

The Ladder of Causation

Zhedong Zheng

THE SVERIGES RIKSBANK PRIZE
IN ECONOMIC SCIENCES IN MEMORY
OF ALFRED NOBEL 2021

Illustration: Niklas Elmehed



David
Card

"for his empirical
contributions to labour
economics"

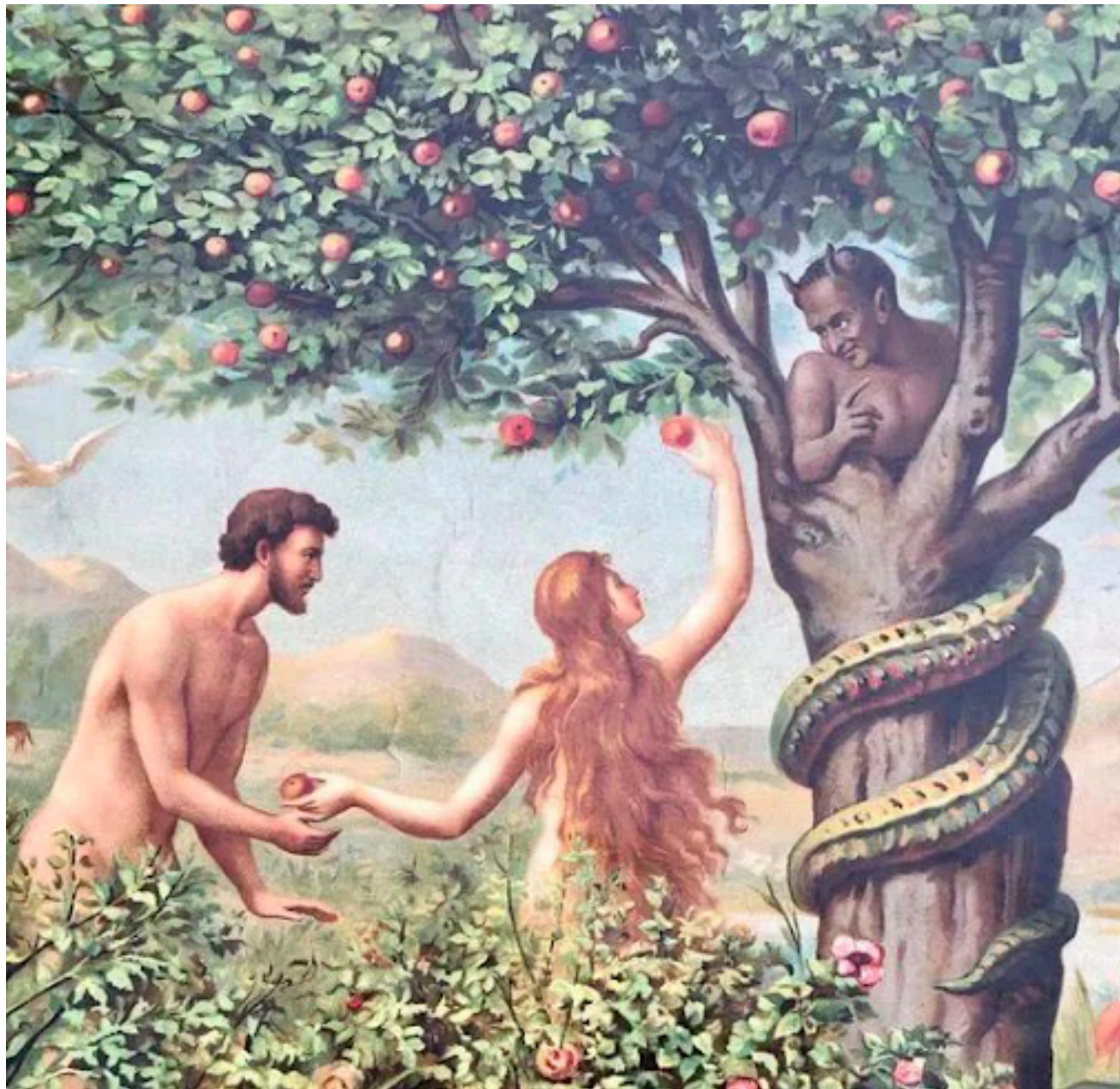
Joshua
D. Angrist

"for their methodological
contributions to the analysis
of causal relationships"

Guido
W. Imbens

- 1. Sample in Daily Life**
2. Causality Levels
3. Mini Turing Test
4. Probability and Causality

Adam Eve



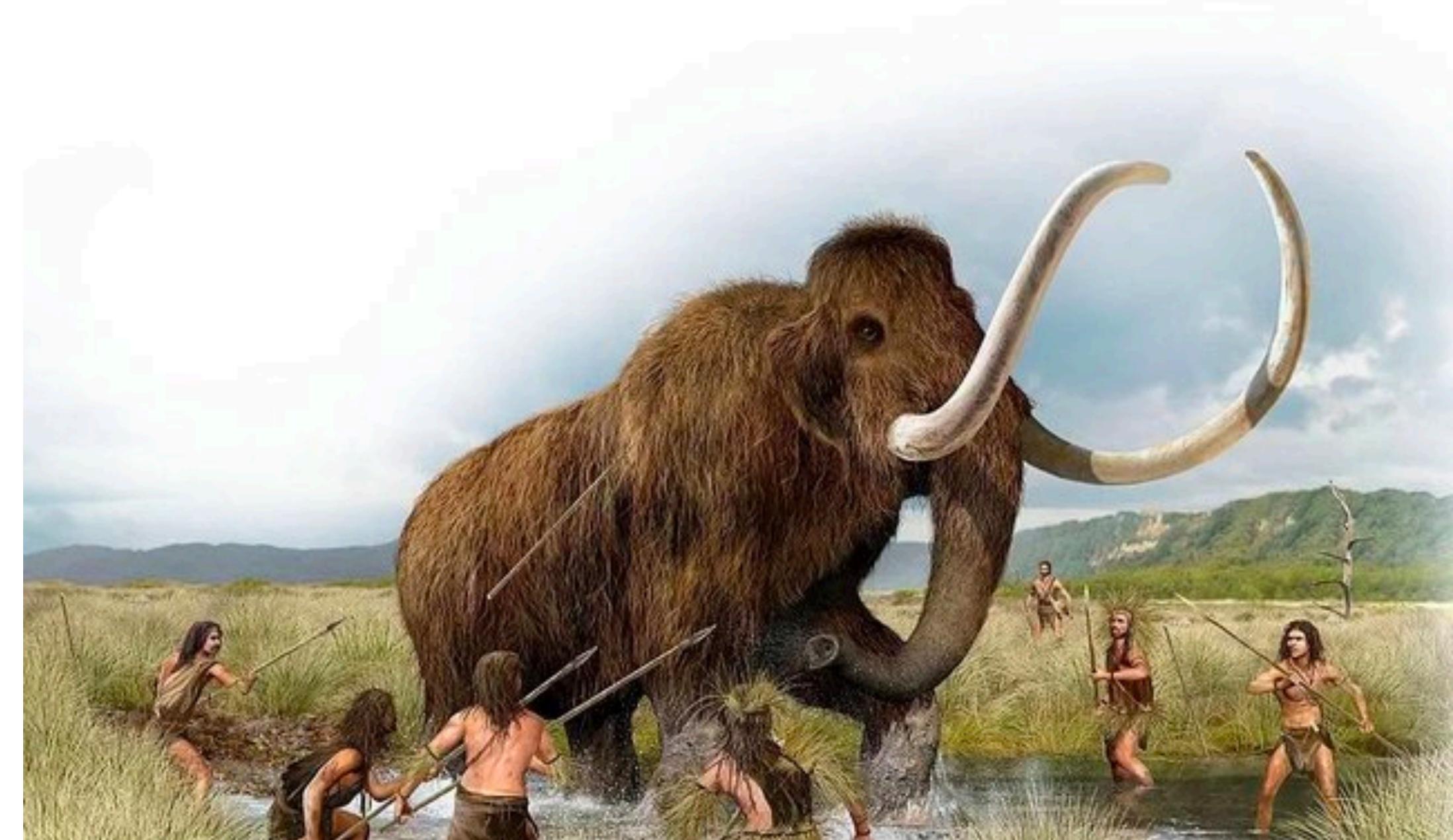
1. Data cannot derive causal relationships;
2. Cause and effect constitute most knowledge;
3. Interpretation of data requires external effort.

Sphinx



1. Imagining something that doesn't exist is key.

Hunting mammoths



1. How to successfully catch a mammoth?

Causal diagram (因果图)

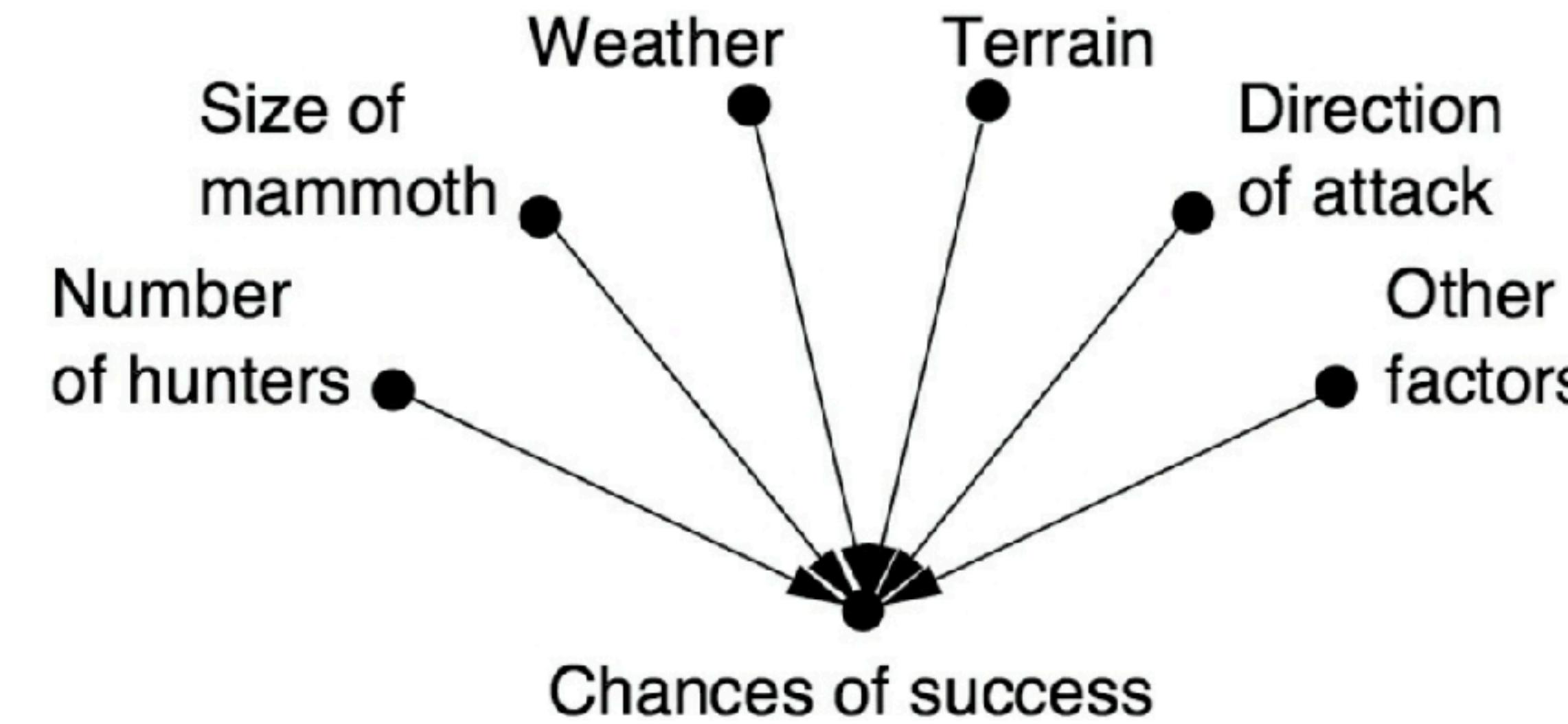
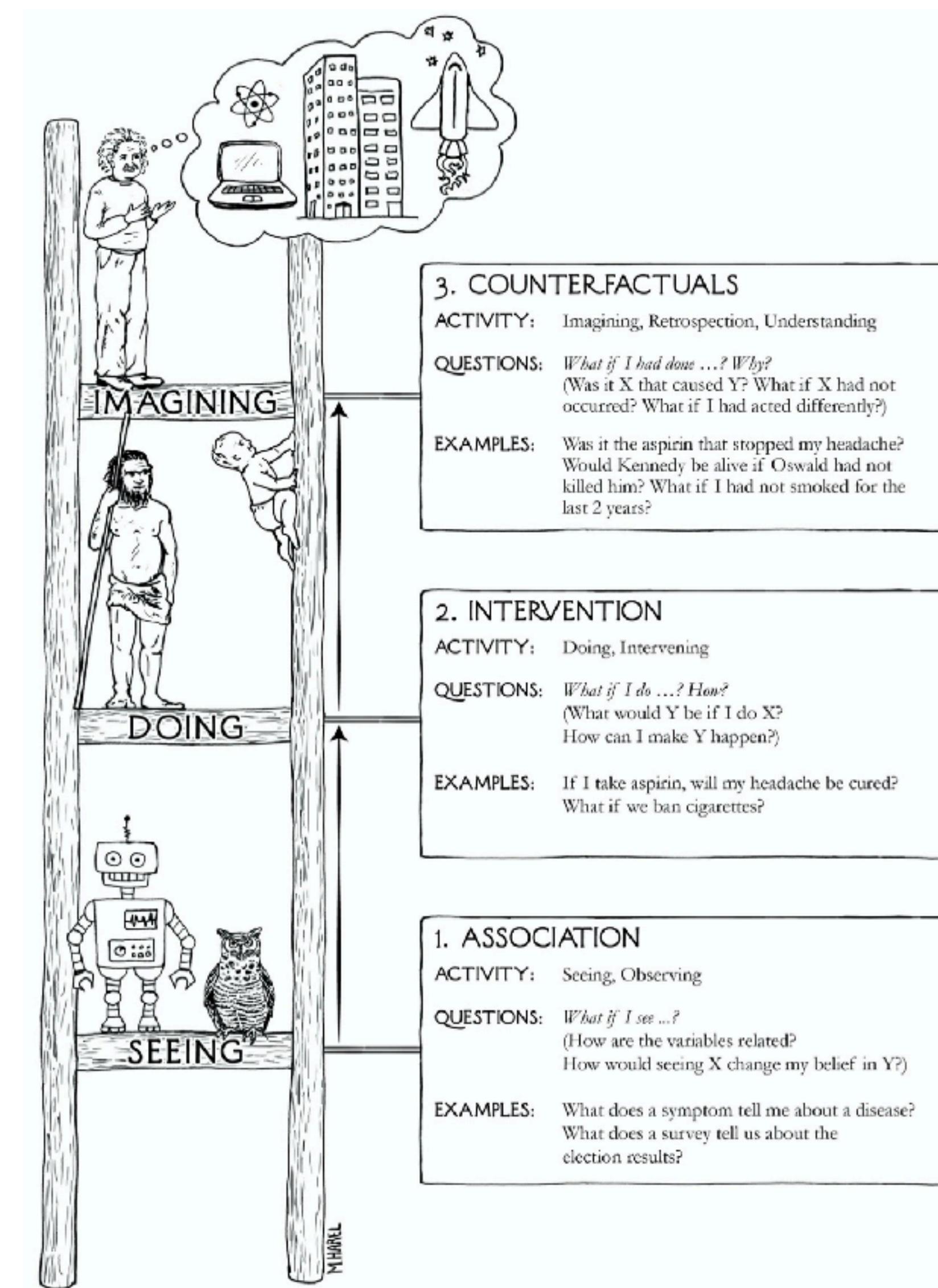


FIGURE 1.1. Perceived causes of a successful mammoth hunt.

1. Sample in Daily Life
2. **Causality Levels**
3. Mini Turing Test
4. Probability and Causality

Ladder of Causation(因果之梯)



1. ASSOCIATION

ACTIVITY: Seeing, Observing

QUESTIONS: *What if I see ...?*

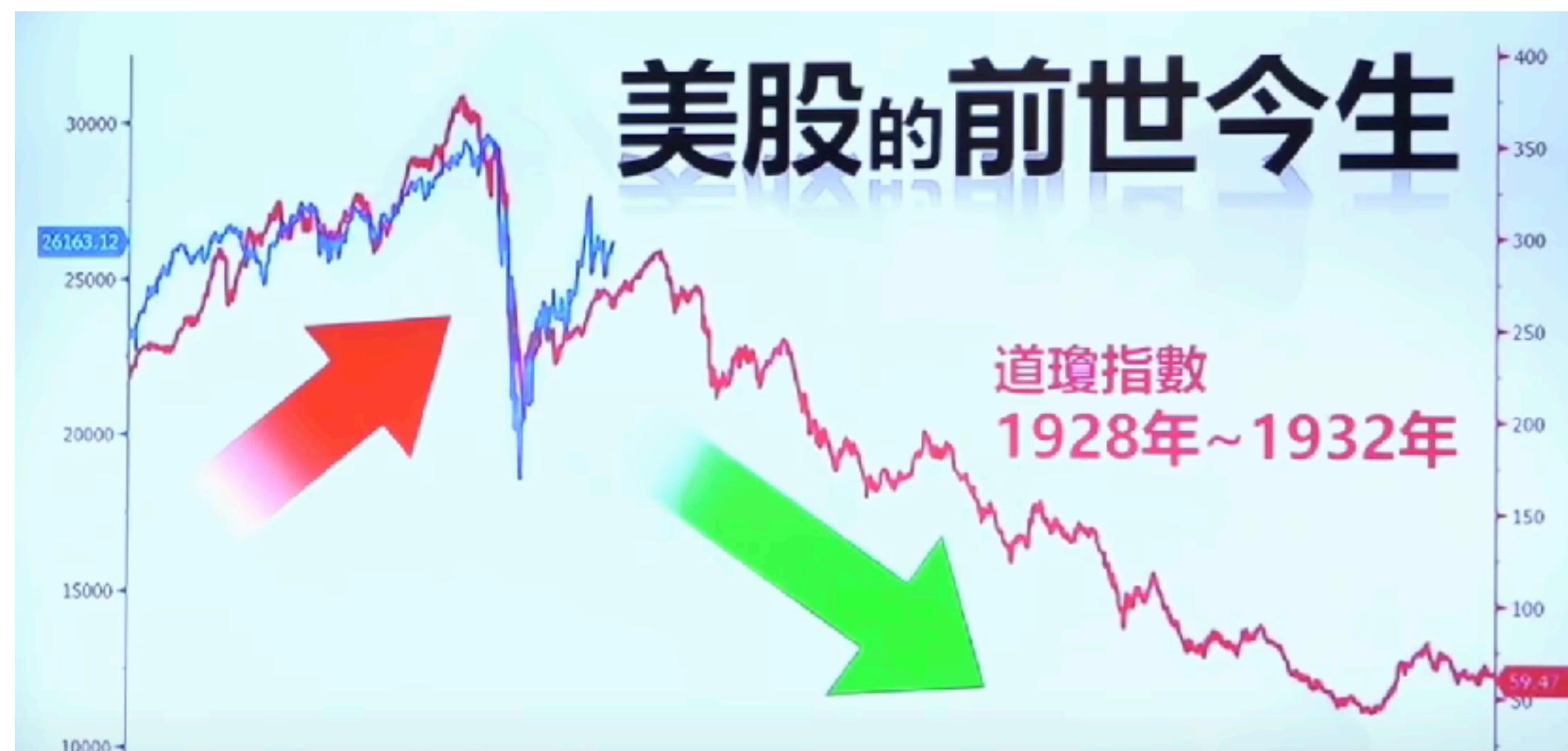
(How are the variables related?)

How would seeing X change my belief in Y?)

EXAMPLES: What does a symptom tell me about a disease?
What does a survey tell us about the election results?

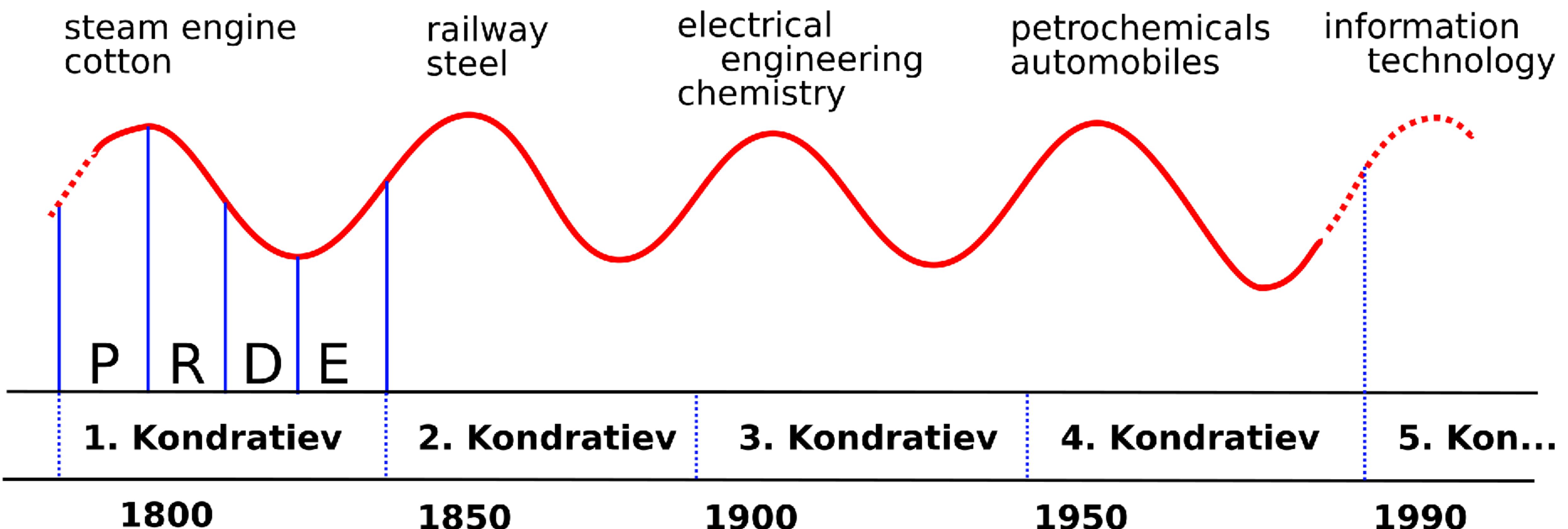


Observe the loop



Shoeshine Boy Theory (1927 Joseph P. Kennedy)

Kondratiev wave



P: prosperity
R: recession
D: depression
E: improvement

2. INTERVENTION

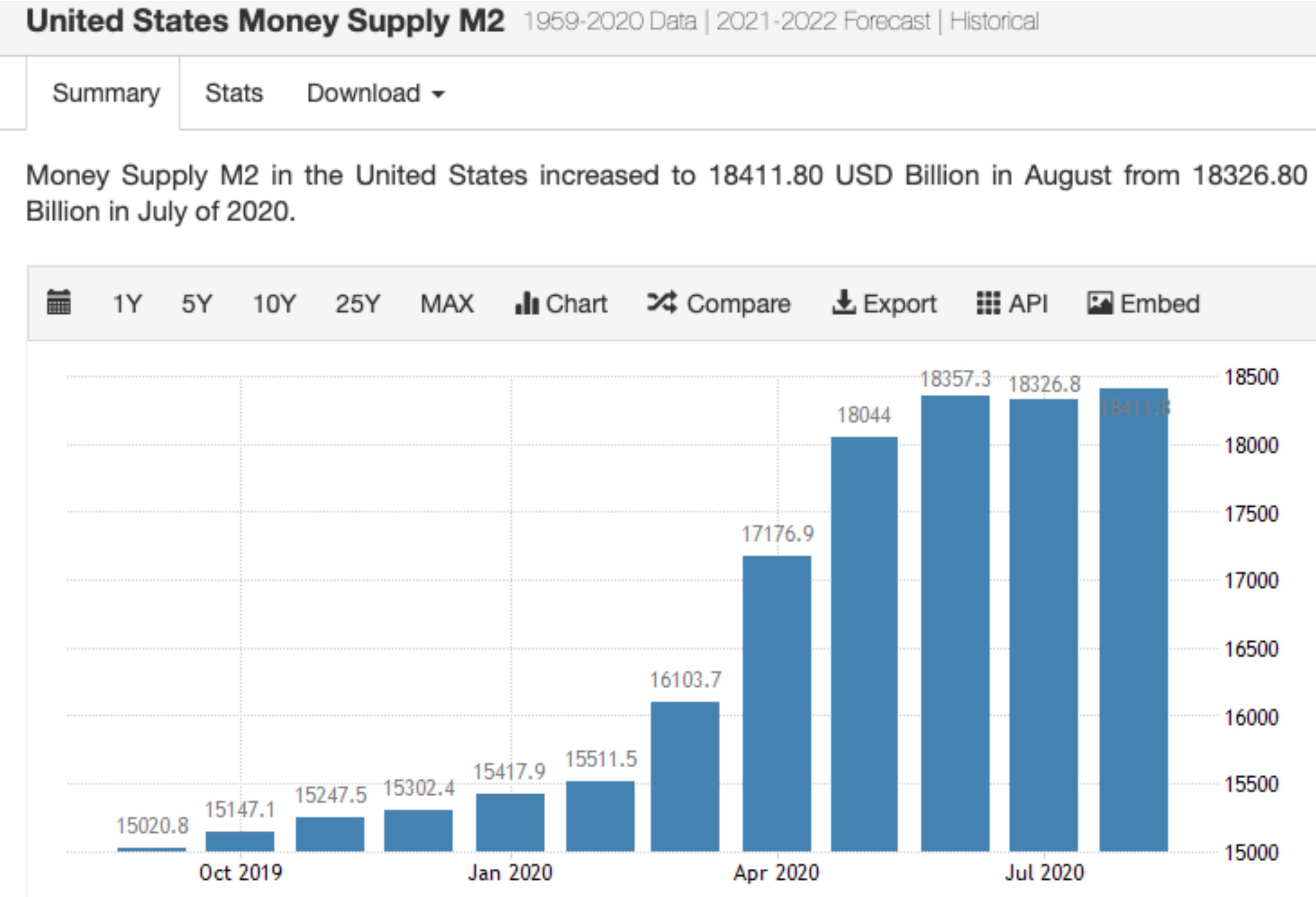
ACTIVITY: Doing, Intervening

QUESTIONS: *What if I do ...? How?*

(What would Y be if I do X?
How can I make Y happen?)

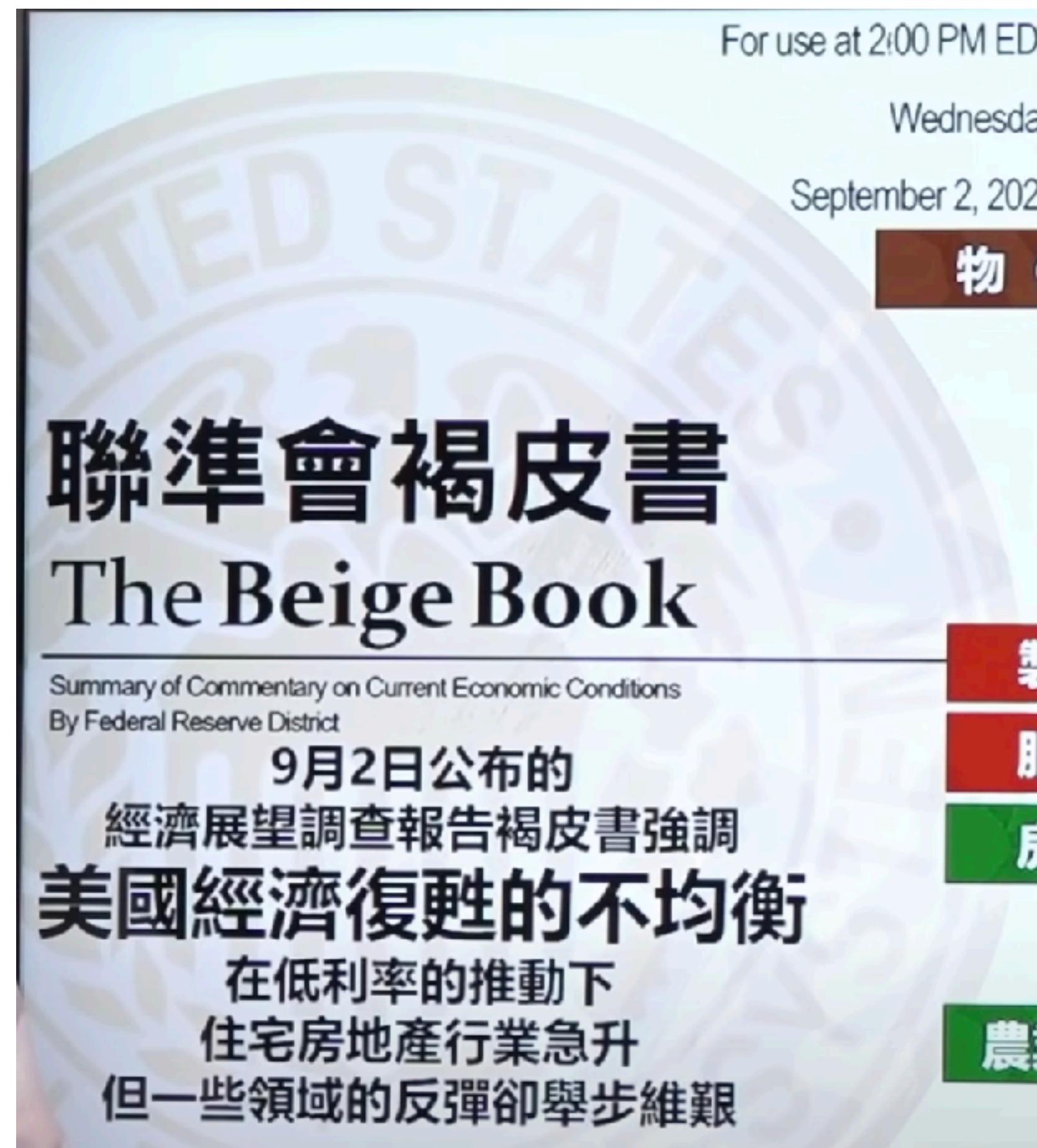
EXAMPLES: If I take aspirin, will my headache be cured?
What if we ban cigarettes?

FED Intervention



FED Intervention

Shadow Bank



For use at 2:00 PM EDT
Wednesday
September 2, 2020

聯準會褐皮書

The Beige Book

Summary of Commentary on Current Economic Conditions
By Federal Reserve District

9月2日公布的經濟展望調查報告褐皮書強調美國經濟復甦的不均衡，在低利率的推動下，住宅房地產行業急升，但一些領域的反彈卻舉步維艱。

就業與薪資 ➤

- 總體就業成長，以製造業就業成長最多。
- 但部分地區服務業就業成長放緩和招聘波動加劇
- 薪資持平或稍增長，不過低薪職位的壓力變得更大。

物 價 ➤

- 物價壓力略增，但仍在適度水平。原材料價格上漲快於銷售品價格，總體溫和。
- 值得注意的例外是，因需求激增或供應鏈中斷的原材料(如建築木材)價格飆升，個人防護設備的成本和投入高。因需求回升，交通貨運價格上升。同時，零售需求疲軟或缺乏定價能力，是零售價格成長放緩因素。

製造業 ➤ 製造業活動增長，和港口及運輸活動的成長相符。

服務業 ➤ 強勁的汽車銷售、旅遊和零售業改善激發消費者支出持續增長。

房地產 ➤ 商業建築活動下降，商業房地產建設萎縮。相反，住宅建設成長，住宅銷售增加，房價也因需求和庫存短缺上漲。而商業銀行由於住房抵押貸款活動活躍，總體貸款需求略增。

農業 能源 ➤ 農業則繼續受到低物價的困擾，能源部門活動也處於低水平，近期幾乎無法得到改善。

3. COUNTERFACTUALS

ACTIVITY: Imagining, Retrospection, Understanding

QUESTIONS: *What if I had done ...? Why?*
(Was it X that caused Y? What if X had not occurred? What if I had acted differently?)

EXAMPLES: Was it the aspirin that stopped my headache?
Would Kennedy be alive if Oswald had not killed him? What if I had not smoked for the last 2 years?

If FED did not print money?

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Koch's postulates (科赫原则)

Koch's four postulates are:

1. The microorganism must be found in abundance in all organisms suffering from the disease but should not be found in healthy organisms
2. The microorganism must be isolated from a diseased organism and grown in pure culture
3. The cultured microorganism should cause disease when introduced into a healthy organism
4. The microorganism must be re-isolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

How about missing one postulates?

Koch's postulates (科赫原则)

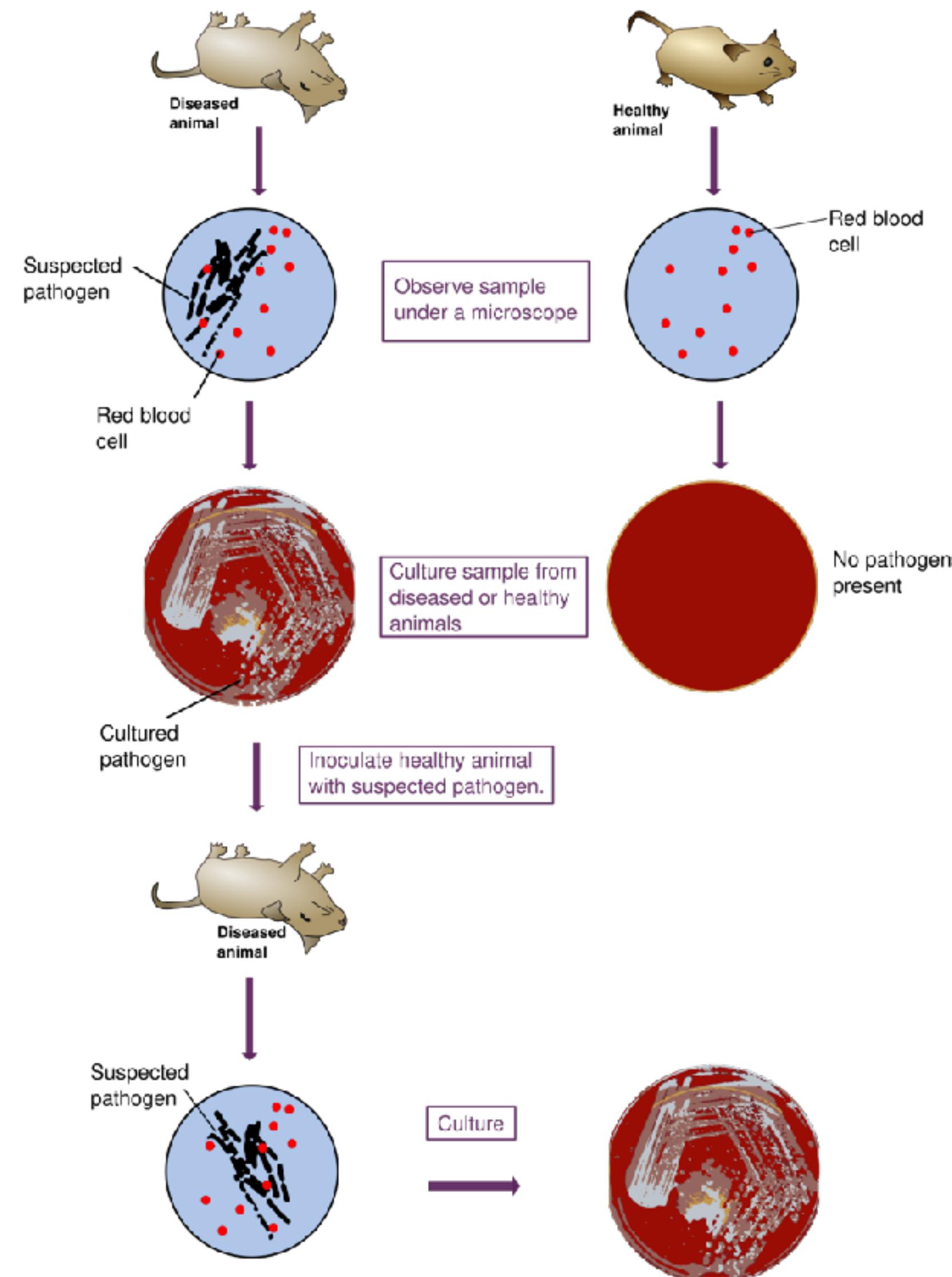
Koch's Postulates:

① The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy organisms.

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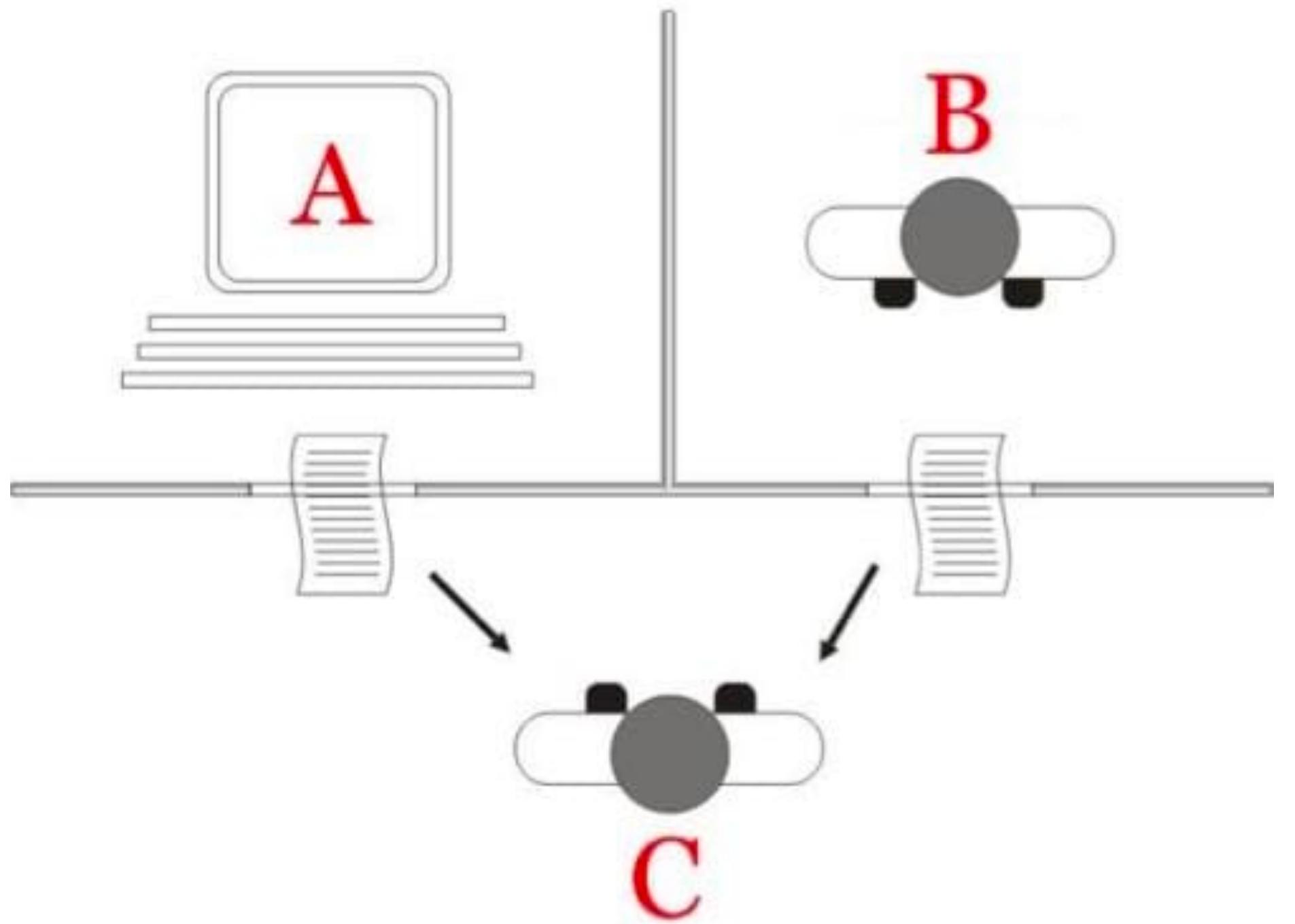


How about current AI?

1. Strong artificial intelligence is the creation of machines with human intelligence, allowing them to communicate with humans and guide the direction of human inquiry.
2. Artificial intelligence is still at the first level and lacks flexibility and adaptability.

1. Sample in Daily Life
2. Causality Levels
3. **Mini Turing Test**
4. Probability and Causality

Turing Test -> Children's Turing Test



Mini Turing Test == Reading Comprehension?

小张：刘局长，一点小意思……

刘局长：你这是什么意思嘛？

小张：没别的意思 就是哪个意思。

刘局长：你这人太有意思了，那我就不好意思了。

小张：其实我没那个意思！就是那个意思意思！

刘局长：我明白你的意思了，这事就按照你的意思去做！

Cheating? Clever Hans



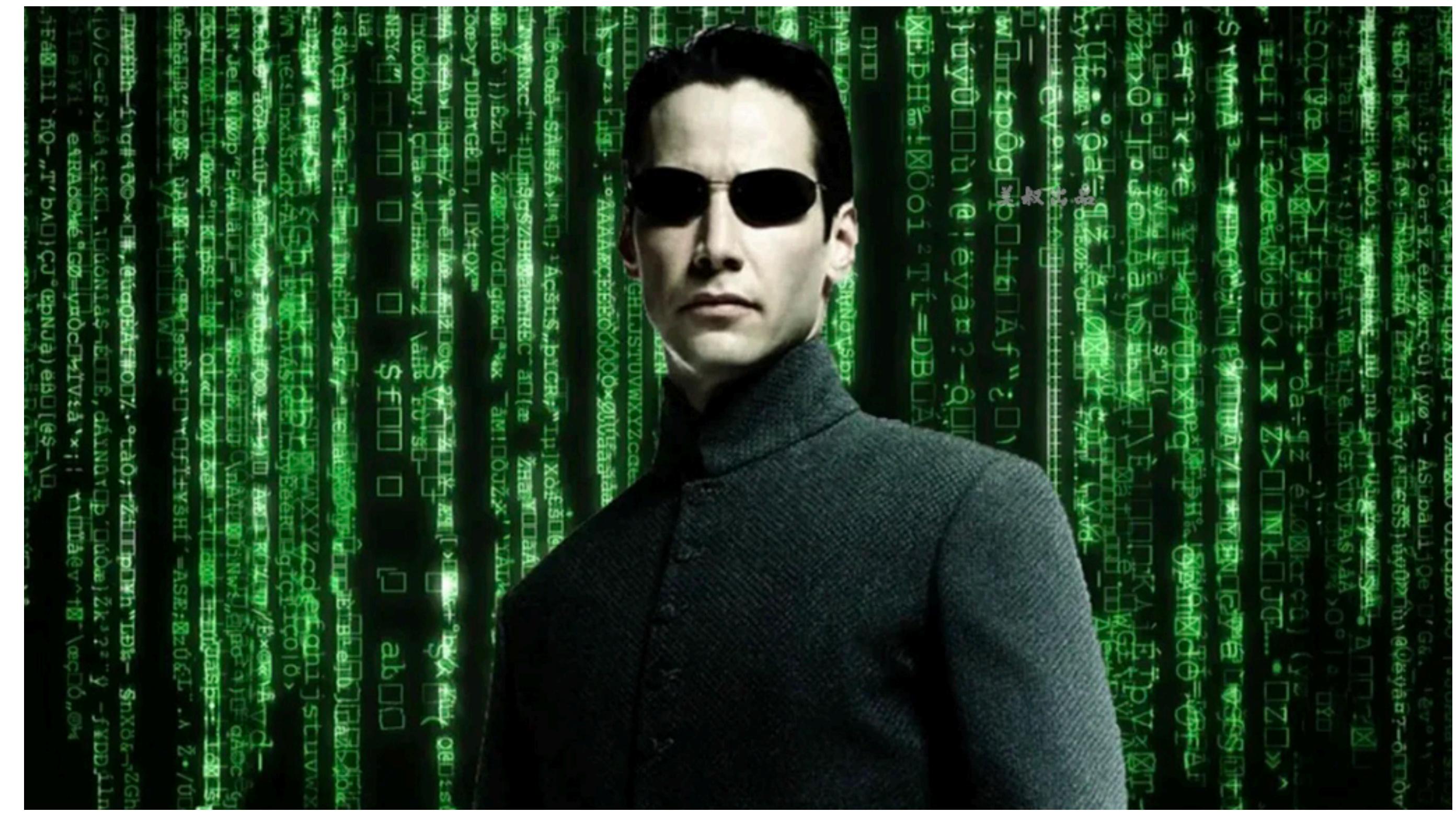
Unless the ghost gets you!

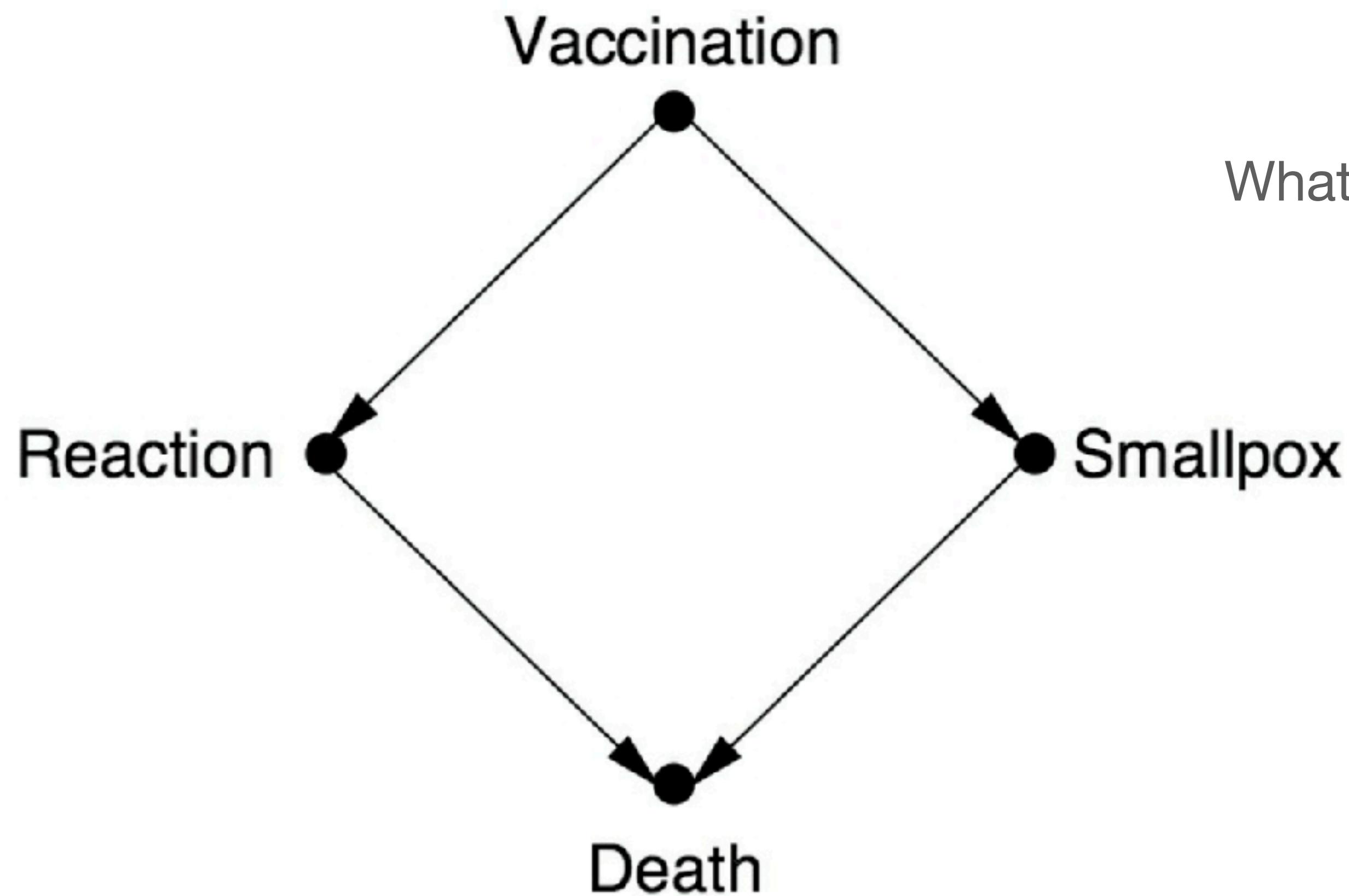


The hand of God: concise expression -> cause and effect diagram



第一手天元





counterfactual question
What happens if you don't get vaccinated?

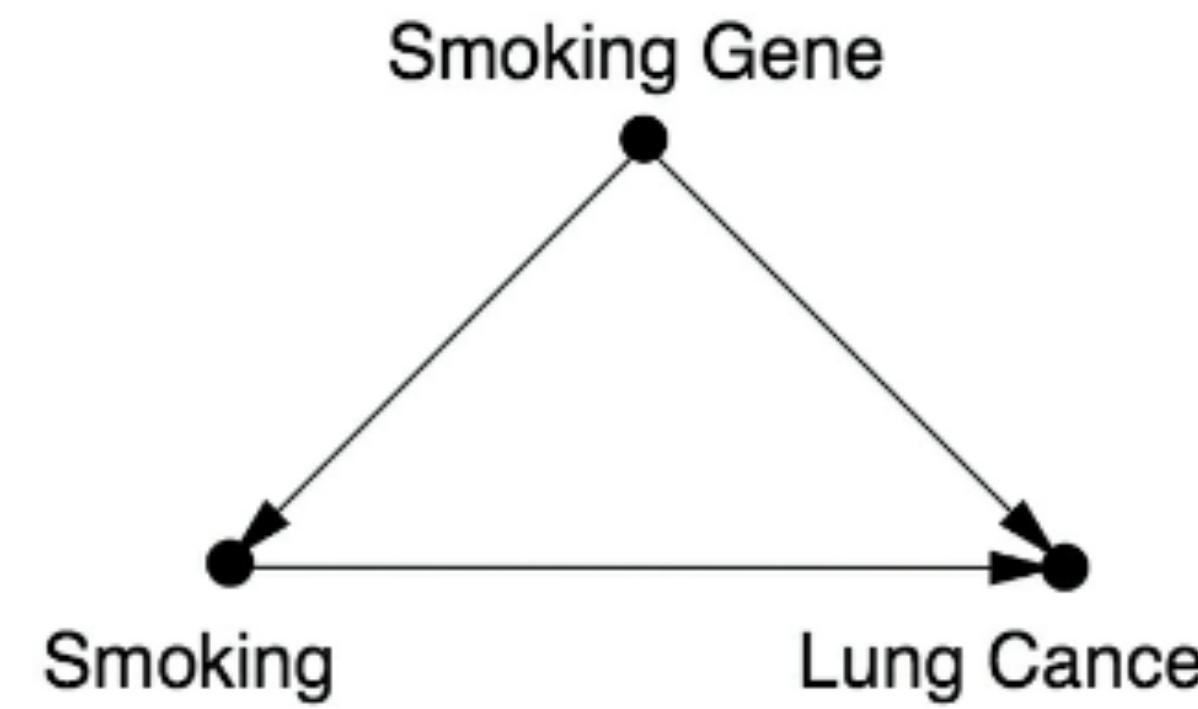


DIAGRAM 5.1.

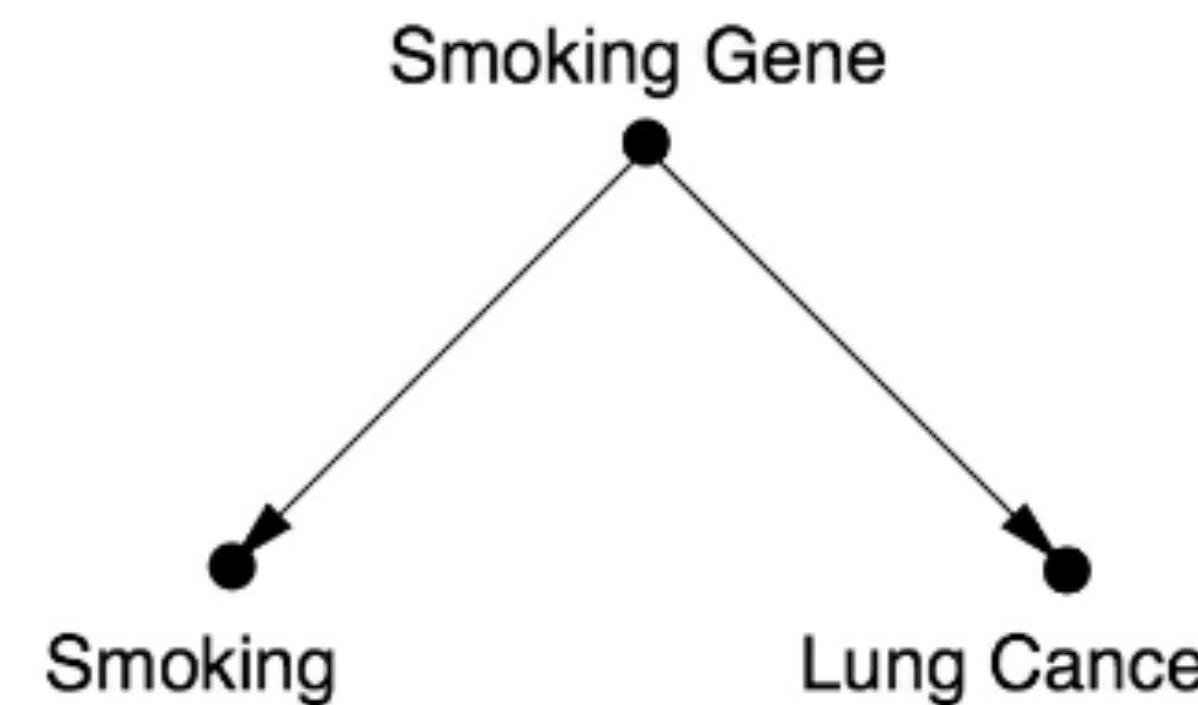


DIAGRAM 5.2.

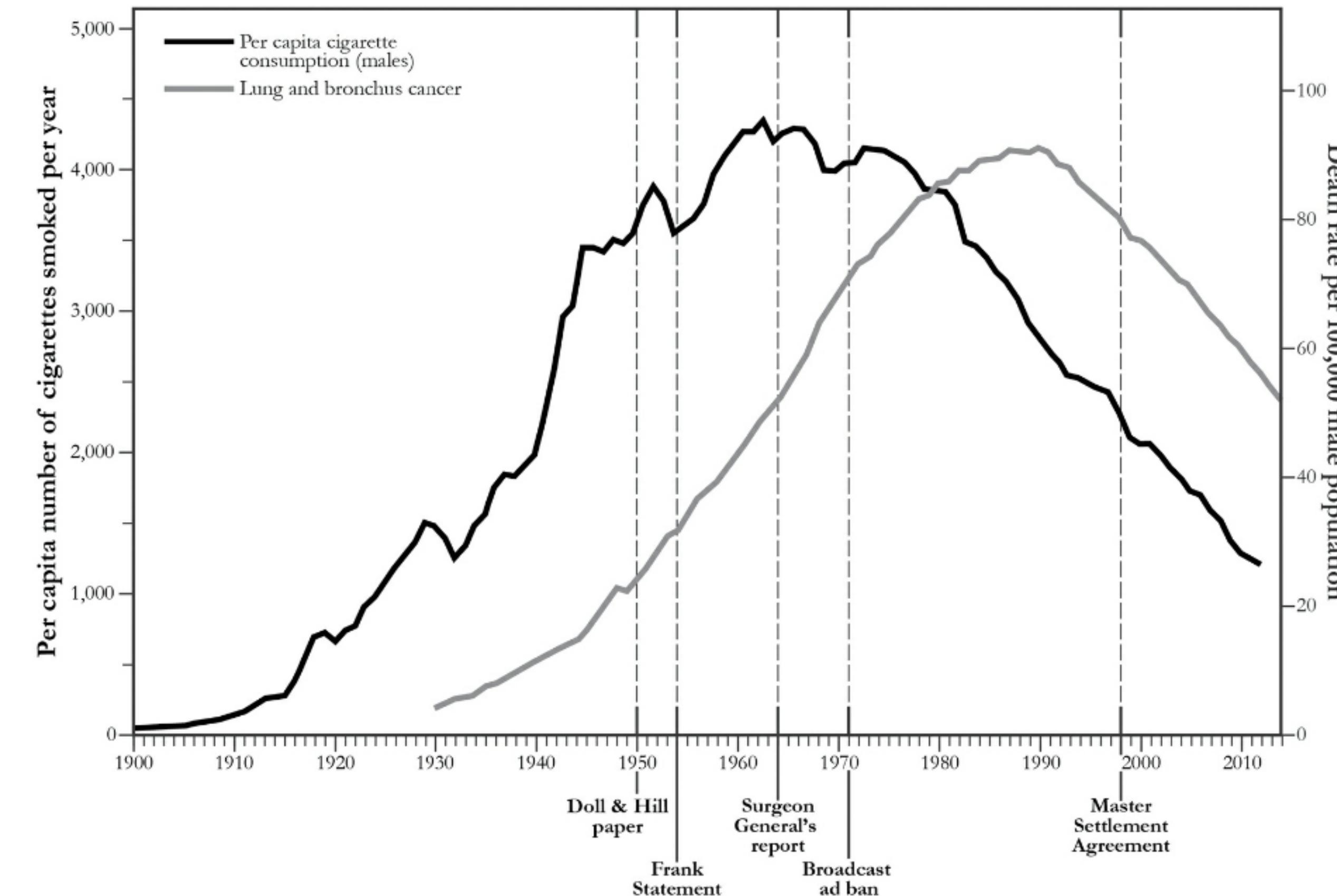


FIGURE 5.2. A graph of the per capita cigarette consumption rate in the United States (black) and the lung cancer death rate among men (gray) shows a stunning similarity: the cancer curve is almost a replica of the smoking curve, delayed by about thirty years. Nevertheless, this evidence is circumstantial, not proof of causation. Certain key dates are noted here, including the publication of Richard Doll and Austin Bradford Hill's paper in 1950, which first alerted many medical professionals to the association between smoking and lung cancer. (Source: Graph by Maayan Harel, using data from the American Cancer Society, Centers for Disease Control, and Office of the Surgeon General.)

Simpson's Reversal & Paradox

Kidney Stone Treatment

	Treatment A	Treatment B
Small stones	Group 1 93% (81/87)	Group 2 87% (234/270)
Large stones	Group 3 73% (192/263)	Group 4 69% (55/80)
Both	78% (273/350)	83% (289/350)

Quiz: Which treatment is better?

Simpson's Reversal & Paradox

Heart disease drugs (fictitious data to make a point)

	Treatment with Drug A	Treatment with Drug B
Low blood pressure	Group 1 93% (81/87)	Group 2 87% (234/270)
High blood pressure	Group 3 73% (192/263)	Group 4 69% (55/80)
Both	78% (273/350)	83% (289/350)

Quiz: Which drug is better?

1. Sample in Daily Life
2. Causality Levels
3. Mini Turing Test
- 4. Probability and Causality**

Everyone is on the first level: connection

“probability raising”: X causes Y if X raises the probability of Y .

$$P(Y | \bar{X}) > P(Y)$$

$$P(\bar{Y} | X, K = k) > P(\bar{Y} | K = k),$$



that we are defining a cause in terms of itself.

I'm on the second level:
intervention

$$P(Y \mid do(X)) > P(Y)$$

.

.

.

ZZD Comments:

- 1. Beyond cause and effect, emotion**
- 2. Laplace's Demon**

“ 我们可以把宇宙现在的状态视为其过去的果以及未来的因。假若一位智者会知道在某一时刻所有促使自然运动的力和所有组构自然的物体的位置，假若他也能够对这些数据进行分析，则在宇宙里，从最大的物体到最小的粒子，它们的运动都包含在一条简单公式里。对于这位智者来说，没有任何事物会是含糊的，并且未来只会像过去般出现在他眼前。

拉普拉斯这里所说的“智者” (*intelligence*) 便是后人所称的拉普拉斯妖。