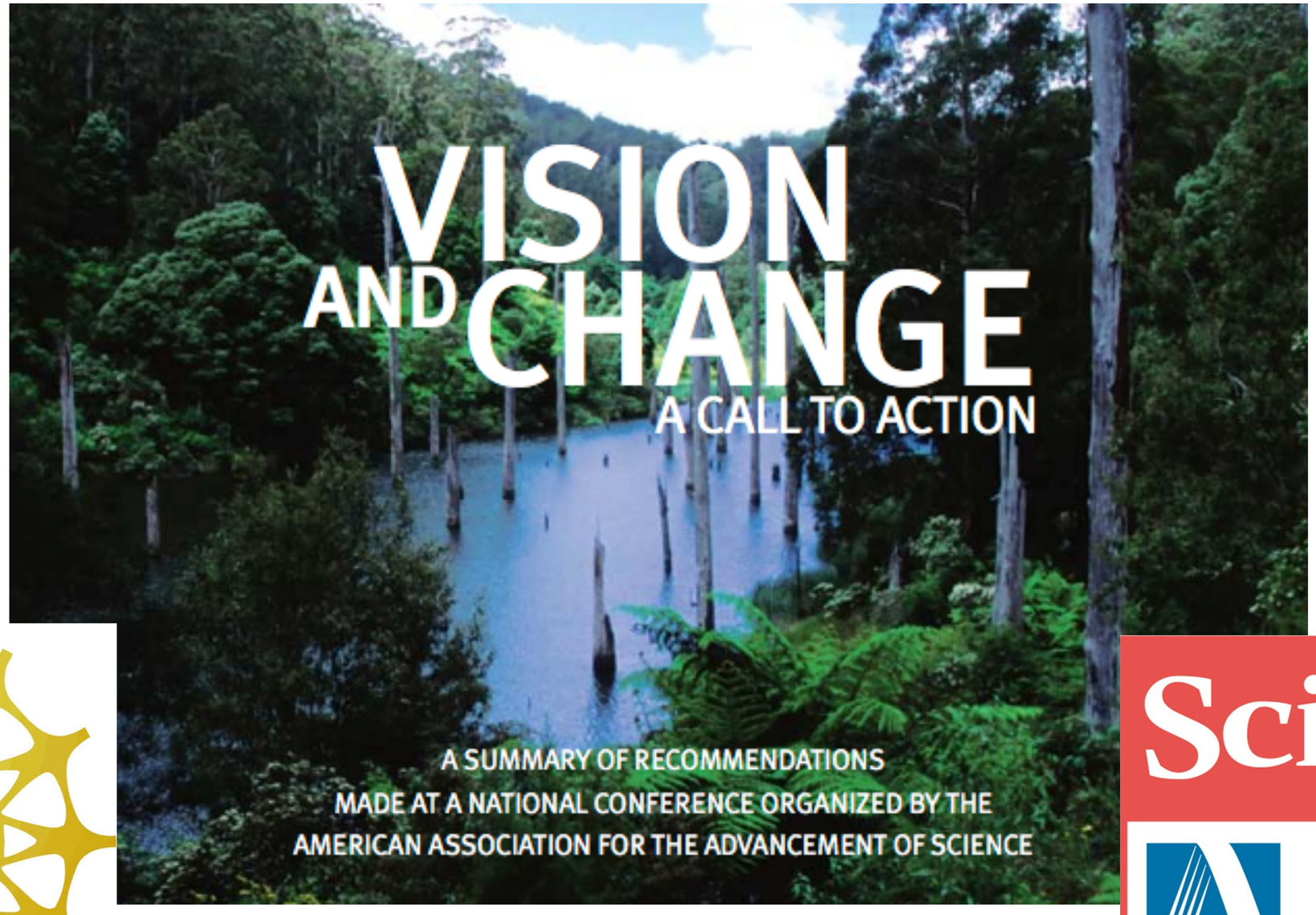
How does *ICB* integrate evolution and homeostasis?

Do students meet learning objectives (content and attitude)?

How do we run our classrooms? Write tests?

You can access the book for free today.

National Recognition of Need to Change



NSF

Science

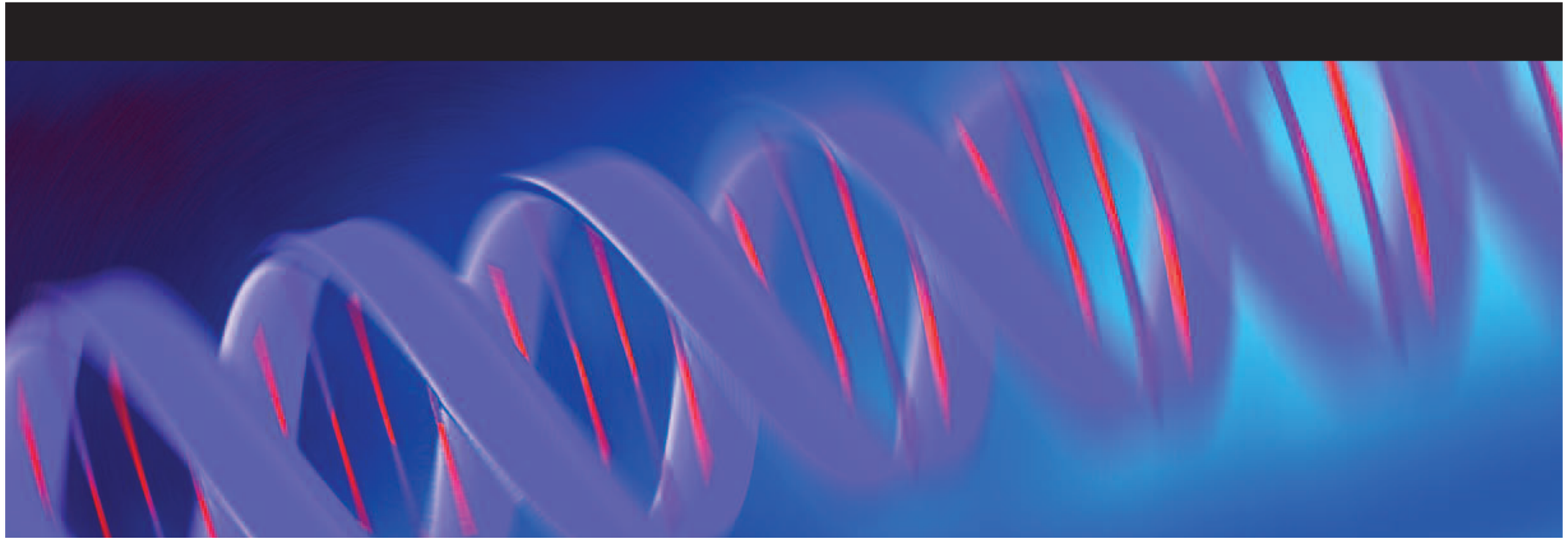
AAAS

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

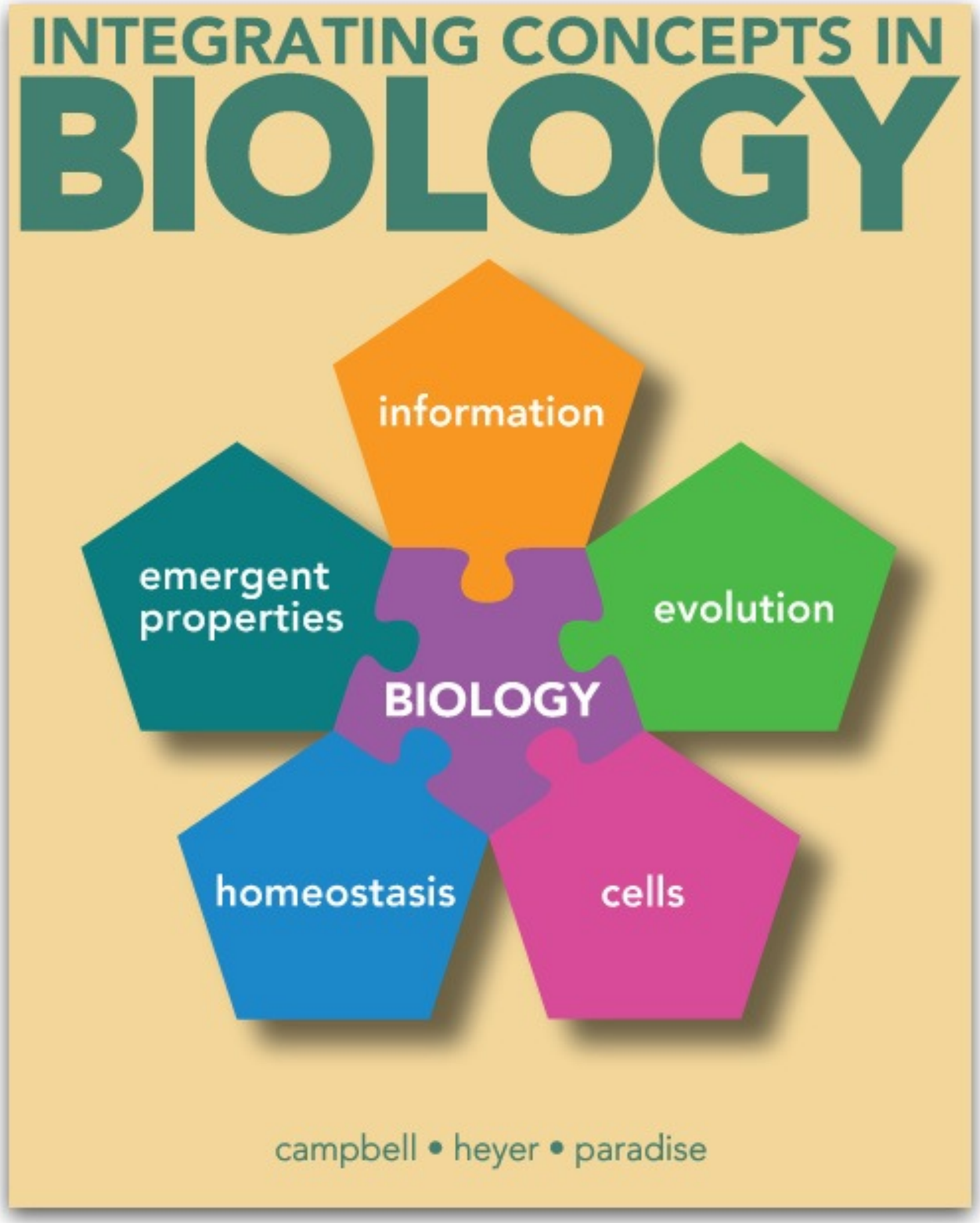
Critical Analysis and Reasoning Skills: analyze, evaluate, and apply information provided in passages

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.

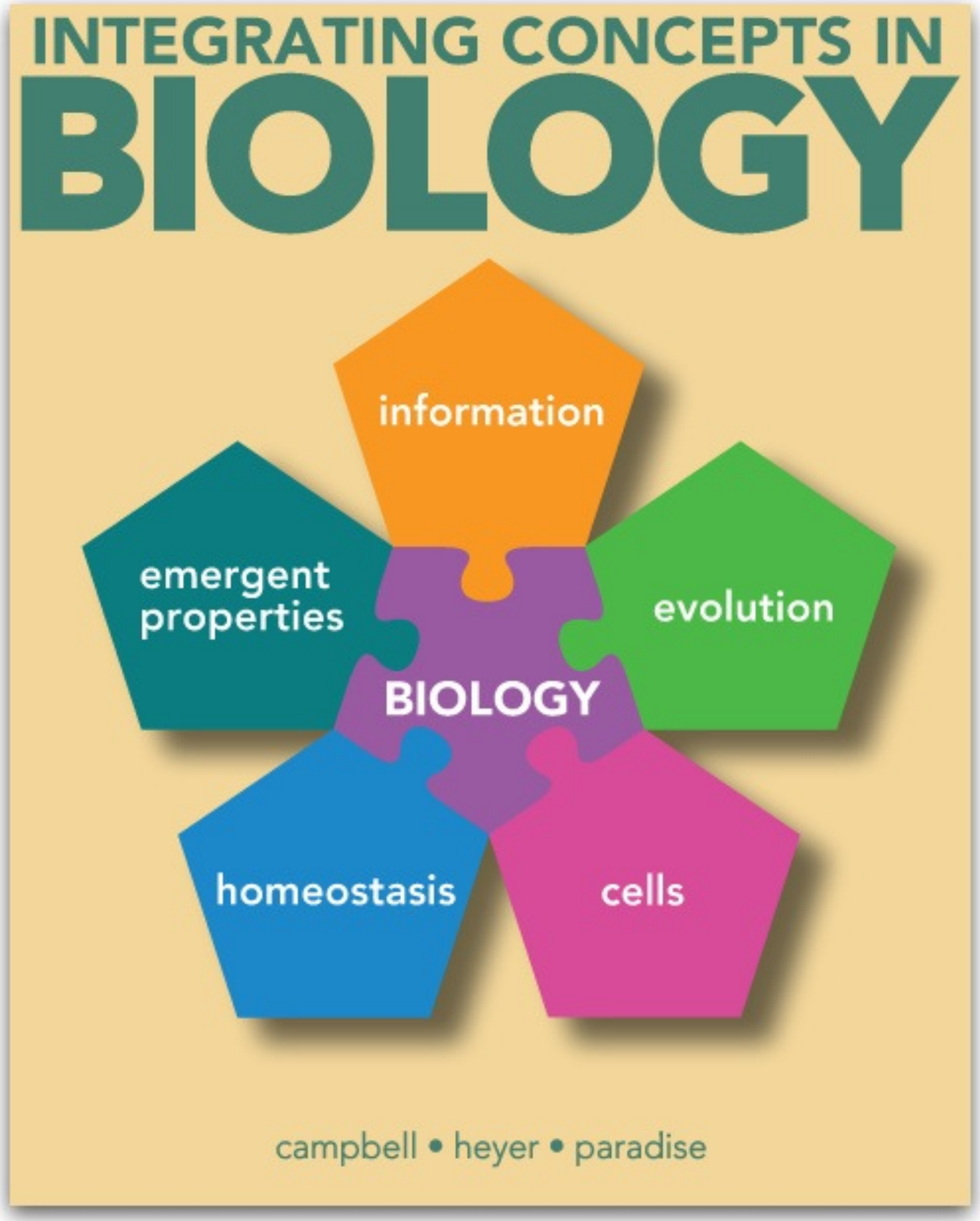
Psychological, Social, and Biological Foundations of Behavior

full disclosure

ICB is a commercial product



- 3 years to write, 4 years to publish
- eBook hosted by Trunity
- David Botstein gift funded book
- traditional publishers rejected
- 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 (interpret data)
- Use quantitative reasoning (analyze 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)

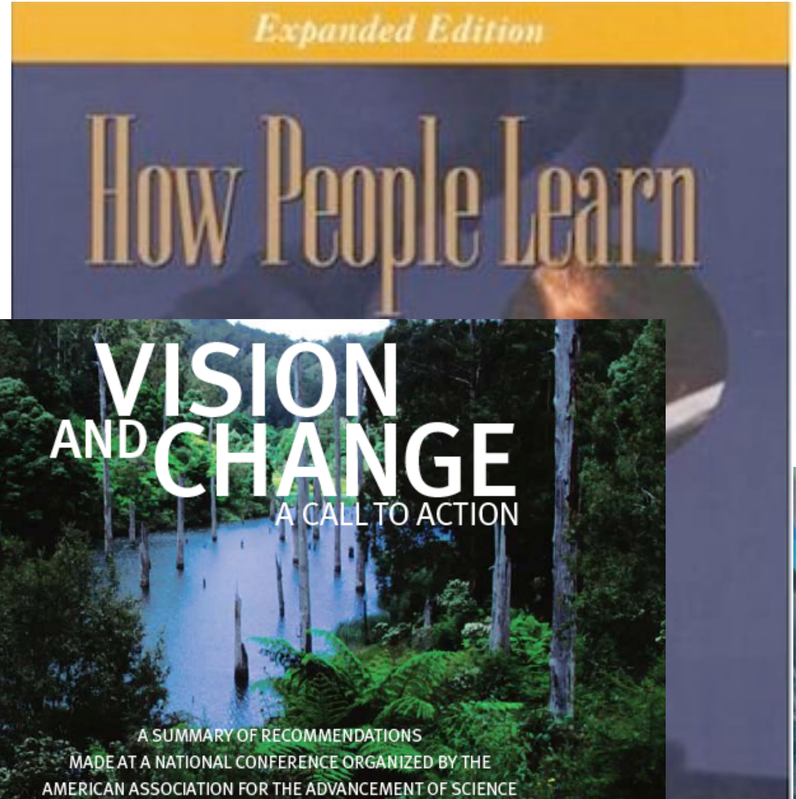
What's Wrong with Biology Education Now?

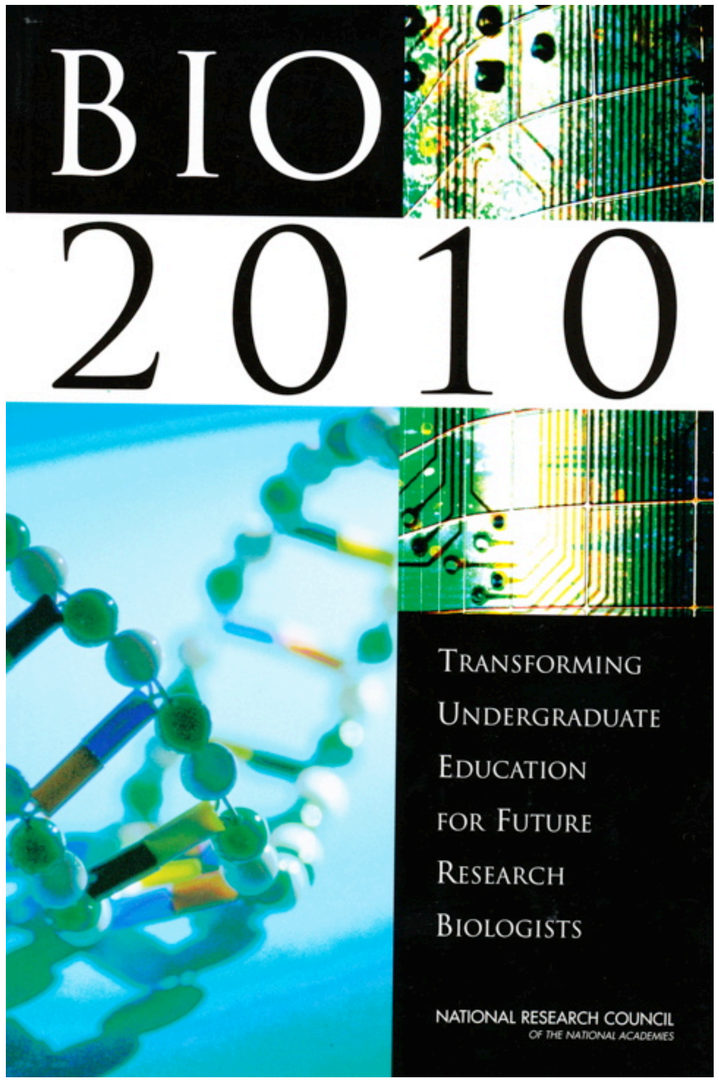
- **Vocabulary is emphasized (800-1000 vs 1400)**
- **Experimental approaches are minimized**
- **Math is absent**
- **Memorization is rewarded**
- **Critical thinking is discouraged**
- **Information is irrelevant to students**

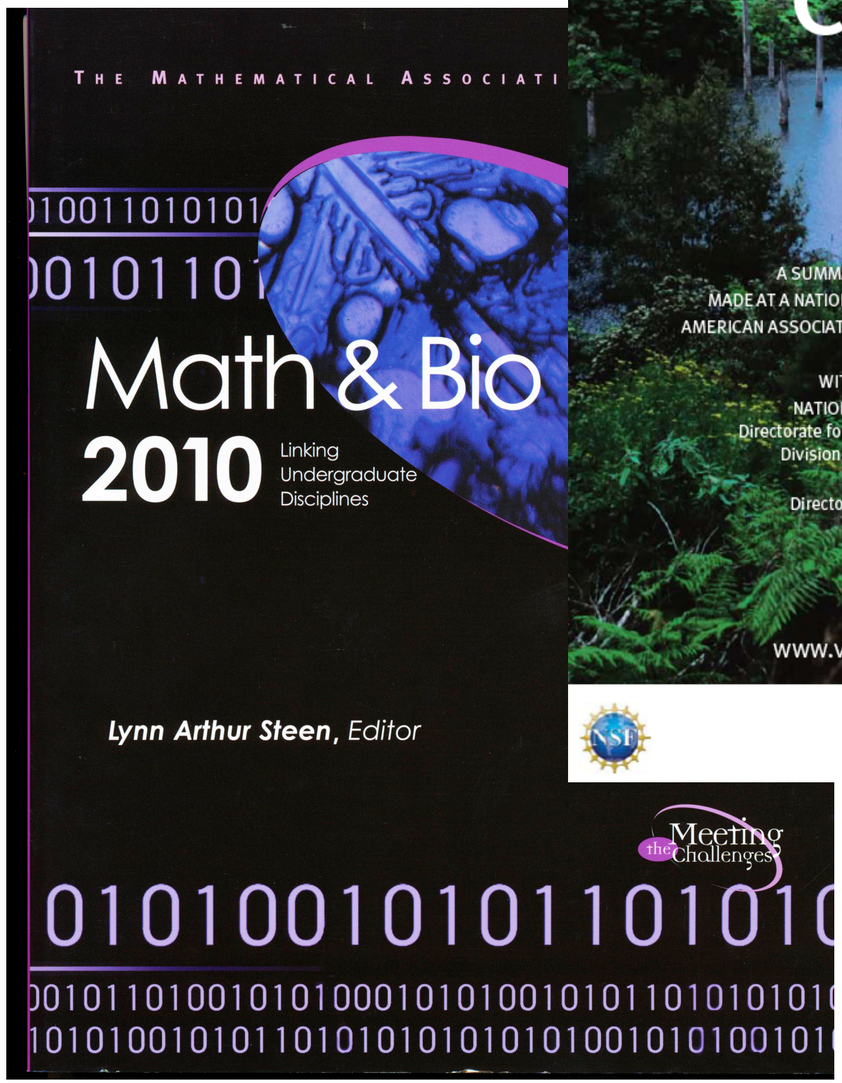
Present information and data…

… in the context of the big picture.

Start with the literature…







Artificial Divide within Biology

Small Biology

Big Biology

Five Levels of Organization

Molecular

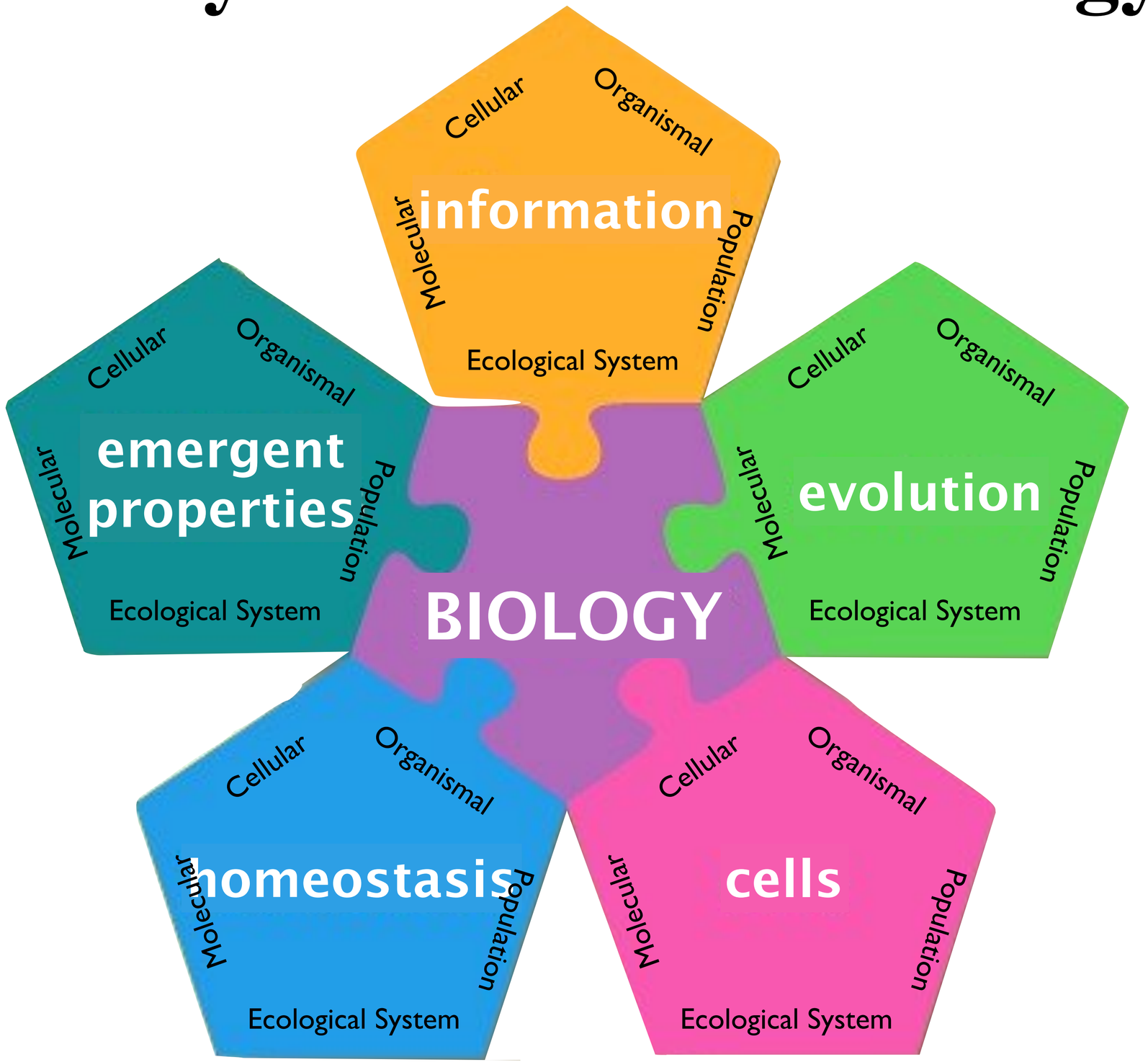
Cellular

Organismal

Population

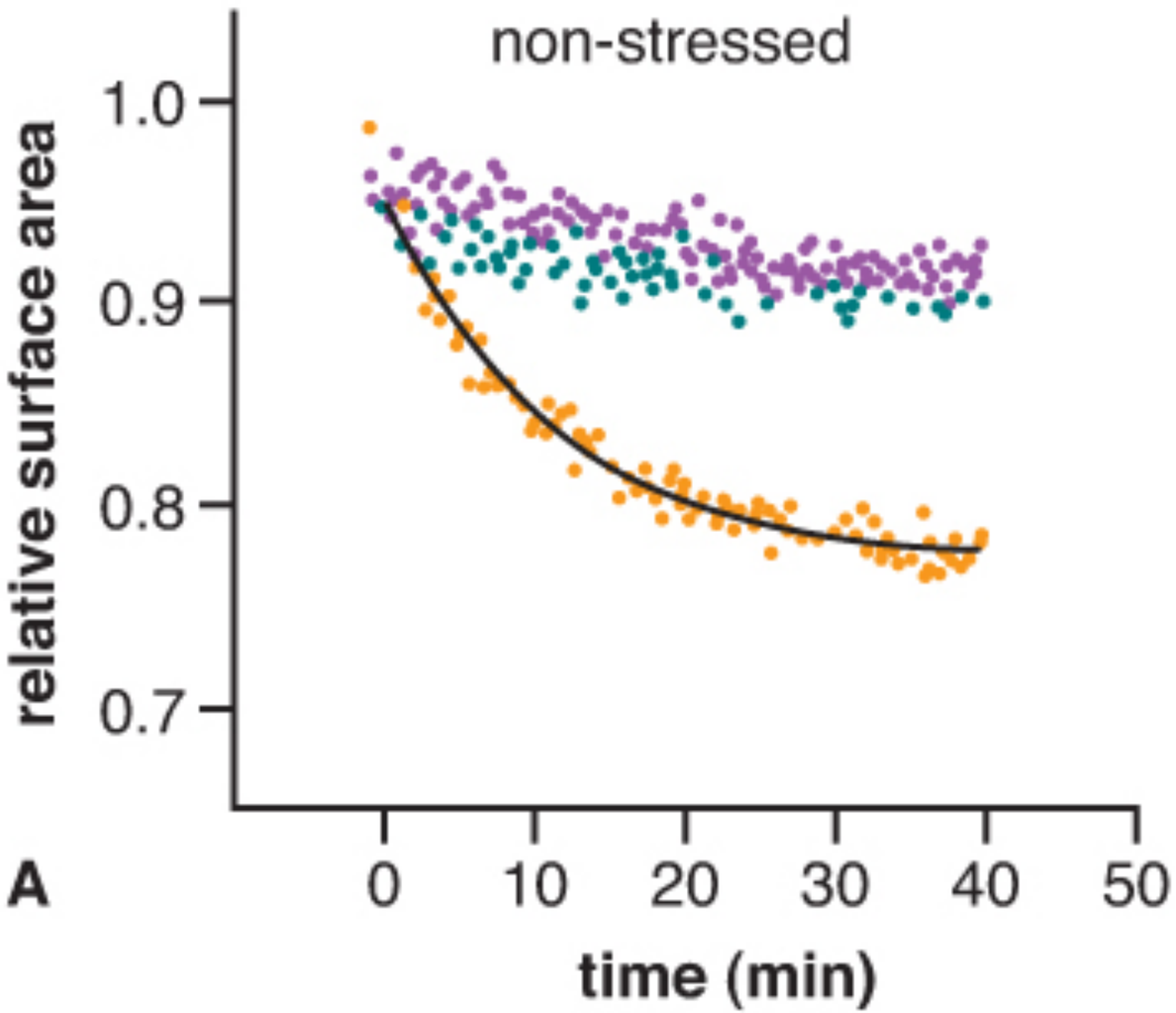
Ecological System

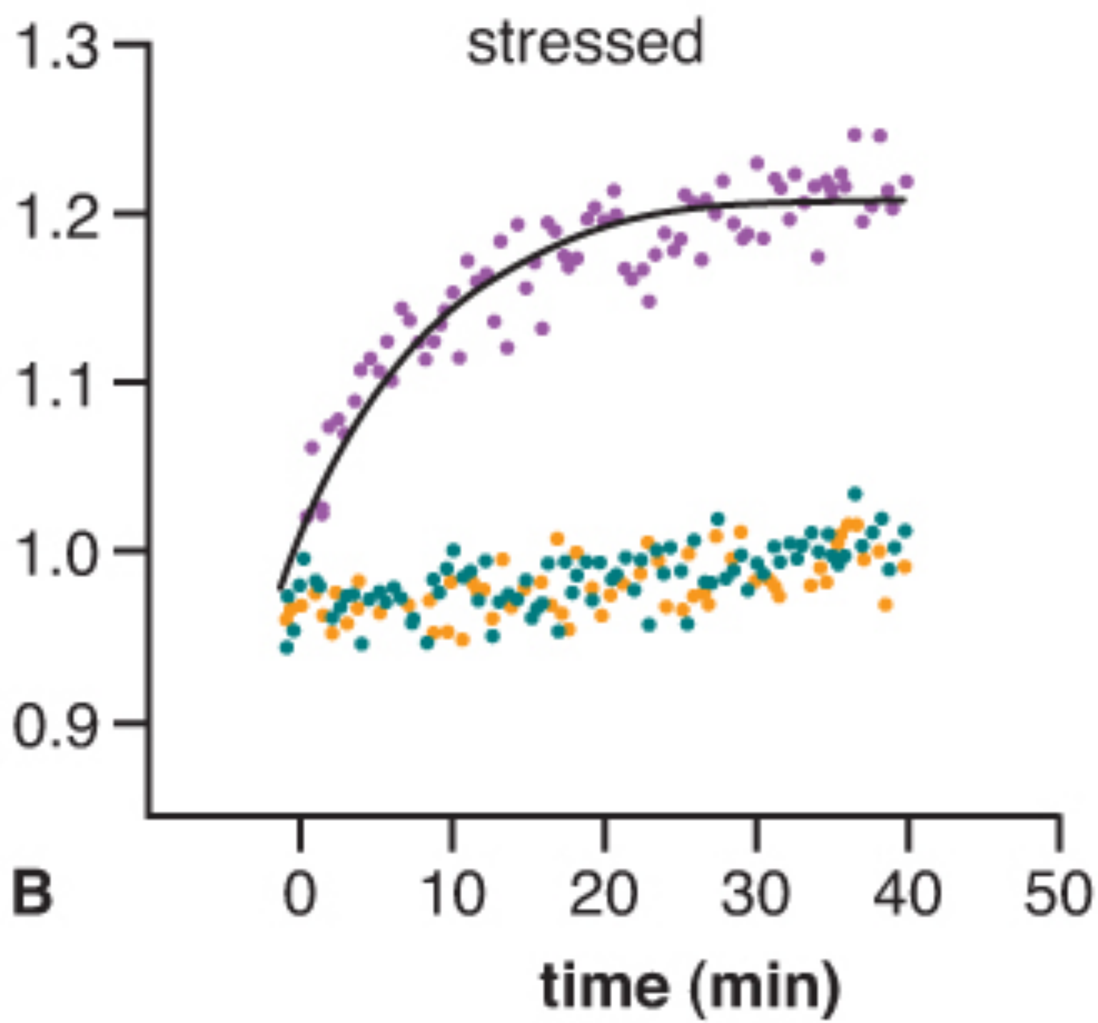
Five by Five Matrix of Biology



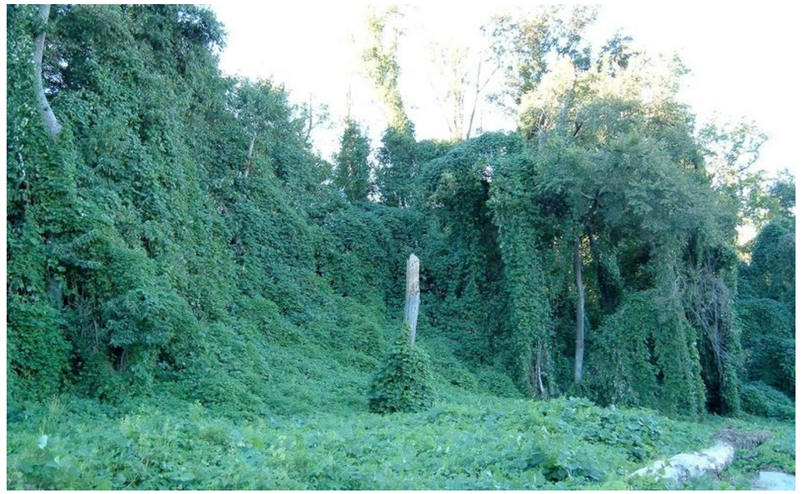
BioMath Exploration 4.2 (BME)

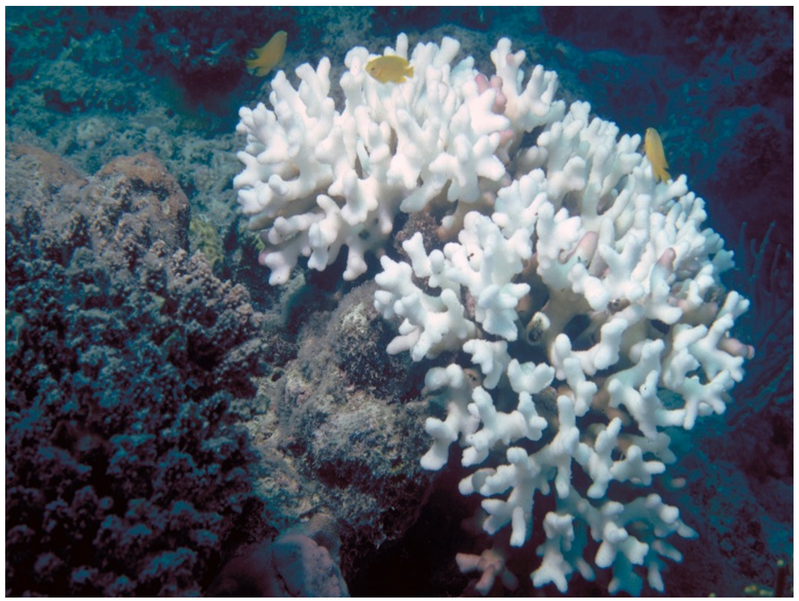
How fast is the vesicle size changing?





Ethical, Legal and Social Implications (ELSI)



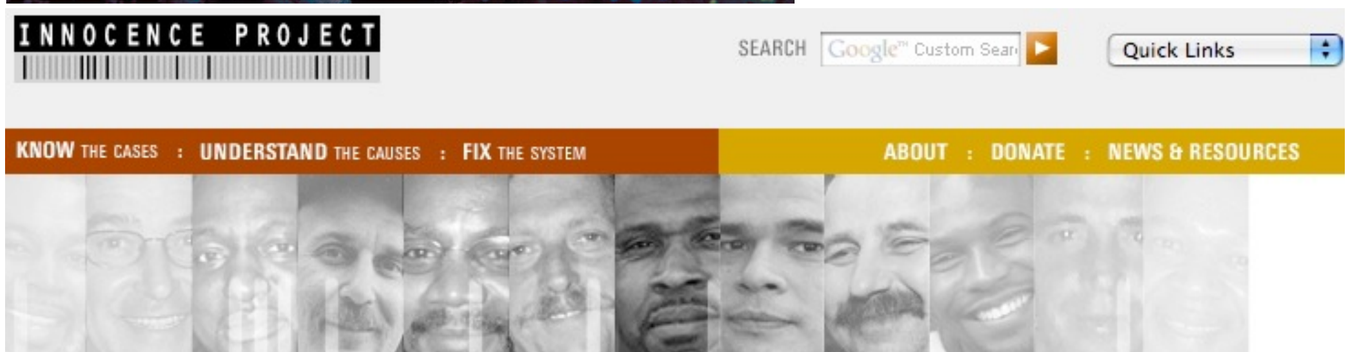


Are religion and evolution compatible?

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?



How do you fit evolution and homeostasis into an already full curriculum?

If we currently cover all the important stuff….

…how can we add more content?

Too much content for the containers

Too much content for the containers

“Never mistake activity for achievement.”

John Wooden

Evolution

change in *allele* frequency in a *population* over *time*

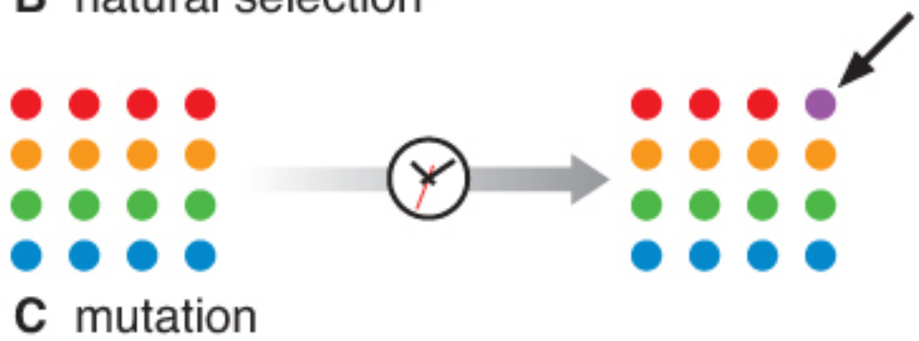
A evolution

Evolution

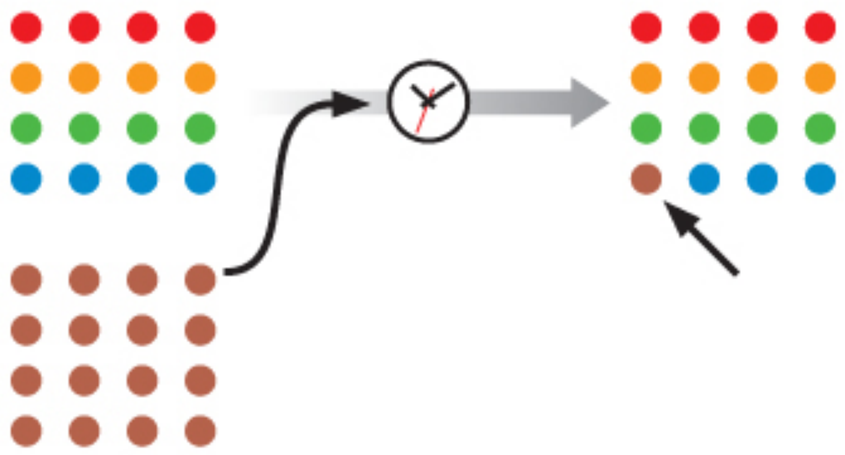
change in *allele* frequency in a *population* over *time*

A evolution

B natural selection



C mutation



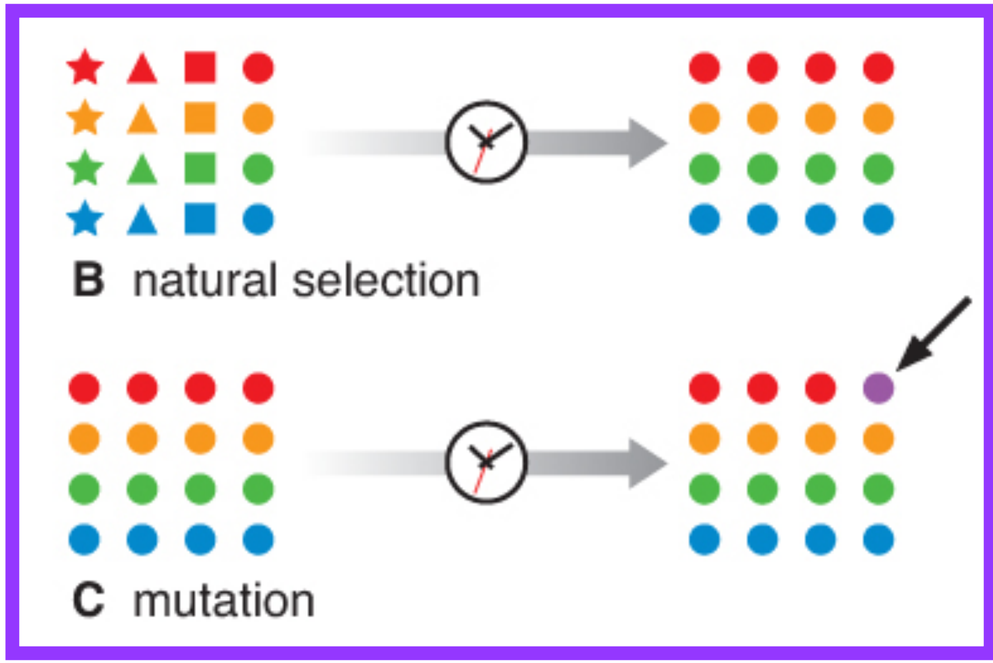
D gene flow

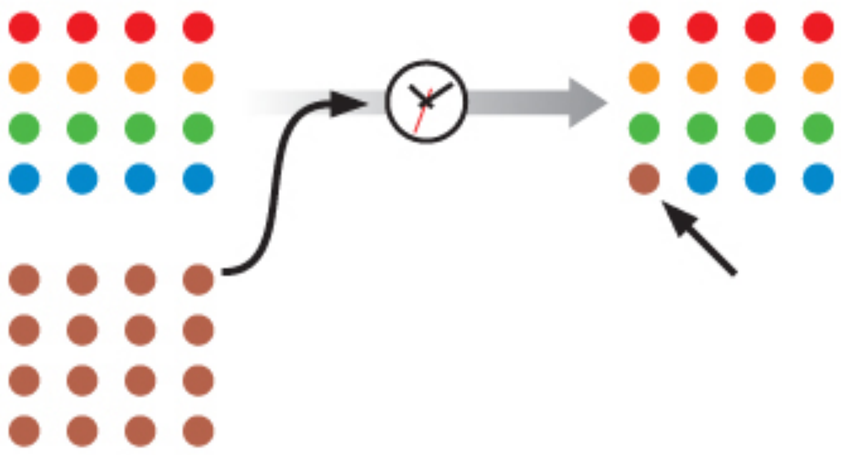
E genetic drift

Evolution

change in *allele* frequency in a *population* over *time*

A evolution





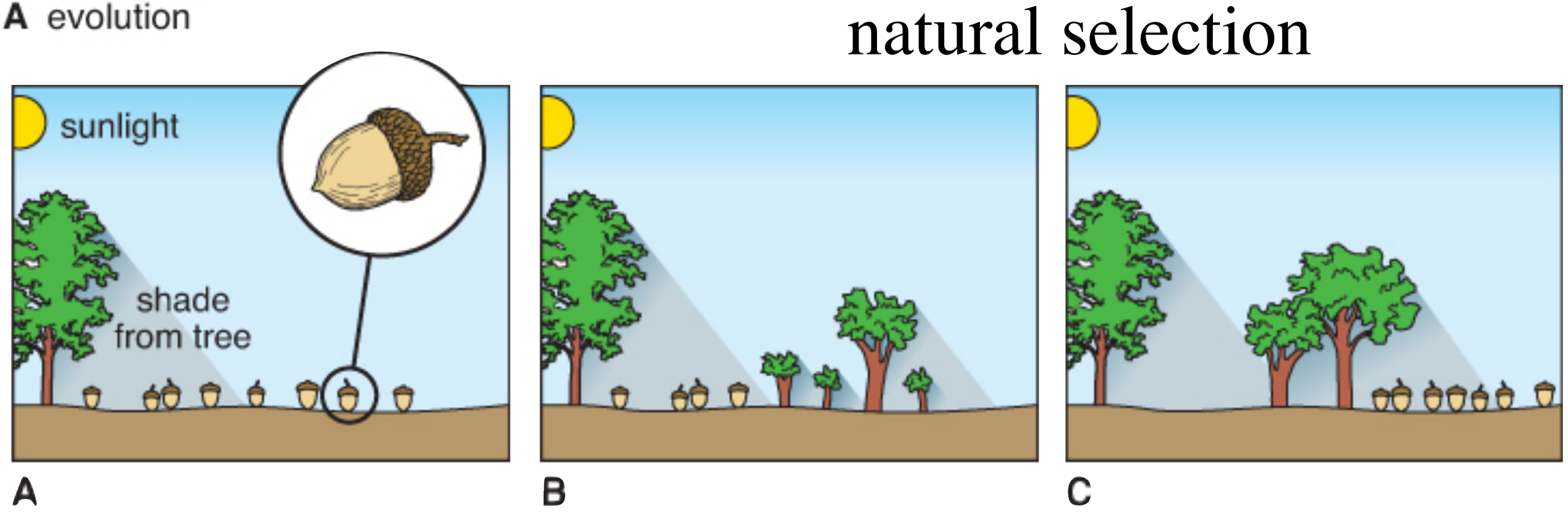
D gene flow

E genetic drift

Evolution

change in *allele* frequency in a *population* over *time*

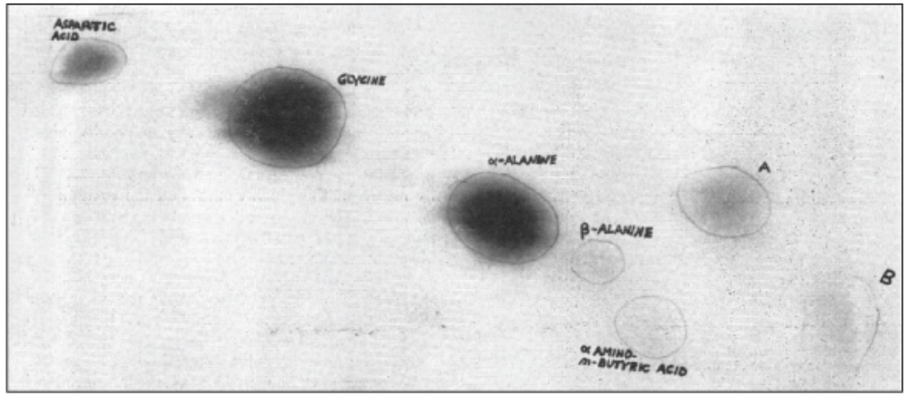
natural selection

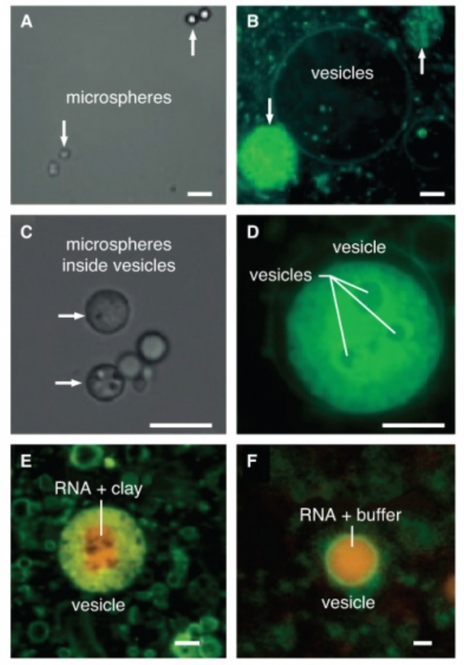


Evolution @ molecular

Ch. 4: Origin of Cells

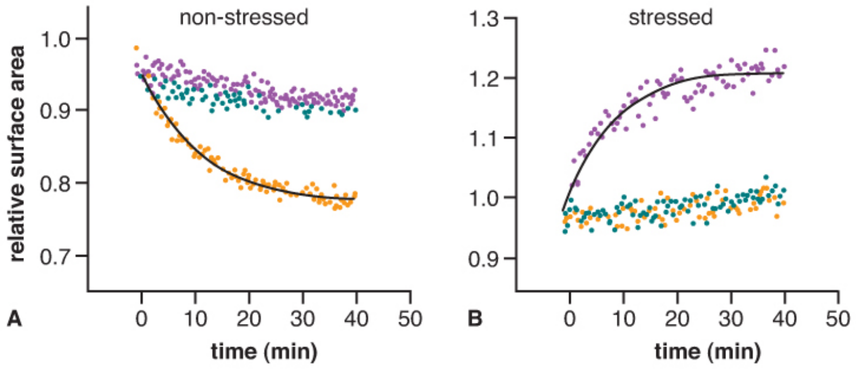
1. define evolution
2. biological molecules
3. self-organizing spheres
4. abiotic growth
5. abiotic replication
6. energy harvesting

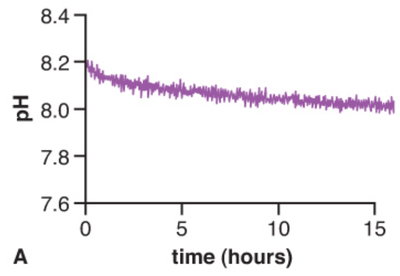


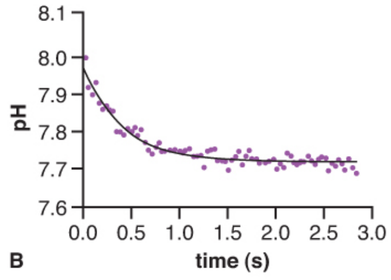


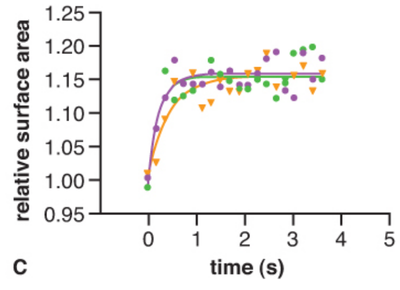
3 BMEs

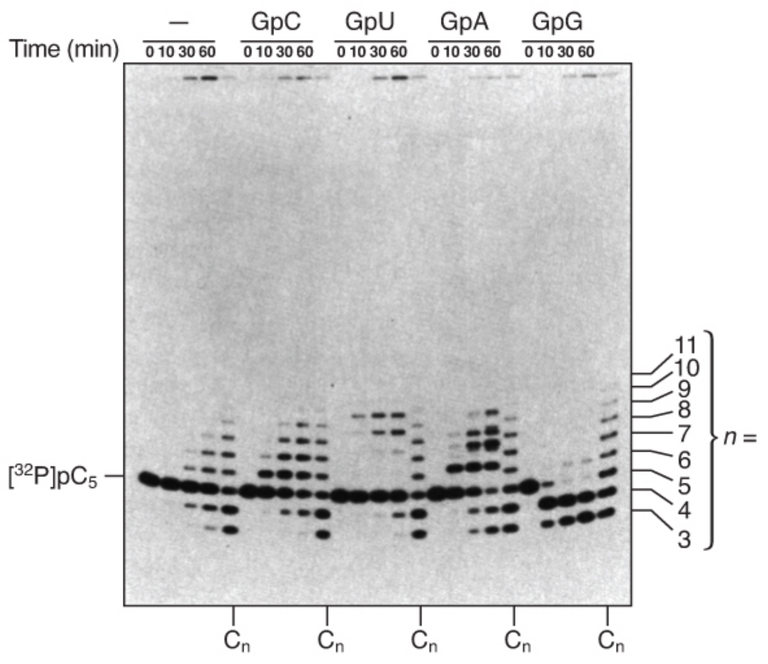
1 ELSI











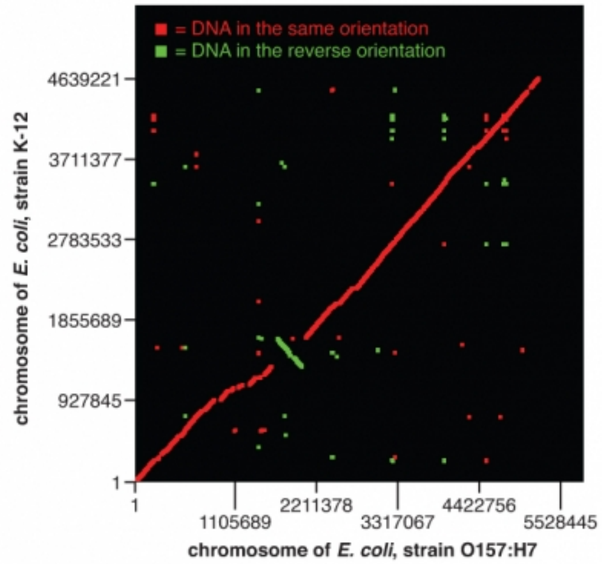
Evolution @ cellular

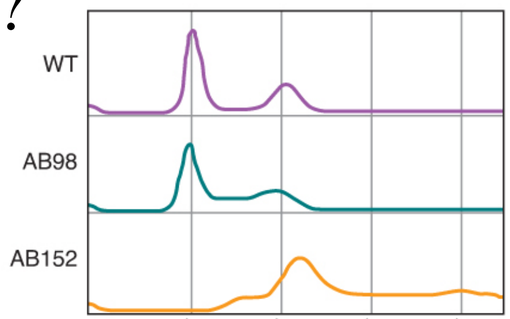
Ch. 5: Evolution Applied

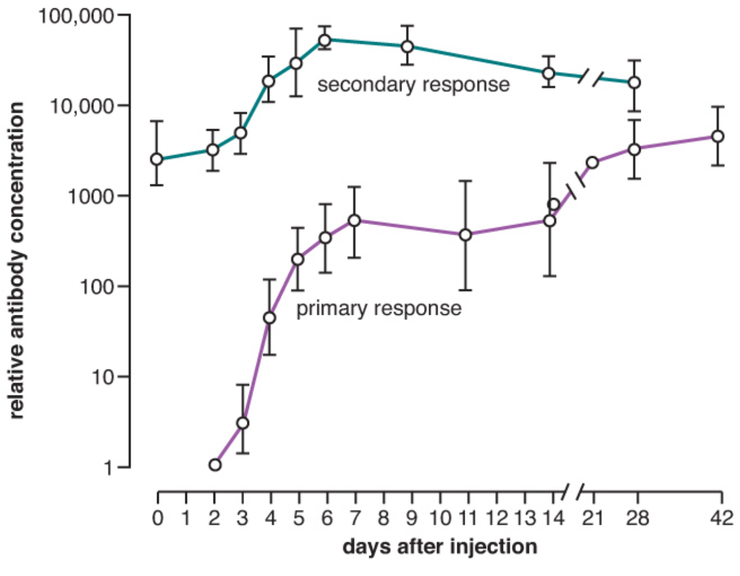
1. How do diseases arise?
2. How do new species evolve?
3. Why do my allergies get worse each year?

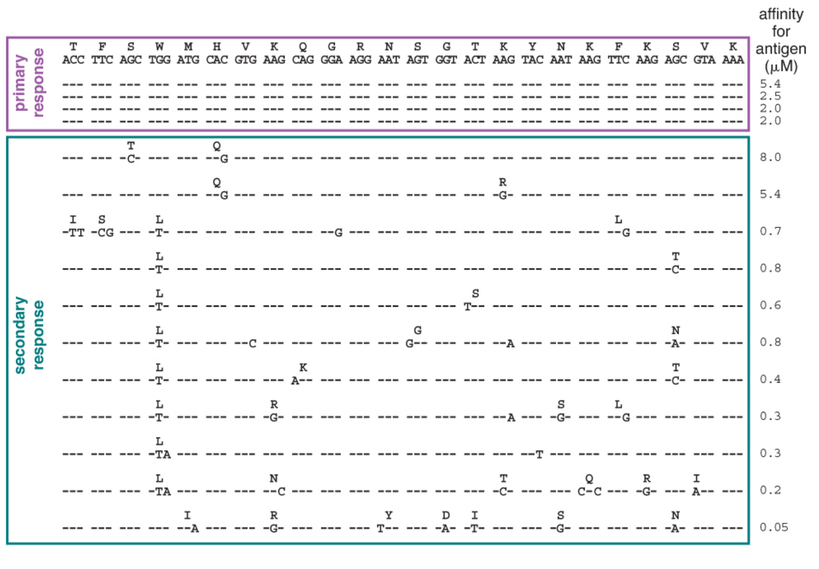
1 BME
2 ELSIs

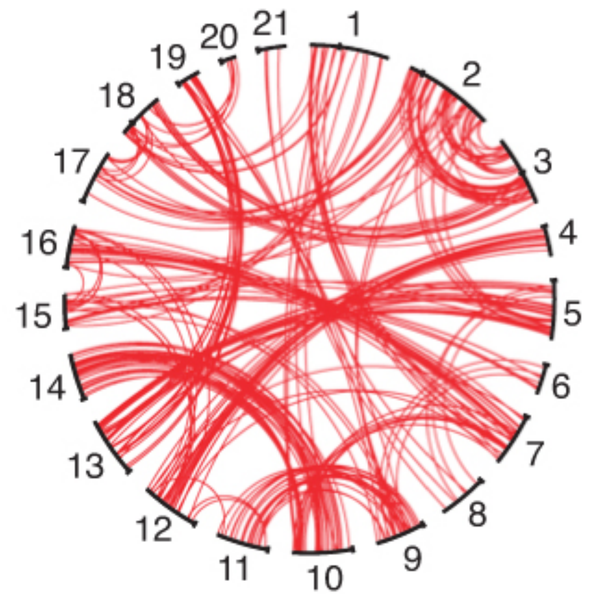
DNA polymerase	ion	bases polymerized	error rate
young	Mg^{2+}	17,300	1 in 1821 bases
old	Mg^{2+}	5,400	1 in 474 bases
young	Mn^{2+}	26,800	1 in 1848 bases
old	Mn^{2+}	18,800	1 in 556 bases











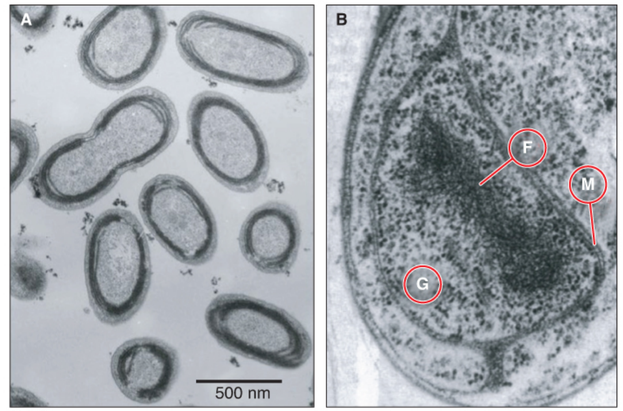
Evolution @ organismal

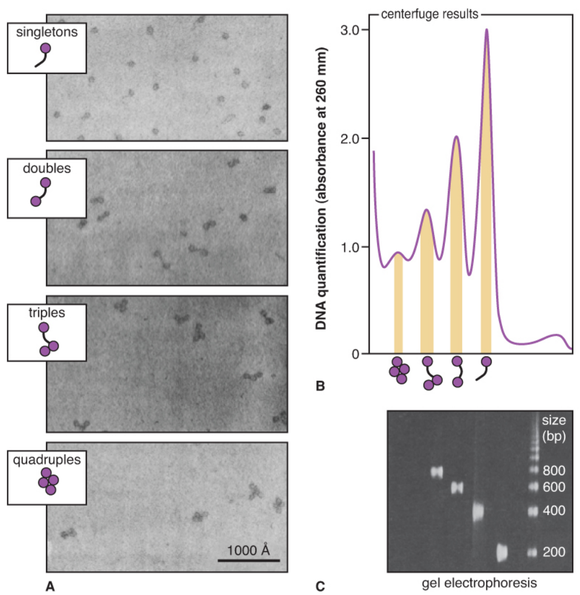
Ch. 6: Evolution of Eukaryotes

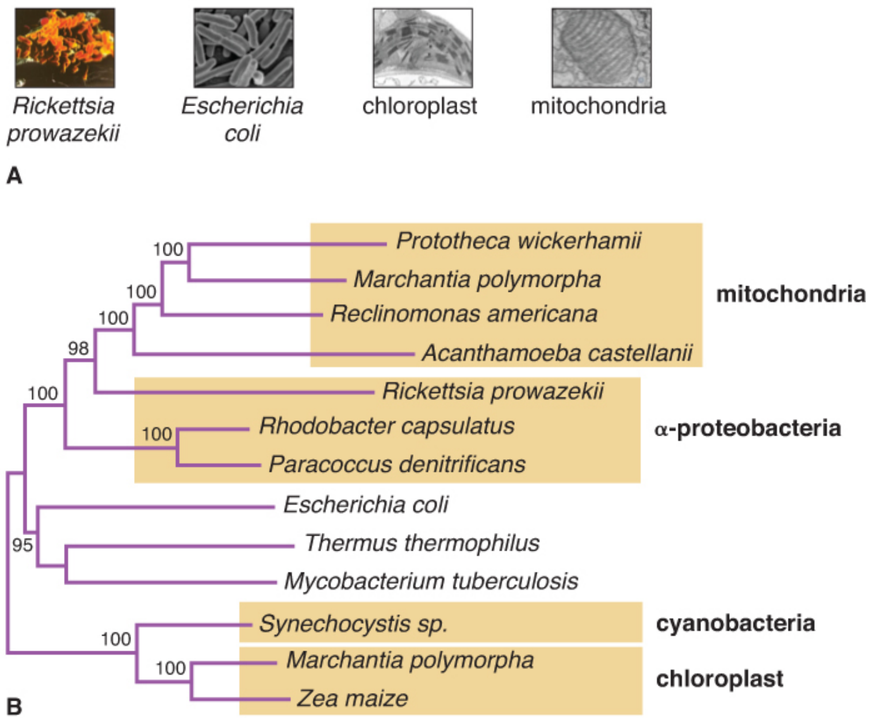
1. How did the first nucleus come into being?
2. How does a genome fit into a tiny space?
3. Why did mitochondria and chloroplast originate?
4. How did multicellular organisms evolve?

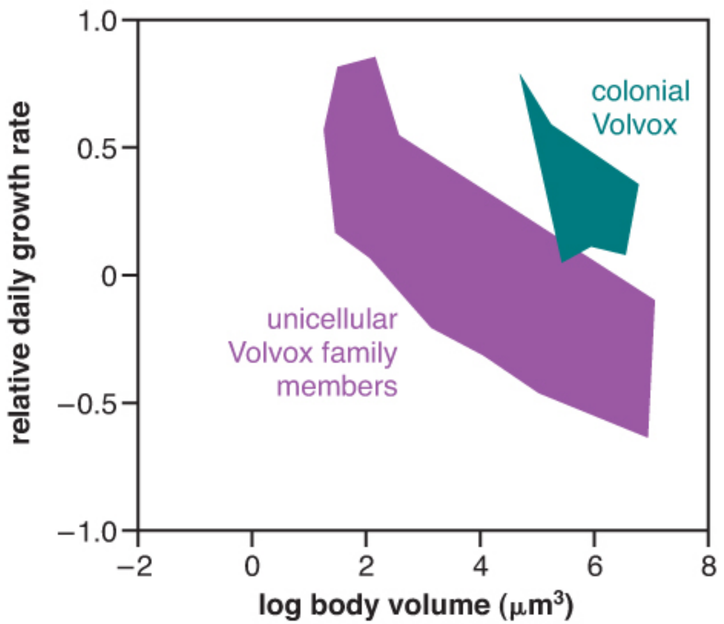
2 BMEs
1 ELSI

human protein number	protein function	protein location	best match domain
NP_001009	translation	cytoplasm/rER	archaea
NP_003185.1	transcription factor	nucleus	archaea
NP_001001937	ATP synthase	mitochondria	bacteria
NP_005521	energy harvesting	mitochondria	bacteria
NP_000393	energy harvesting	cytoplasm	bacteria
NP_004138	cell signaling	cytoplasm	archaea
NP_061816	cytoskeleton	cytoplasm	bacteria



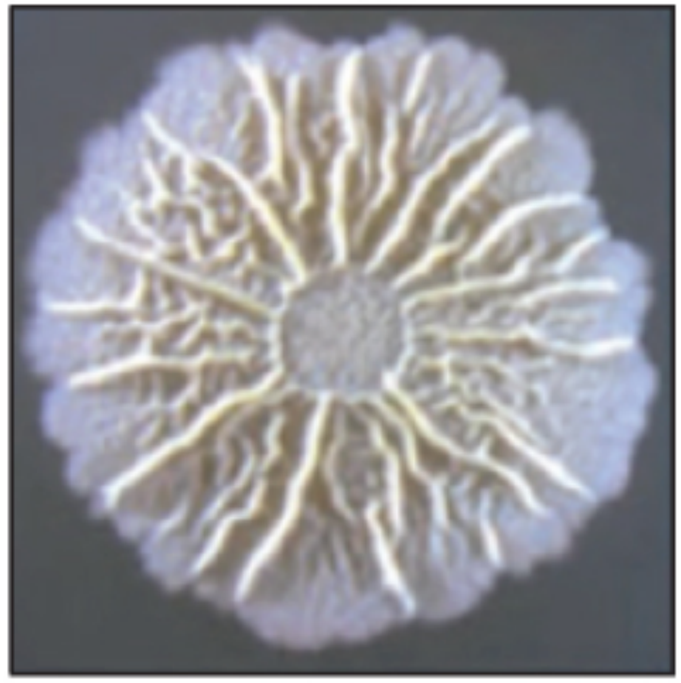


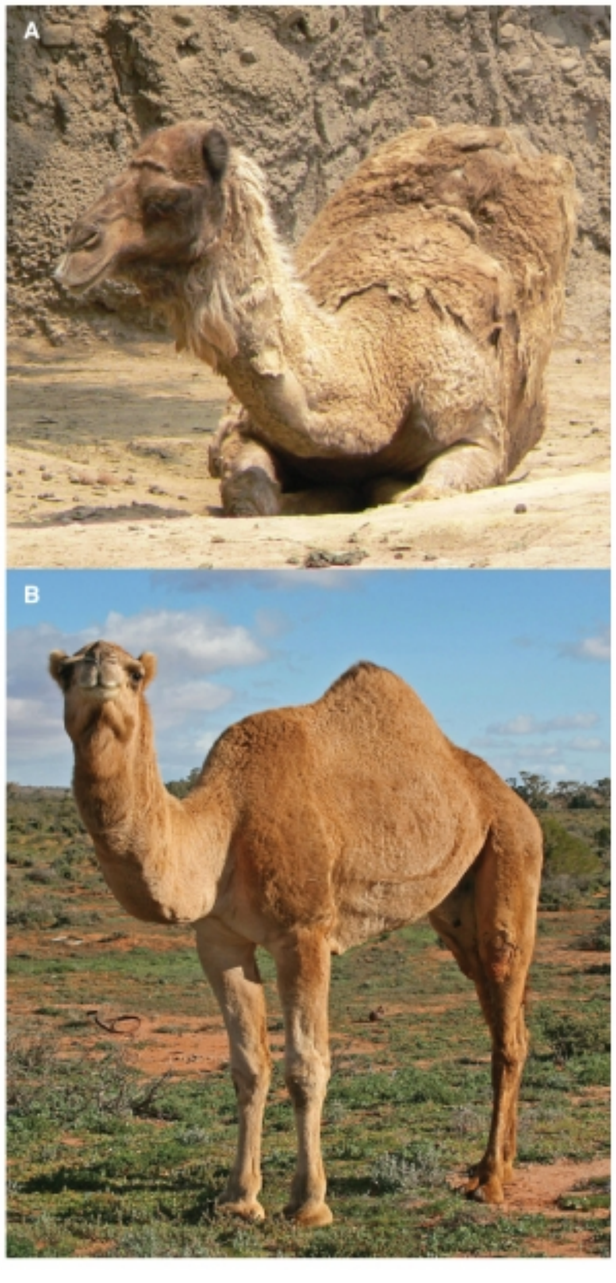




Homeostasis

maintain internal conditions within a range of acceptable extremes





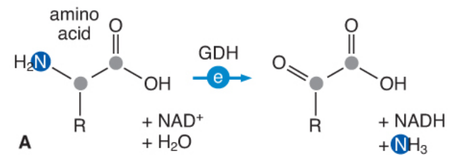
Homeostasis @ molecular

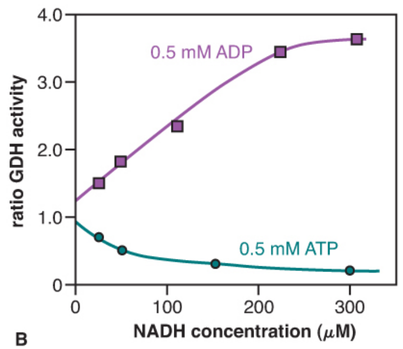
Ch. 10: Cellular Respiration

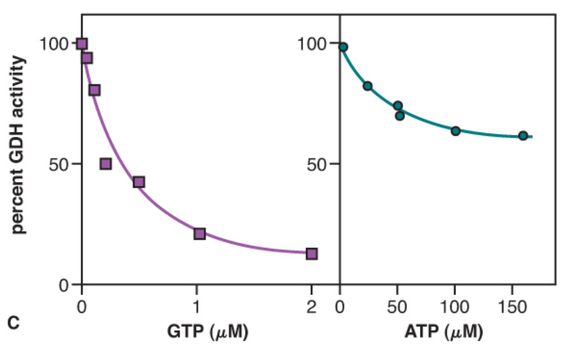
1. How do biological molecules carry energy?
2. How does food get converted to molecular energy?
3. How is energy extracted from 2-C intermediates?
4. How is ATP produced?

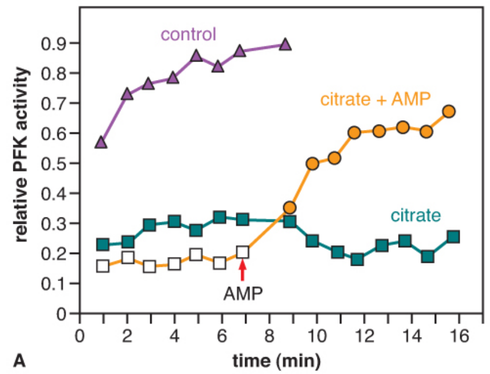
1 BME

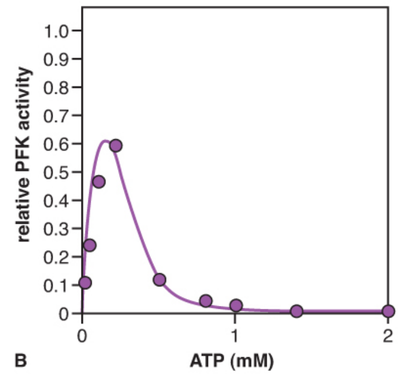
2 ELSIs

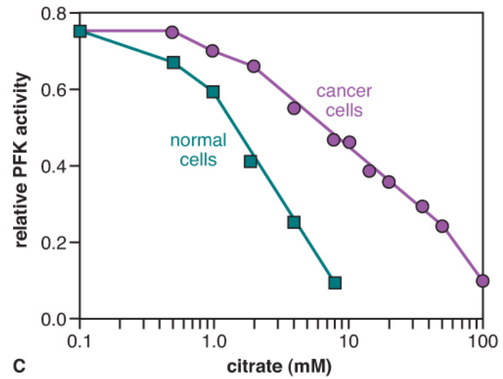


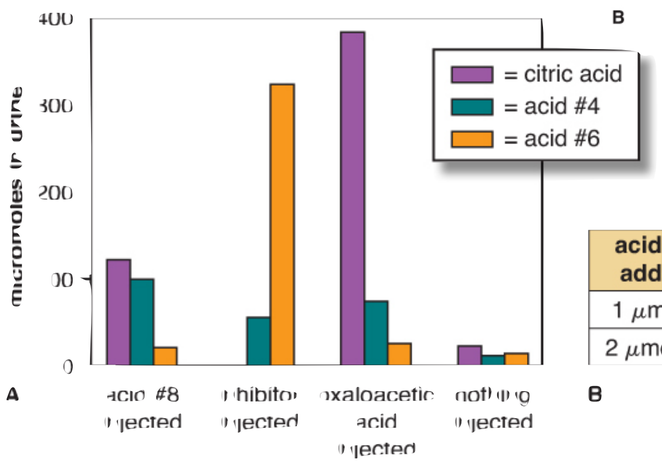






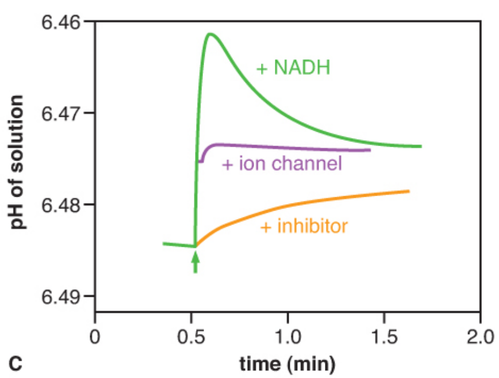


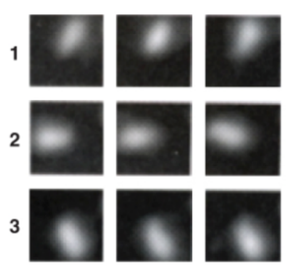


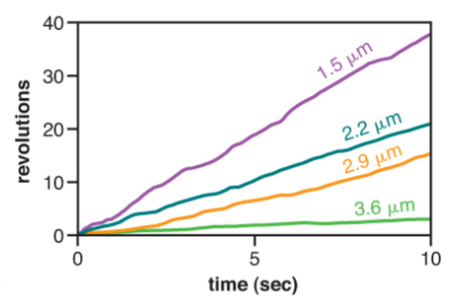


acid #8 added	oxygen uptake (calculated)	oxygen uptake (measured)
1 μmole	6 μmoles	47.2 μmoles
2 μmoles	12 μmoles	69.4 μmoles

B



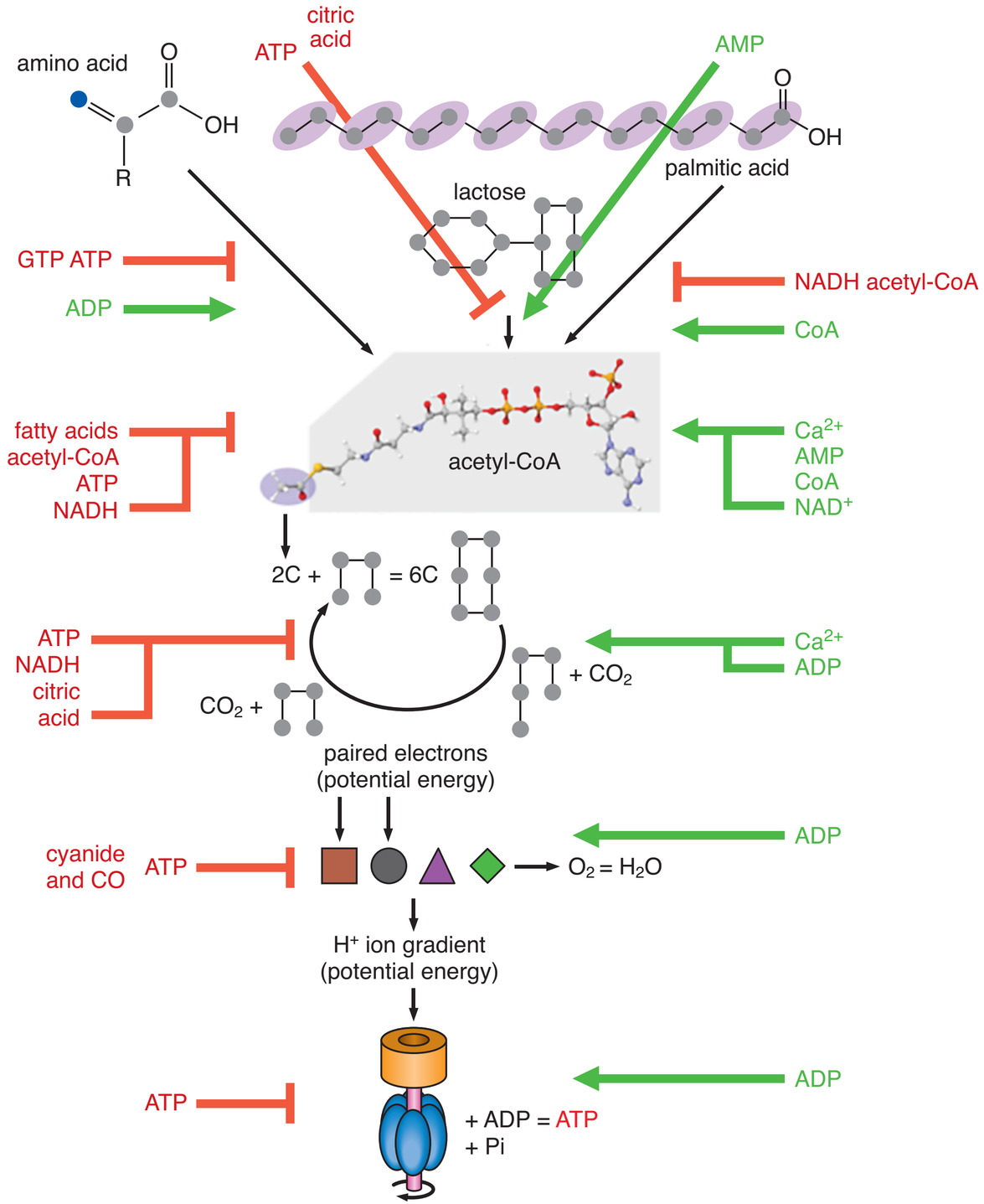




Homeostasis @ molecular

energy-rich molecules

energy-poor molecules



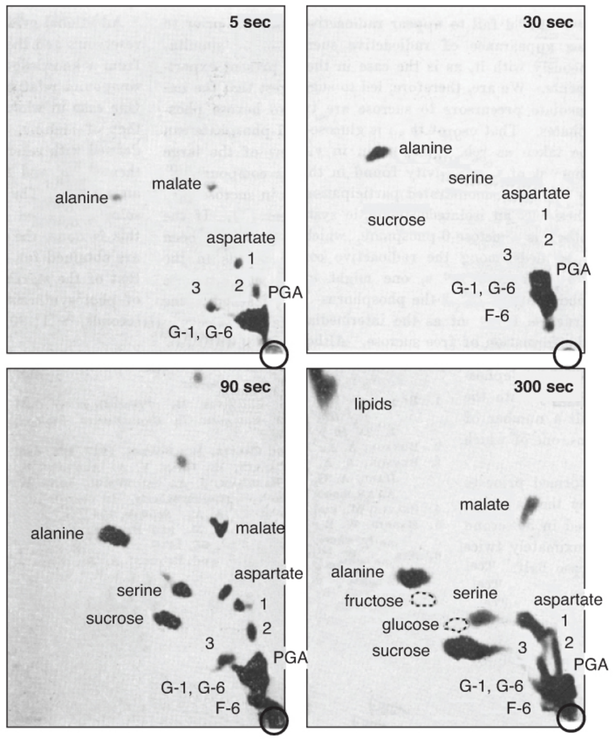
Homeostasis @ cellular

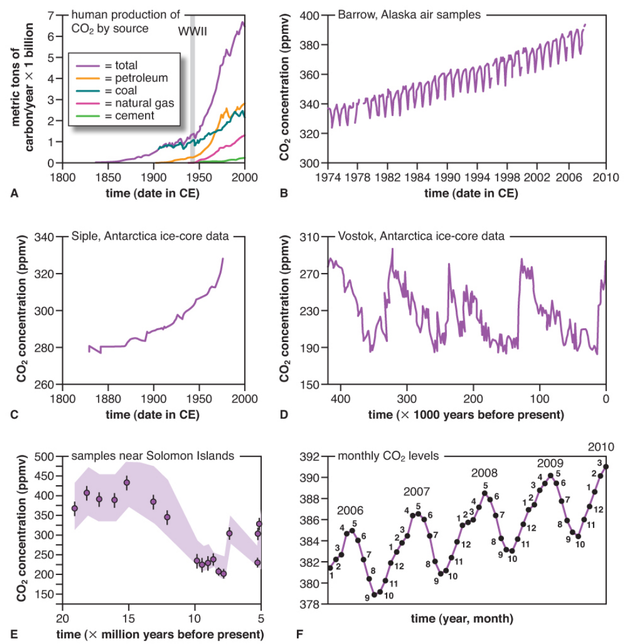
Ch. 11: Photosynthesis

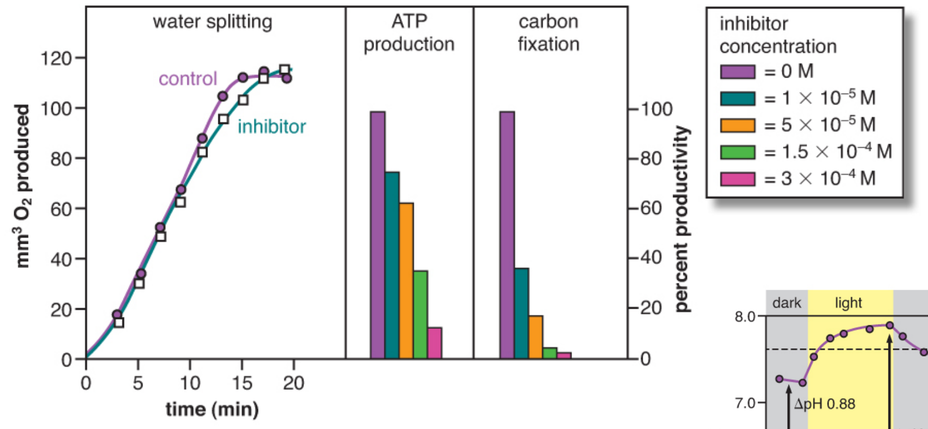
1. Why does the US still use paraquat?
2. How are Brazil and Greenland connected?
3. Is there anywhere devoid of life?

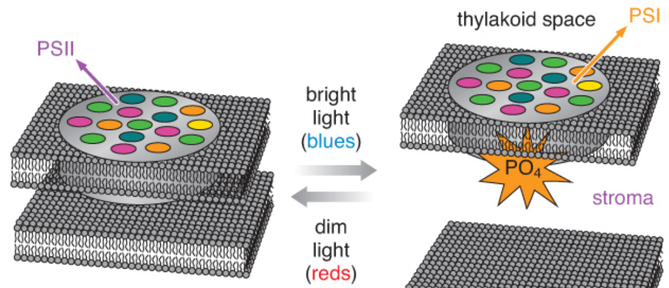
1 BME

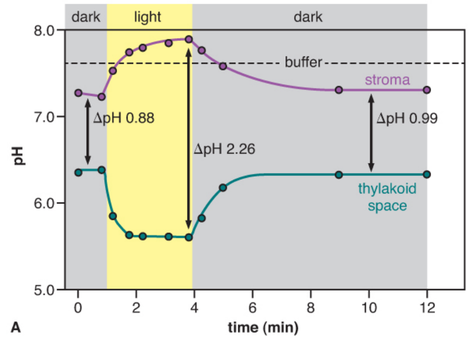
1 ELSI

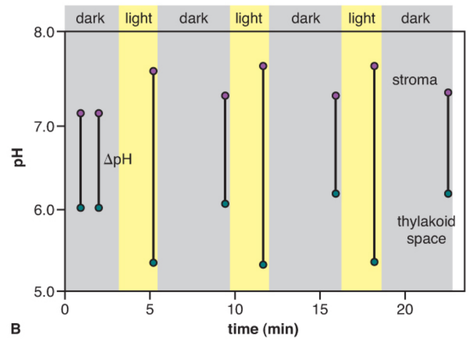


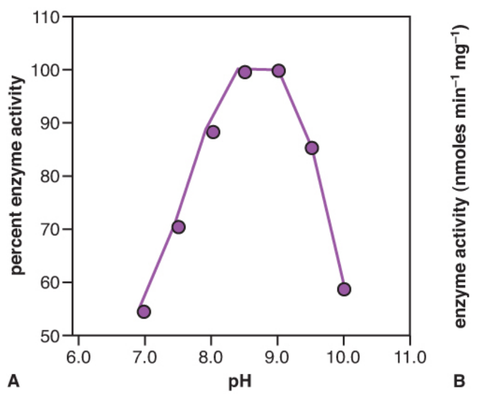


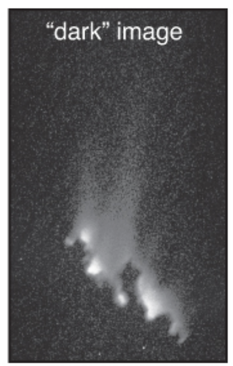


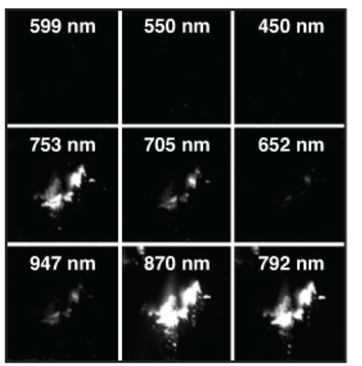




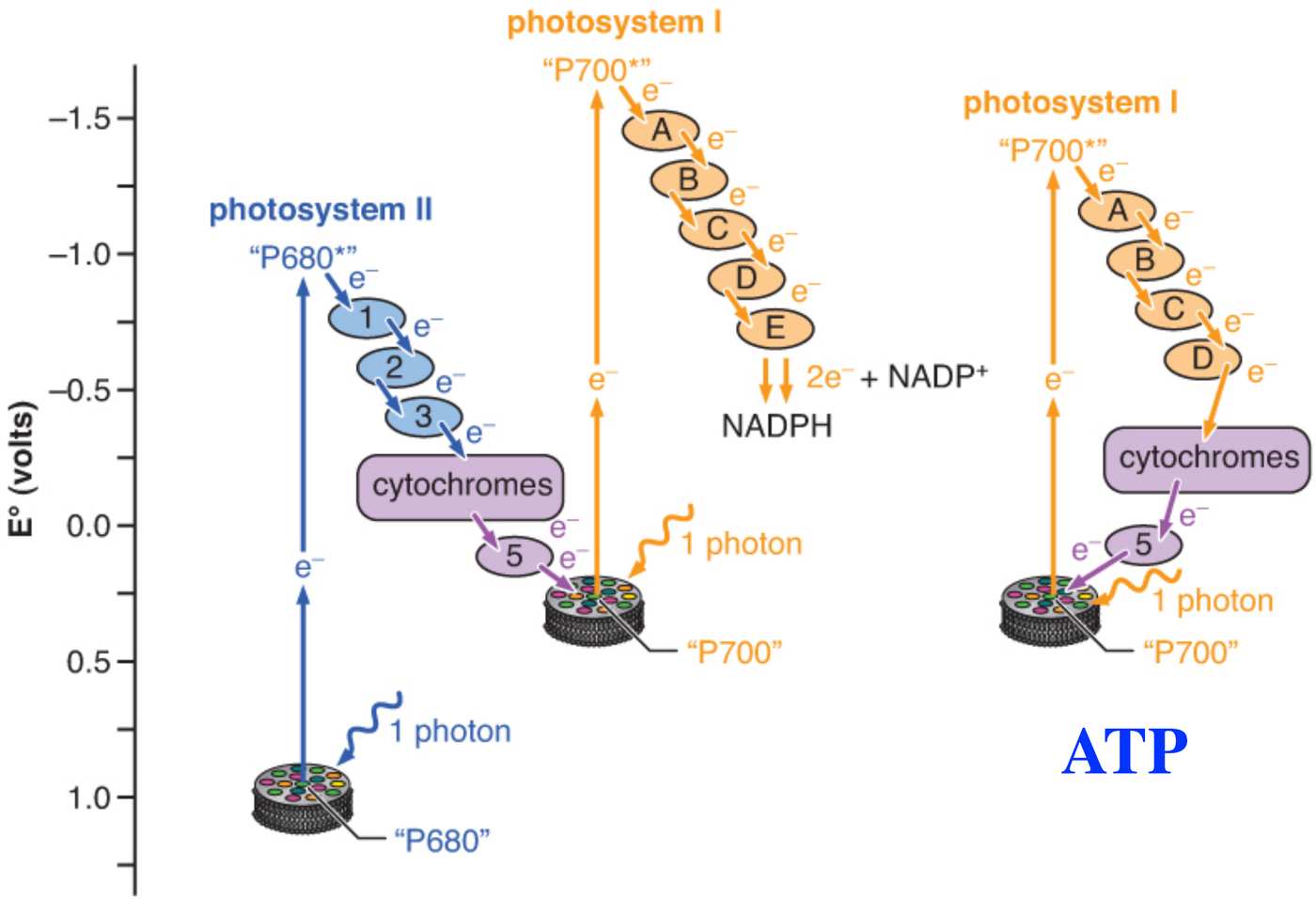








Homeostasis @ cellular

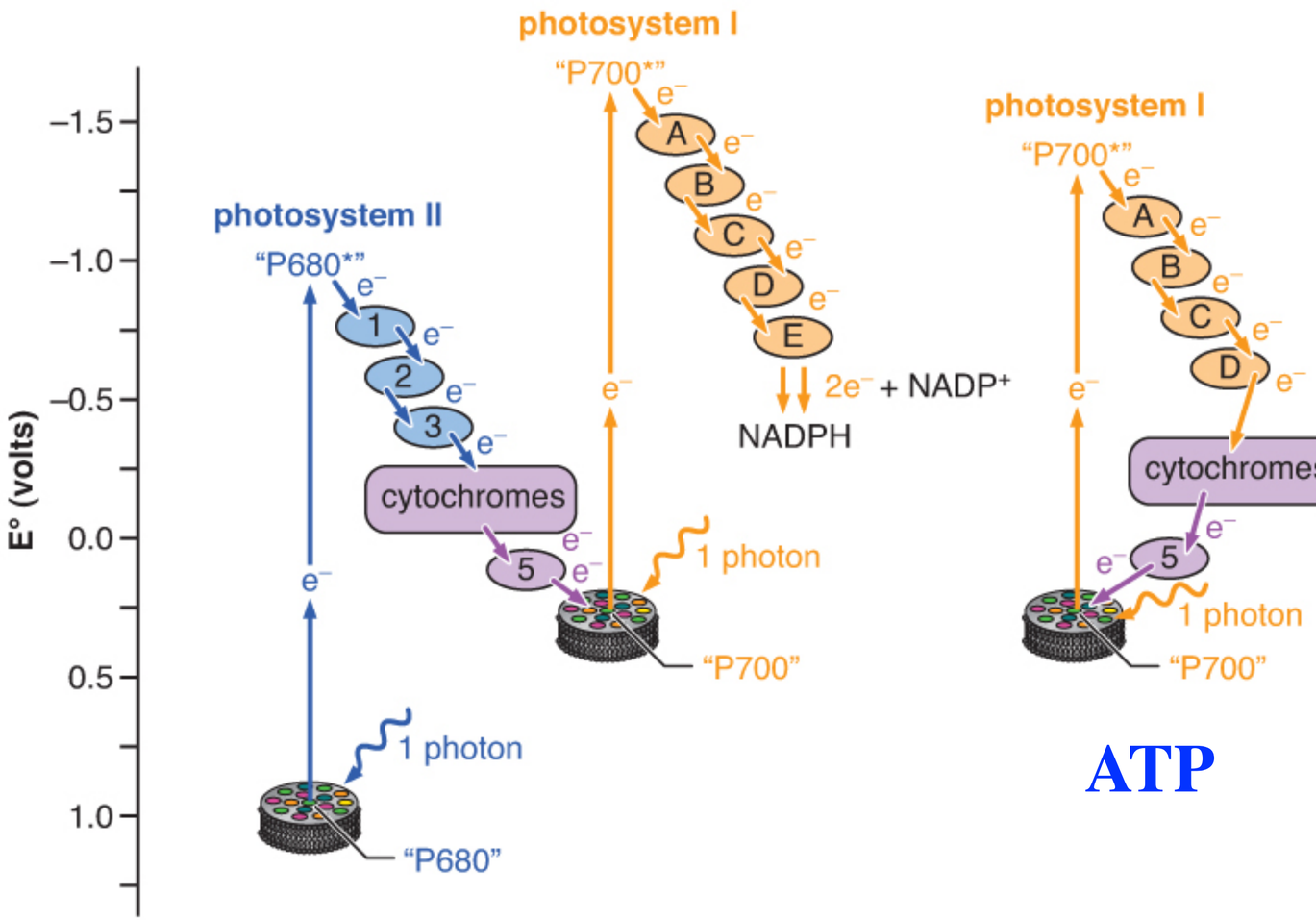


consumes water

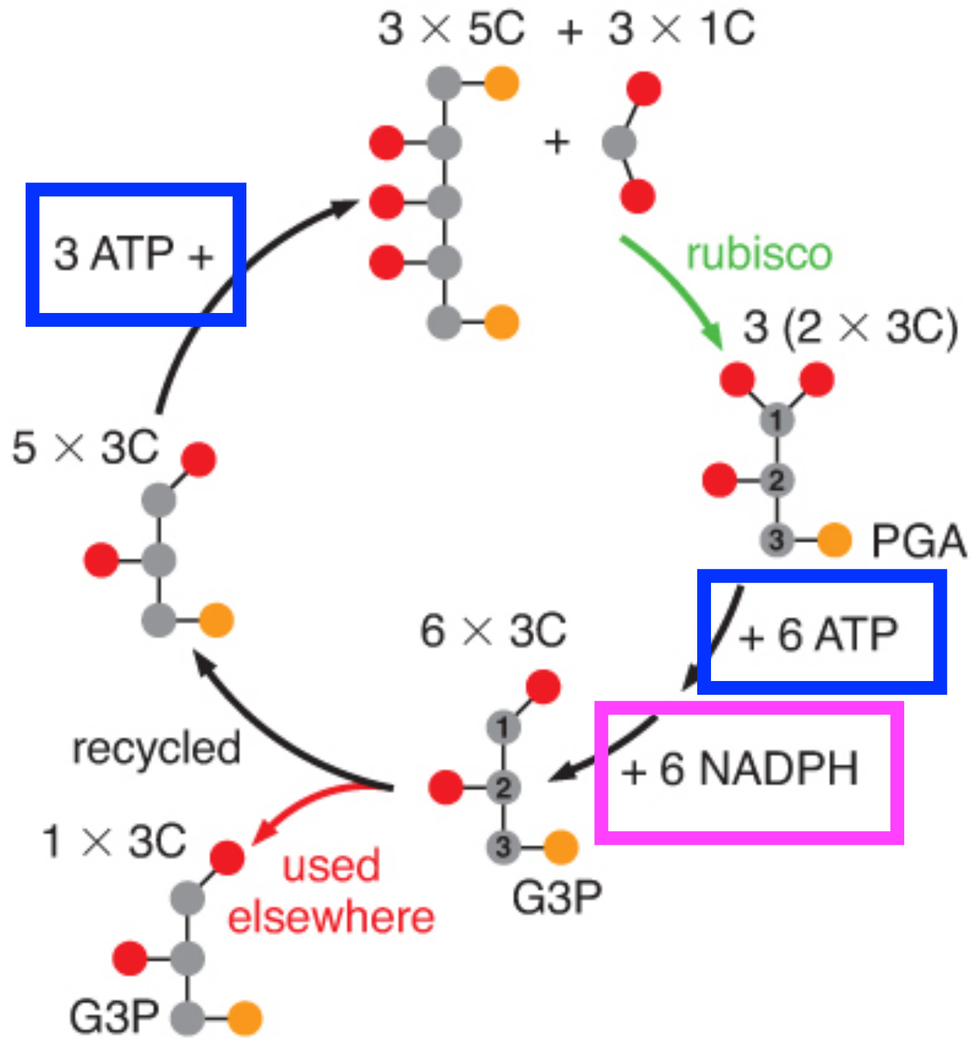
ATP + NADPH

ATP

Homeostasis @ cellular



ATP



consumes water

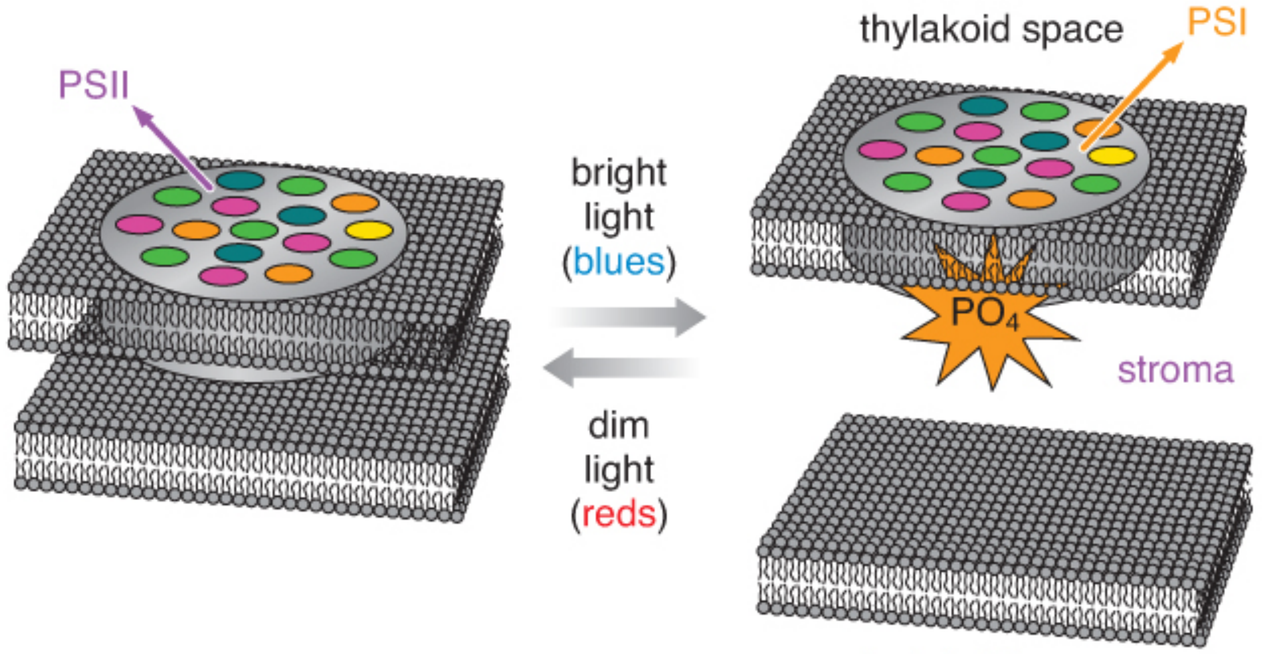
ATP + NADPH

Homeostasis @ cellular

water

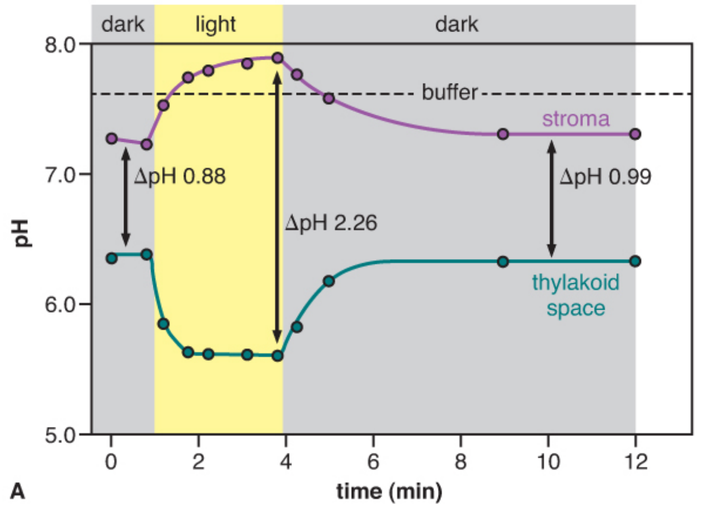
ATP +

NADPH

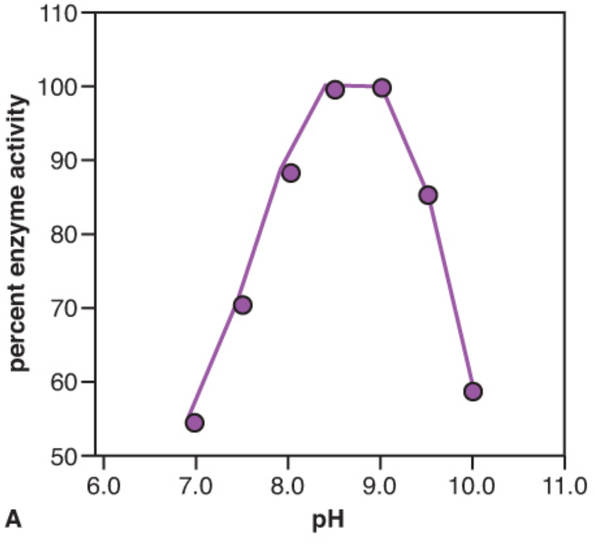


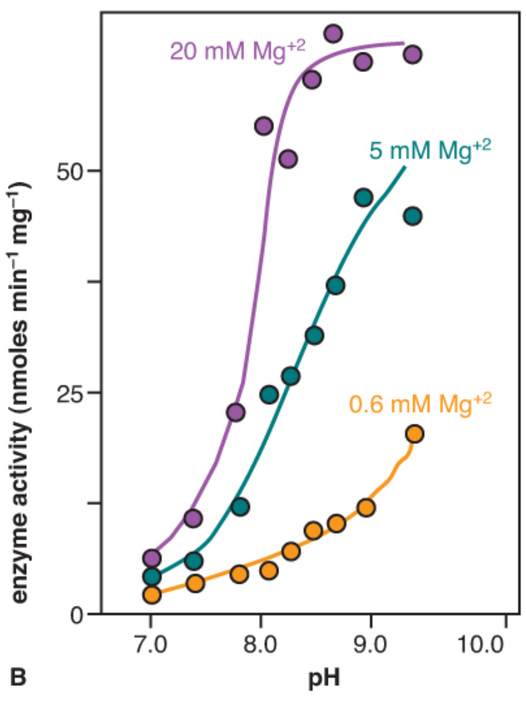
no water

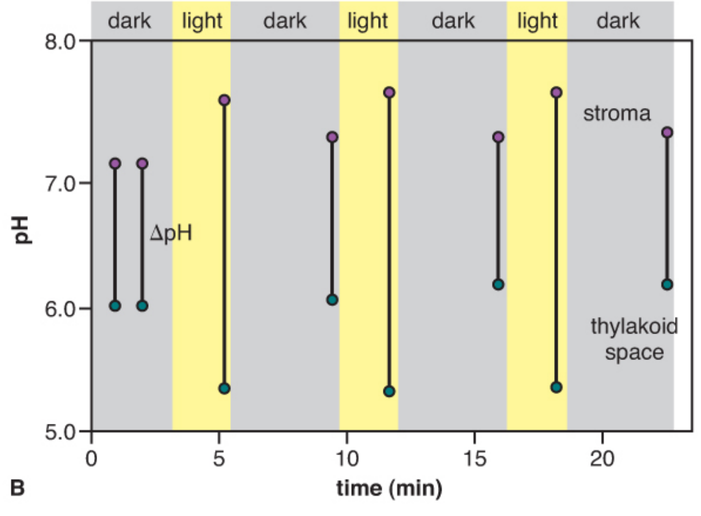
ATP



rubisco





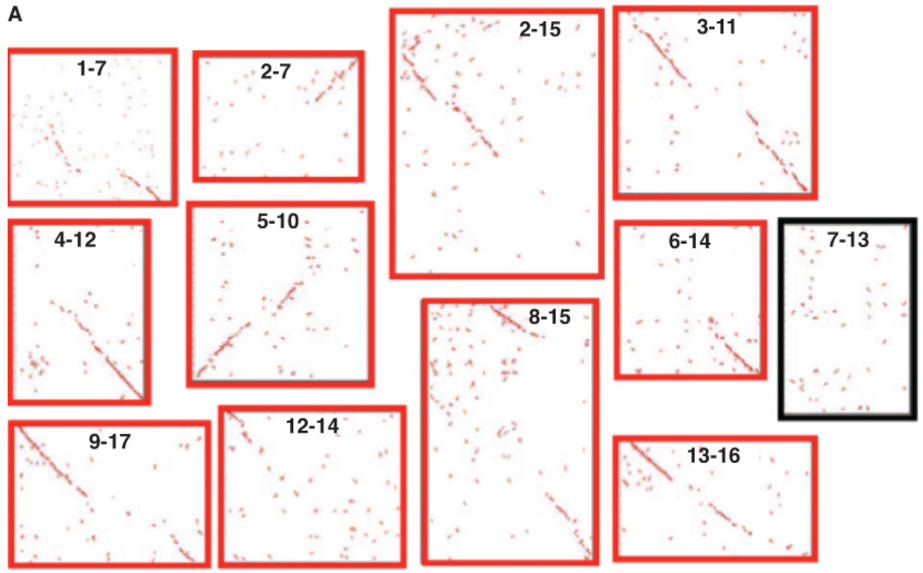


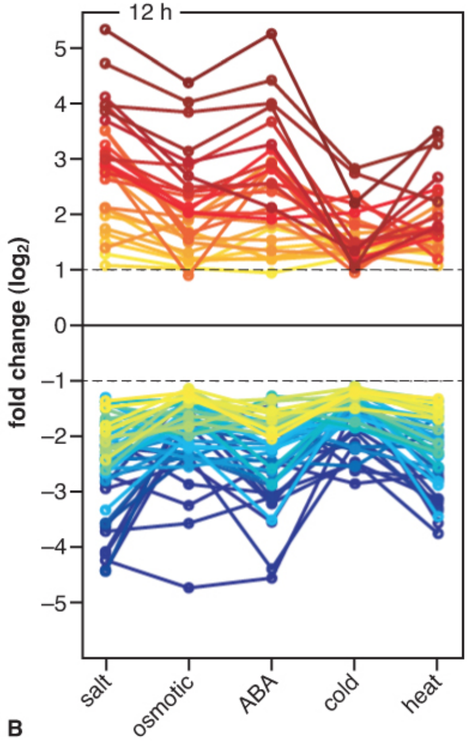
Homeostasis @ organismal

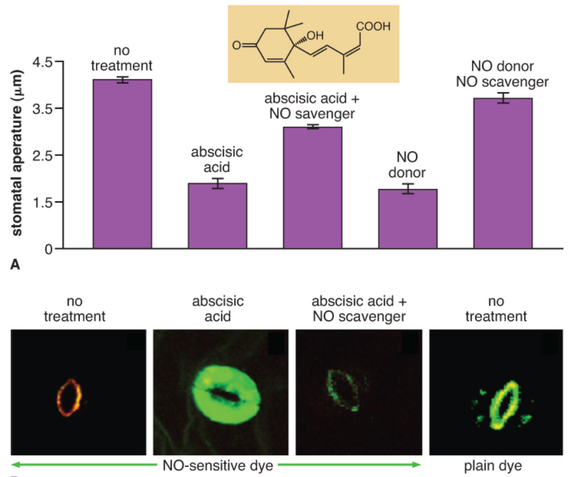
Ch. 12: Plant Physiology

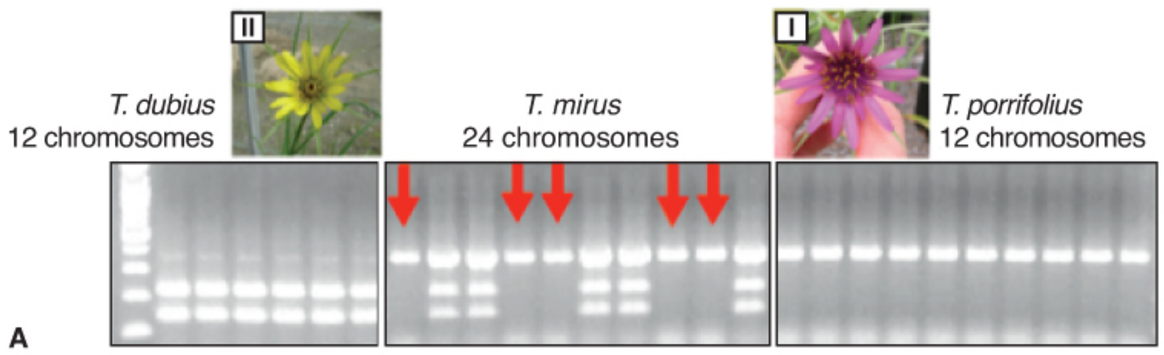
1. How do respond to changes?
2. How can two cells influence entire plant?
3. How does Venus flytrap catch its prey?

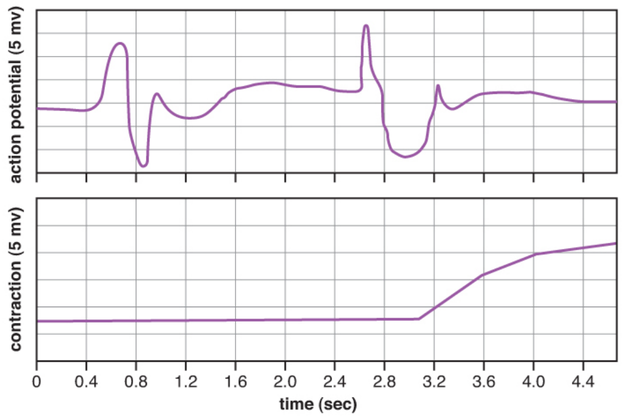
1 BME
1 ELSI

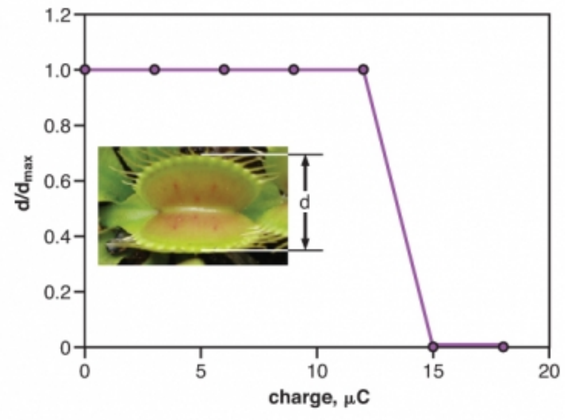






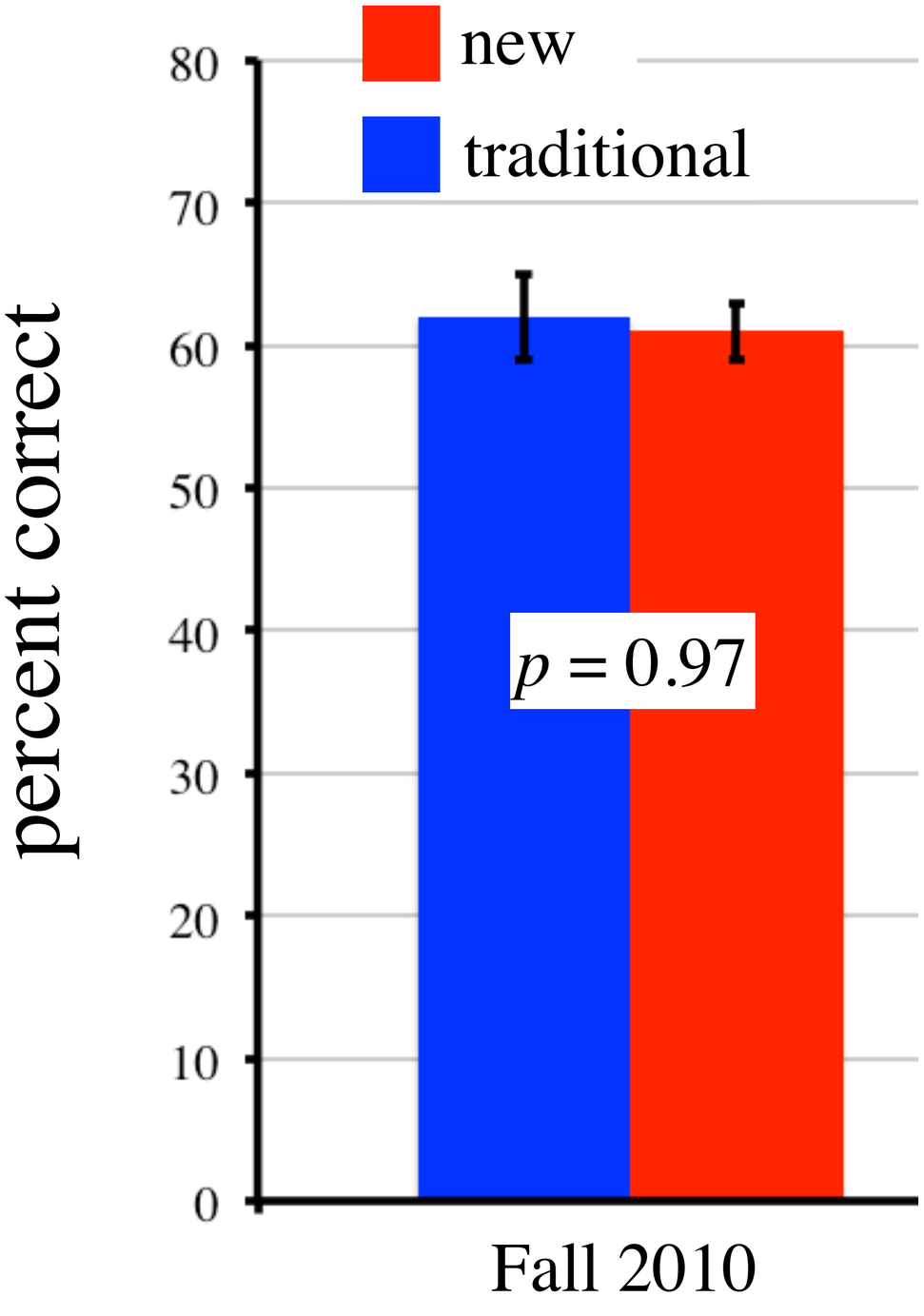






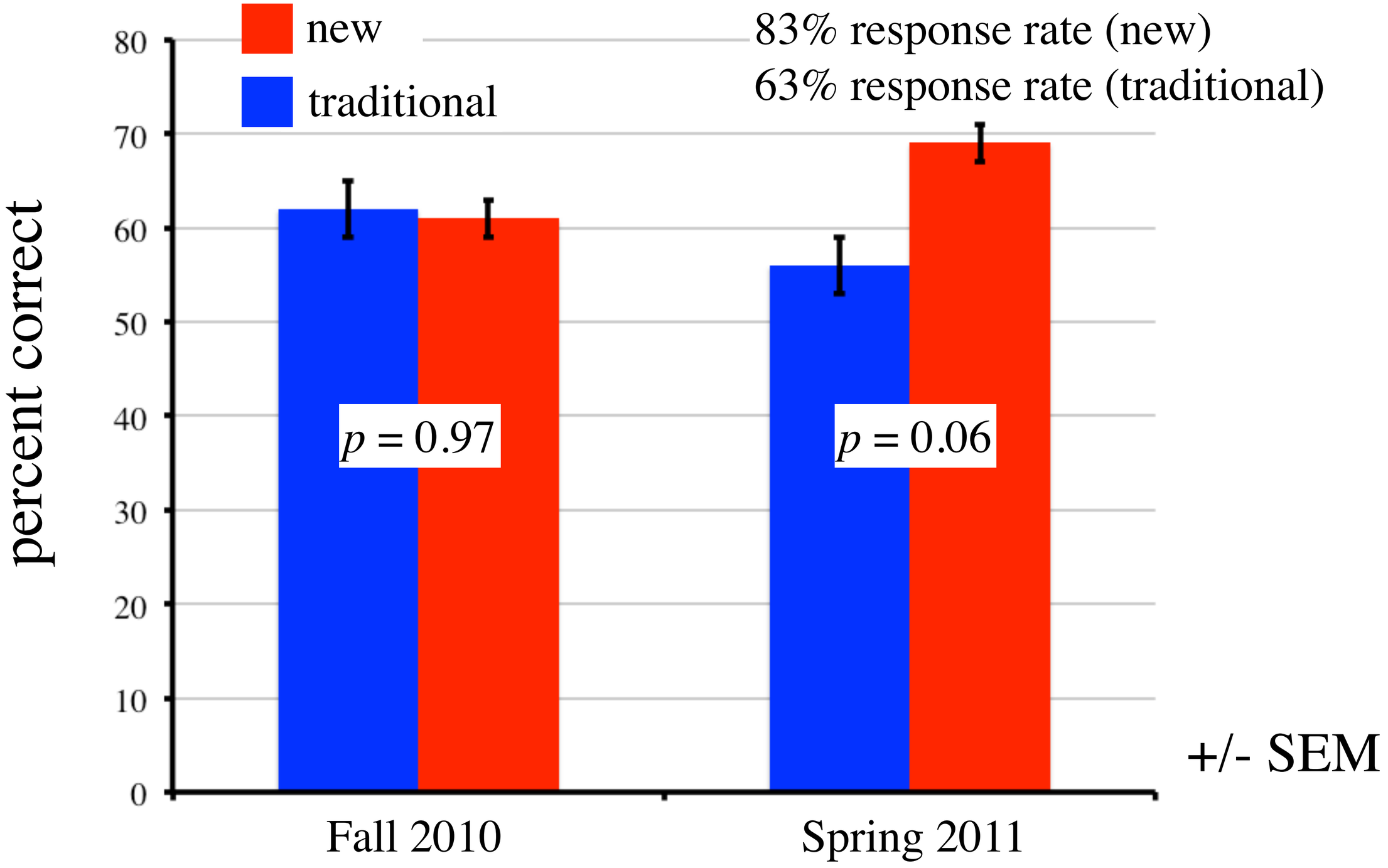
Did my students “learn less” content?

Core Concepts Assessment



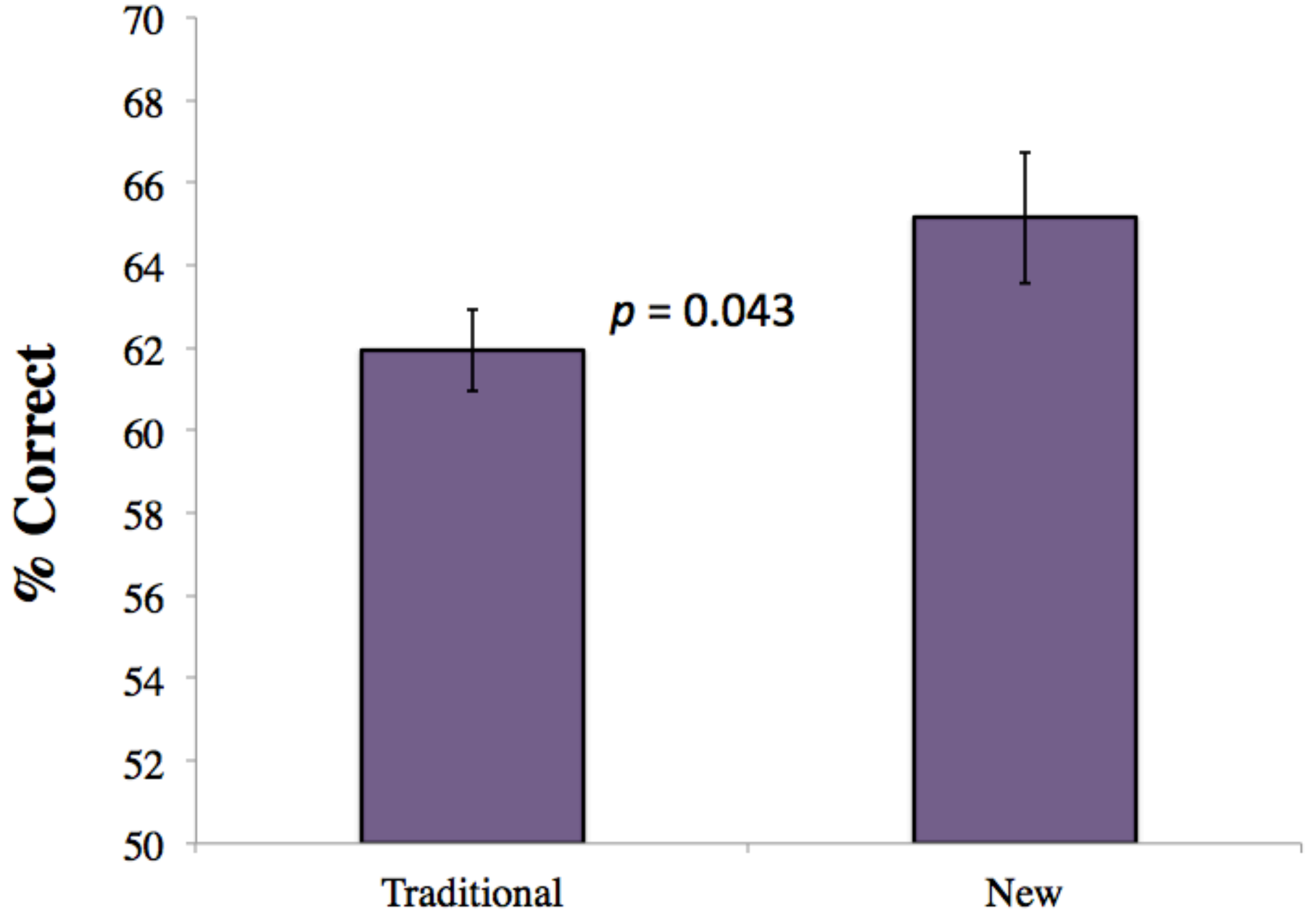
+/- SEM

Core Concepts Assessment

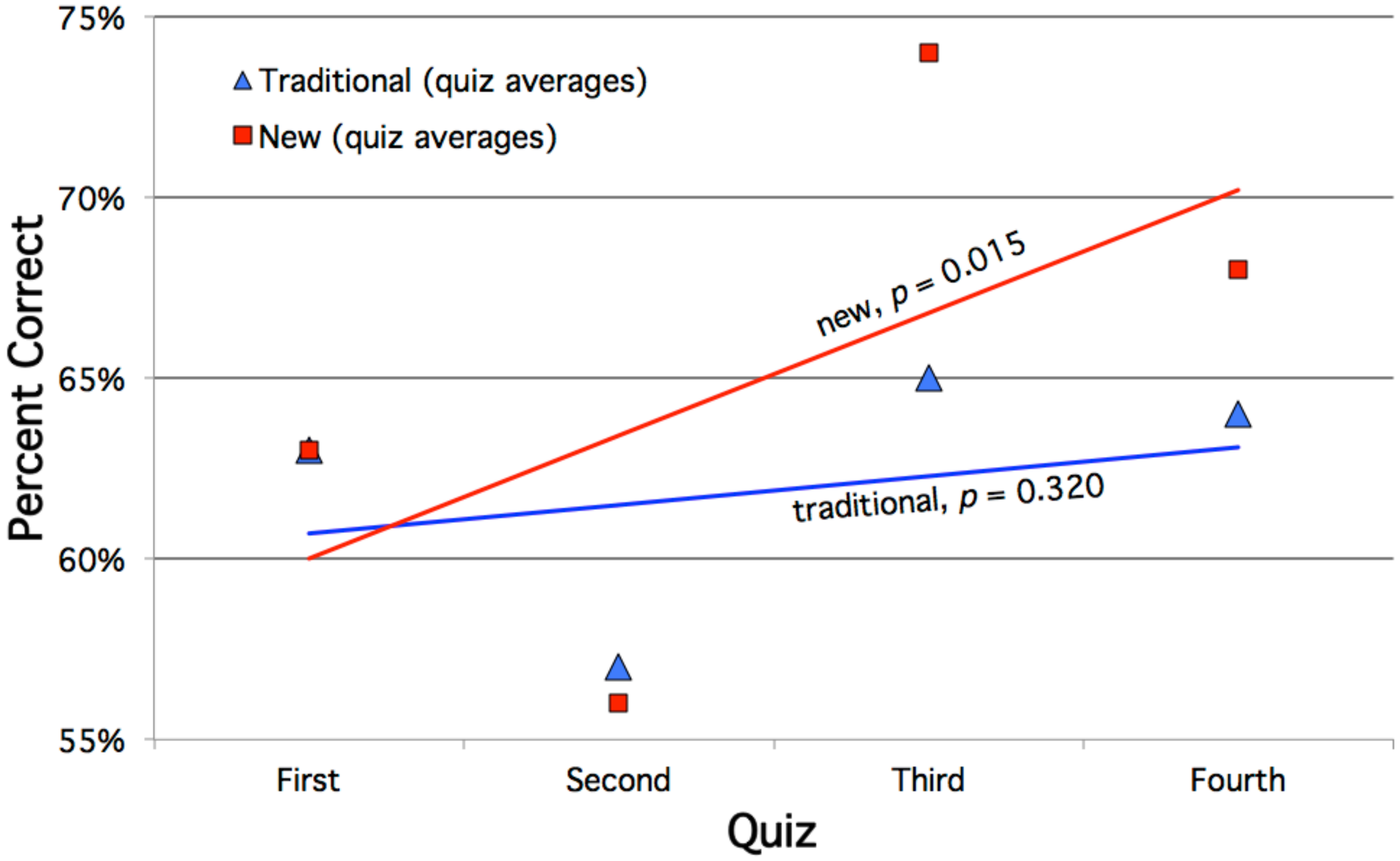


Can my students analyze data better?

Competency Assessment



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

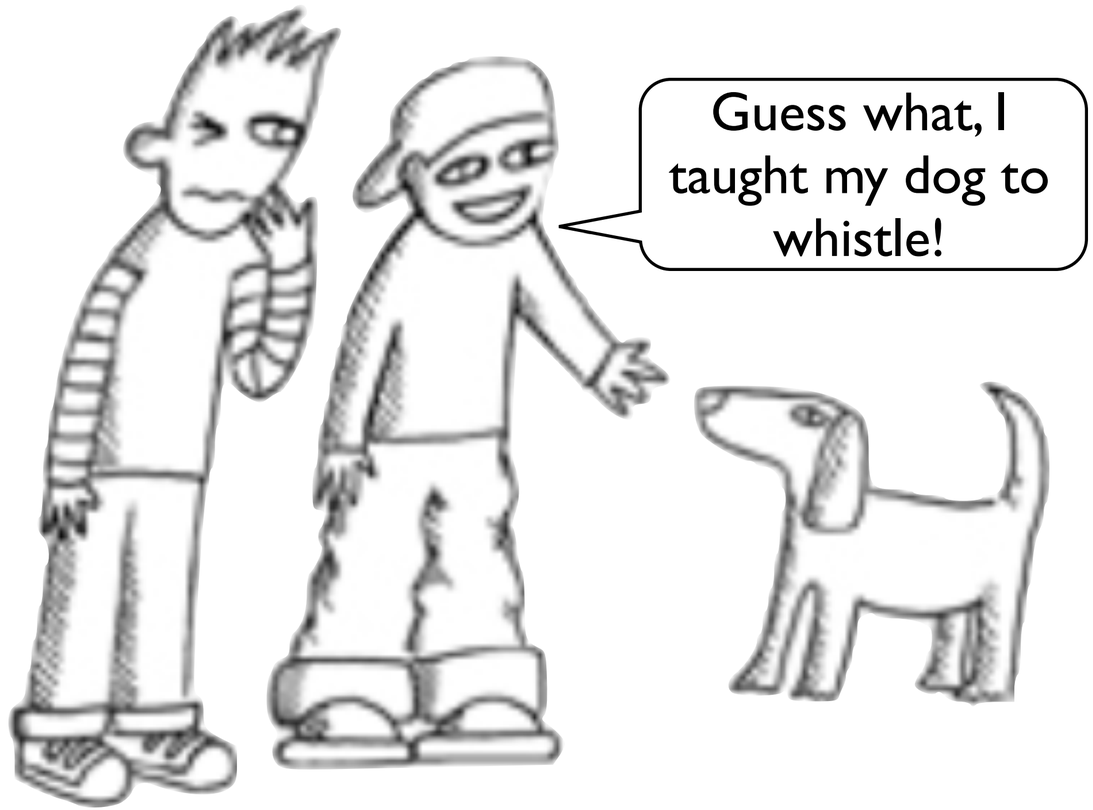
How do I run my class?

- Assume they have read before class.
- Go through reading like a journal club.
- Cold call on students to answer questions.
- It is ok to be wrong.
- Students ask more than just clarifying questions.
- Try to answer Integrating Questions on their own.
- I do not collect IQ answers, but will review some in office.
- I cover key points but do not present the information to them.
- Remember learning is not the same thing as teaching.
- Value added by coming to class.

How do I assess student learning?

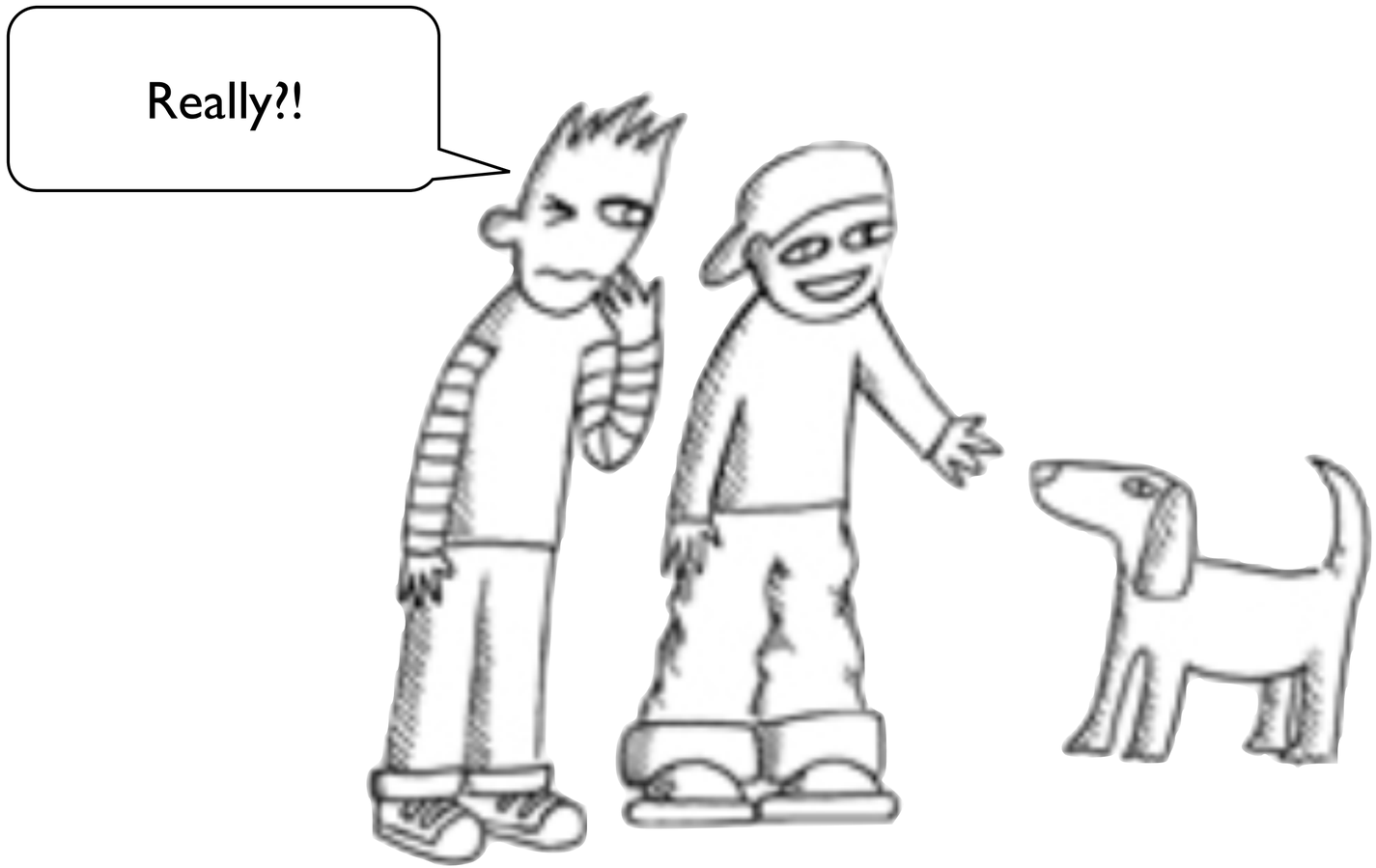
- 10% of questions come from lab
- questions are based on Integrating Questions (not identical)
- questions are based on Review Questions (not identical)
- support their answers with data!!!
- focus on learning objectives and **Bloom's terms**
- they draw some answers
- design experiments with controls
- could be multiple choice format

Teaching *vs* Learning

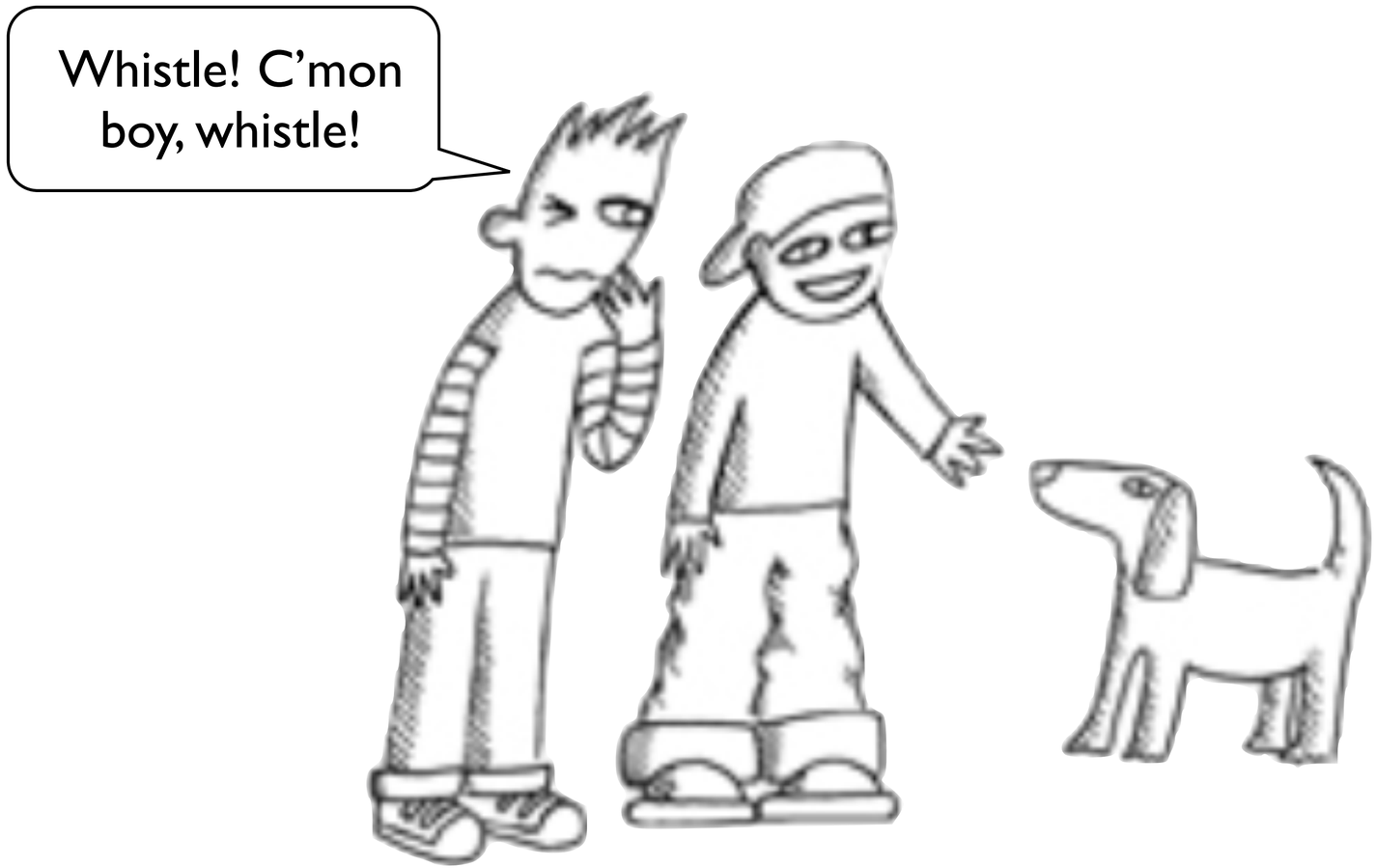


http://thegoodpeople.se/blog/?p=208

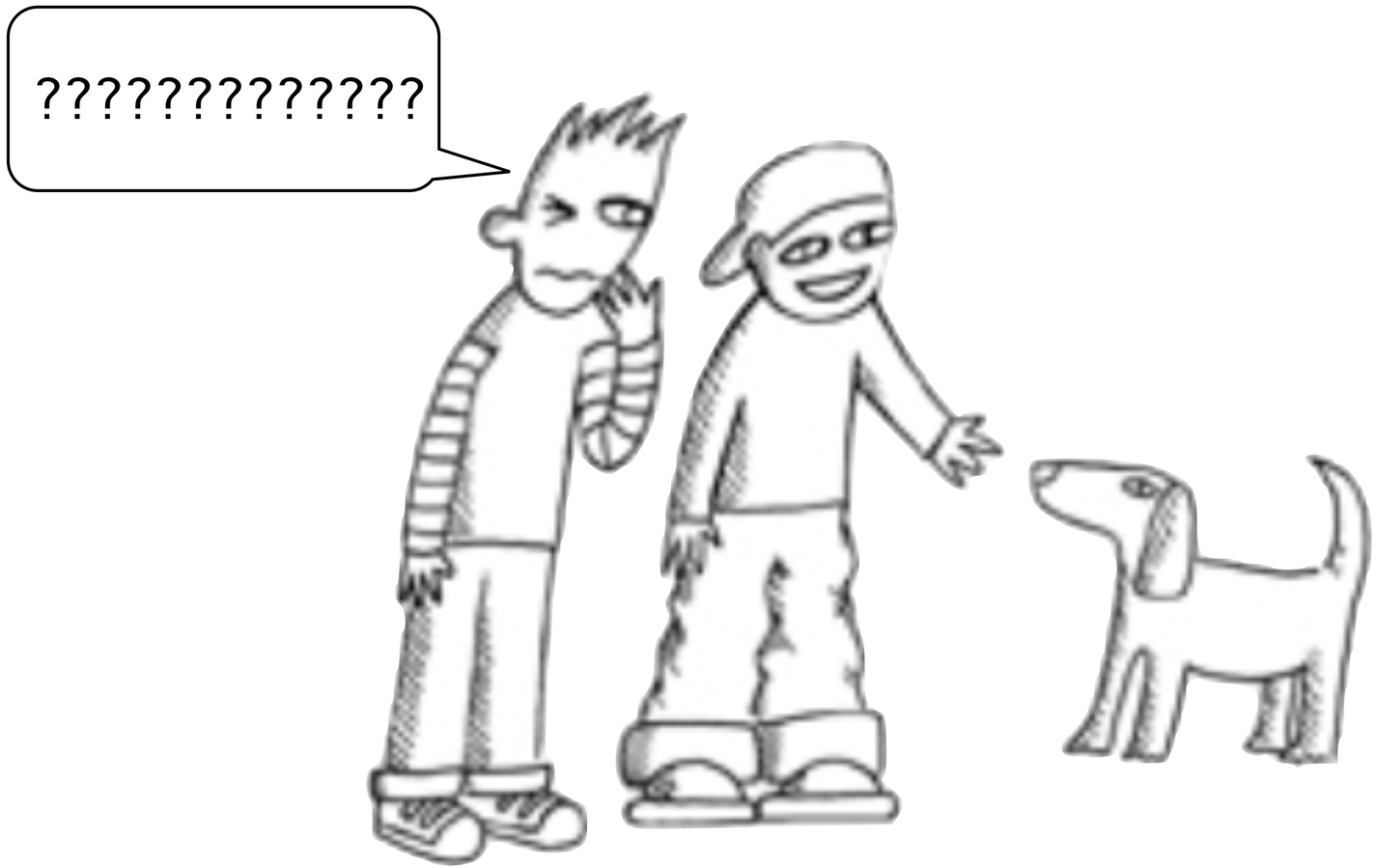
Teaching *vs* Learning



Teaching *vs* Learning



Teaching *vs* Learning



Teaching *vs* Learning

Teaching *vs* Learning

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