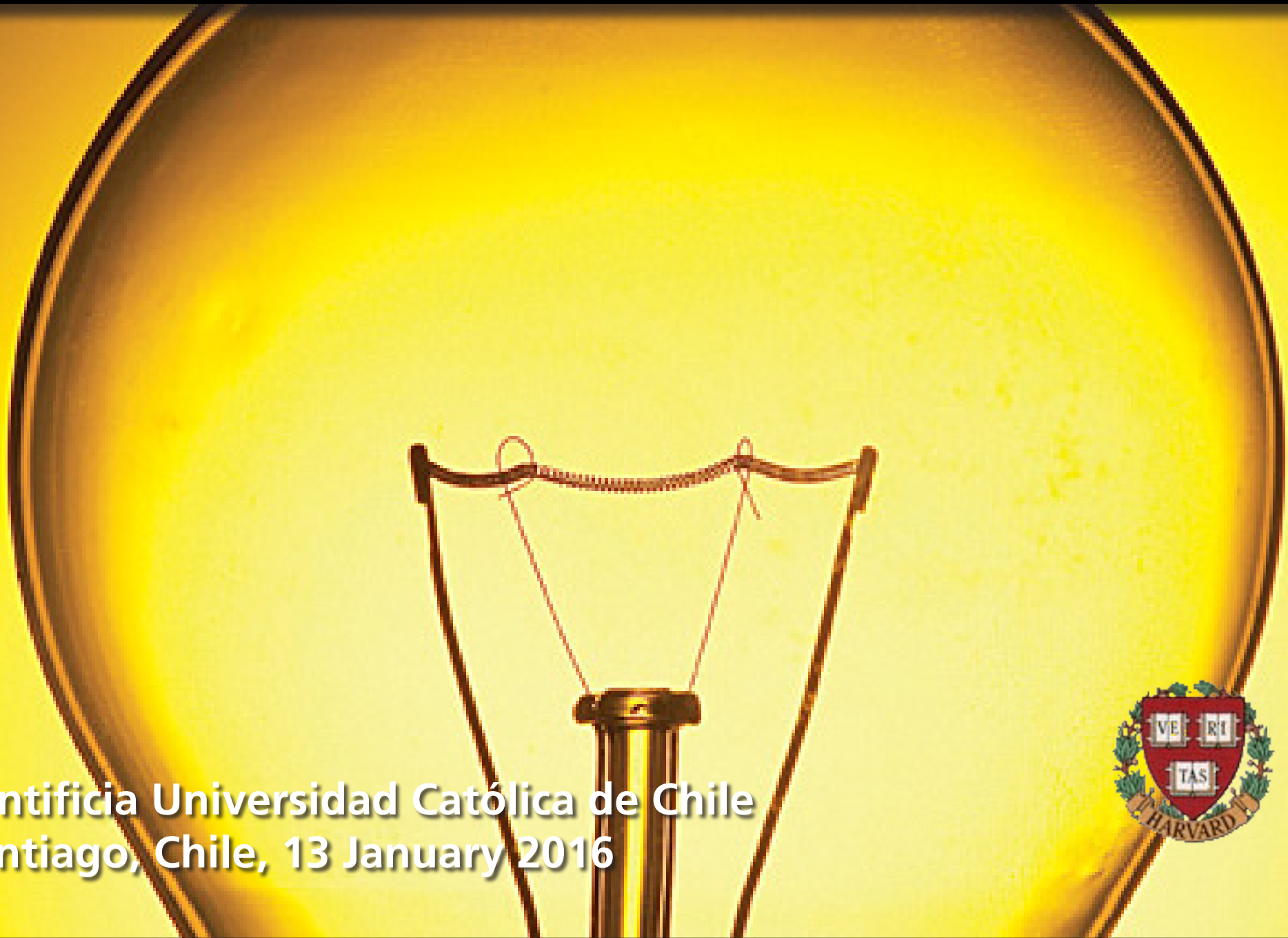
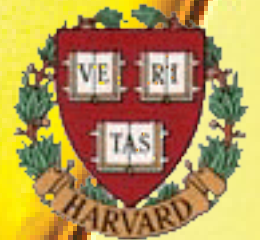


# Educating the innovators of the 21st century



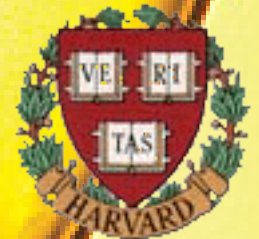
Pontificia Universidad Católica de Chile  
Santiago, Chile, 13 January 2016





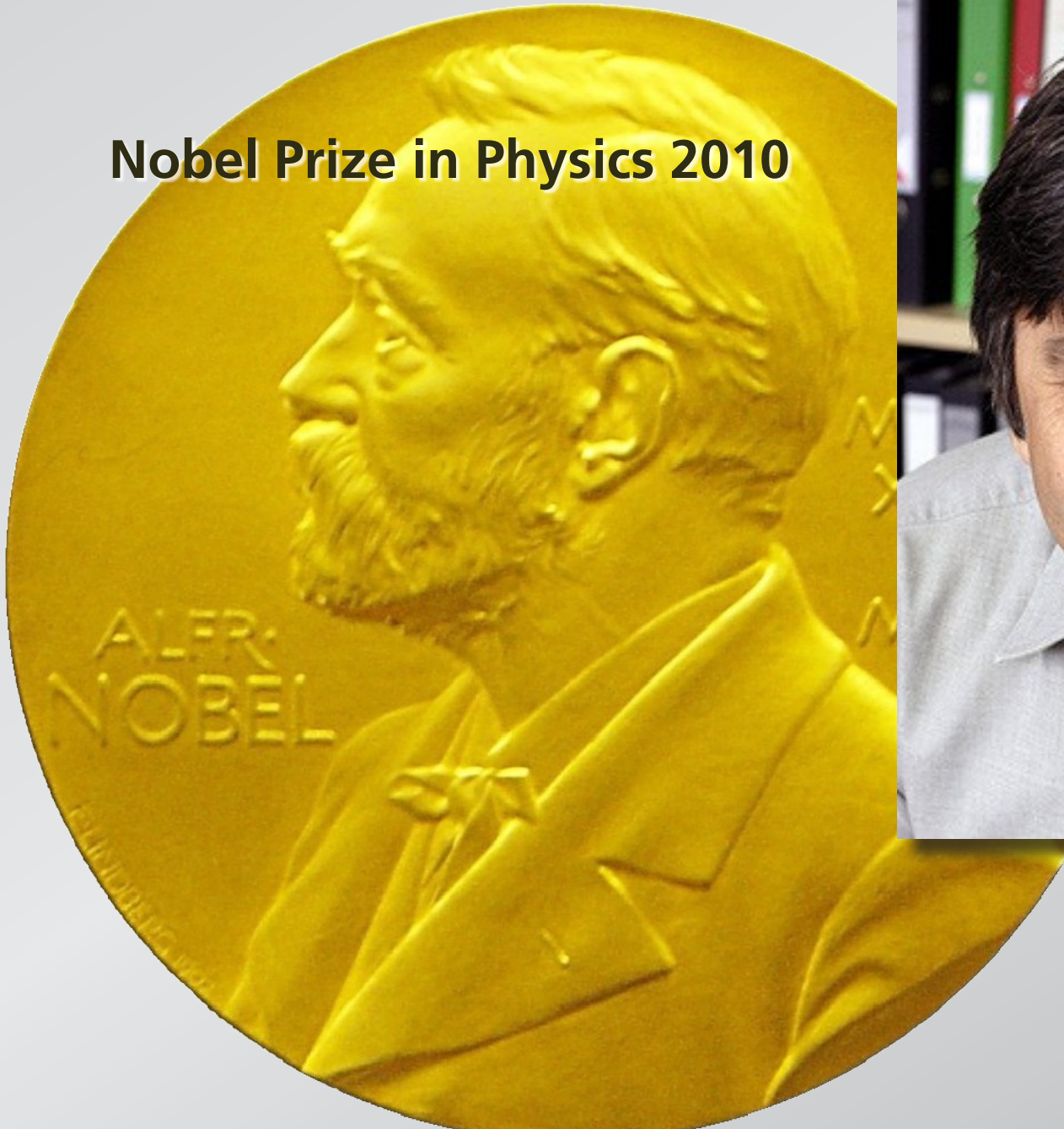
**@eric\_mazur**

Pontificia Universidad Católica de Chile  
Santiago, Chile, 13 January 2016



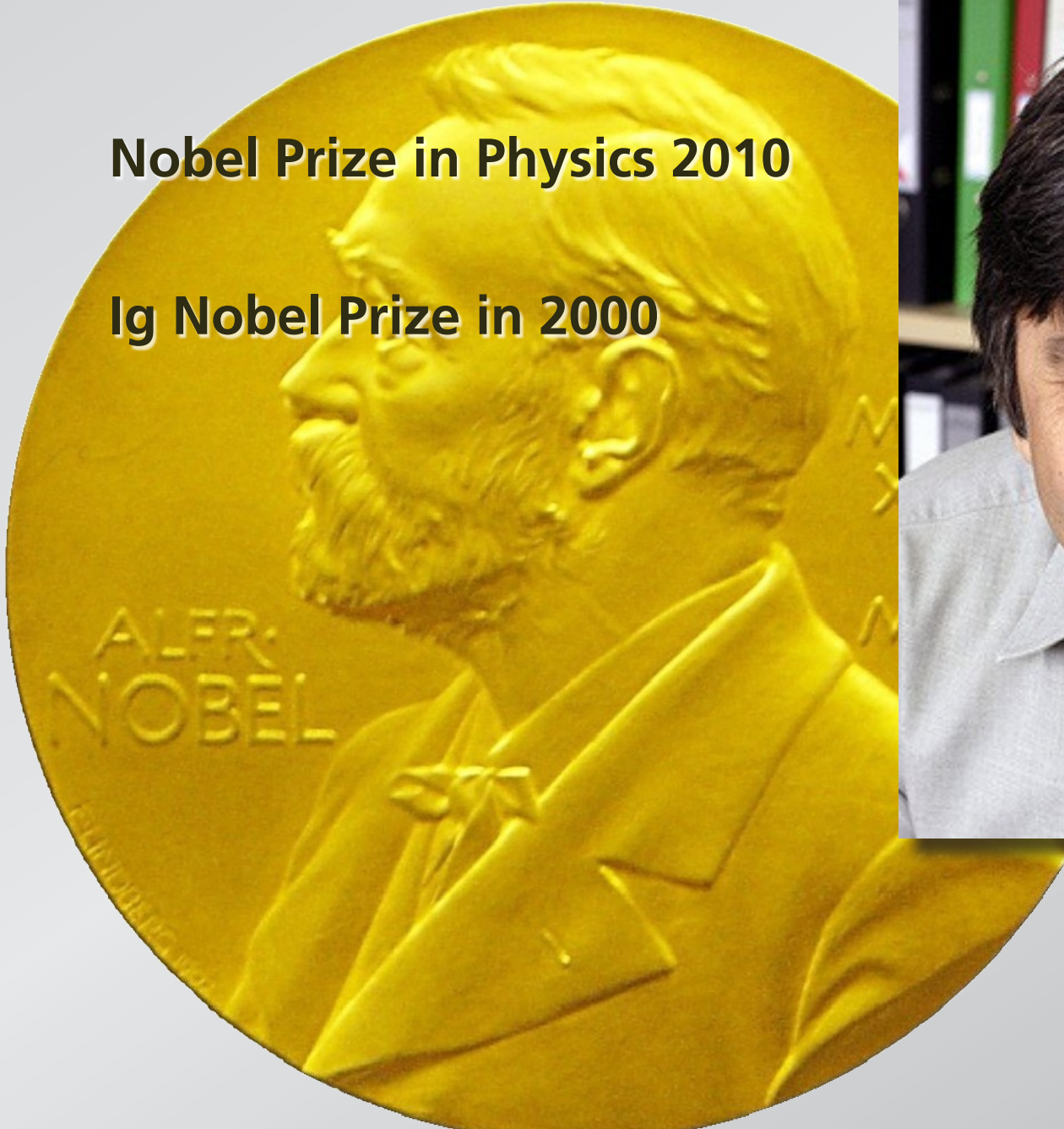
**Innovation**

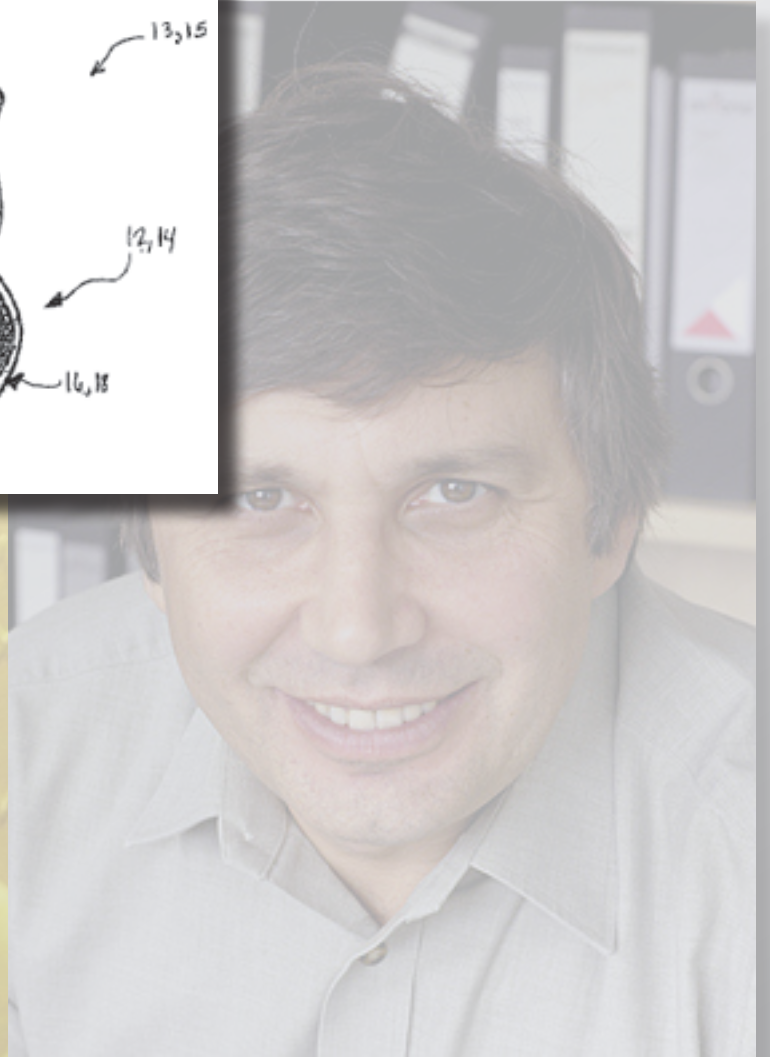
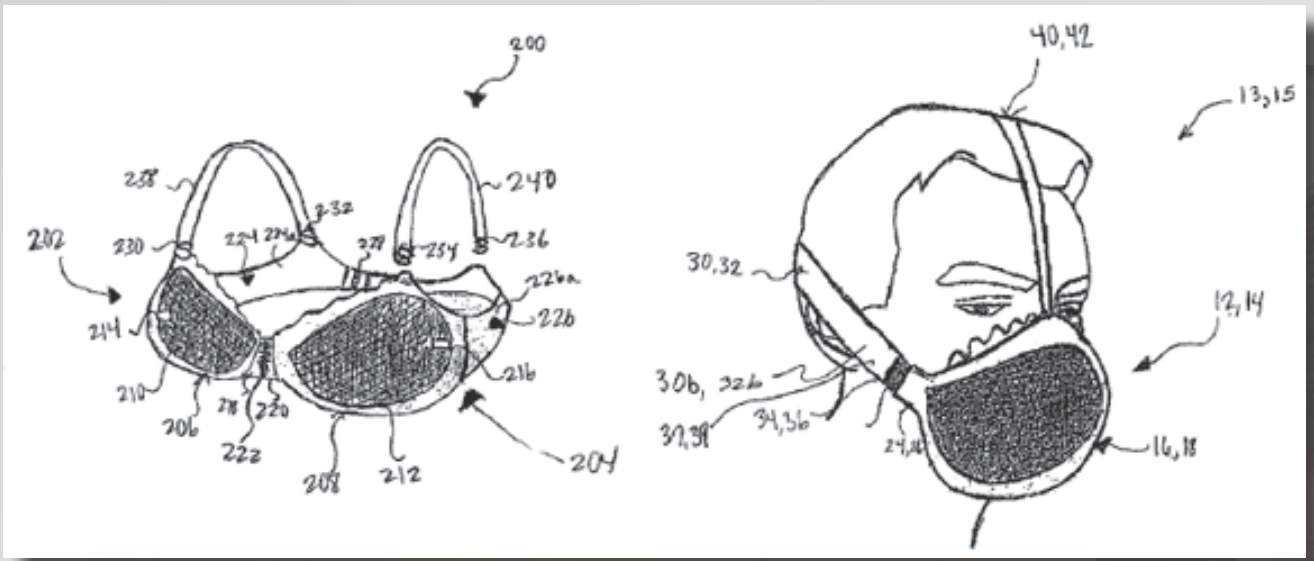
**Nobel Prize in Physics 2010**

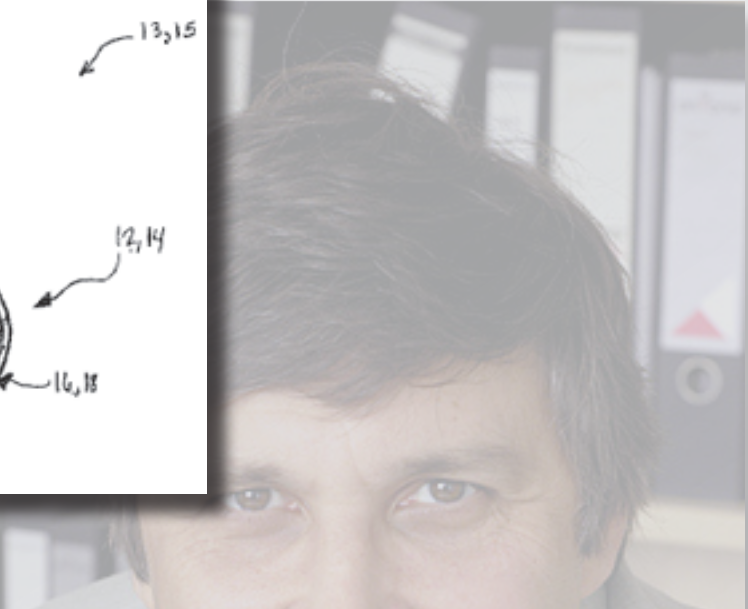
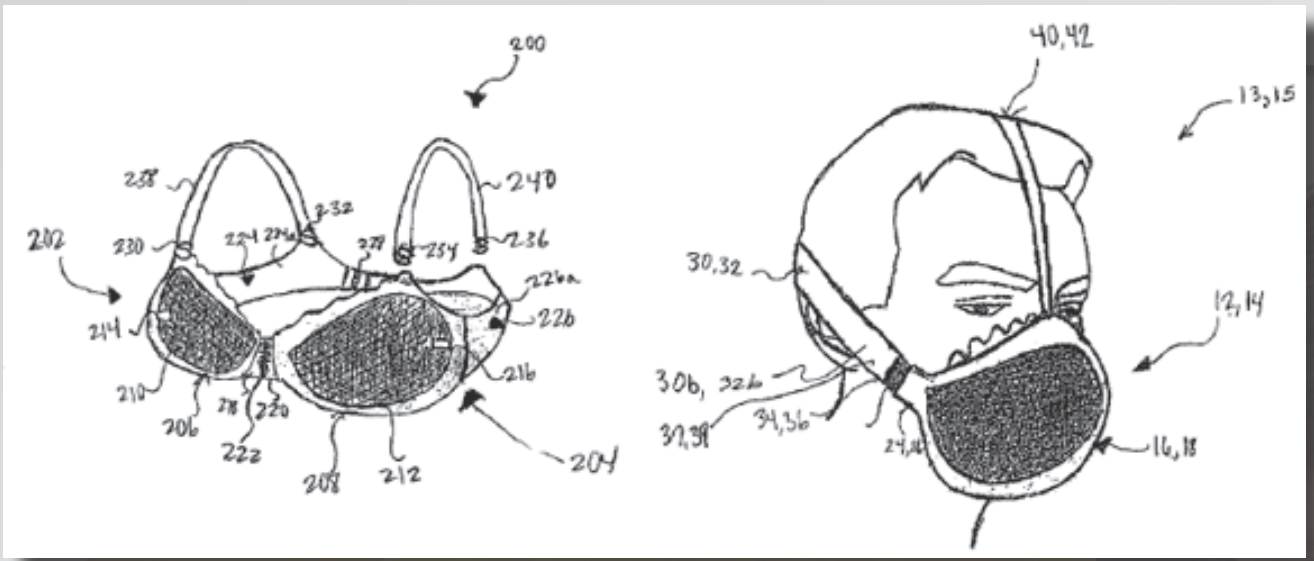


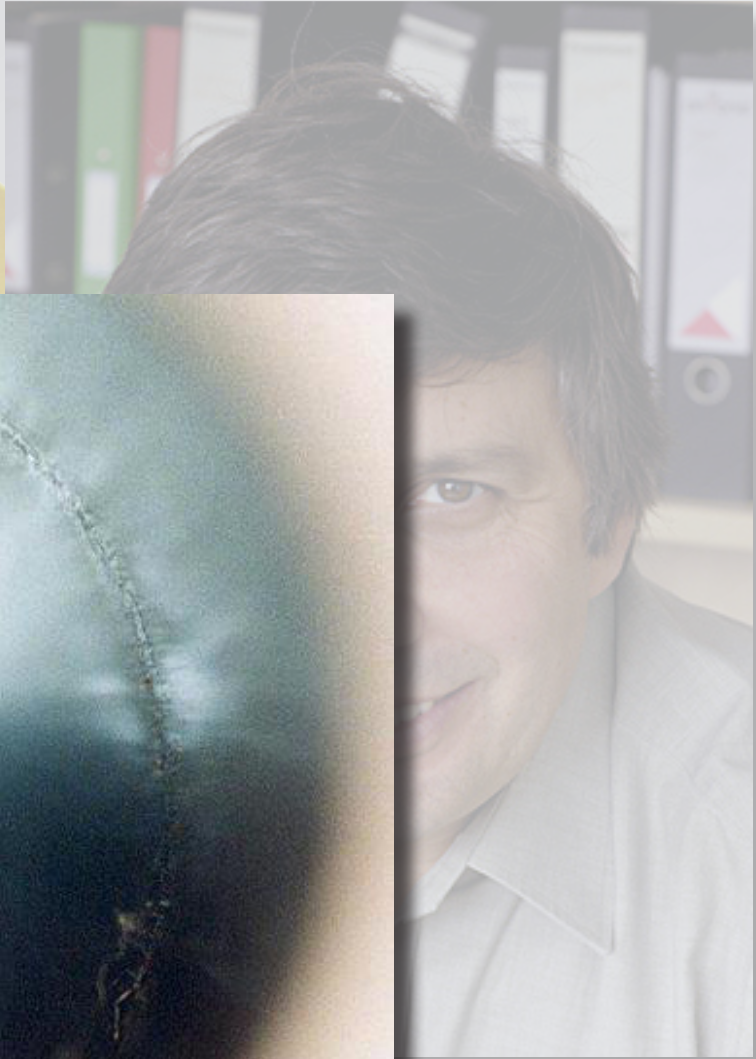
**Nobel Prize in Physics 2010**

**Ig Nobel Prize in 2000**





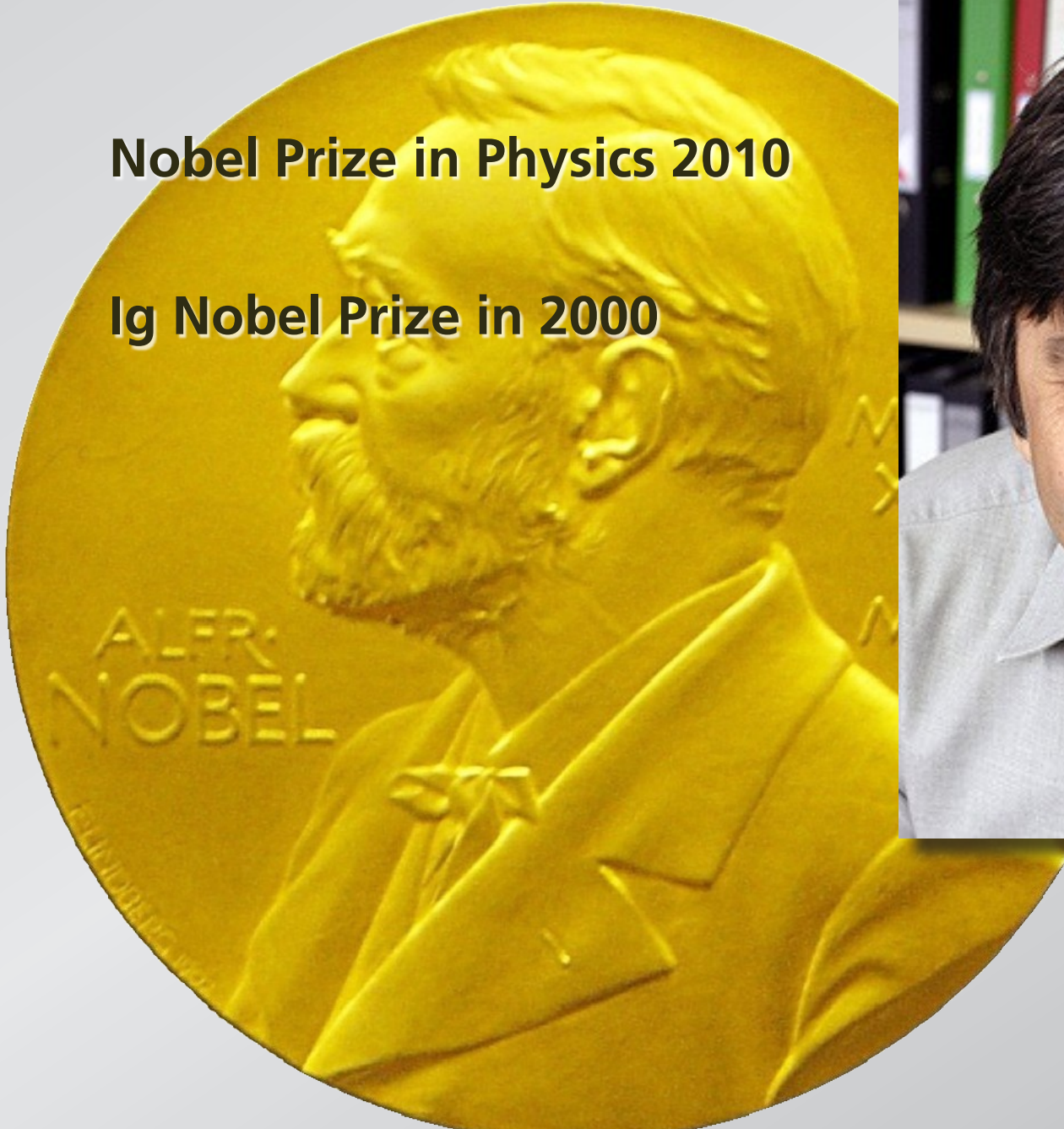




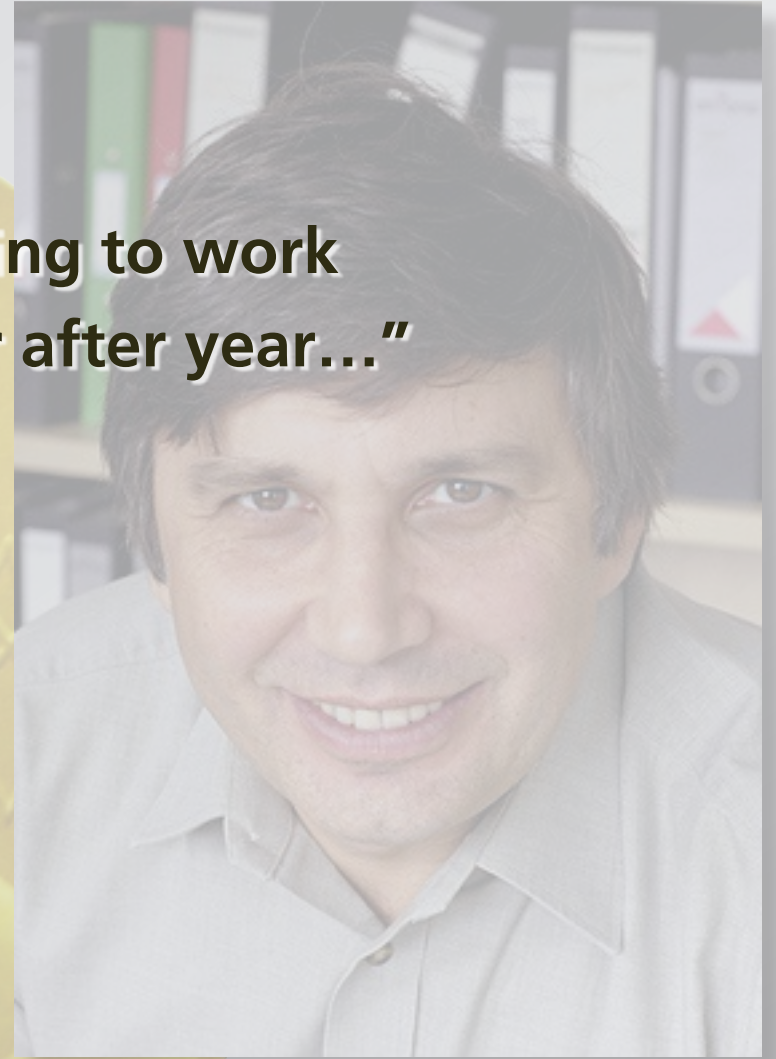


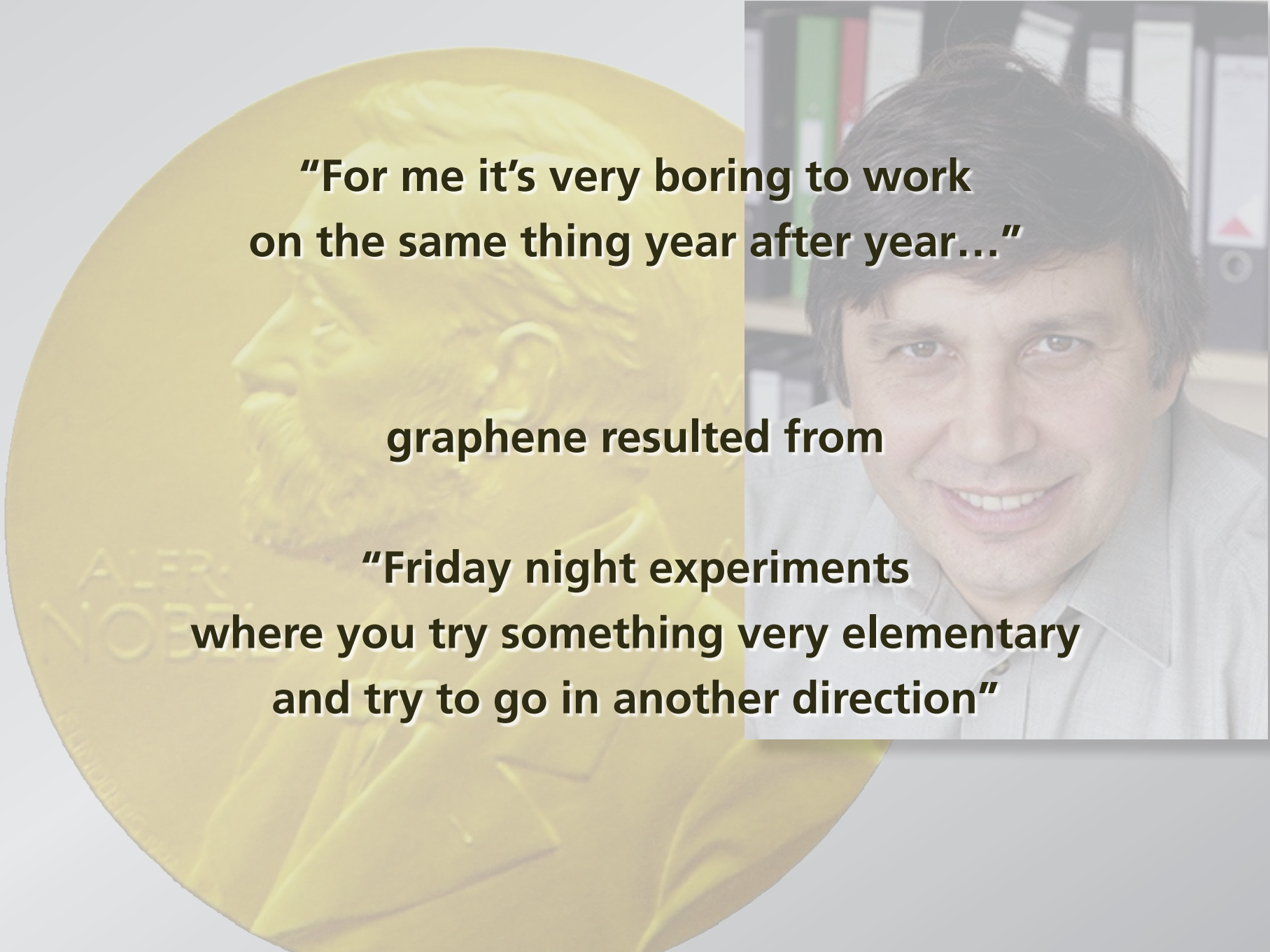
**Nobel Prize in Physics 2010**

**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 filament is visible. 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?

- Temperature
- Concentration
- Surface area
- Catalyst

Diagram: A vertical rod with a horizontal line through its center, representing a reaction coordinate diagram.

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

SECTION: \_\_\_\_\_





1 education

2 PI



1 education

2 PI

3 test



**better pay  
attention!**

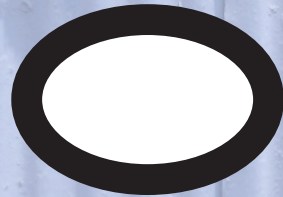
**1** education

**2** PI

**3** test



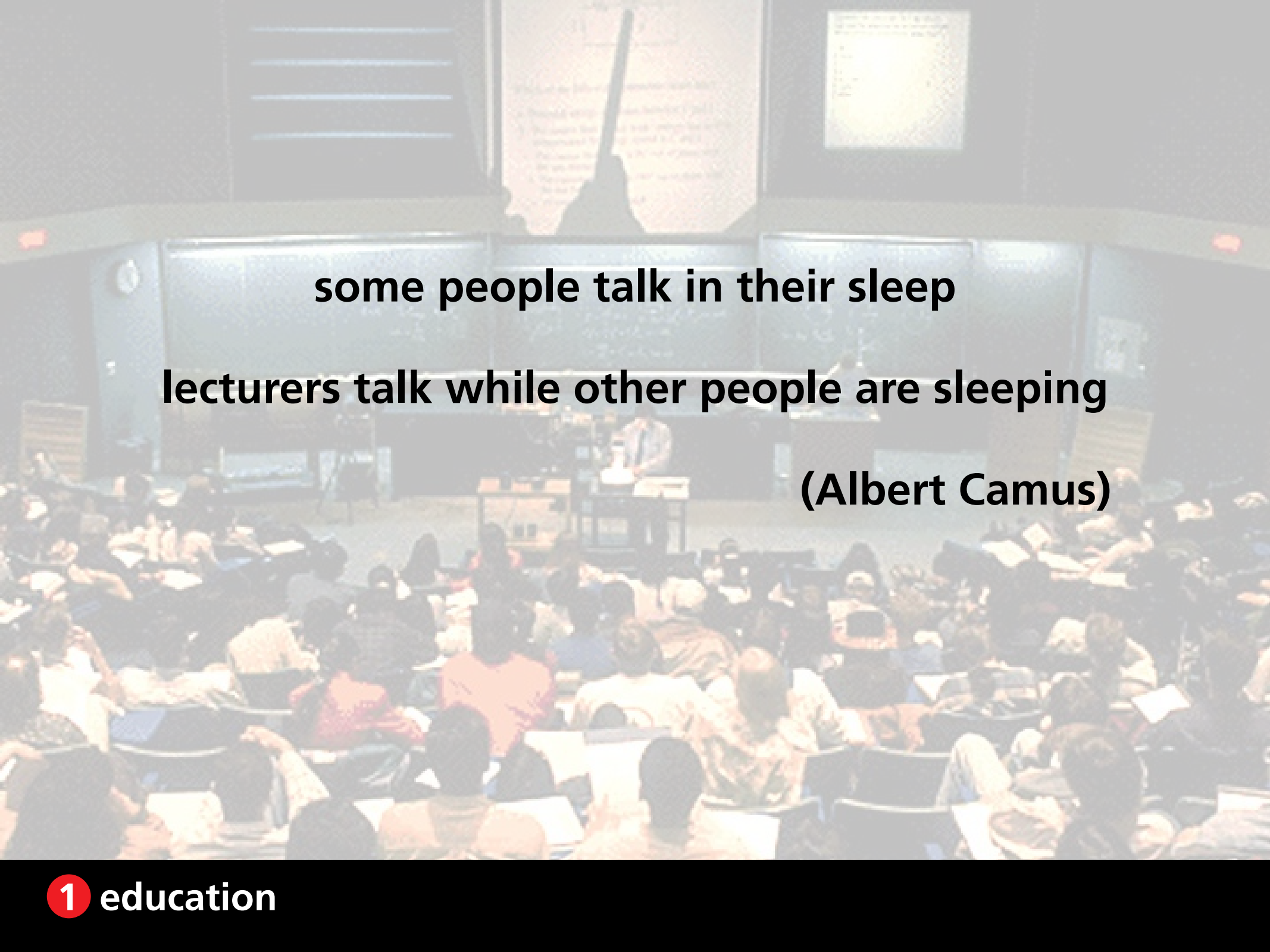
**What happens  
in a lecture?**





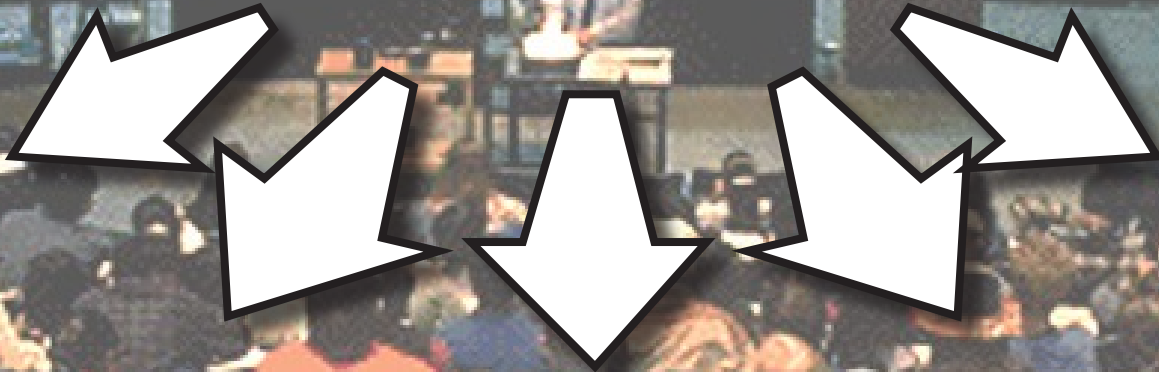
A large lecture hall with a professor at a podium and students in the audience. The professor is standing at a podium in the center of the stage, facing the audience. The audience is seated in rows of chairs, filling the lower two-thirds of the frame. The stage is lit, and there are several large screens or whiteboards in the background. The overall atmosphere is that of a formal academic setting.

**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 of the stage, facing the audience. The audience is seated in rows of chairs, and many people have their heads down or are looking away from the lecturer. 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**

**not transfer but assimilation of information is key**

**EDUCACION**



**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

UNKNOWN

KNOWN

problem

procedure

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

answer

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

answer

KNOWN

problem

solution

outcome

UNKNOWN

KNOWN

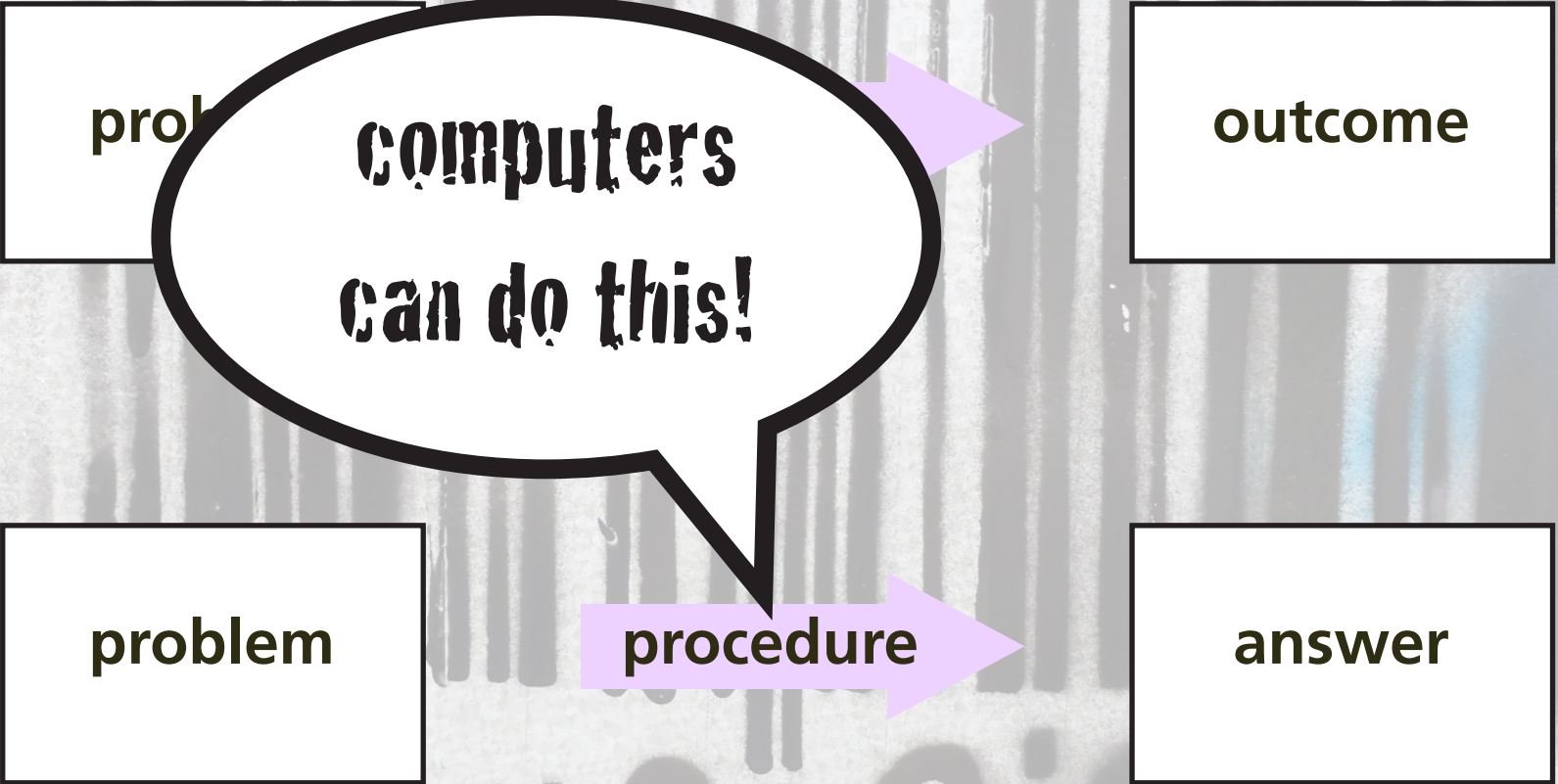
problem

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**



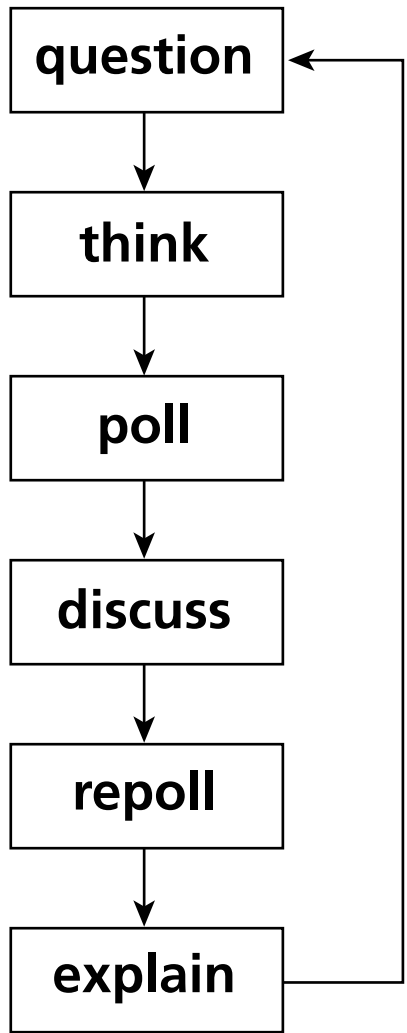
**discuss**

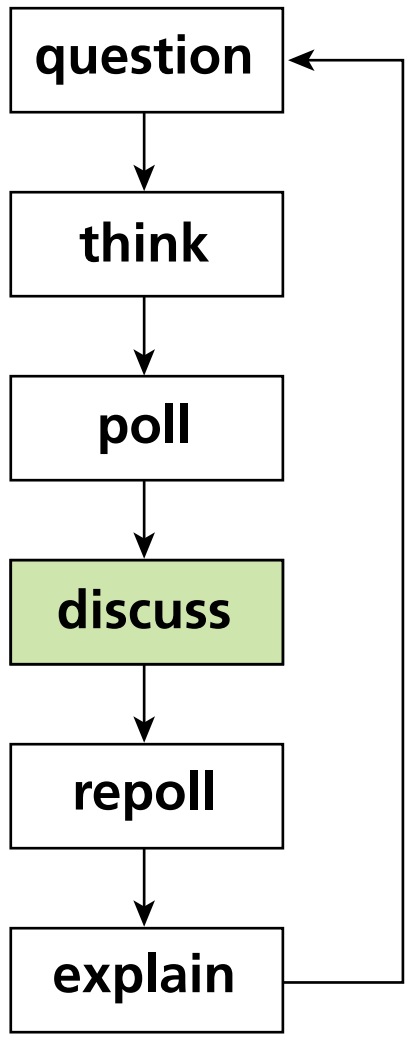


**repoll**



**explain**





**1** lecture

**2** PI



Let's try it!

QUESTION

think

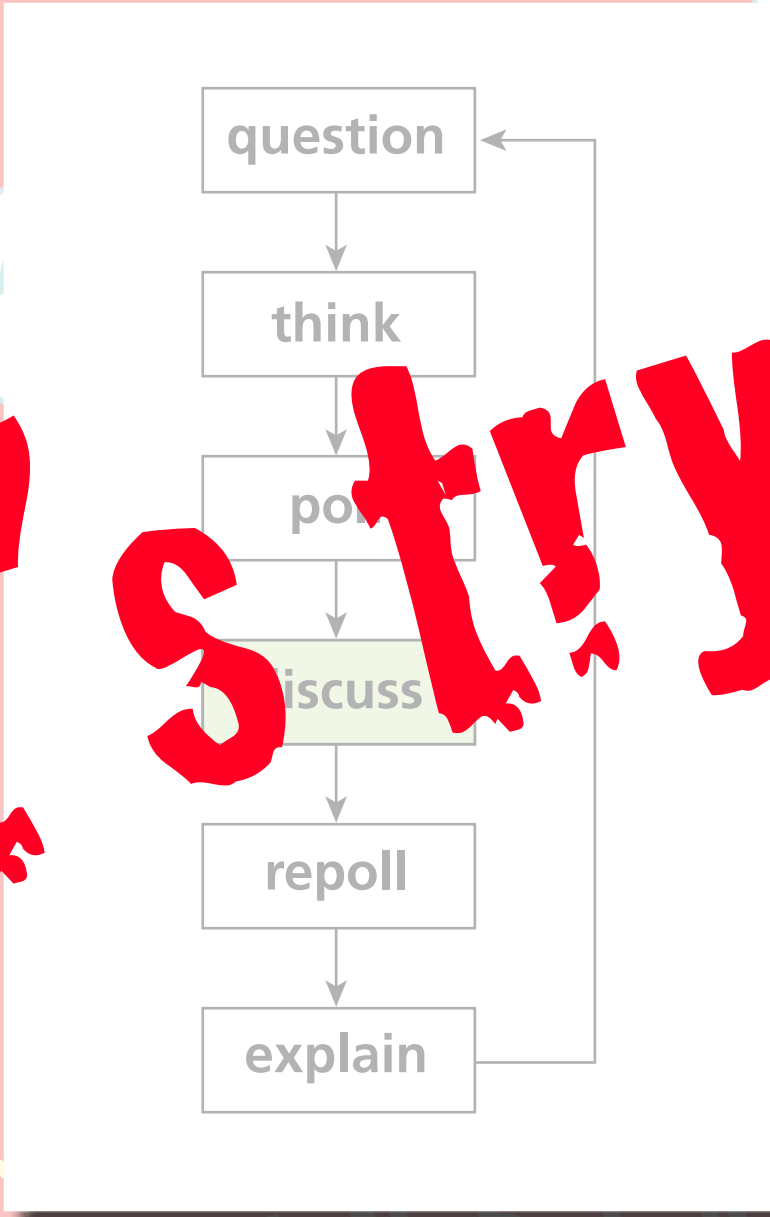
poll

discuss

repoll

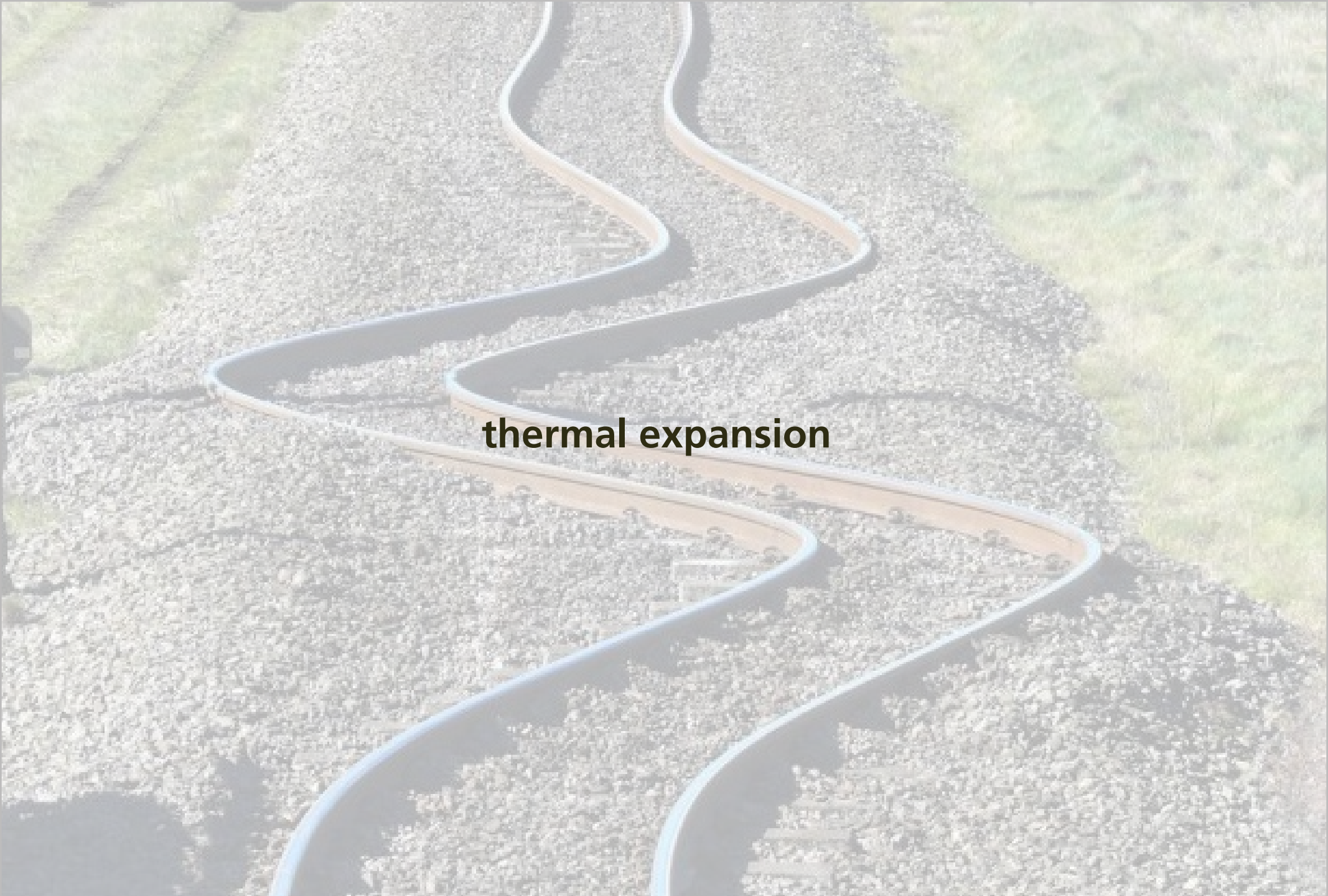
explain

ACTION

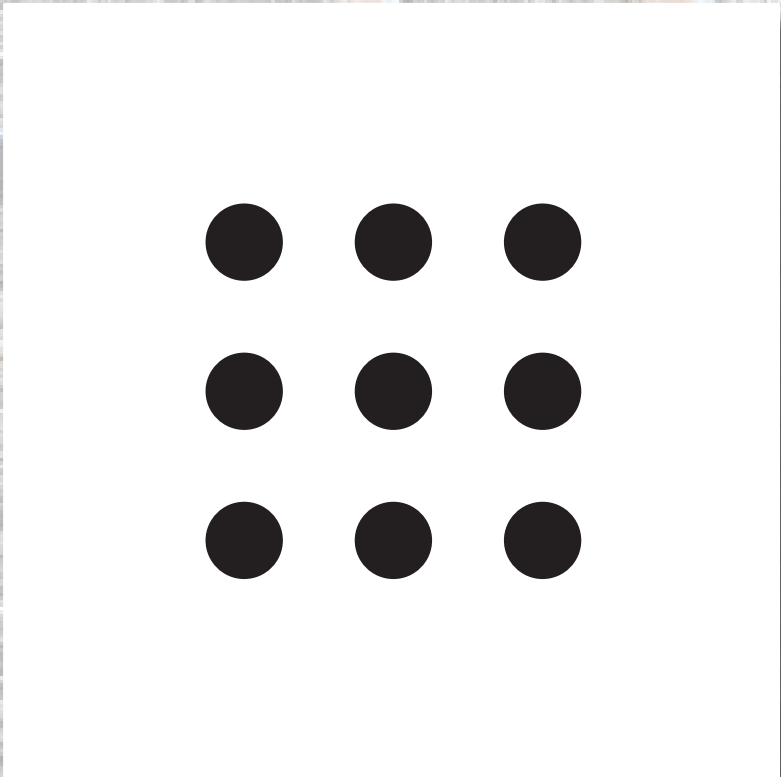


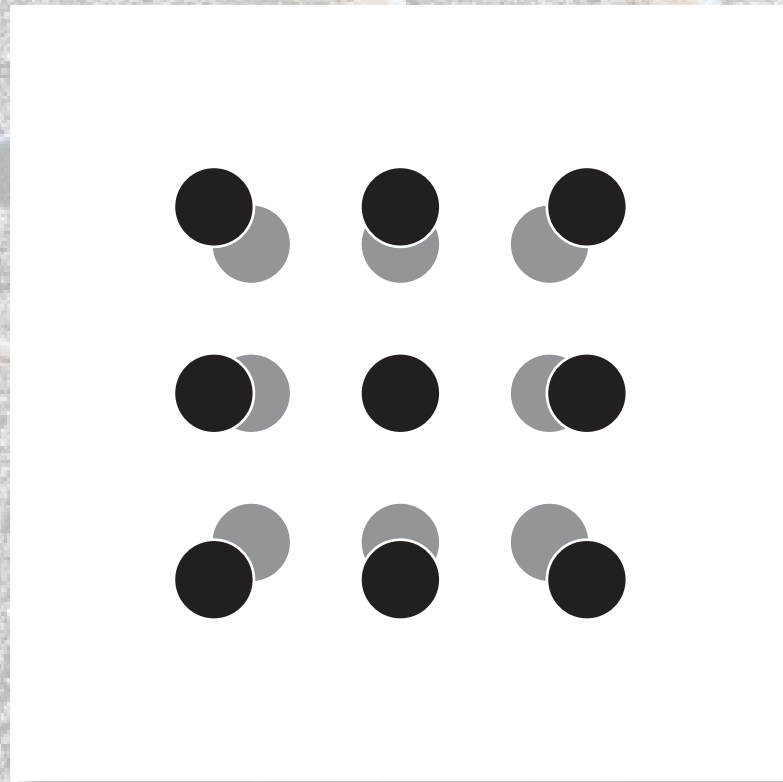
1 education

2 PI



**thermal expansion**



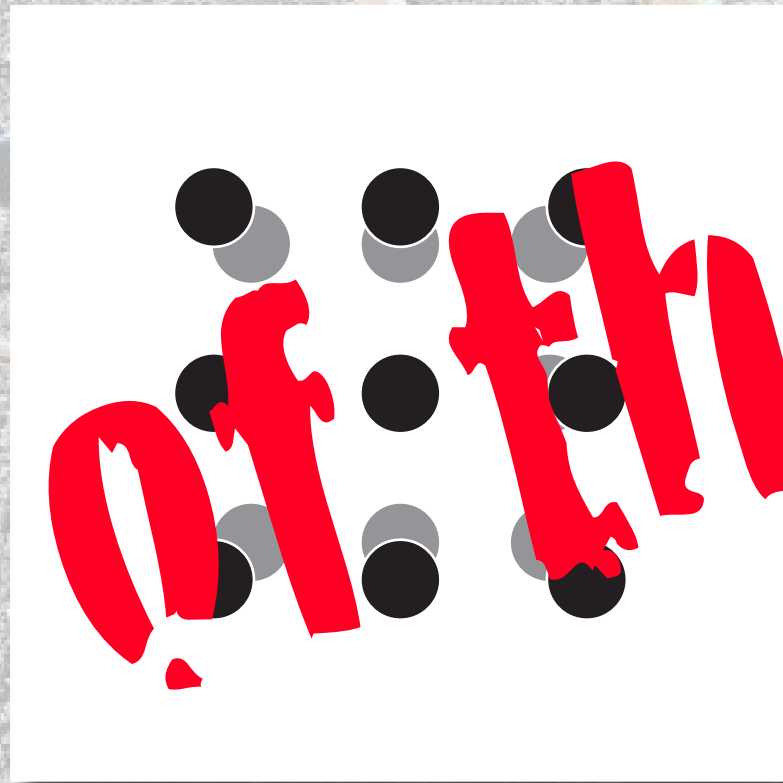


**all of them**

**1** education

**2** PI

**all of them!**

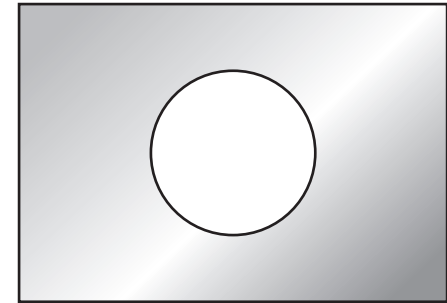


**1** education

**2** PI

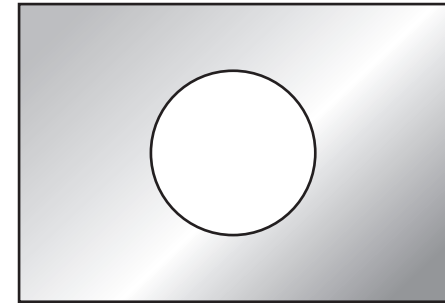
**3** test?

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



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

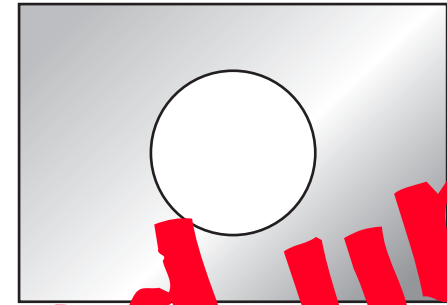
**When the plate is uniformly heated, the diameter of the hole**



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



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



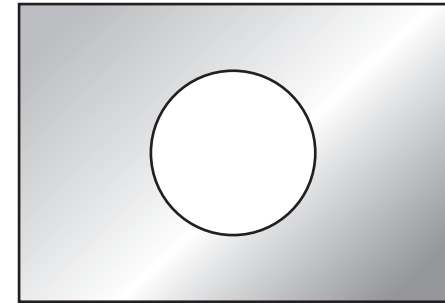
When the plate is uniformly heated, the diameter of the hole

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**

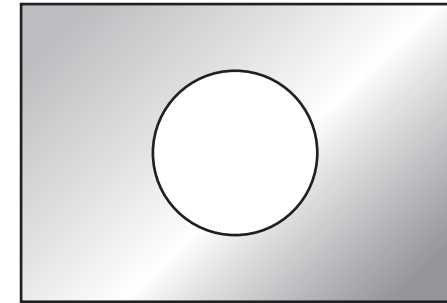
**Before I tell you the answer, let's analyze what happened.**

**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**



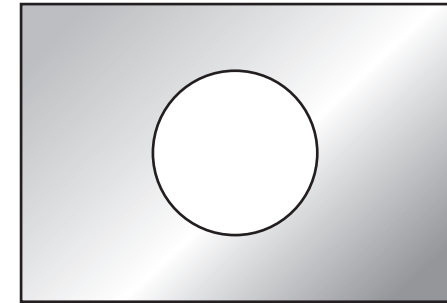
**Consider a rectangular metal plate with a circular hole in it.**



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

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

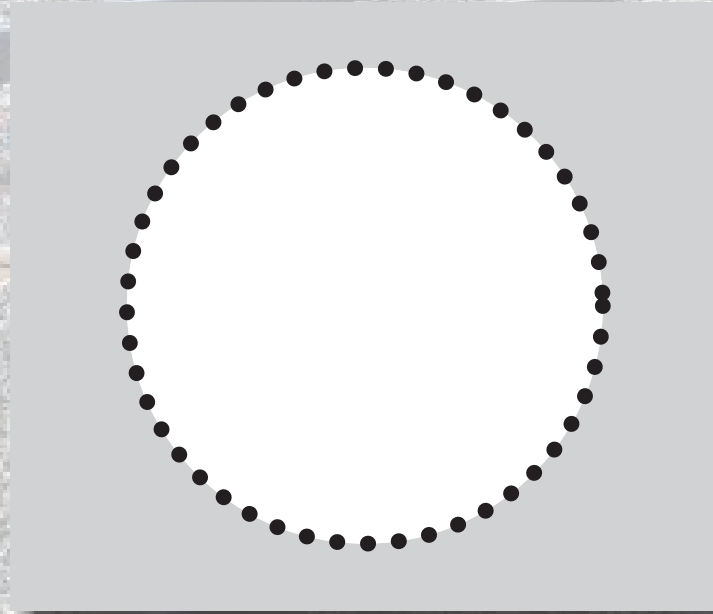
Consider a rectangular metal plate with a circular hole in it.



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

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

consider atoms at rim of hole

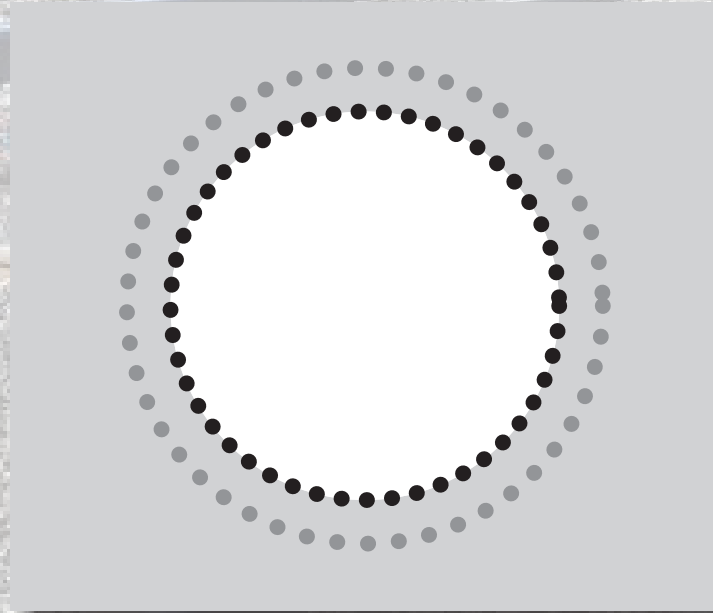


1 education

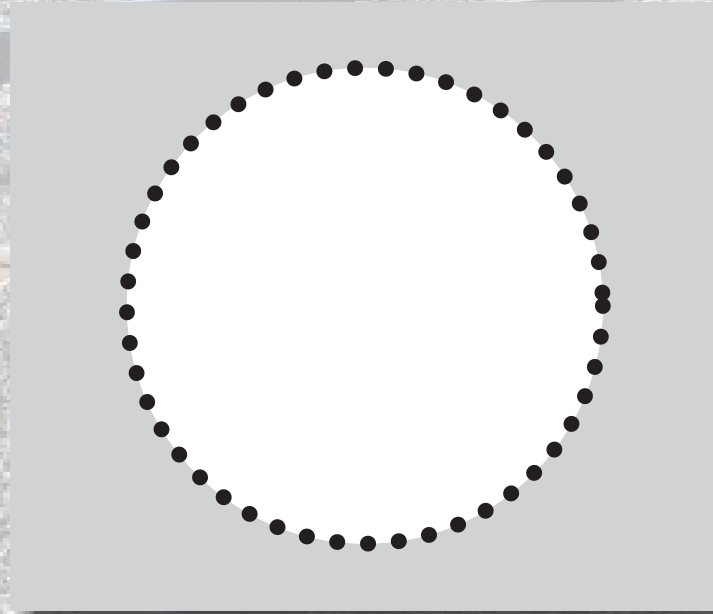
2 PI

3 test

consider atoms at rim of hole



consider atoms at rim of hole

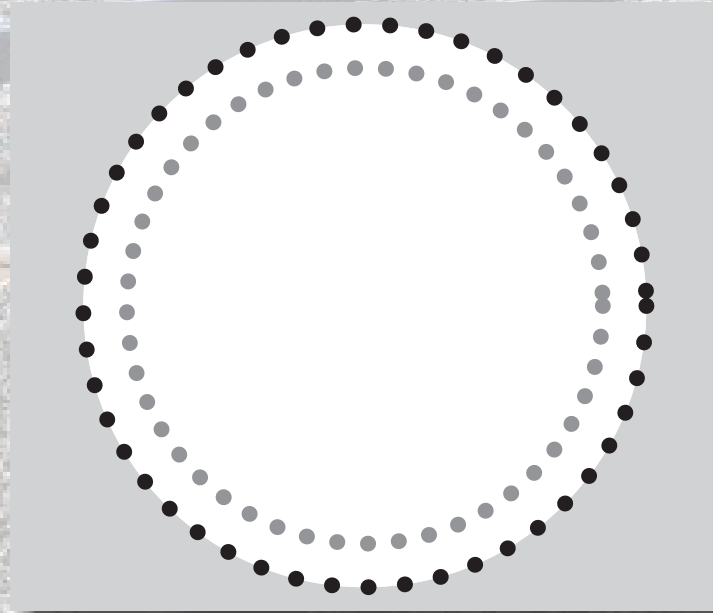


1 education

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

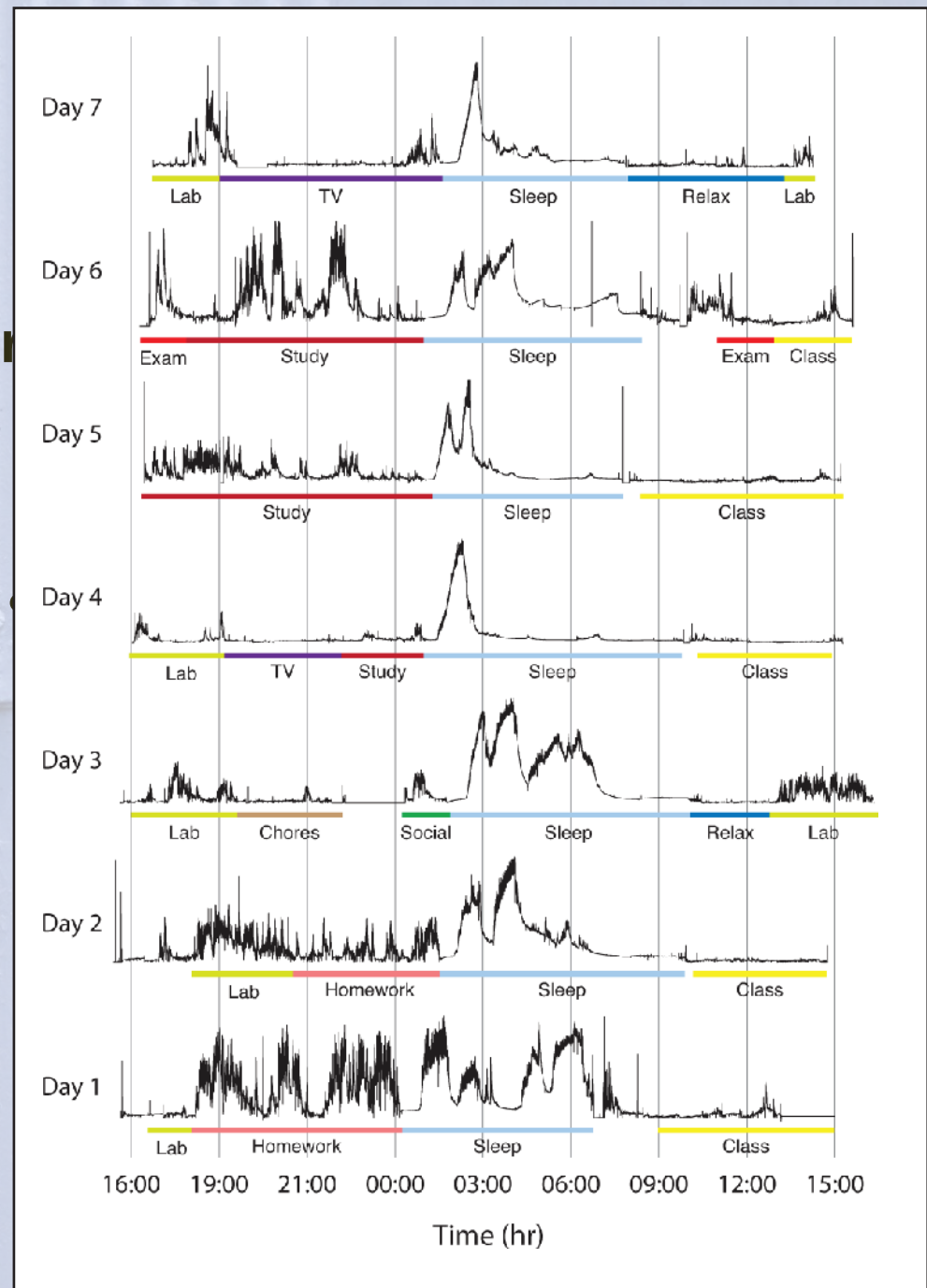
**3** test

**in a lecture, students...**

**1. don't pay utmost attention**

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

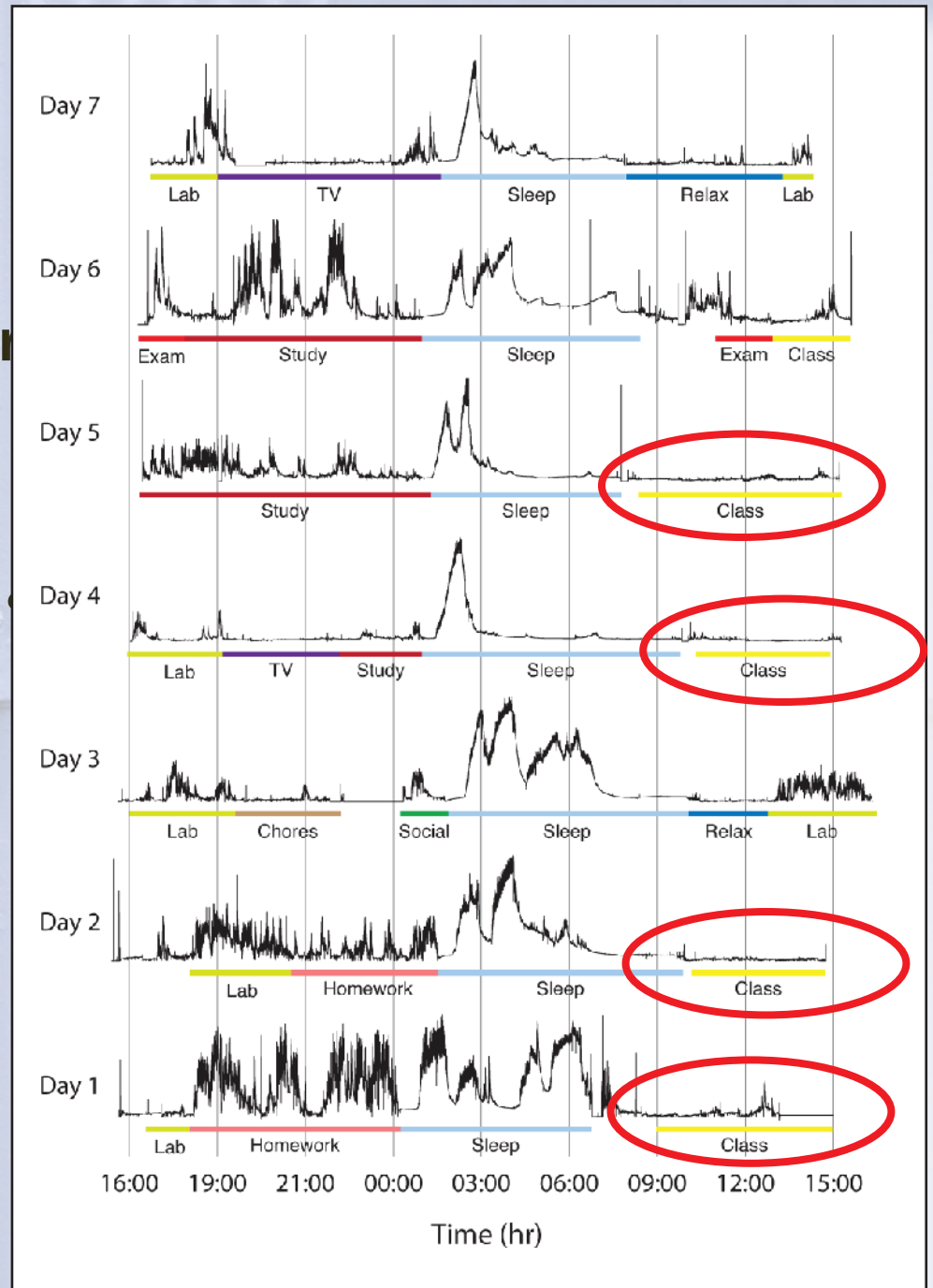
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

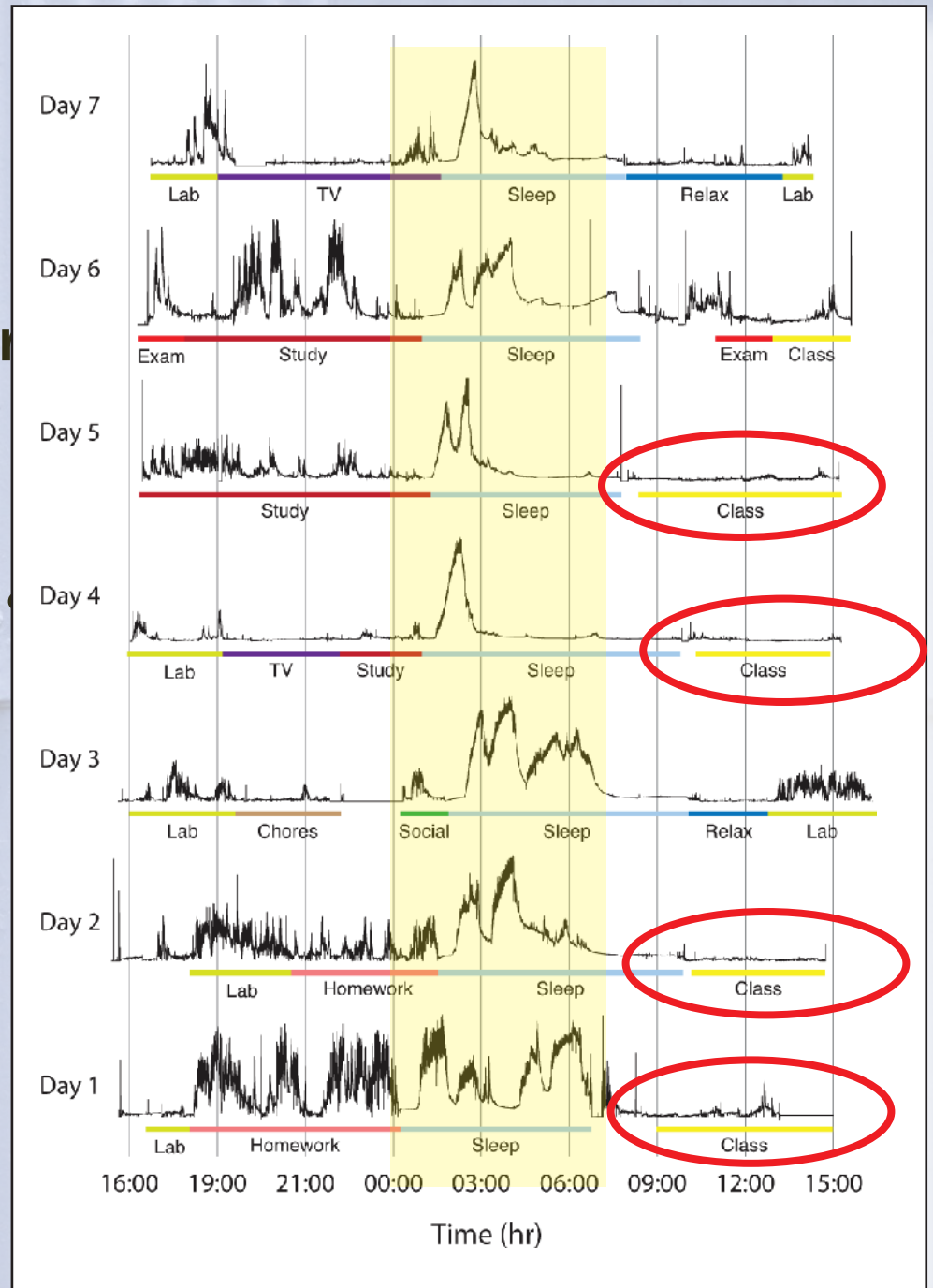
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

1 education

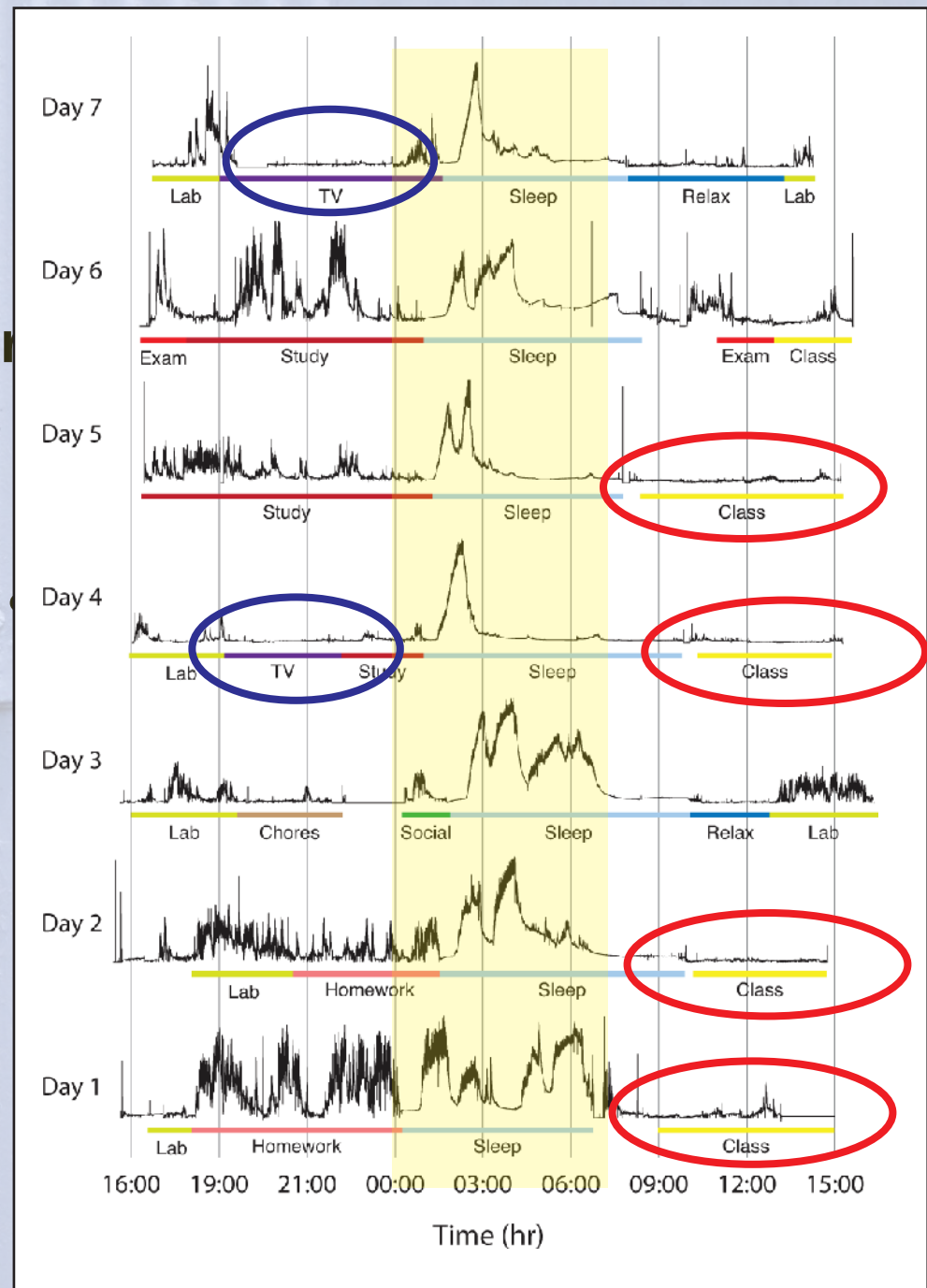
2 PI

3 test



in a lecture

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:**

**National Science Foundation**

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