

Educating the innovators of the 21st century



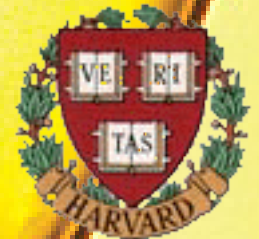
Ann Ferren Conference
American University
Washington, DC, 11 January 2013





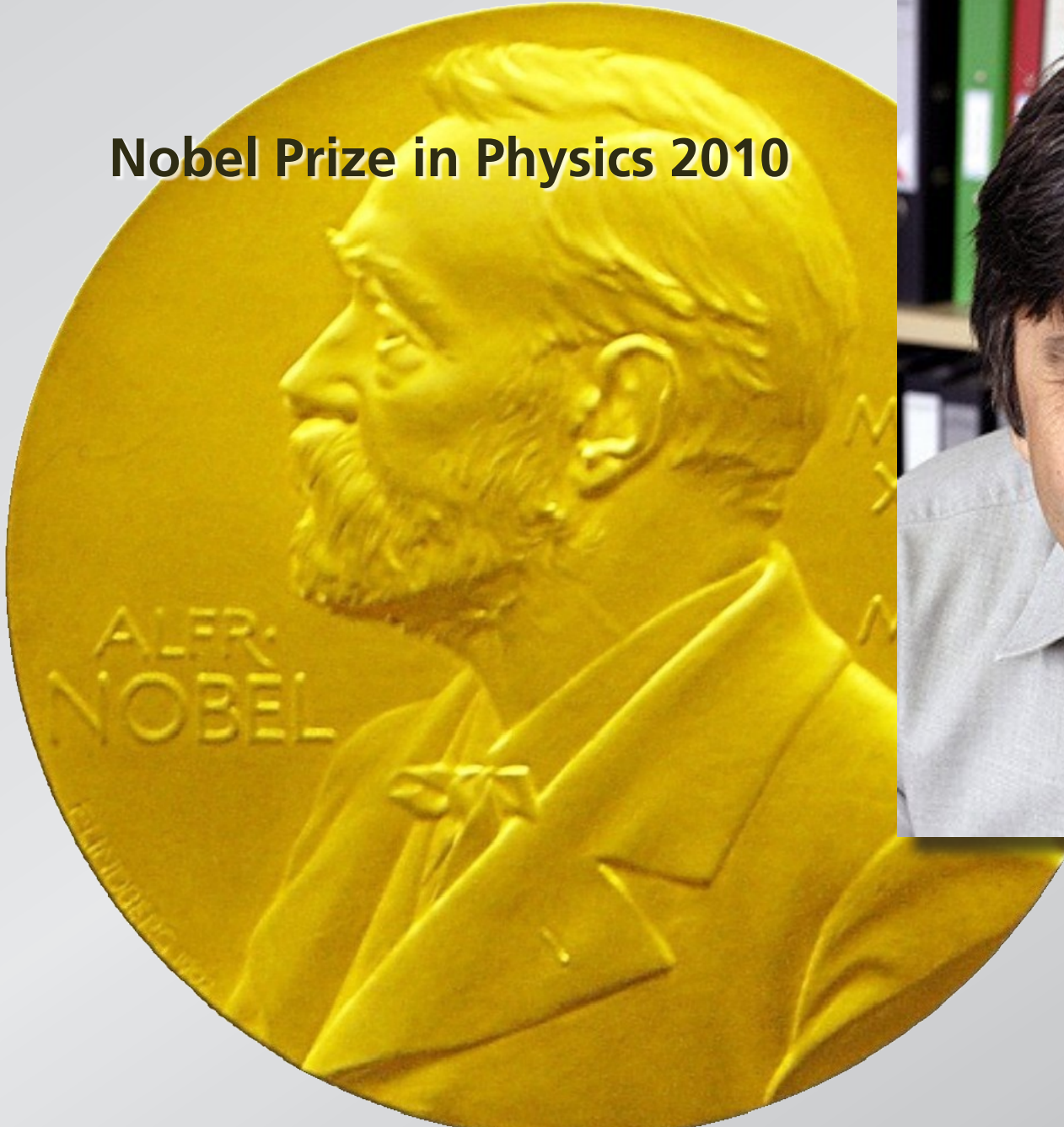
@eric_mazur

Ann Ferren Conference
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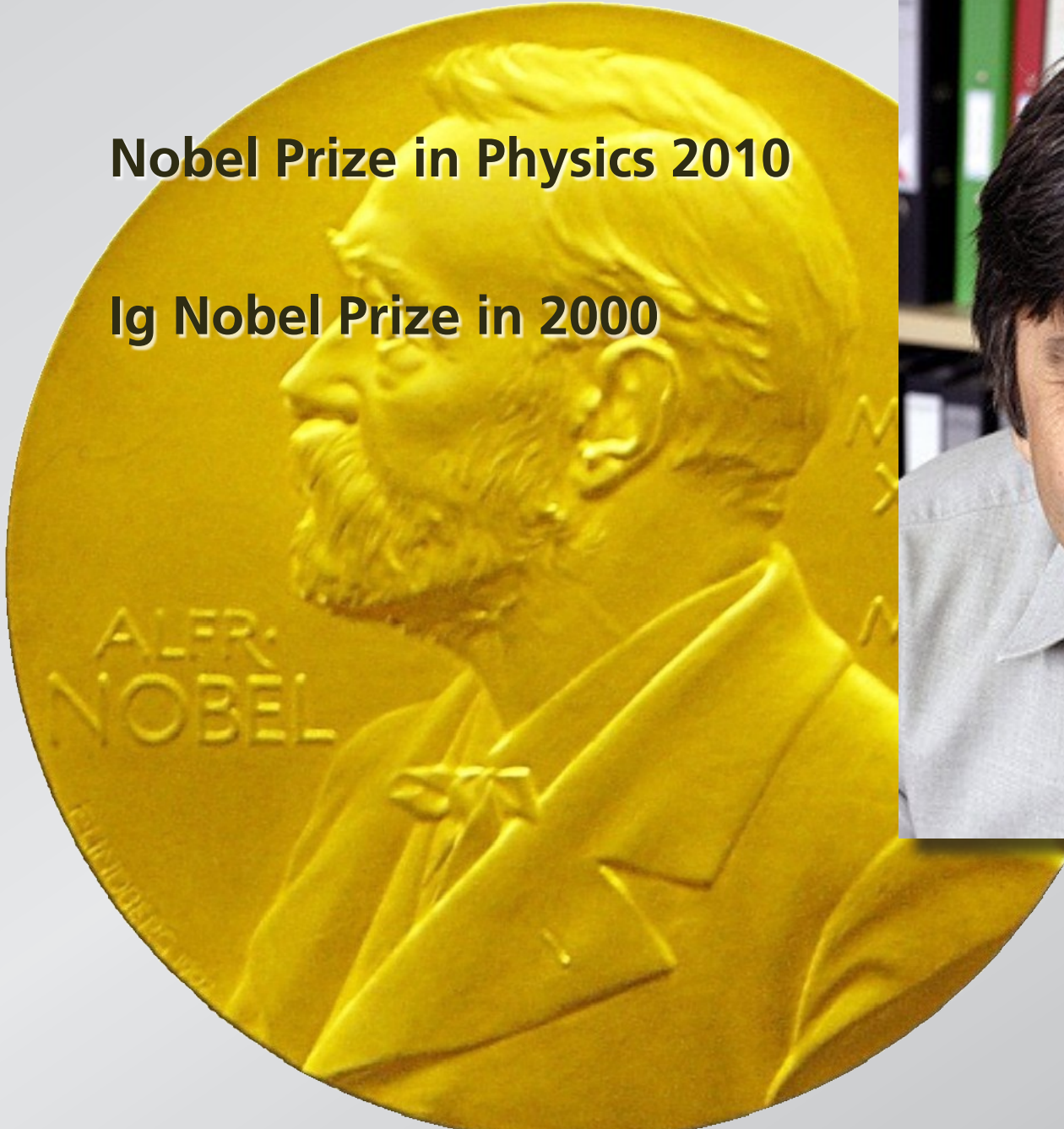
Innovation

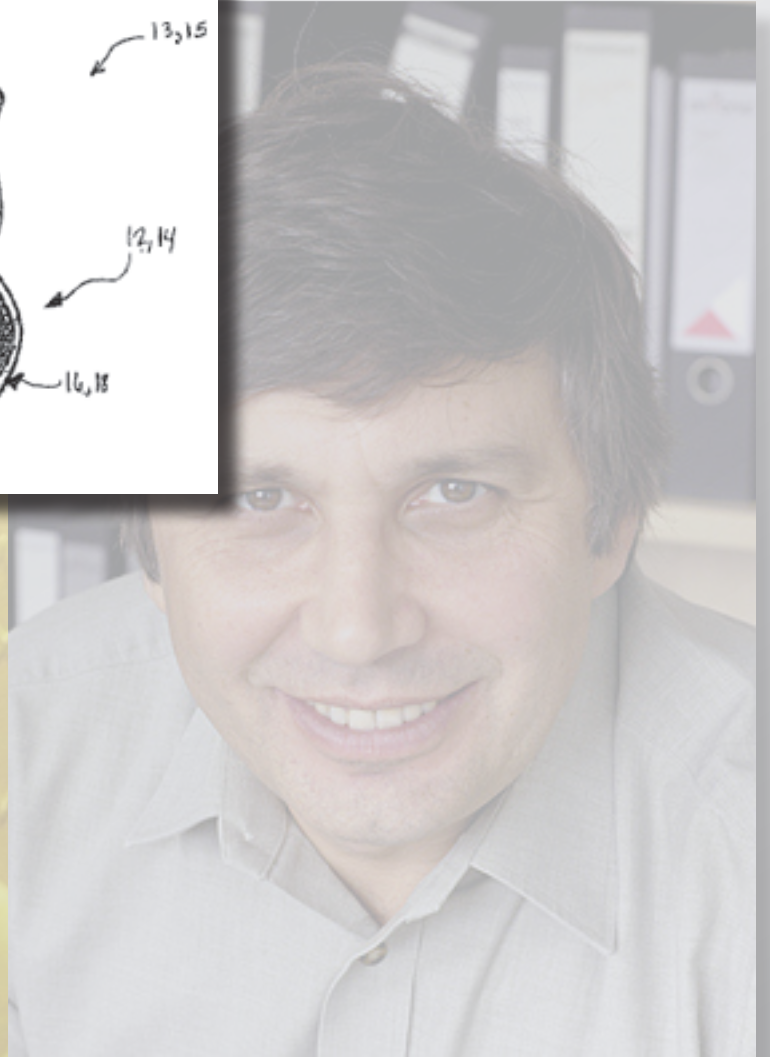
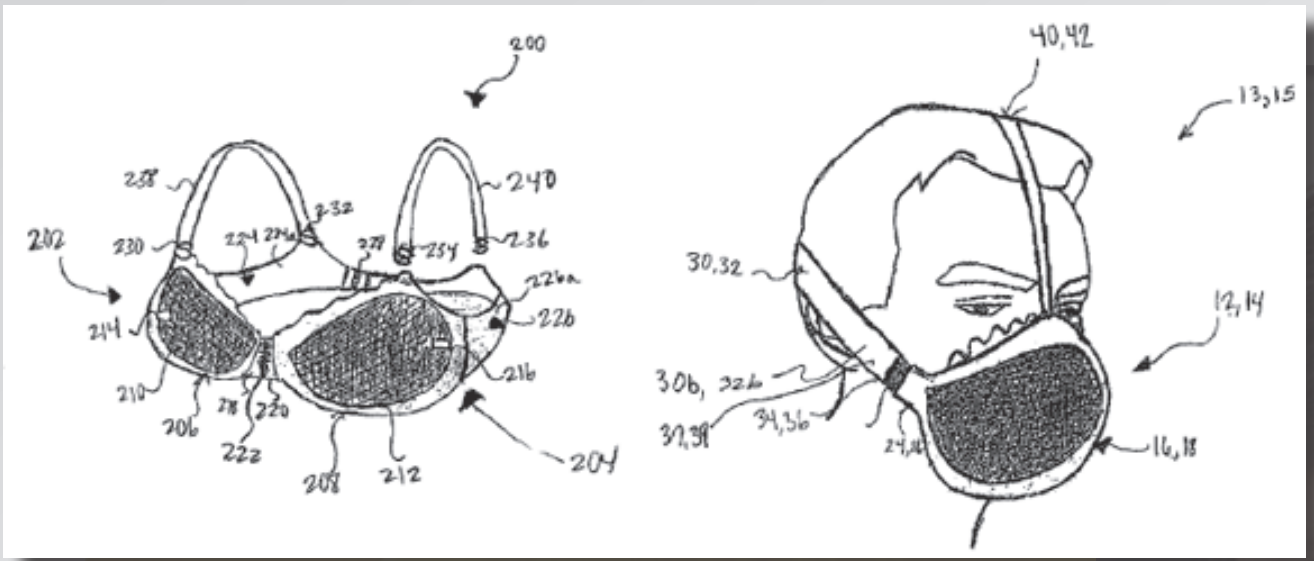
Nobel Prize in Physics 2010

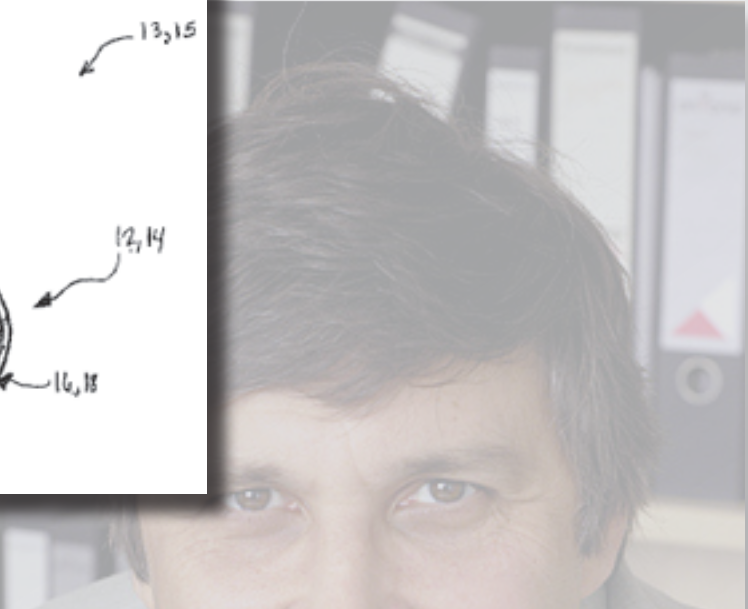
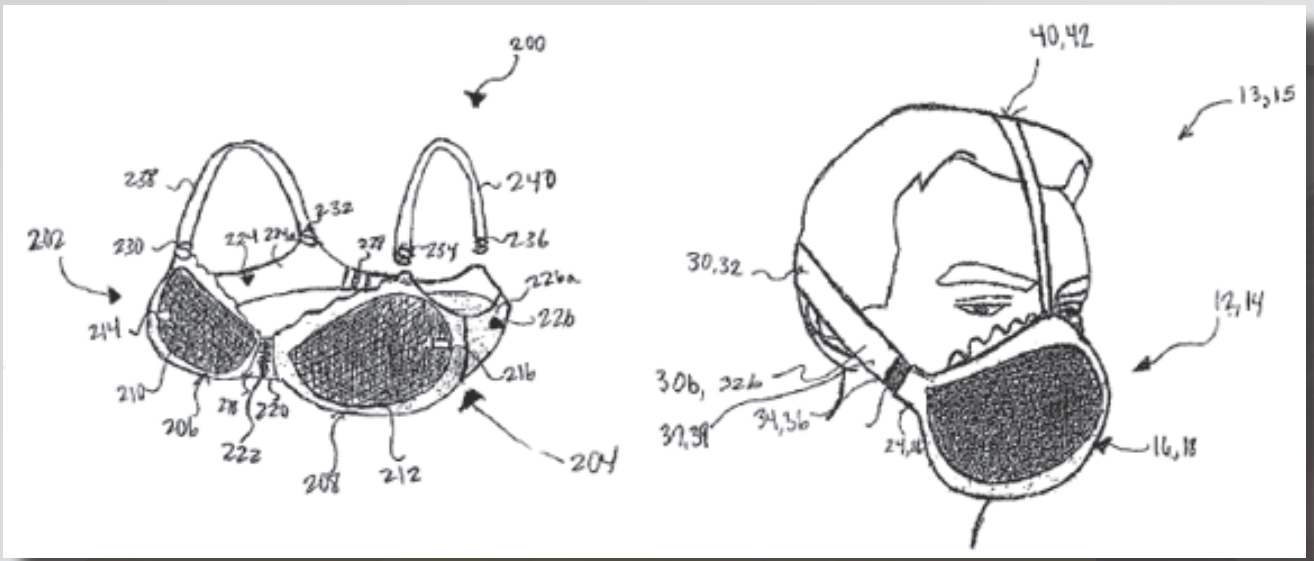


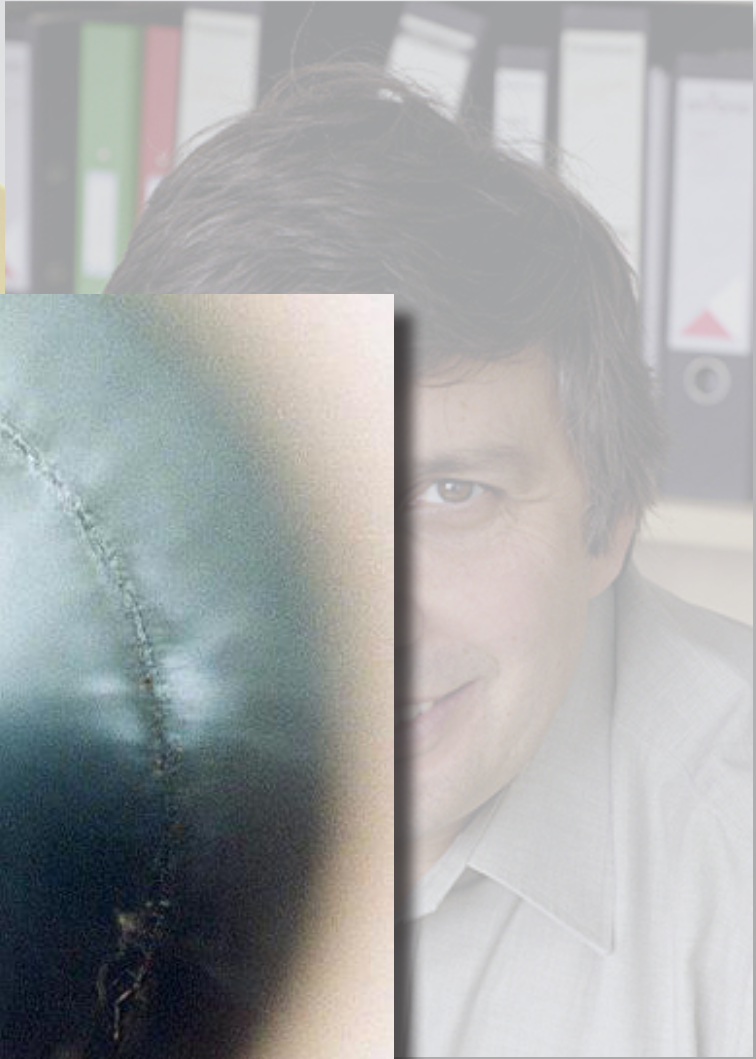
Nobel Prize in Physics 2010

Ig Nobel Prize in 2000



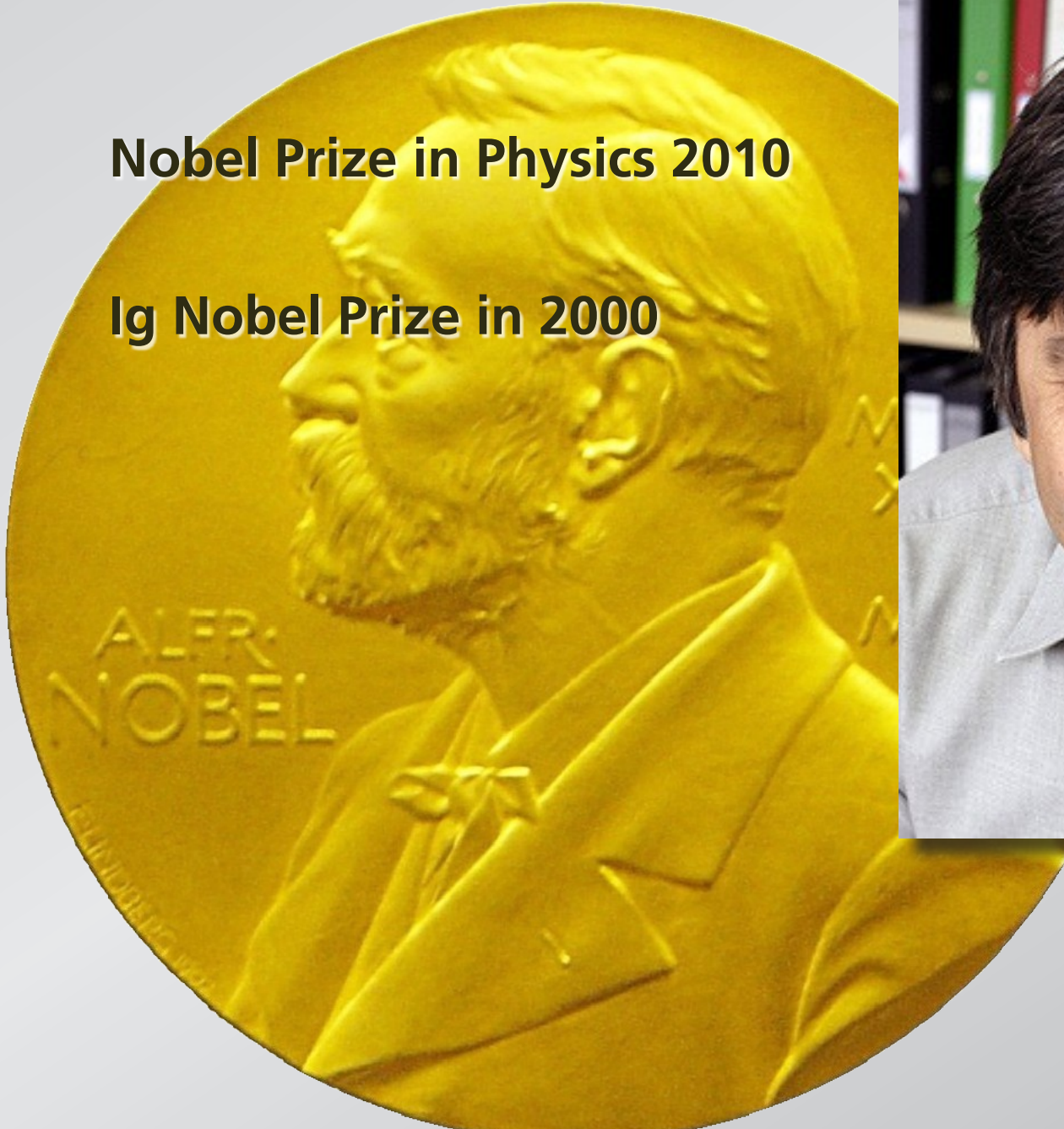




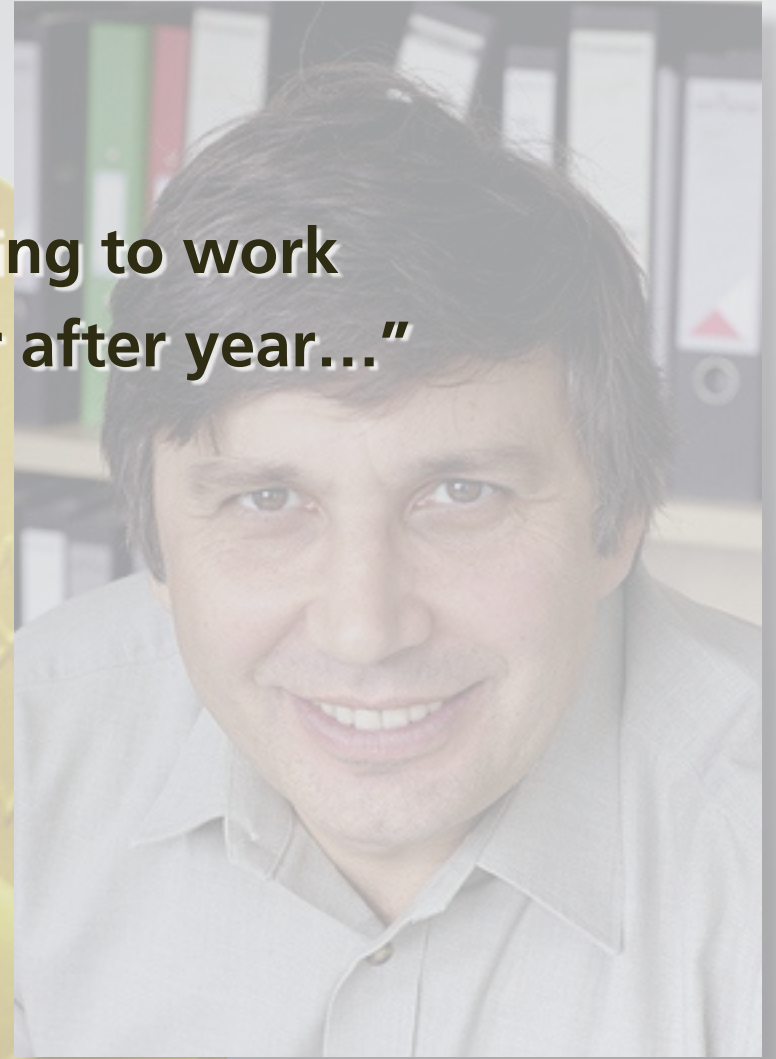


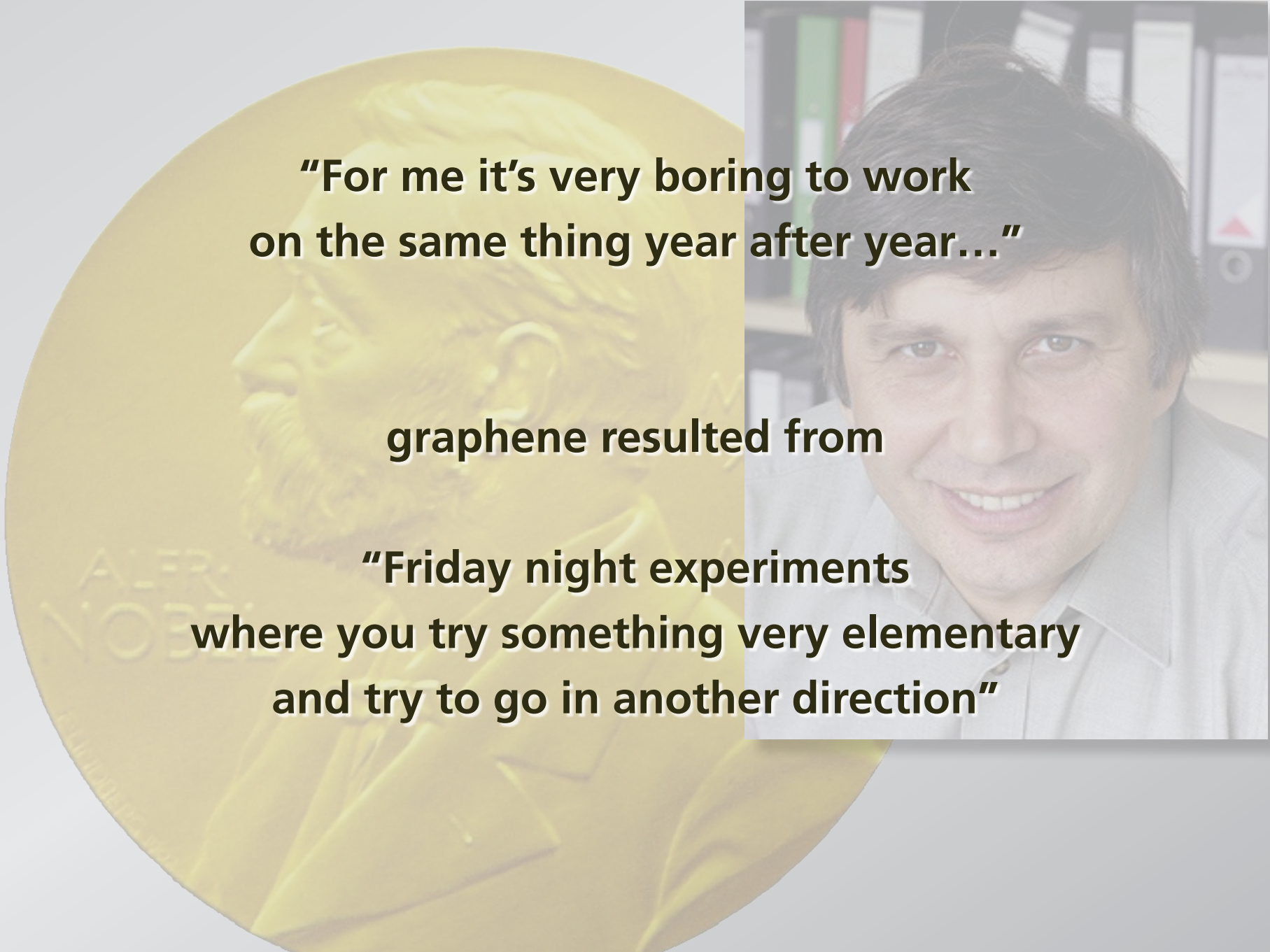
Nobel Prize in Physics 2010

Ig Nobel Prize in 2000



**“For me it’s very boring to work
on the same thing year after year...”**





**“For me it’s very boring to work
on the same thing year after year...”**

graphene resulted from

**“Friday night experiments
where you try something very elementary
and try to go in another direction”**

A glowing lightbulb with a warm, yellow-orange light emanating from it. The bulb is centered in the frame, and its glass is slightly textured. The filament is visible at the bottom. The background is a soft, gradient of yellow and orange, matching the light from the bulb. The text "how can we foster/teach innovation?" is centered on the bulb's surface.

how can we foster/teach innovation?



Need to...

- **teach *problem* solving**
- **encourage risk taking**



- no ON/OFF button
- only last "click" counts
- display shows recorded answer



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unique ID on back of clicker



Think of something you are good at

EDUCACION

Think of something you are good at

How did you become good at this?

EDUCACION

Became good at it by:

- 1. trial and error**
- 2. lectures**
- 3. practicing**
- 4. apprenticeship**
- 5. other**

EDUCACION





What are the factors that determine the rate of a chemical reaction? How do we measure the rate of a reaction? How do we determine the order of a reaction? How do we determine the activation energy of a reaction?

Rate of reaction = $\frac{1}{V} \frac{d[A]}{dt}$

Chemical reaction: $A + B \rightarrow C + D$

Rate of reaction: $r = -\frac{1}{V} \frac{d[A]}{dt} = -\frac{1}{V} \frac{d[B]}{dt} = \frac{1}{V} \frac{d[C]}{dt} = \frac{1}{V} \frac{d[D]}{dt}$

Order of reaction: $r = k[A]^m[B]^n$

Activation energy: $\ln k = \ln A - \frac{E_a}{RT}$

Half-life: $t_{1/2} = \frac{\ln 2}{k}$

Arrhenius equation: $\ln k = \ln A - \frac{E_a}{RT}$







Fought







1 education

2 PI



1 education

2 PI

3 test



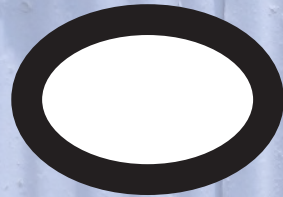
**better pay
attention!**

1 education

2 PI

3 test

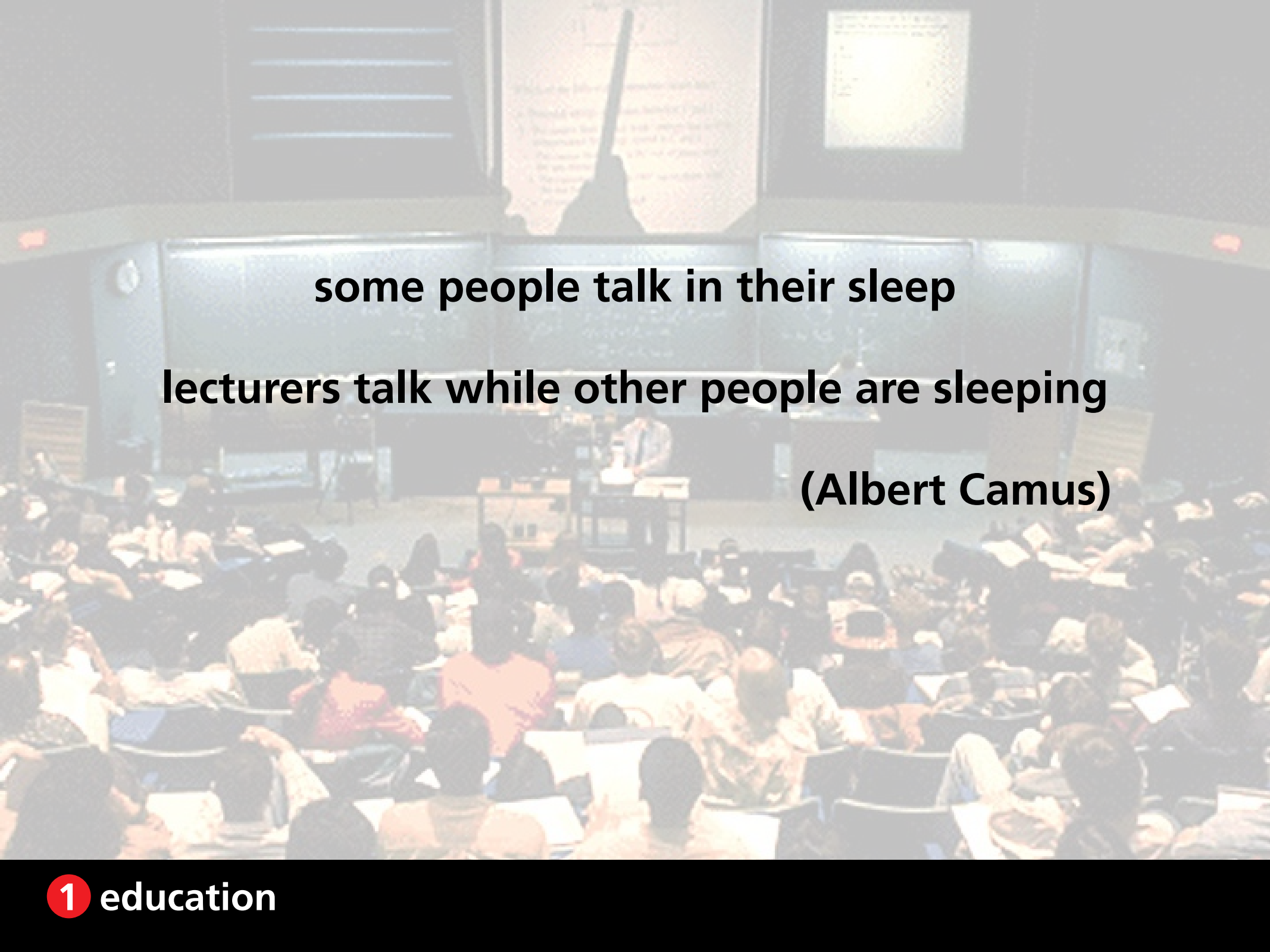
**What happens
in a lecture?**





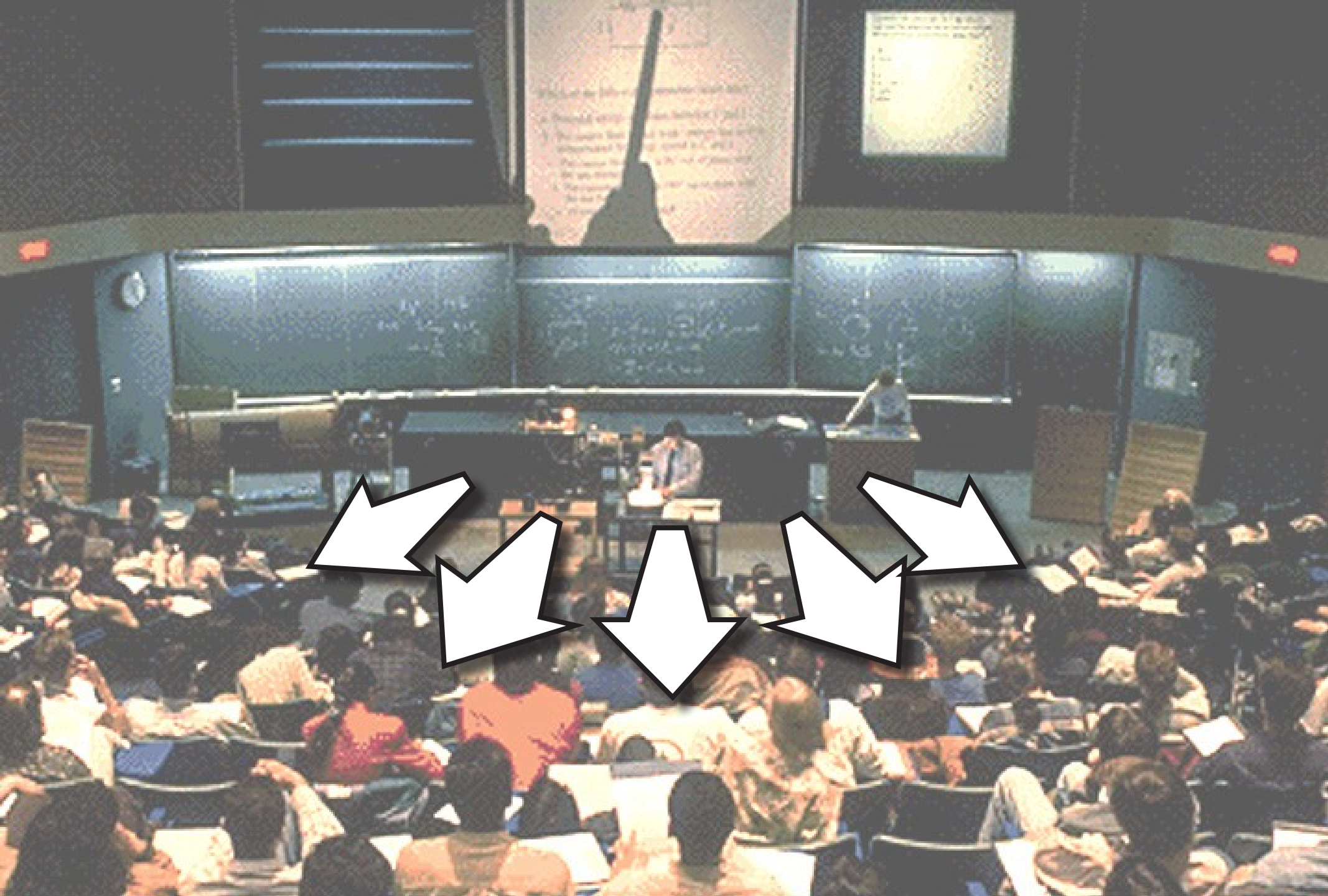
A large lecture hall with a professor at a podium and students in the audience. The professor is standing at a podium in the center of the stage, facing the audience. The audience is seated in rows of chairs, filling the room. The room has a curved wall and a large screen at the front. The text "some people talk in their sleep" is overlaid on the image.

some people talk in their sleep

A large lecture hall with a lecturer at a podium and an audience of students. The room is filled with people, many of whom appear to be sleeping or resting. The lecturer is standing at a podium in the center, facing the audience. The audience is seated in rows of chairs, and many people have their heads down or are looking away. The room has a high ceiling and large windows. The text is overlaid on the image.

some people talk in their sleep
lecturers talk while other people are sleeping
(Albert Camus)





The result?

EDUCACION

Lack of learning

EDUCACION

Lack of learning

Lack of retention

assessment promotes memorization and stifles creativity

EDUCACION

problem

EDUCACION

problem

outcome

EDUCACION

problem

solution

outcome

EDUCACION

problem

solution

outcome

KNOWN

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

problem

EDUCACION

problem

solution

outcome

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KNOWN

problem

procedure

EDUCACION

problem

solution

outcome

UNKNOWN

problem

procedure

answer

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solution

outcome

UNKNOWN

KNOWN

problem

procedure

answer

KNOWN

problem

solution

outcome

UNKNOWN

KNOWN

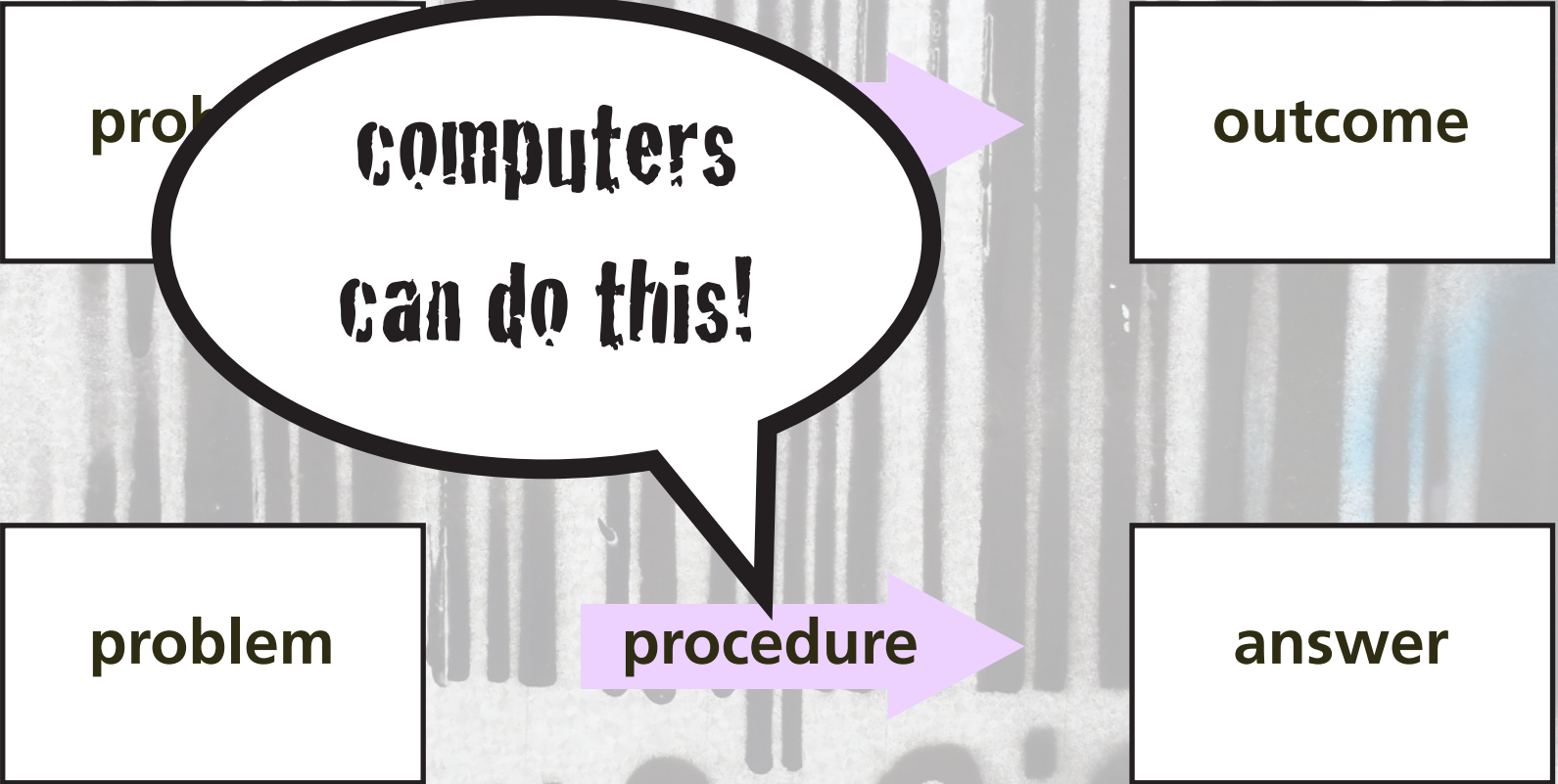
problem

procedure

answer

KNOWN

UNKNOWN



problem

solution

outcome

problem

pre... ver

REAL
problem solving

problem

approach 1

approach 3

approach 2

outcome

EDUCACION

problem

approach 1

approach 3

approach 2

outcome

assessment incompatible with real problem solving

EDUCACION

Traditional assesement

- focuses on outcome, not process

EDUCACION

Traditional assesement

- focuses on outcome, not process
- discourages risk taking

EDUCACION

Traditional assesement

- focuses on outcome, not process
- discourages risk taking
- focuses on individual, not group

EDUCACION

Traditional assesement

- **focuses on outcome, not process**
- **discourages risk taking**
- **focuses on individual, not group**
- **does not mirror future work environment**





1 education

2 PI



1. transfer of information



1. transfer of information

2. assimilation of that information




1. transfer of information (in class)

2. assimilation of that information



1. transfer of information (in class)

2. assimilation of that information (out of class)



**Should focus
on THIS!**

1. transfer of information (in class)

2. assimilation of that information (out of class)



1. transfer of information (in class)

2. assimilation of that information (out of class)



1. transfer of information (out of class)

2. assimilation of that information (in class)

Peer



1. transfer of information (out of class)

2. assimilation of that information (in class)

INSTRUCTION

question

1 education

2 PI

question



think

question



think



poll

question



think



poll



discuss

question



think



poll



discuss



repoll

question



think



poll



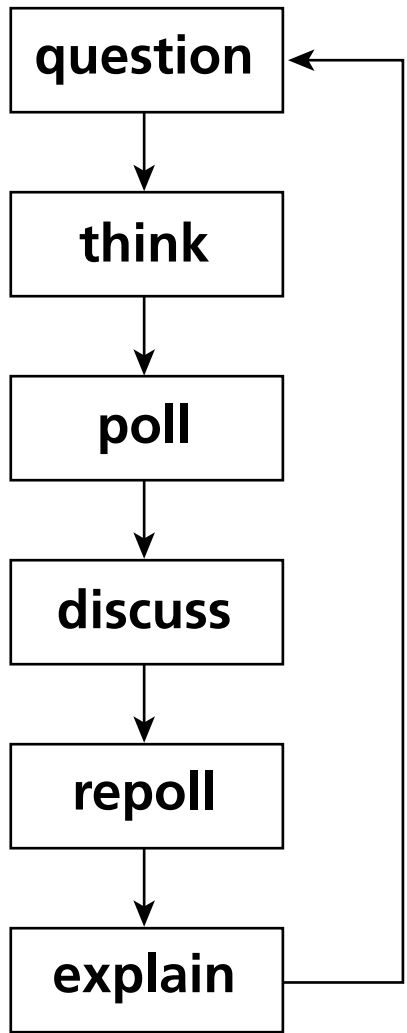
discuss

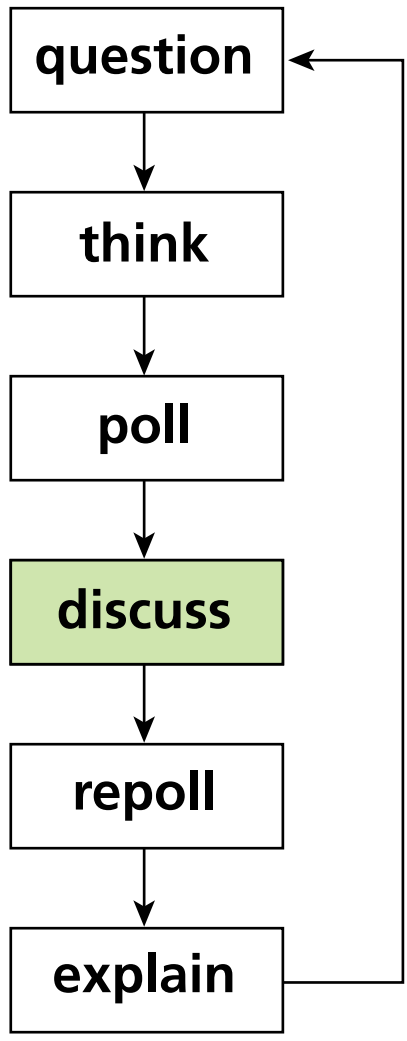


repoll



explain





1 lecture

2 PI

Let's try it!

QUESTION

think

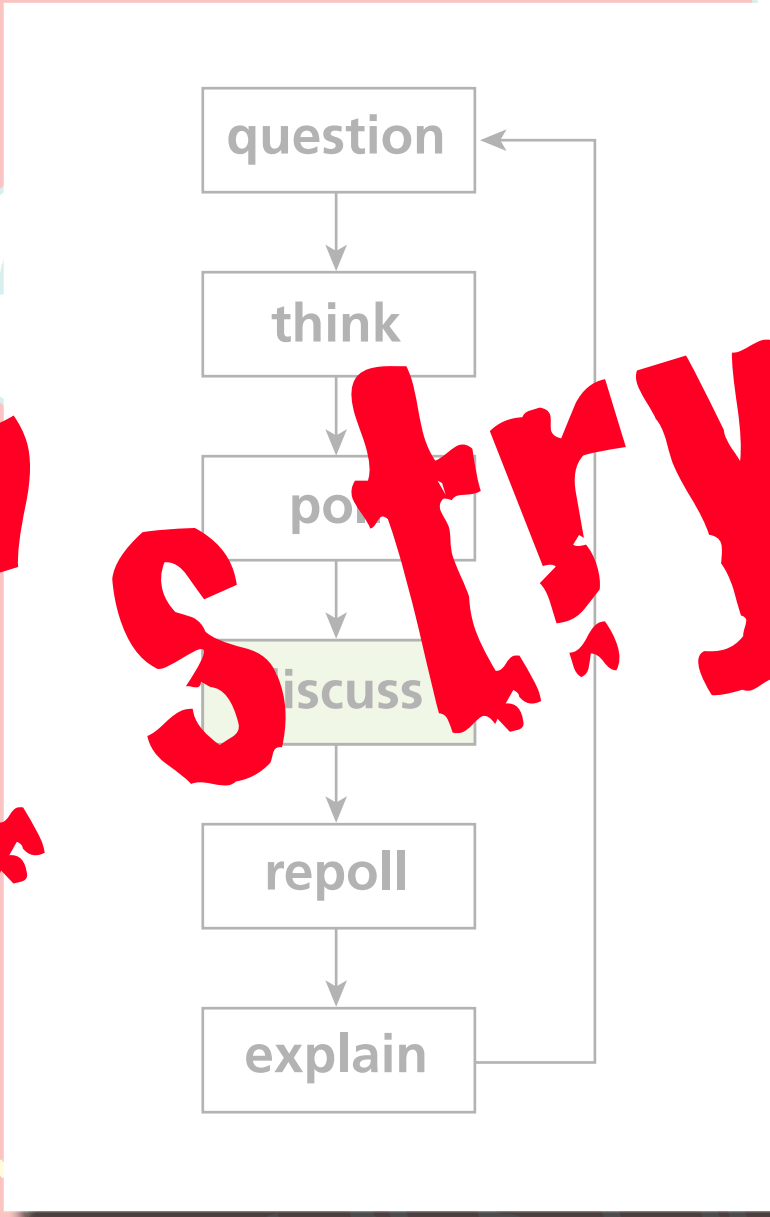
poll

discuss

repoll

explain

ACTION

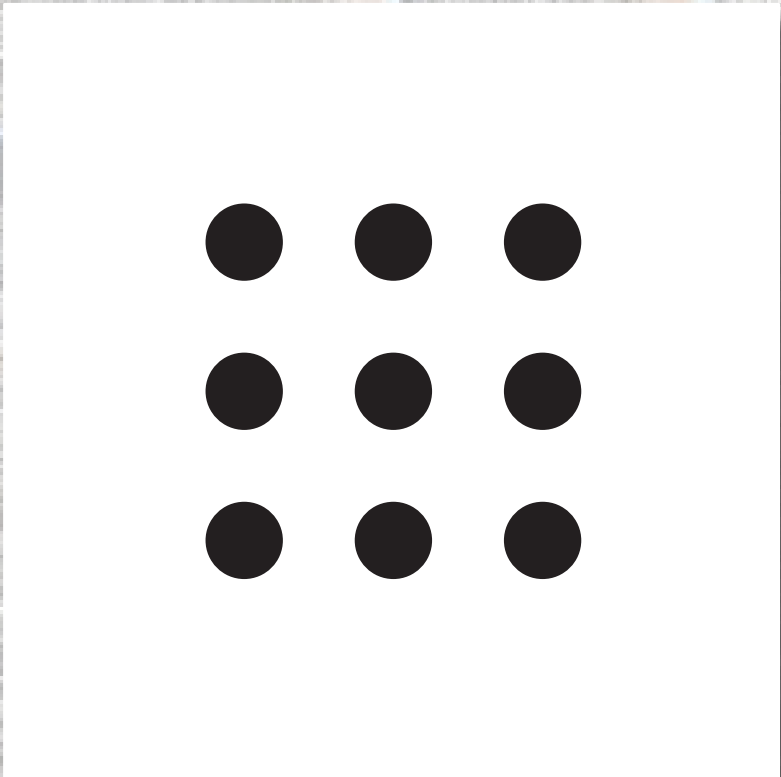


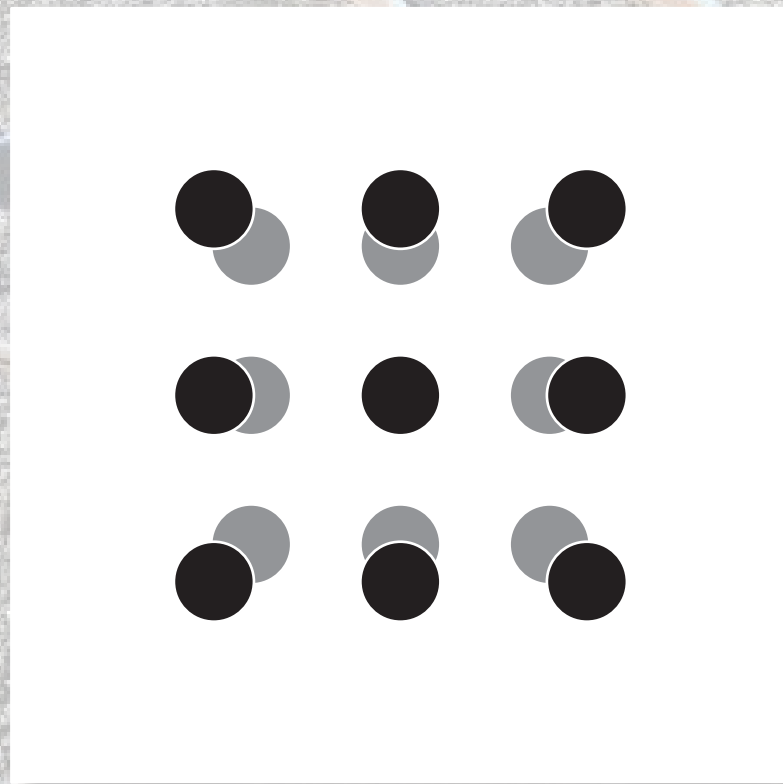
1 education

2 PI

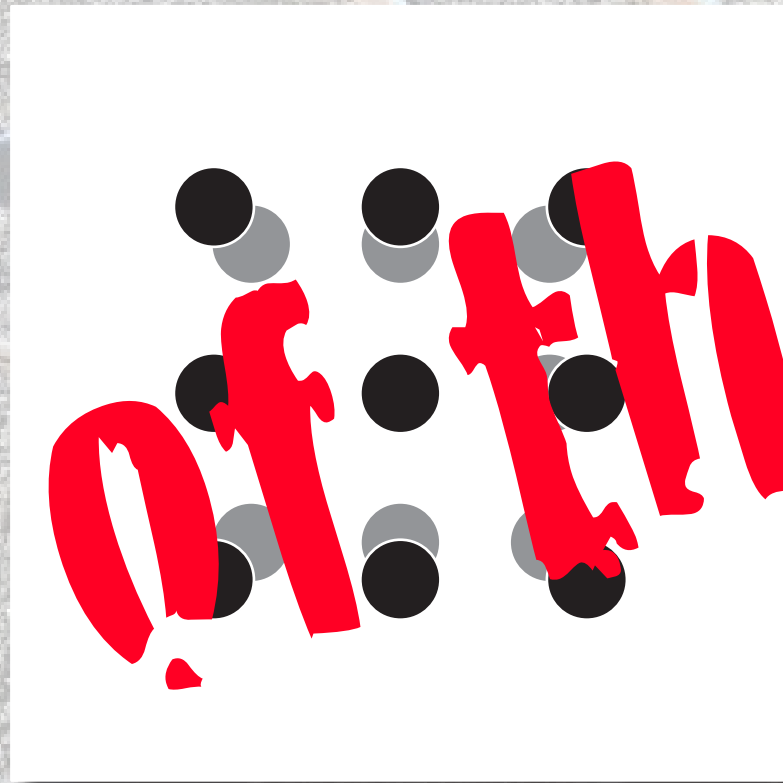


thermal expansion





all of them



1 education

2 PI

all of them!

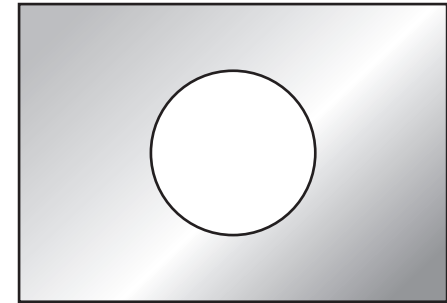


1 education

2 PI

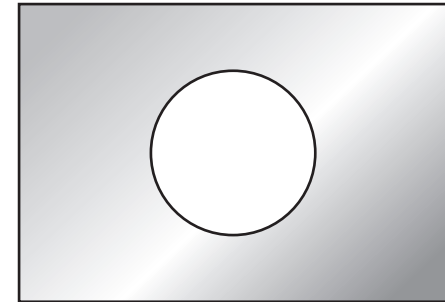
3 test?

**Consider a rectangular metal plate
with a circular hole in it.**



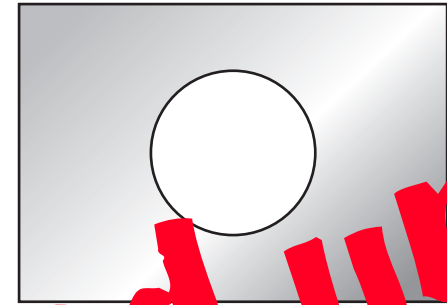
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole



- 1. increases.**
- 2. stays the same.**
- 3. decreases.**

Consider a rectangular metal plate with a circular hole in it.



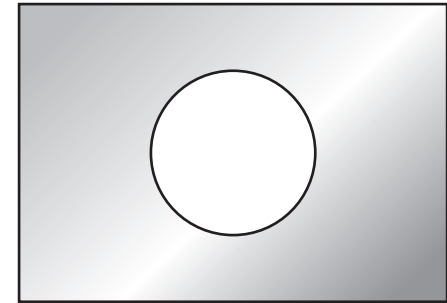
When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.

you got all fired up!

Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole



- 1. increases.**
- 2. stays the same.**
- 3. decreases.**

Before I tell you the answer...

1 education

2 PI

3 test

Before I tell you the answer, let's analyze what happened.

1 education

2 PI

3 test

Before I tell you the answer, let's analyze what happened.

You...

1. made a commitment

Before I tell you the answer, let's analyze what happened.

You...

- 1. made a commitment**
- 2. externalized your answer**

Before I tell you the answer, let's analyze what happened.

You...

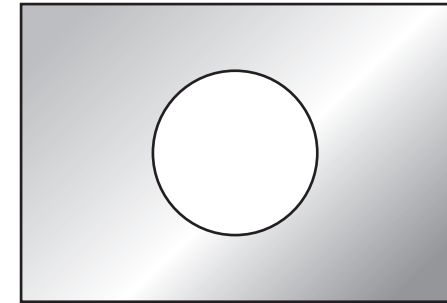
- 1. made a commitment**
- 2. externalized your answer**
- 3. moved from the answer/fact to reasoning**

Before I tell you the answer, let's analyze what happened.

You...

- 1. made a commitment**
- 2. externalized your answer**
- 3. moved from the answer/fact to reasoning**
- 4. became emotionally invested in the learning process**

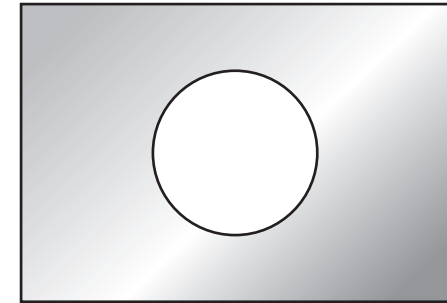
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When the plate is uniformly heated, the diameter of the hole

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- 2. stays the same.**
- 3. decreases.**

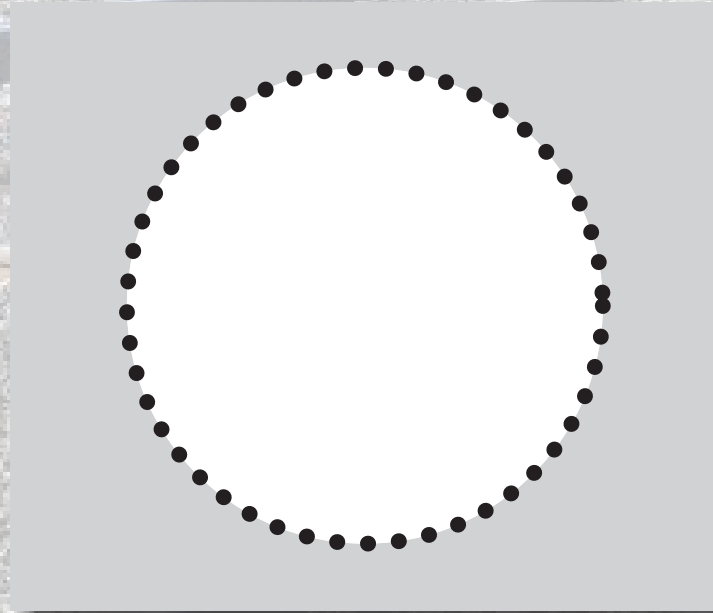
Consider a rectangular metal plate with a circular hole in it.



When the plate is uniformly heated, the diameter of the hole

1. increases. ✓
2. stays the same.
3. decreases.

consider atoms at rim of hole

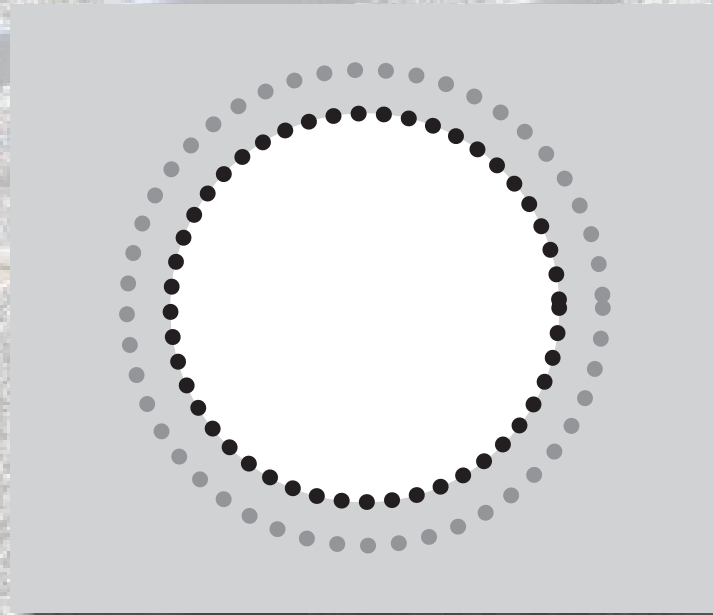


1 education

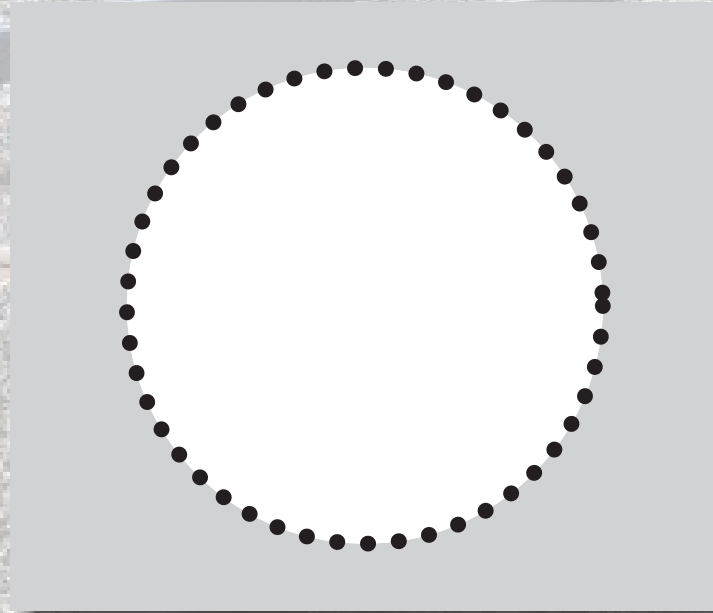
2 PI

3 test

consider atoms at rim of hole



consider atoms at rim of hole

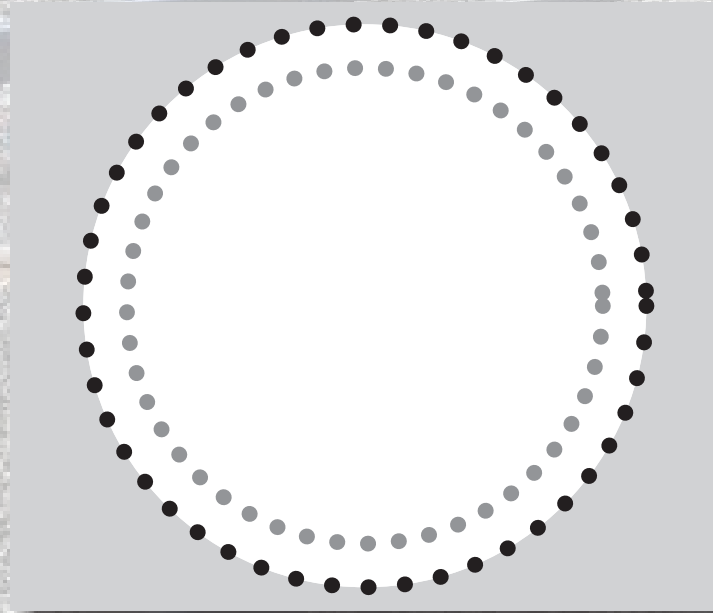


1 education

2 PI

3 test

consider atoms at rim of hole



1 education

2 PI

3 test

consider atoms at rim of hole

you won't forget this



1 education

2 PI

3 test

Peer

back to PI

INSTRUCTION

1 education

2 PI

3 test

Peer
Higher learning & gains

INSTRUCTION

1 education

2 PI

3 test

Higher learning gains

Better retention

INSTRUCTION

1 education

2 PI

3 test



1 education

2 PI

3 test

in a lecture, students...

1 education

2 PI

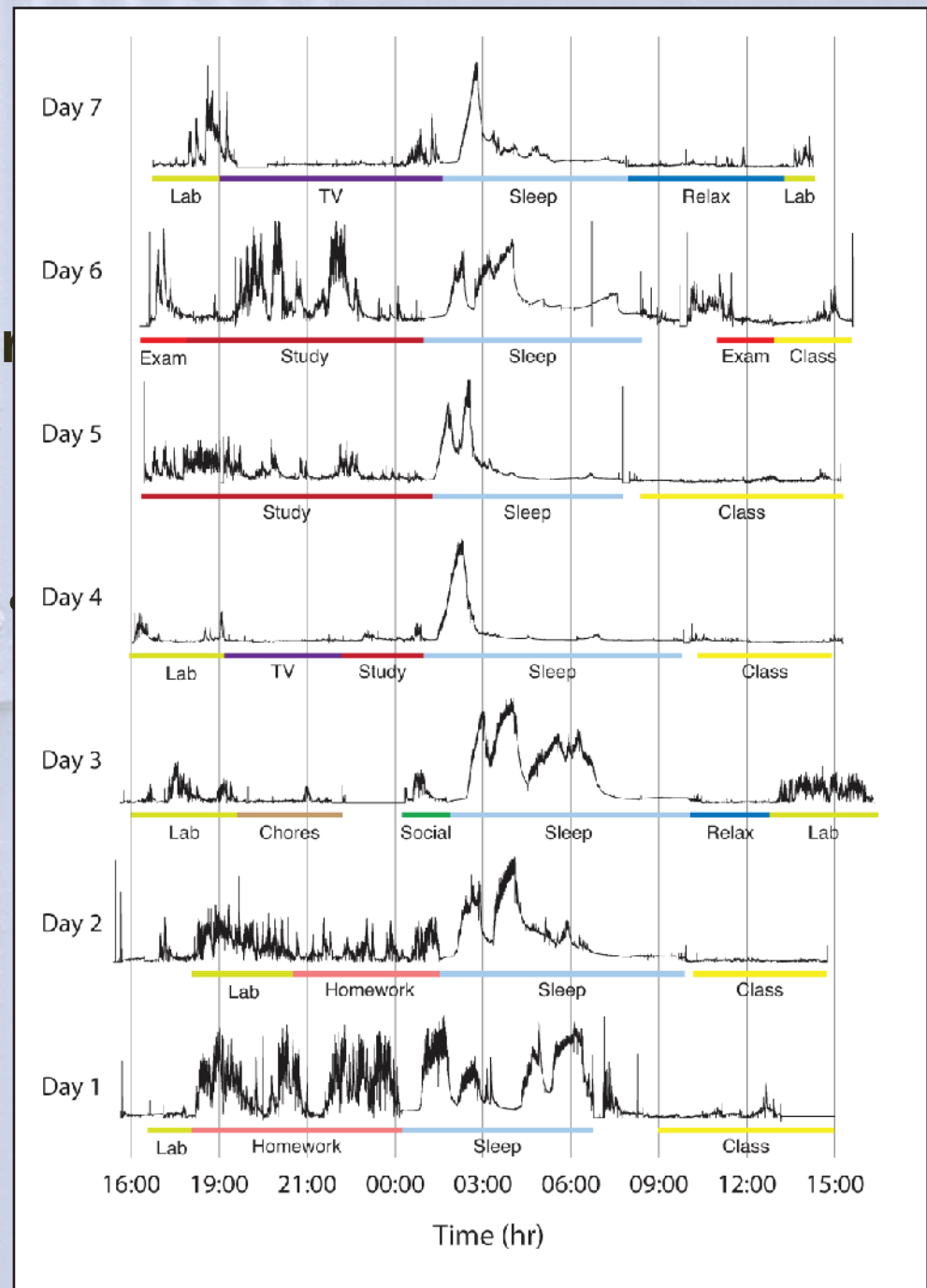
3 test

in a lecture, students...

1. don't pay utmost attention

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

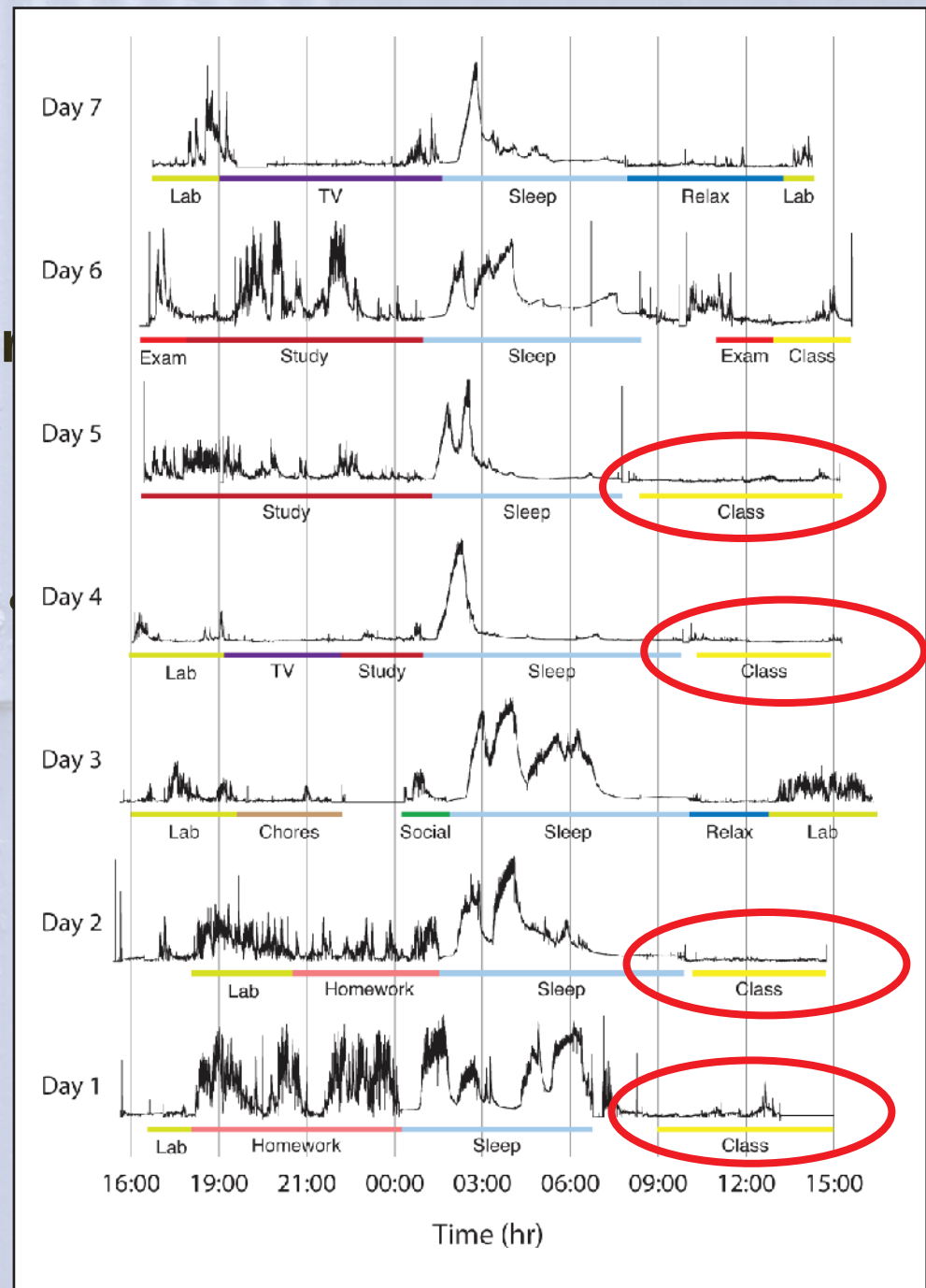
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



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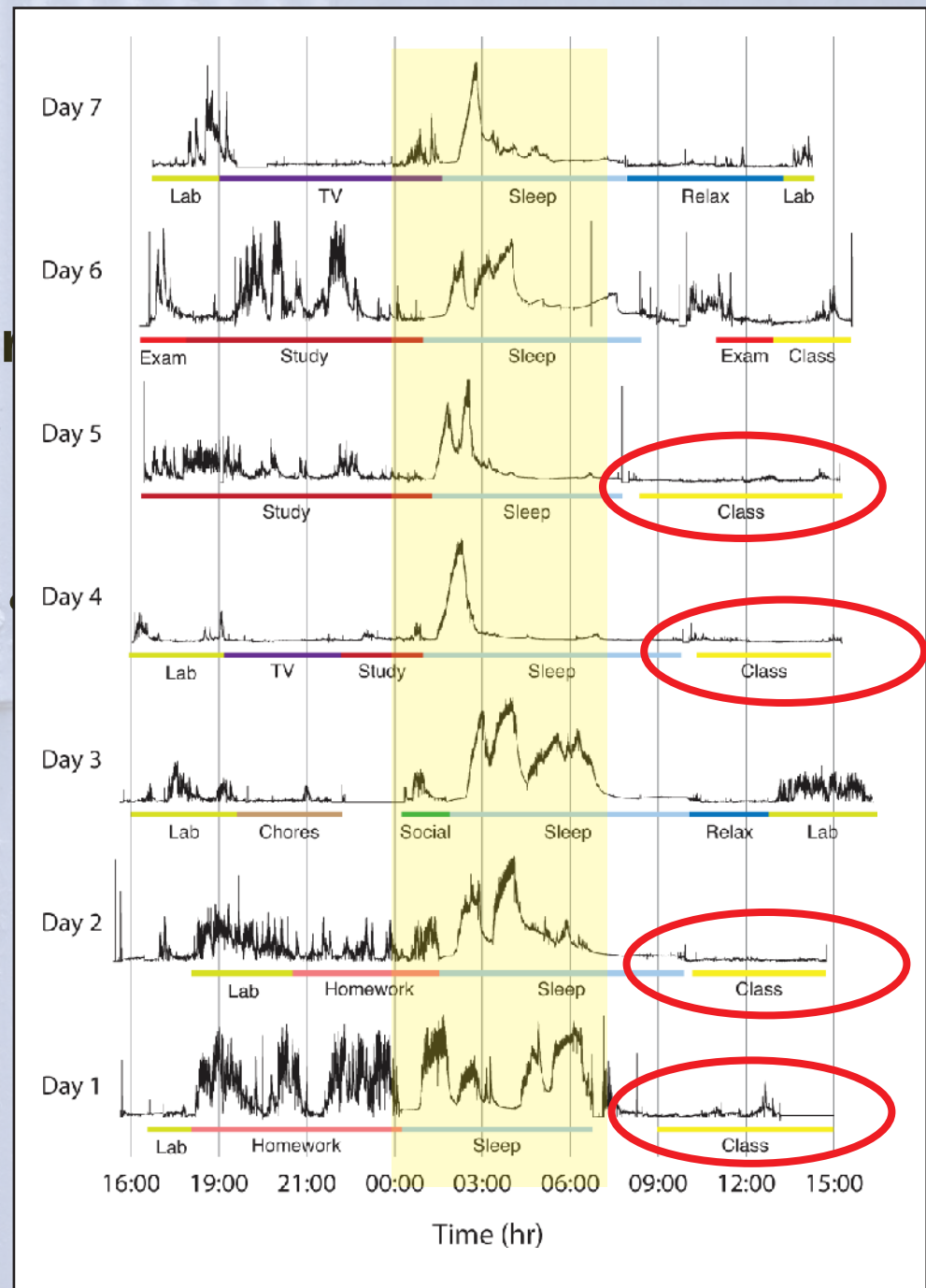
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



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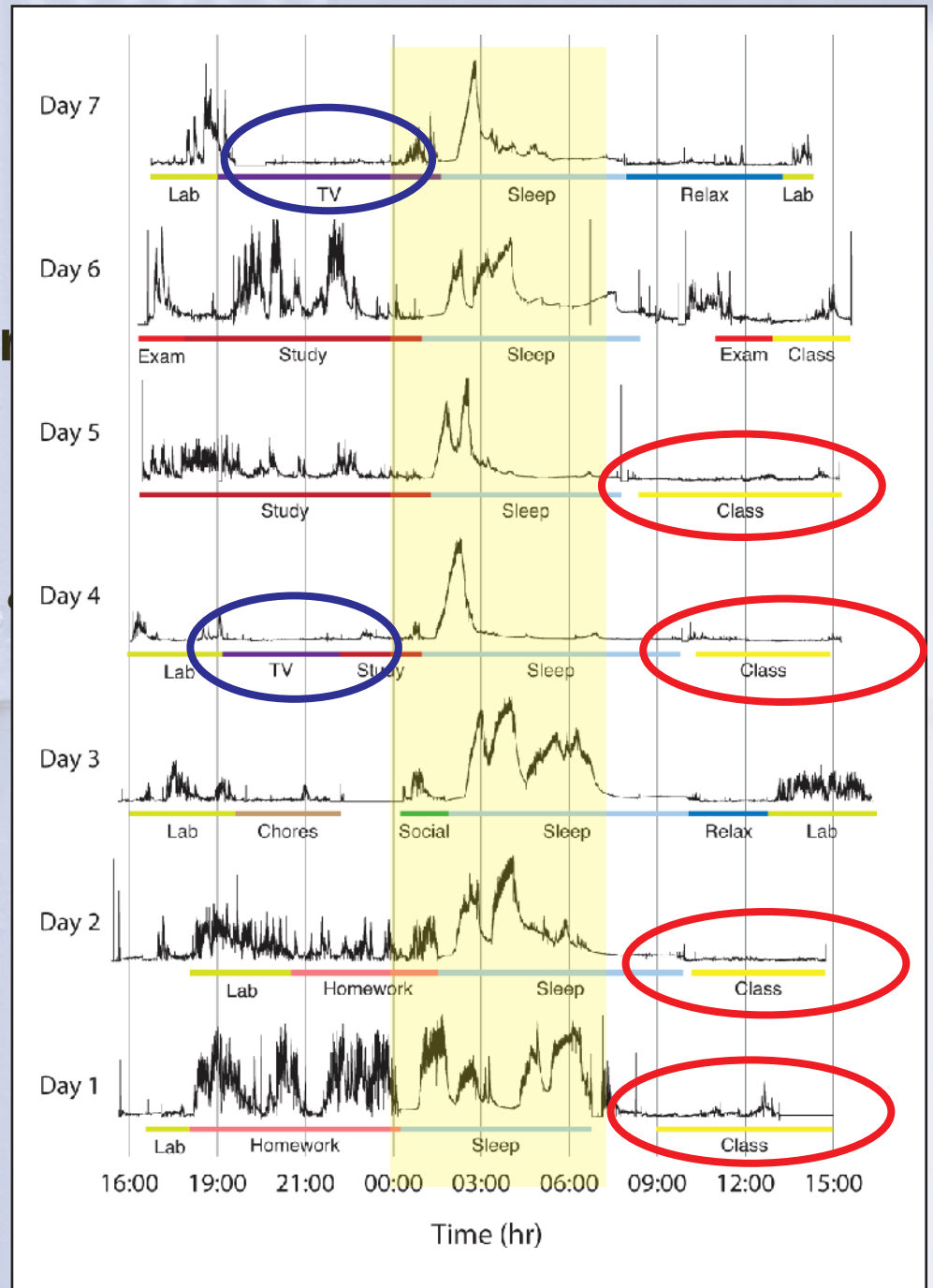
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

1 education

2 PI

3 test

in a lecture, students...

- 1. don't pay utmost attention**
- 2. think they know it**

in a lecture, students...

- 1. don't pay utmost attention**
- 2. think they know it**
- 3. are not confronted with misconceptions**

in a lecture, students...

1. don't pay utmost attention

2. think they know it

3. are not confronted with misconceptions

false
sense of security



1 education

2 PI

3 test



an illusion. . .

1 education

2 PI

3 test



Education is not just about:

- **transferring information**
- **getting students to do what we do**

1 education

2 PI

3 test



Education is not just about:

- **transferring information**
- **getting students to do what we do**

active participation a must!



With a simple change, Peer Instruction...

- teaches *real* problem solving
- encourages risk taking

1 education

2 PI

3 test

Funding:

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