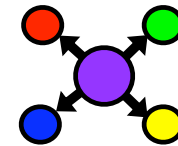
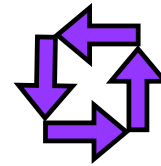
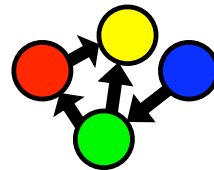
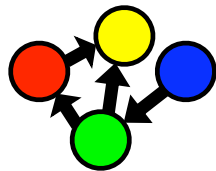


Advanced Students' Resource Selection in Nearly-Novel Situations

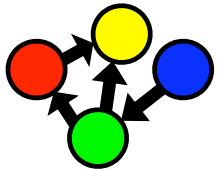


Eleanor C. Sayre

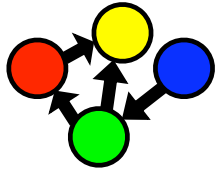
Outline



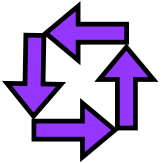
Introduction



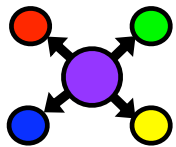
Representing Resources



Refining the problem



Survey design



Four classes of response



Conclusions

Research Questions



Supergoal

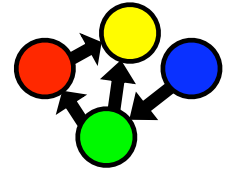
- How can we model changing thought processes in a robust and flexible manner?

–

Can advanced students

- combine disparate physics classes into cohesive physics knowledge?
- solve new problems in situations that are cognitively "near" other ideas they've studied?

Nearly-novel situations

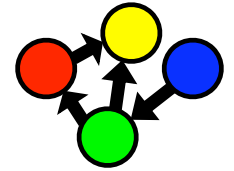


A nearly-novel situation is defined as one in which students have studied the appropriate material, but not encountered the specific situation.

A nearly-novel situation is **not**

- a homework problem
 - (not procedurally or conceptually different from class problems)
- something the student has thought about before
 - (some branches of physics may be more difficult to find NNS)
- universal to all students
 - (different people have different ideas about different things)

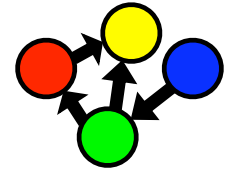
Resources (as expanded)



A resource is like a cardboard box. Like boxes, we label resources with their contents.

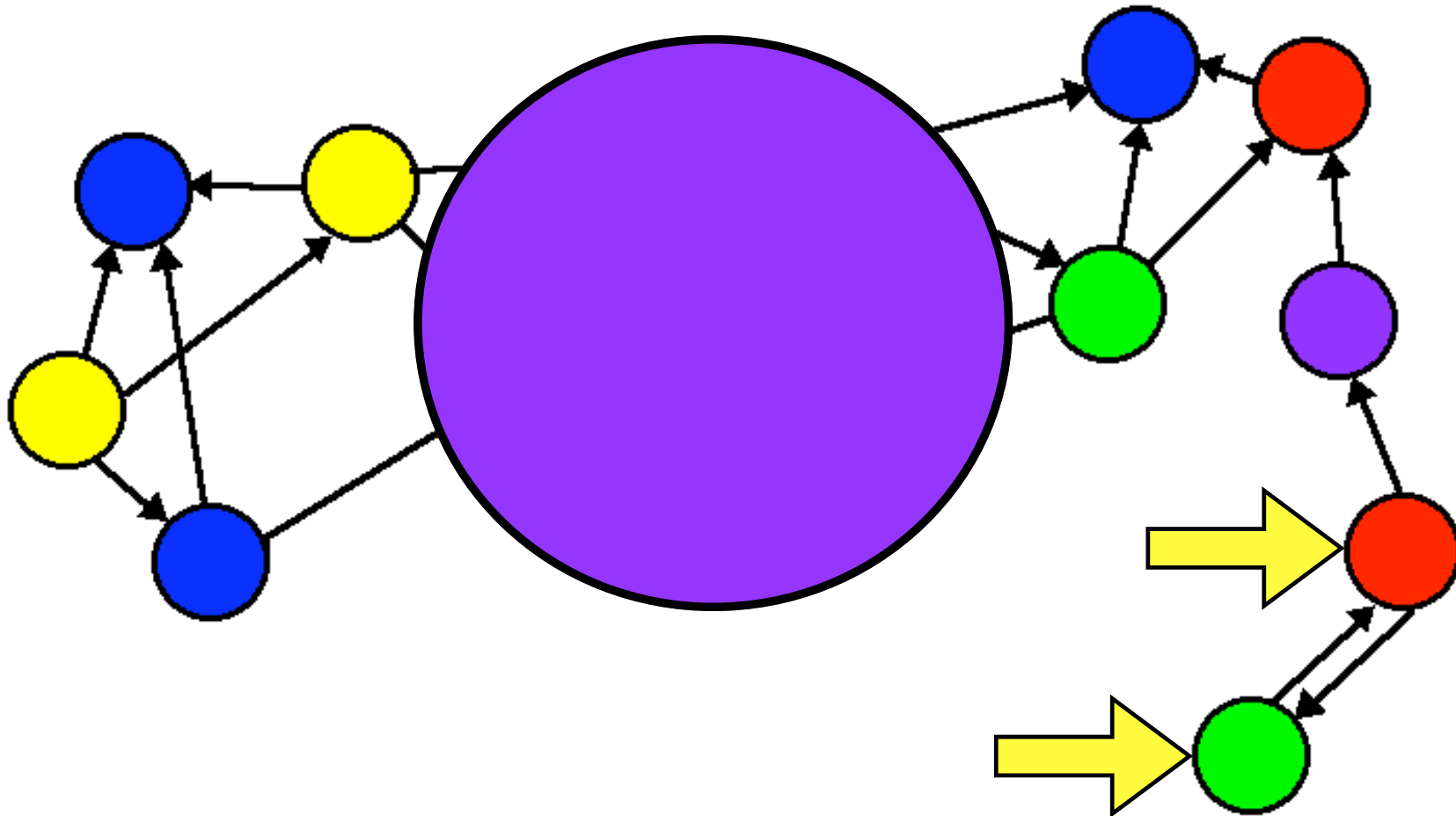
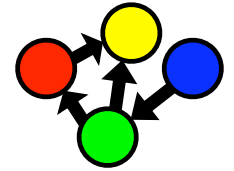
- A resource could contain
 - a bit of content
 - a metacognitive strategy
 - a problem solving strategy
 - a belief about the nature of knowledge
- knowledge-as-derivable and knowledge-as-rememberable
- Resources may be active (on) or inactive (off)
 - whether a resource will activate is a function of which resources are already on and the situation at hand.

Connecting Resources



- Resources connect to other resources via one-way, directional links called “pointers”
 - pointers can activate or block activation of other resources
 - Pointers can be redirected to point to other resources.
- A network of resources and their links can be called a web or a digraph
 - these webs can be built on-the-fly
 - or they could be stable
 - we call stable webs conceptions
- Addresses
 - resources used together are “nearby”
 - orienting is like asking what’s around

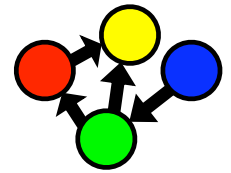
A digraph



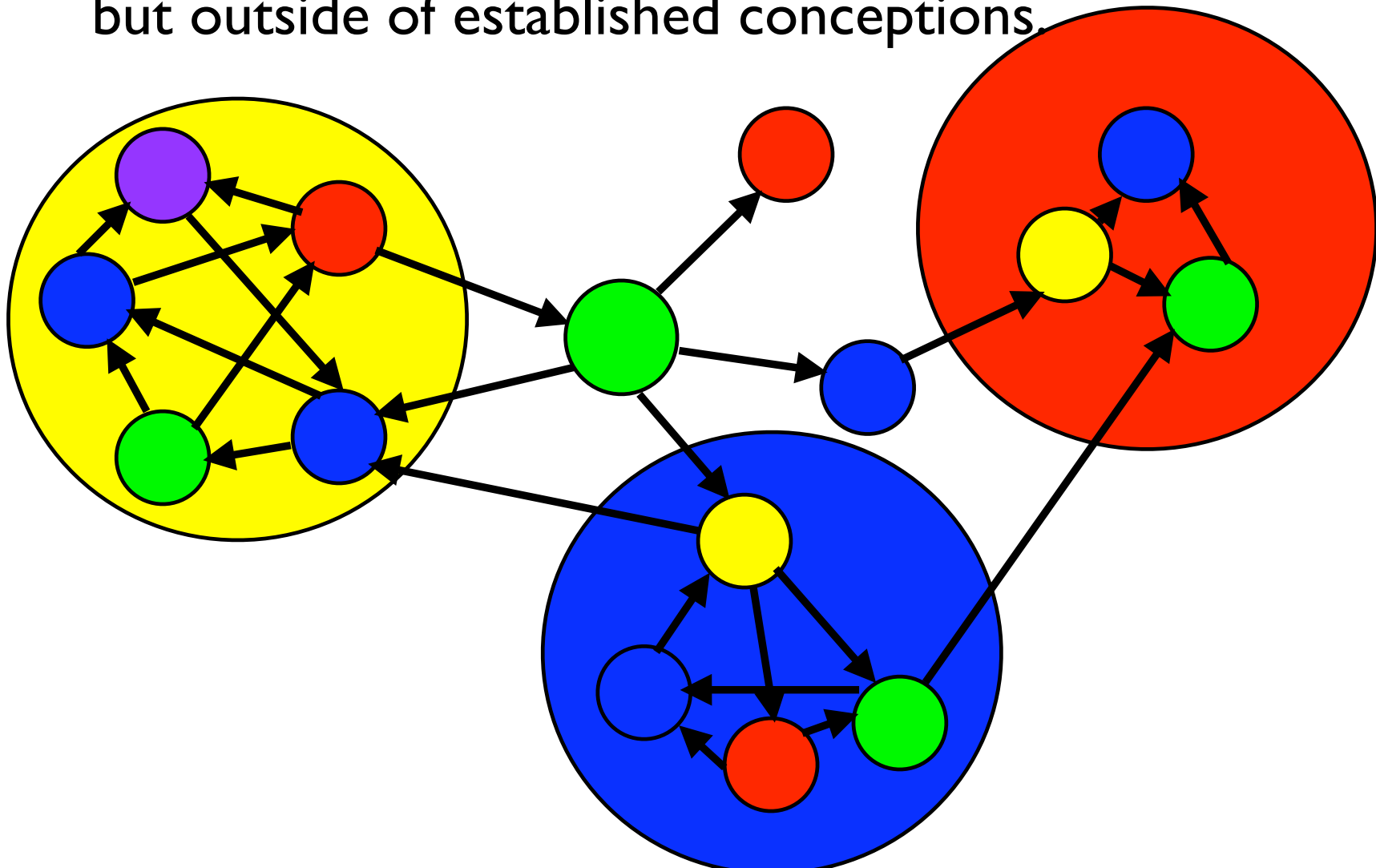
“fractal”
could have different grain sizes

“nearby”
have similar addresses

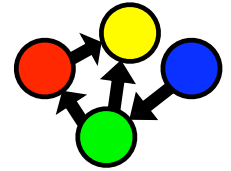
Redefining NNS



- A nearly-novel situation is one near many resources, but outside of established conceptions.



Advanced Problems



- Hard to find problems that
 - Ask new questions
 - Are cognitively "near" studied physics
 - Are rich in physics
 - Lack mathematical complexity

Diode Construction

Population



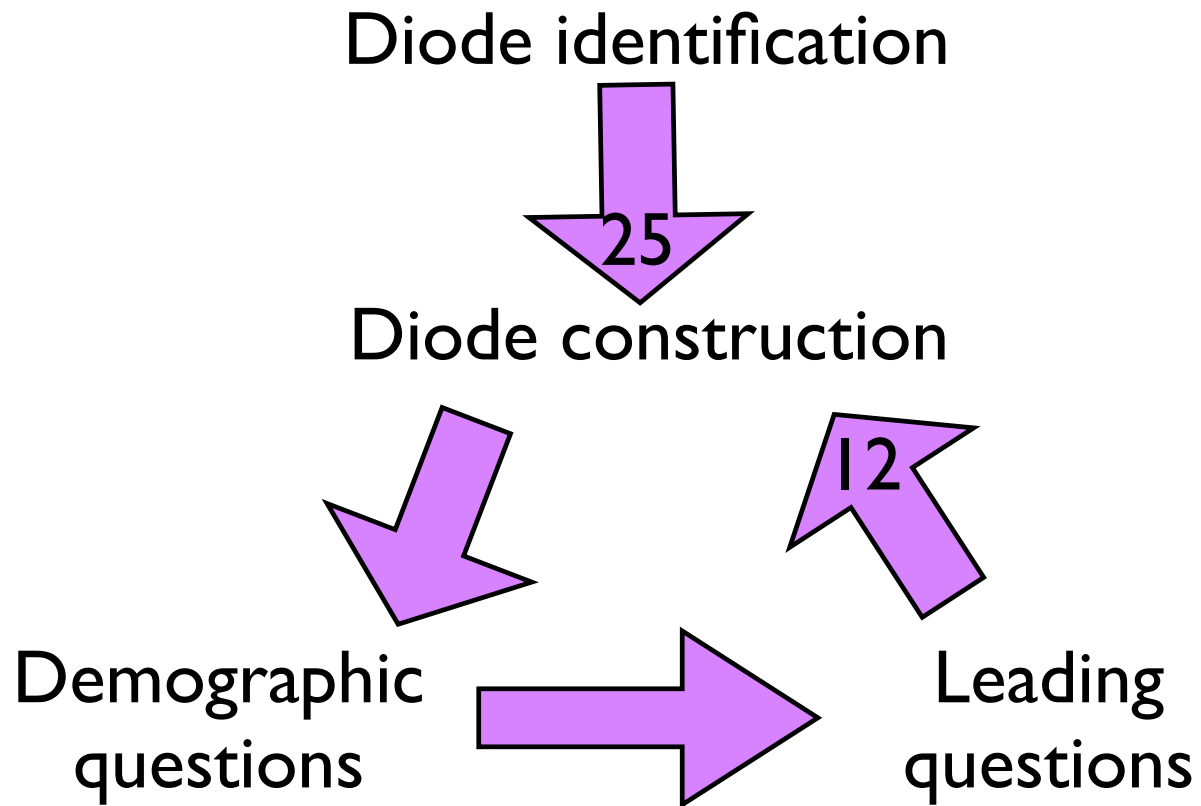
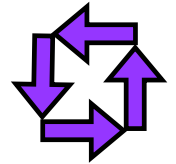
Population constraints

- Students must be able to identify diode behavior in simple circuits to construct diodes.
- Students must be facile with simple E&M topics.

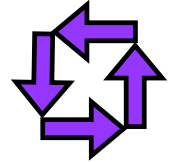
Chosen population

- Upper level undergraduate majors (n=16)
- First year graduate students (n=9)

Iterative Design

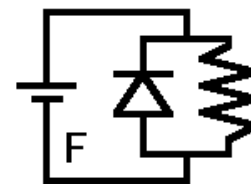
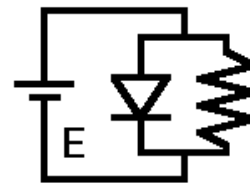
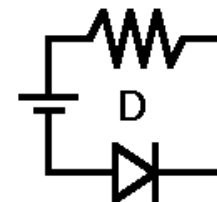
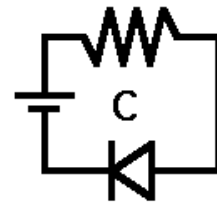
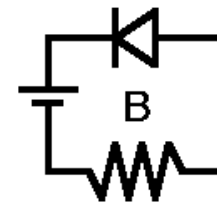
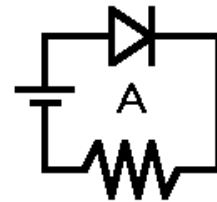


Diode identification

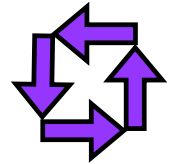


Rank the currents through the resistors. All circuit elements are ideal.

$$A=C=F > E \geq B=D=0$$

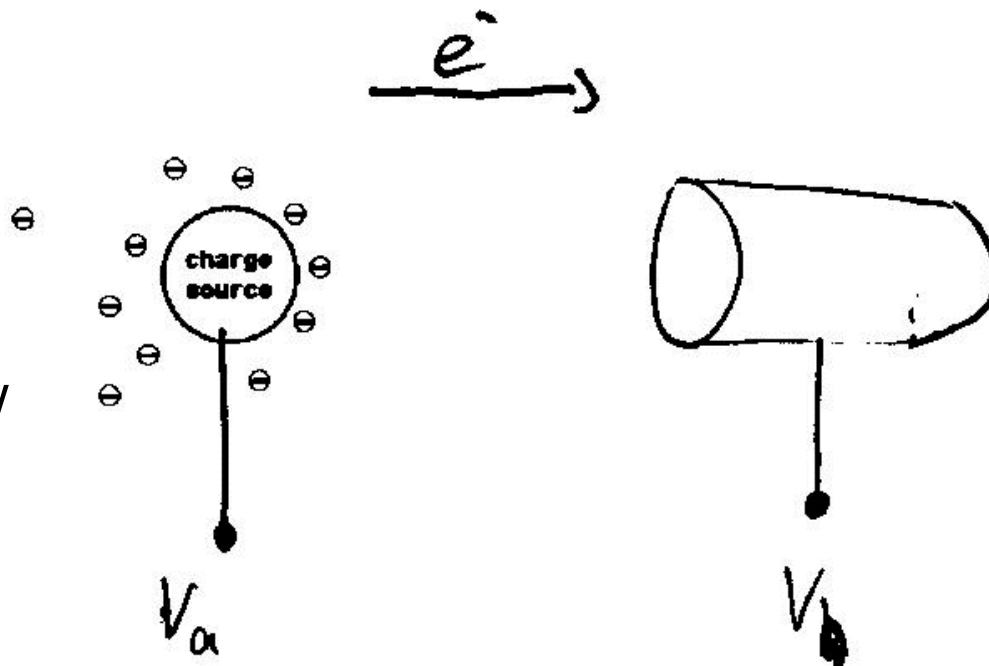


Diode Construction

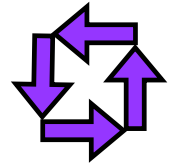


The diagram shows a charge source with a bunch of electrons floating around it. What other apparatus could you add to make it function as part of a diode?

If $V_b > V_a$,
current can flow
If $V_a > V_b$,
no current can flow

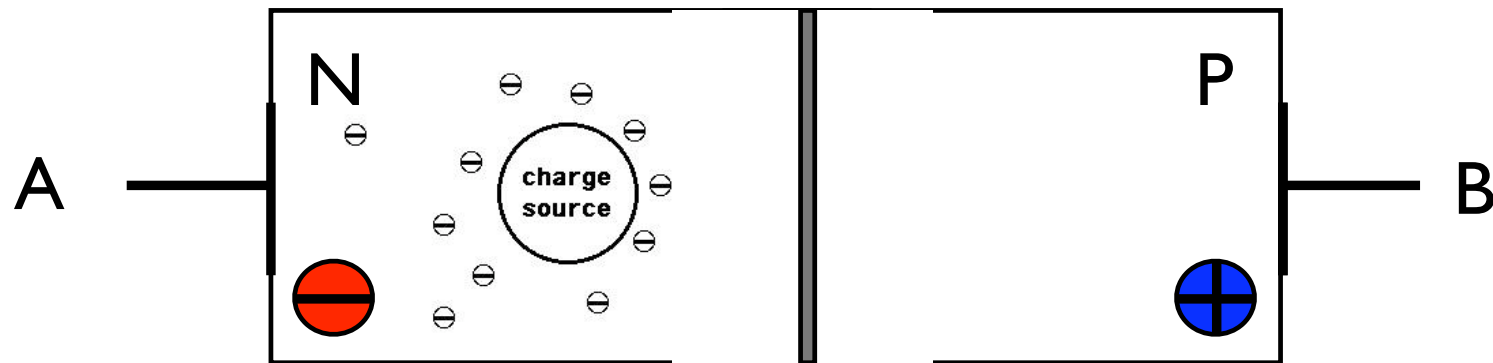


Diode Construction



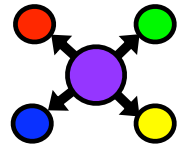
The diagram shows a charge source with a bunch of electrons floating around it. What other apparatus could you add to make it function as part of a diode?

A p-n junction

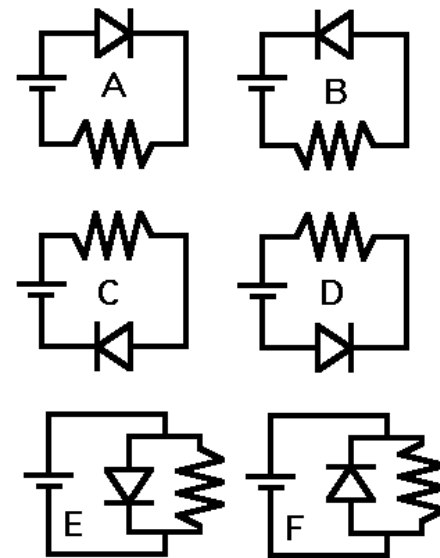


$$V_a < V_b$$

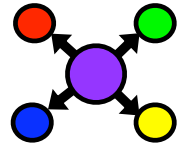
Identification Responses



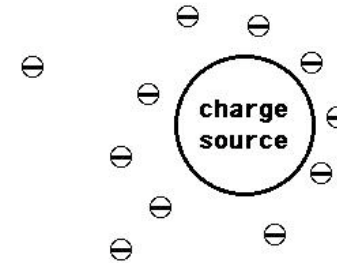
● Acceptable	12
● Current through resistors	8
$A=C=F>E>B=D=0$	
$A=C=F>B=D=E=0$	
● Current through batteries	2
$E>A=C=F>B=D=0$	
● Current through diodes	1
$E>A=C>B=D=F=0$	
● Finger tracers	1
● Unacceptable	9
● Ohmic if on	7
● Order matters	2
● Other	4



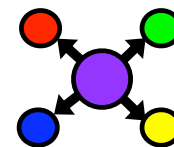
Design Responses



● Diode	7
<hr/>	
● Semiconductor	6
● Vacuum tube	1
<hr/>	
● Protodiode	9
<hr/>	
● Nearby charge source	6
● Capacitor	3
<hr/>	
● <u>Unsuccessful</u>	<u>9</u>

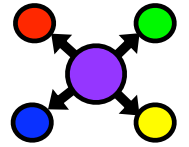


Correlation?



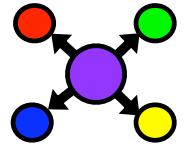
		diode		protodiode		Unsuccessful
		Semiconductor	Vacuum tube	nearby charge source	Capacitor	
acceptable	Resistor	1		4		3
	battery	1	1			
	diode					1
	finger tracer			1		
unacceptable	Ohmic if on	2			2	3
	Order matters				1	1
other		2		1		1

“Albert”



- Senior physics major at Umaine
- Classes taken include
 - E&M I
 - PHY 236 (modern)

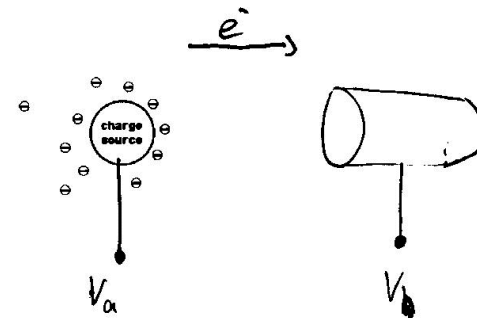
Albert: Construction



“?”

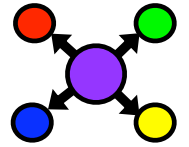
Correct answer:

What other apparatus can you add to make this function as a diode?



If $V_b > V_a$, current can flow
If $V_a > V_b$, no current can flow

Albert: Cueing Question

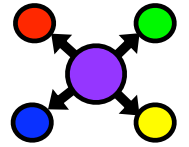


Which of the following effects did you consider in your diode construction? Please check all that apply.

- The effects of an applied electric field
- The effects of an applied magnetic field
- The effects that the charges may have on each other
- The fact that electrons have a negative charge
- The effect of reversing the battery
- Other (please explain)

**"None --
I have not or ever constructed a diode"**

Albert: revision?



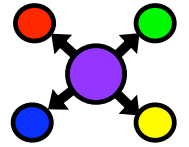
Would you like to revise your answer?

No

Because he has not constructed before,
he cannot do it now.

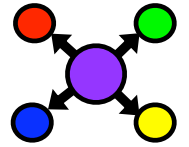
Knowledge-as-rememberable blocks
knowledge-as-derivable from activation.

“Ben”

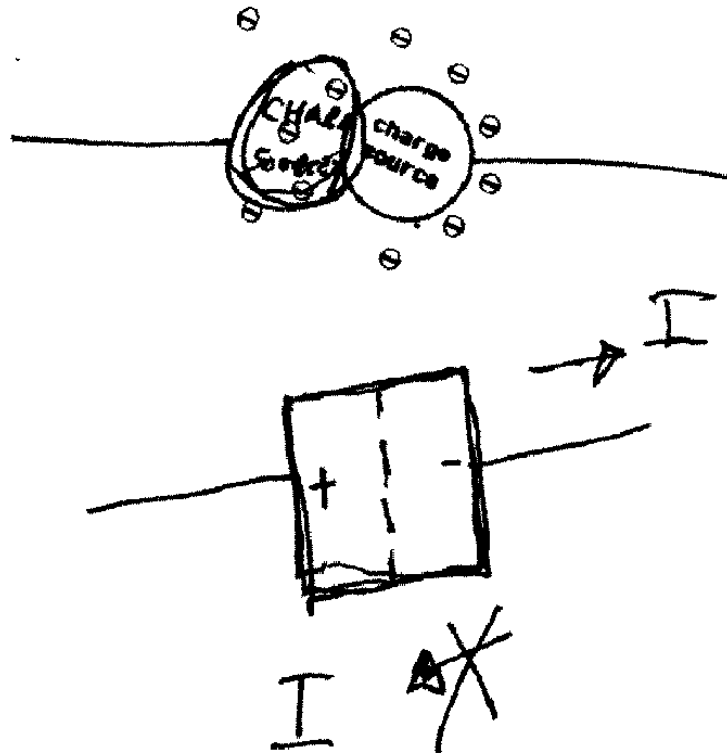


- Senior physics major at UMaine
- Classes taken include
 - E&M I
 - PHY 236 (Modern)
 - PHY 122 (Intro 2)

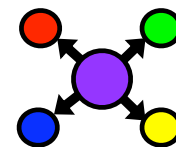
Ben: construction



“add a source of positive charges”



Ben: Cueing Question

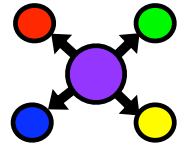


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- The effects of an applied electric field
- The effects of an applied magnetic field
- The effects that the charges may have on each other
- The fact that electrons have a negative charge
- The effect of reversing the battery
- Other (please explain)

I knew that I needed an interface
between two different types of materials
only.

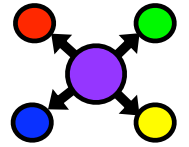
Ben: revised answer



- Not appreciably different from previous answer
- Some evidence of considering battery reversal

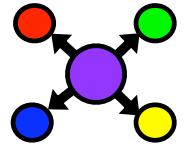
Strongly in semiconductor realm.
Does not derive E&M-based answer in response to cues.

"Alice"



- Senior Engineering Physics / Computer Engineering major at UMaine
- Classes taken include
 - E&M
 - Electrical Networks I and II
 - Electronics
 - Junior Physics lab, with p-n junction creation

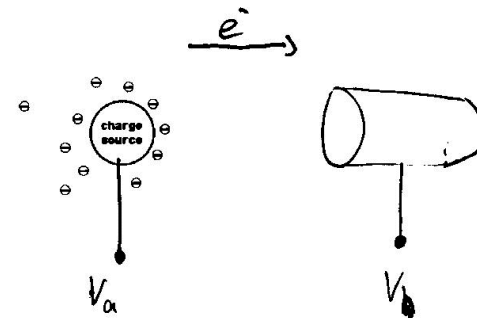
Alice: Construction



"I really can't come up with anything or really don't understand the question."

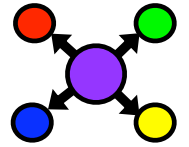
Correct answer:

What other apparatus can you add to make this function as a diode?

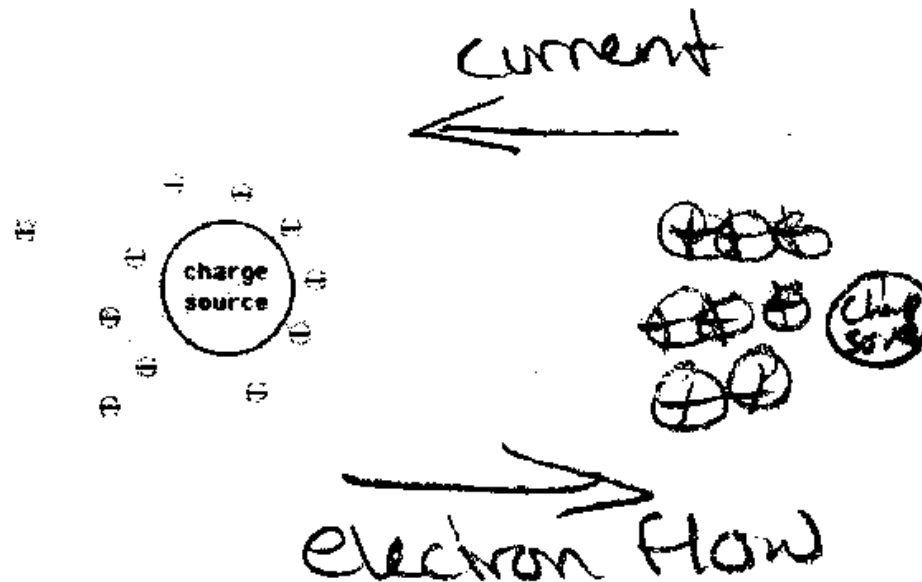


If $V_b > V_a$, current can flow
If $V_a > V_b$, no current can flow

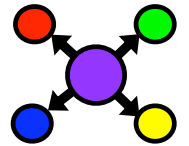
Alice: Revised answer



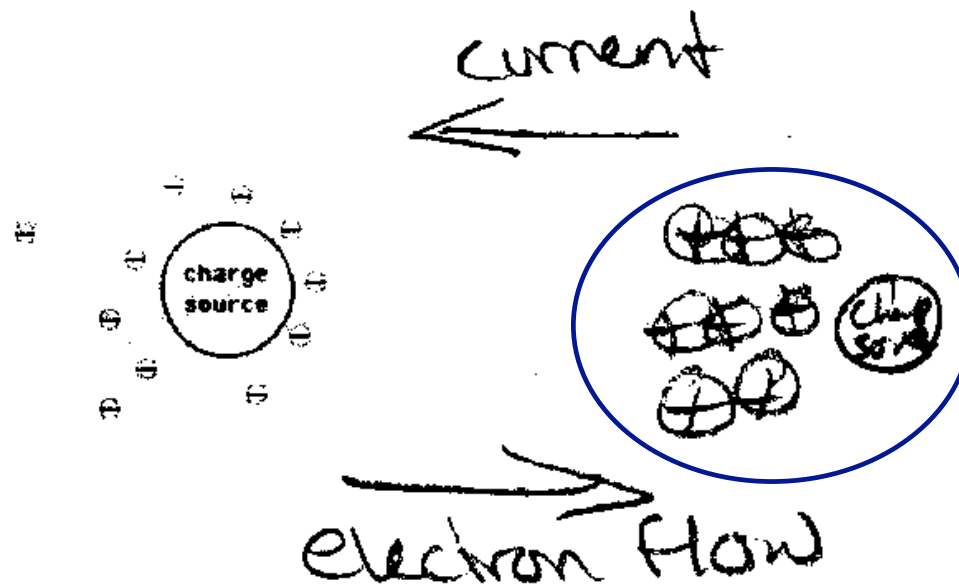
"A diode is a junction of positive doped material up against negatively doped material."



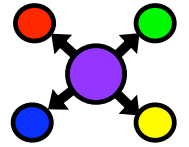
Alice: Revised answer



"A diode is a junction of positive doped material up against negatively doped material."



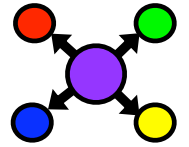
Alice: Cueing Question



Have you studied the construction of diodes before? In what context(s)?

"... in lab – building one
in class – properties of p-n junctions"

Alice: Revised answer



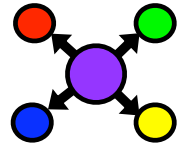
"A diode is a junction of positive doped material up against negatively doped material."

current

- Remembered response
- No demonstrated depth of understanding

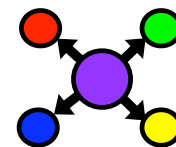
electron flow

"Betsy"



- First year graduate student at UCSB
 - Taken Grad E&M I&II
- Double Physics/Math major as undergrad
- Never studied p-n junctions
- Theorist

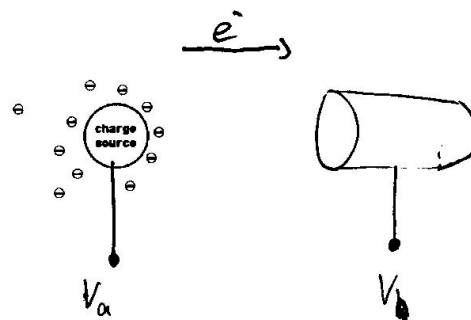
Betsy: Construction



"I have no idea
how diodes work."

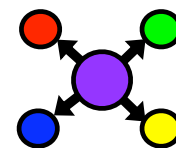
Correct answer:

What other apparatus can
you add to make this function
as a diode?

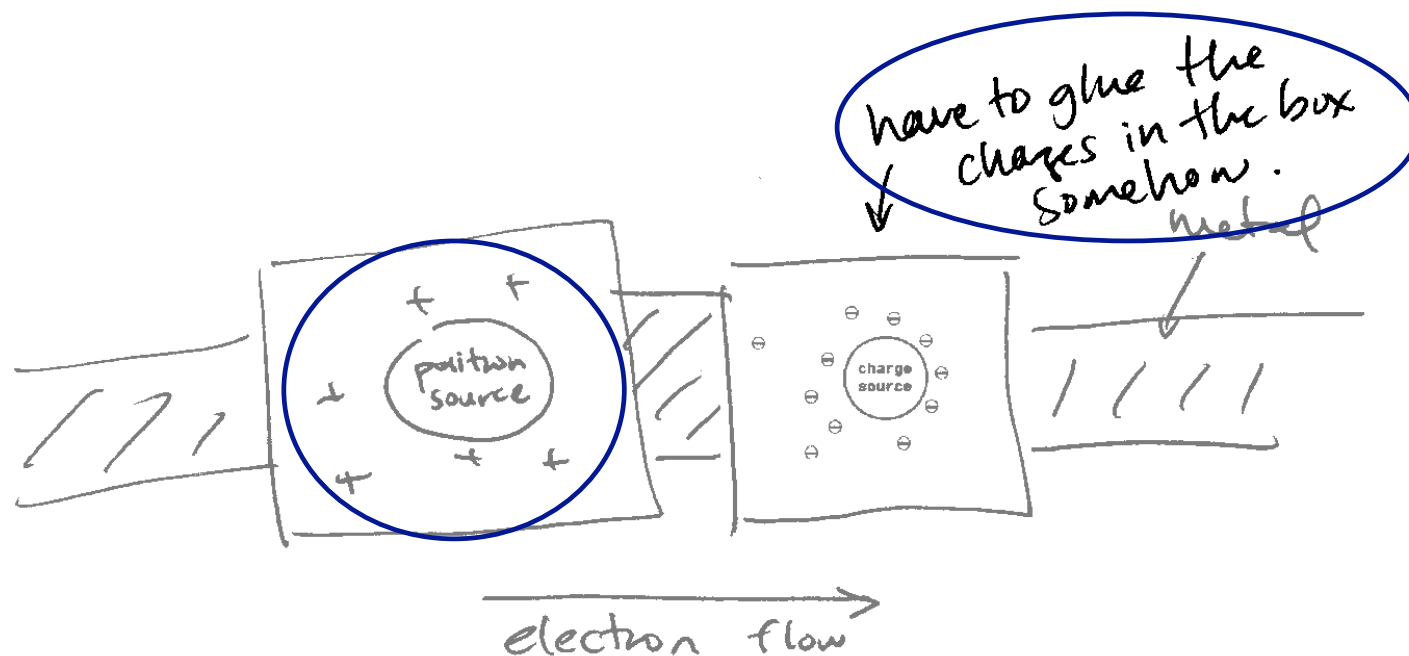


If $V_b > V_a$, current can flow
If $V_a > V_b$, no current can flow

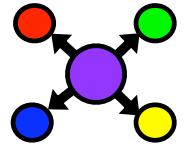
Betsy: Revised answer



"So inside each box the charges are glued. The e^- flowing through the circuit can flow though – through the boxes. An e^- coming from the left needs a voltage to push it past the + box – where it's happy to go. But the e^- coming from the [right] won't want to go near the – box."



Betsy: Cueing Question

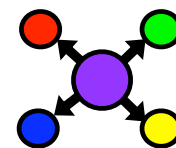


Which of the following effects did you consider in your diode construction? Please check all that apply.

- The effects of an applied electric field
- The effects of an applied magnetic field
- The effects that the charges may have on each other
- The fact that electrons have a negative charge
- The effect of reversing the battery
- Other (please explain)

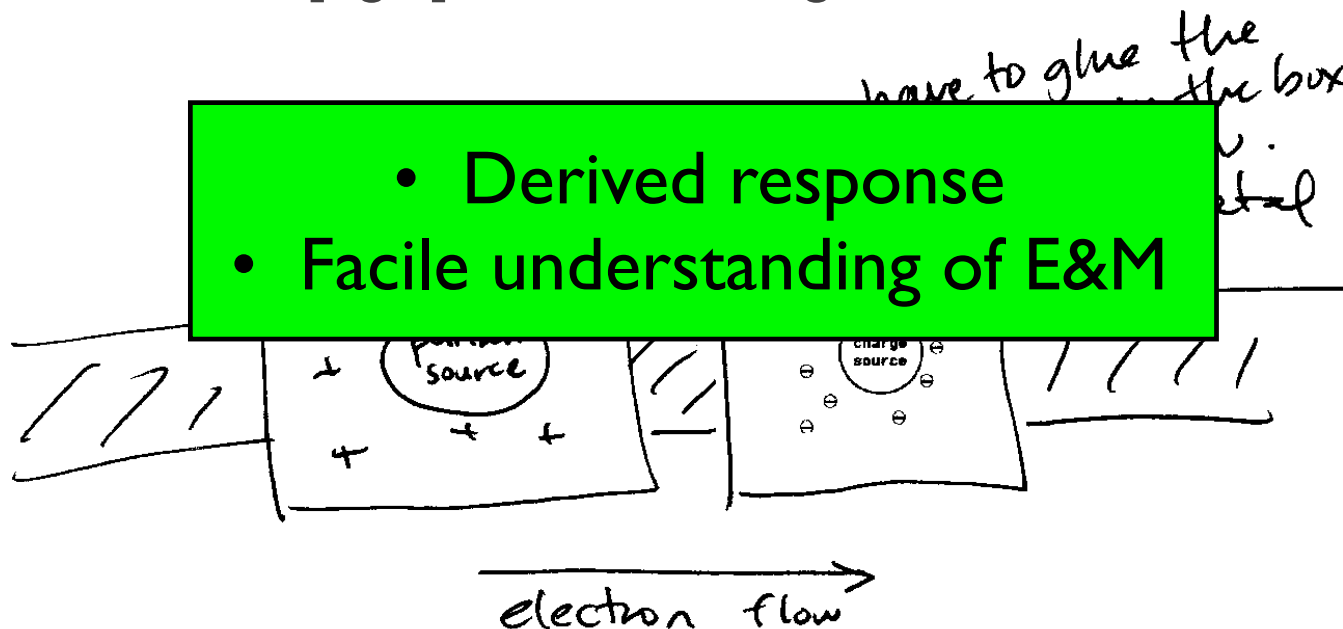
"None"

Betsy: Revised answer

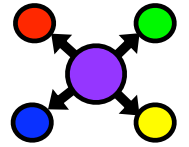


"So inside each box the charges are glued. The e^- flowing through the circuit can flow through – through the boxes. An e^- coming from the left needs a voltage to push it past the + box – where it's happy to go. But the e^- coming from the [right] won't want to go near the – box."

- Derived response
- Facile understanding of E&M



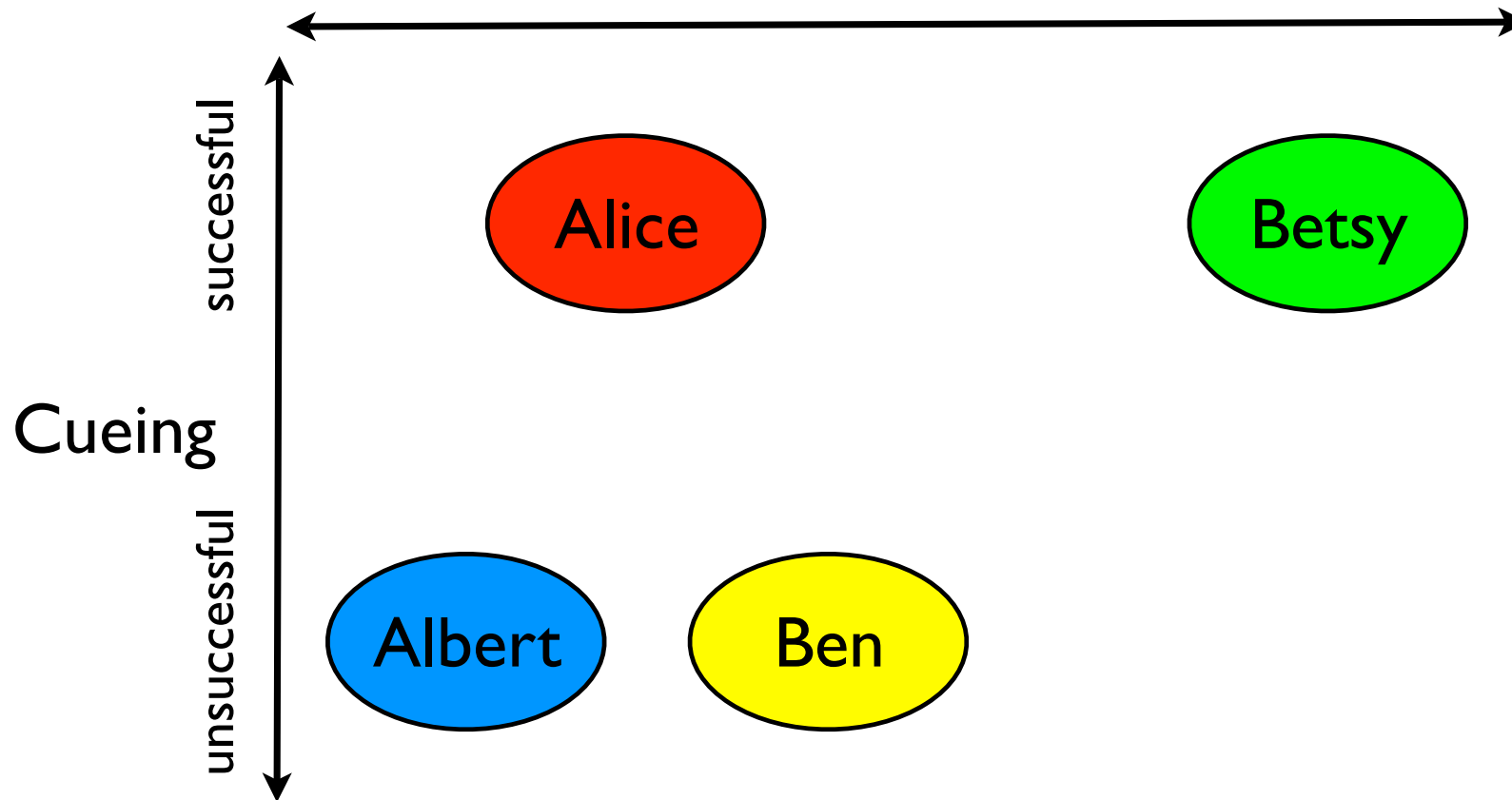
Conclusions



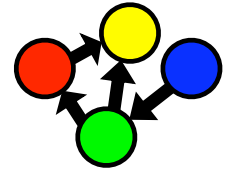
knowledge-as-*

-rememberable

-derivable

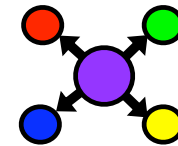
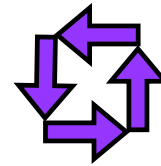
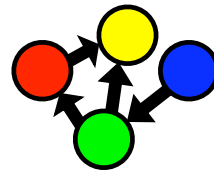
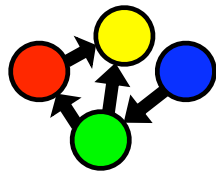


Conclusions



- To reason successfully in a nearly-novel situation,
 - students must possess the necessary content knowledge
 - student must view that knowledge as relevant
 - knowledge-as-derivable must not be blocked from activating.

Advanced Students' Resource Selection in Nearly-Novel Situations



Eleanor C. Sayre