Day 1

PROBABLY THE BEGINNING OF THE COURSE….

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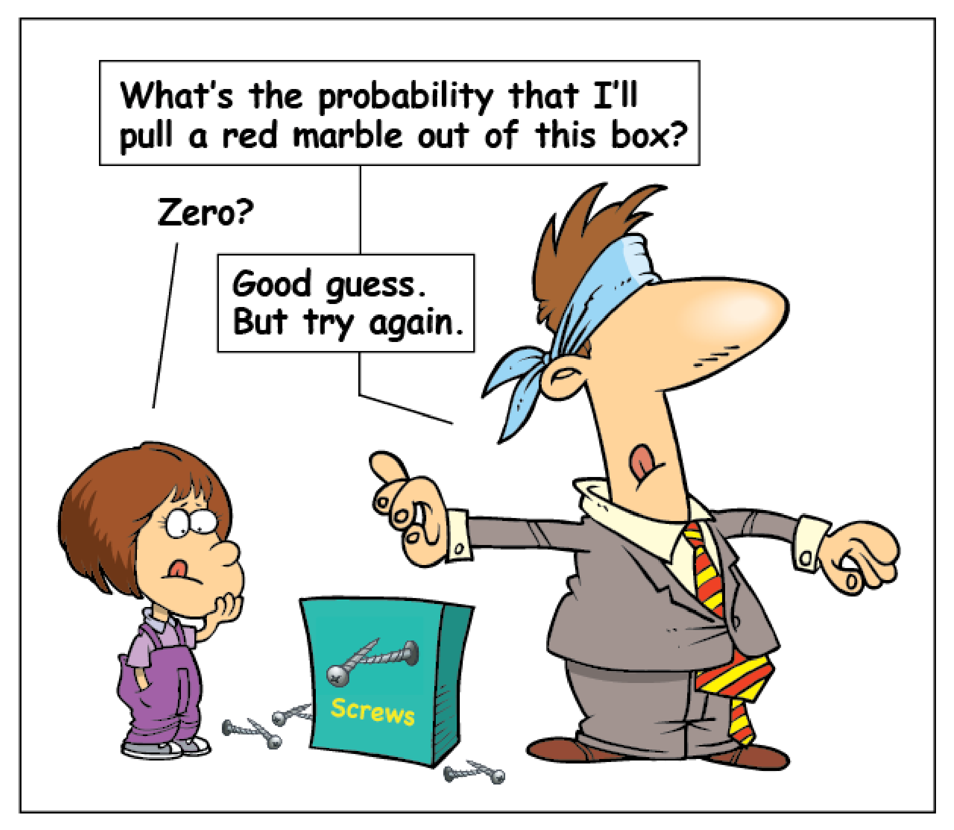
Course introduction

	9.30 – 12.30	14.00 – 16.30
September 18th	Introduction to the course Concept of Probability Frequentist definition Subjective definition Axiomatic definition The Monty Hall problem Biological implications of probability	Practice
September 19th	Descriptive statistics Concept of distribution Gaussian distribution Binomial distribution Exponential distribution Estimation of central tendency and variability	NO
September 20th	Concept of population Sampling strategies Randomization Power analysis	Practice
September 25th	Inferential statistics ANOVA one way ANOVA two ways Non parametrical tests Post hoc tests	Practice
September 26th	Concept of correlation Concept of regression Forecasting models Hints of multivariate statistics (clustering, grouping)	Practice

Before starting, some consideration about the probability.



- … the effect of the treatment was statistically significant ($p<0,01$) …

Can you give me a definition of the word «probability»?

PROBABILITY

Classical definition

The probability of an event is the ratio of the number of cases favorable to it, to the number of all cases possible when nothing leads us to expect that any one of these cases should occur more than any other, which renders them, for us, equally possible.

1. the probability of an event is a number between 0 and 1;
2. the probability of a certain event is equal to 1;
3. the probability of occurrence of one of two incompatible events, that is, of two events that can not occur simultaneously, is equal to the sum of the probabilities of the two events.

to play dice

Criticisms:

The definition is circular: the probability for a "fair" coin is... A "fair" coin is defined by a probability of...

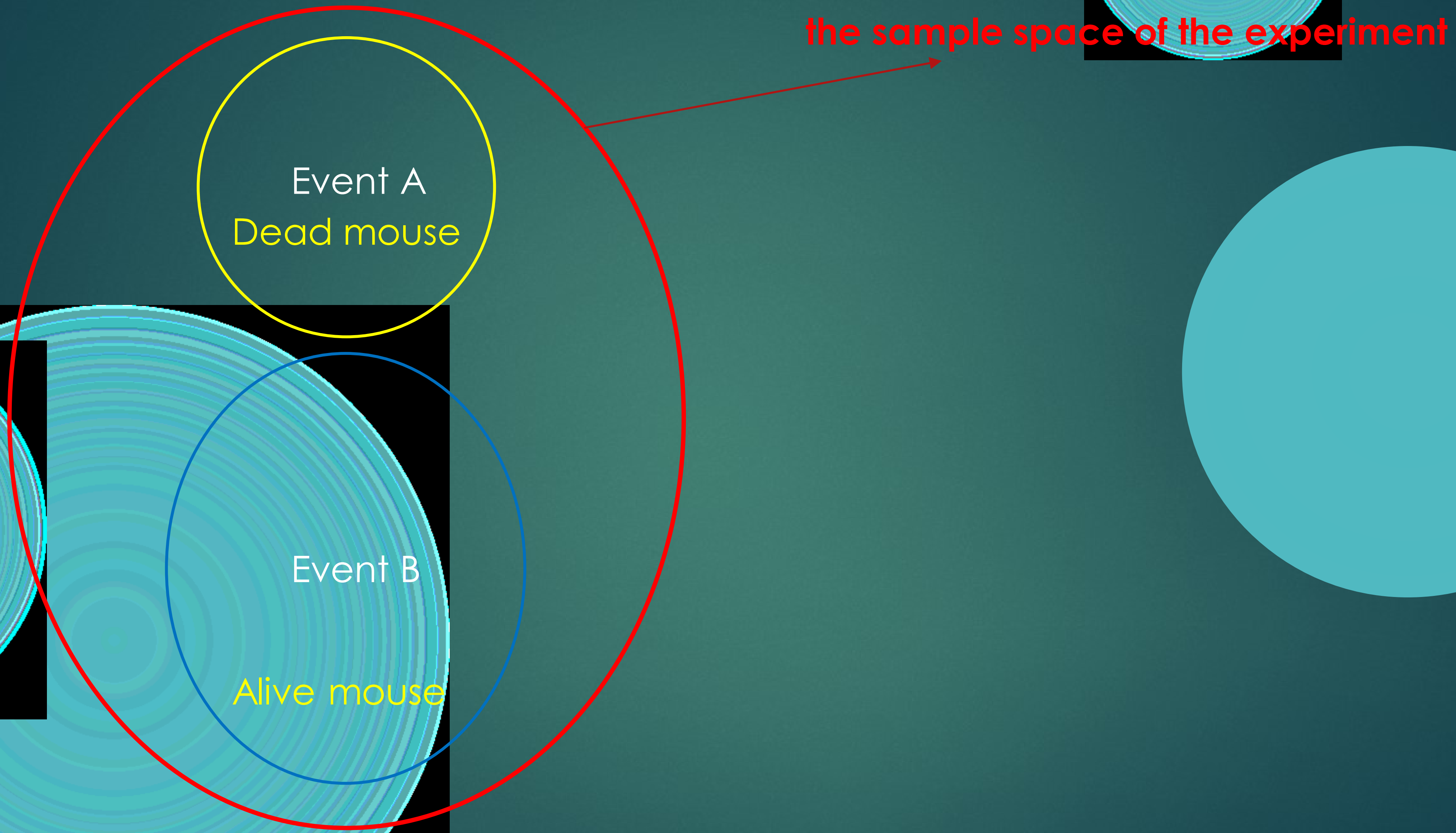
The definition is very limited. It says nothing about cases where no physical symmetry exists. For example coins are not truly symmetric. Can we assign equal probabilities to each side? Can we assign equal probabilities to any real world experience?

It assumes a finite number of possible results and consequently can not be used in the continuum.

PROBABILITY

Frequentist defintion

The set of all possible outcomes of a random experiment is called the sample space of the experiment. An event is defined as a particular subset of the sample space to be considered. For any given event, only one of two possibilities may hold: it occurs or it does not. The relative frequency of occurrence of an event, observed in a number of repetitions of the experiment, is a measure of the probability of that event.


the sample space of the experiment
Event A
Dead mouse
Event B
Alive mouse

Criticisms:

- The relative frequency of occurrence of an event, observed in a number of repetitions of the experiment, is a measure of the probability of that event.

- it is impossible to replicate some experiments!
- is it always impossible, in real world, to exactly replicate an experiment!
- how many replications are needed?
- It could be very hard to consider rare events

PROBABILITY

Subjective defintion

the probability of an event is the price that an individual feels is fair to pay to receive 1 if the event occurs, 0 if the event does not occur.

IT is the cost fair?

1 numero = 6/90	0,066667	prob 1
2 numero = 5/89	0,05618	prob 2
3 numero = 4/88	0,045455	prob 3
4 numero = 3/87	0,034483	prob 4
5 numero = 2/88	0,023256	prob 5
6 numero = 1/87	0,011765	prob 6

prob TOT (prob 1*2*3*4*5*6) = 1,61E-09 = 1/622.614.630

se due possibilità a s[redacted] 1/311.307.315

montepremi/probabilità > cost[redacted]edina

montepremi = 1E+08

valore schedina = 0,321226

Criticisms:

- Subjective probability is a probability derived from an individual's personal judgment about whether a specific outcome is likely to occur. It contains no formal calculations and only reflects the subject's opinions and past experience. Subjective probabilities differ from person to person, and they contains a high degree of personal bias.

PROBABILITY

2.1.1 Axiomatic definition of probability

Probability is a measure of uncertainty. Once a random experiment is defined, we call *probability of the event* $\mathcal{E}$ the real number $\text{Prob}\{\mathcal{E}\} \in [0,1]$ assigned to each event $\mathcal{E}$. The function $\text{Prob}\{\cdot\} : \Omega \rightarrow [0,1]$ is called *probability measure* or *probability distribution* and must satisfy the following three axioms:

1. $\text{Prob}\{\mathcal{E}\} \geq 0$ for any $\mathcal{E}$.
2. $\text{Prob}\{\Omega\} = 1$
3. $\text{Prob}\{\mathcal{E}_1 + \mathcal{E}_2\} = \text{Prob}\{\mathcal{E}_1\} + \text{Prob}\{\mathcal{E}_2\}$ if $\mathcal{E}_1$ and $\mathcal{E}_2$ are mutually exclusive.

These conditions are known as the axioms of the theory of probability [76]. The first axiom states that all the probabilities are nonnegative real numbers. The second axiom attributes a probability of unity to the universal event Ω, thus providing a normalization of the probability measure. The third axiom states that the probability function must be additive, consistently with the intuitive idea of how probabilities behave.

Criticisms:

- how to assign the probability value to events?

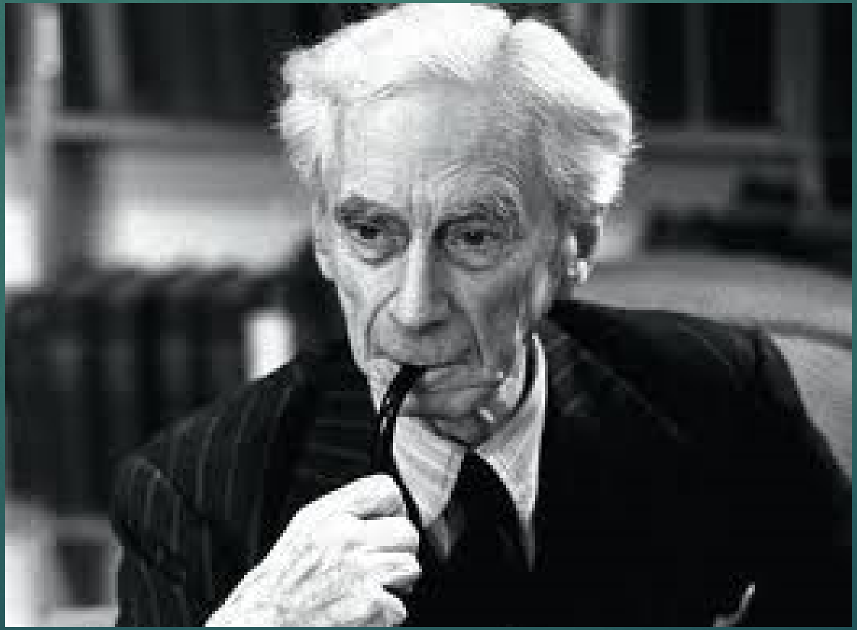
In conclusion …

1)lack of a unique definition / measurement criterion;

2) sometimes counterintuitive.

Probability is the most important concept in modern science, especially as nobody has the slightest notion what it means.

- Attributed to Bertrand Russell -

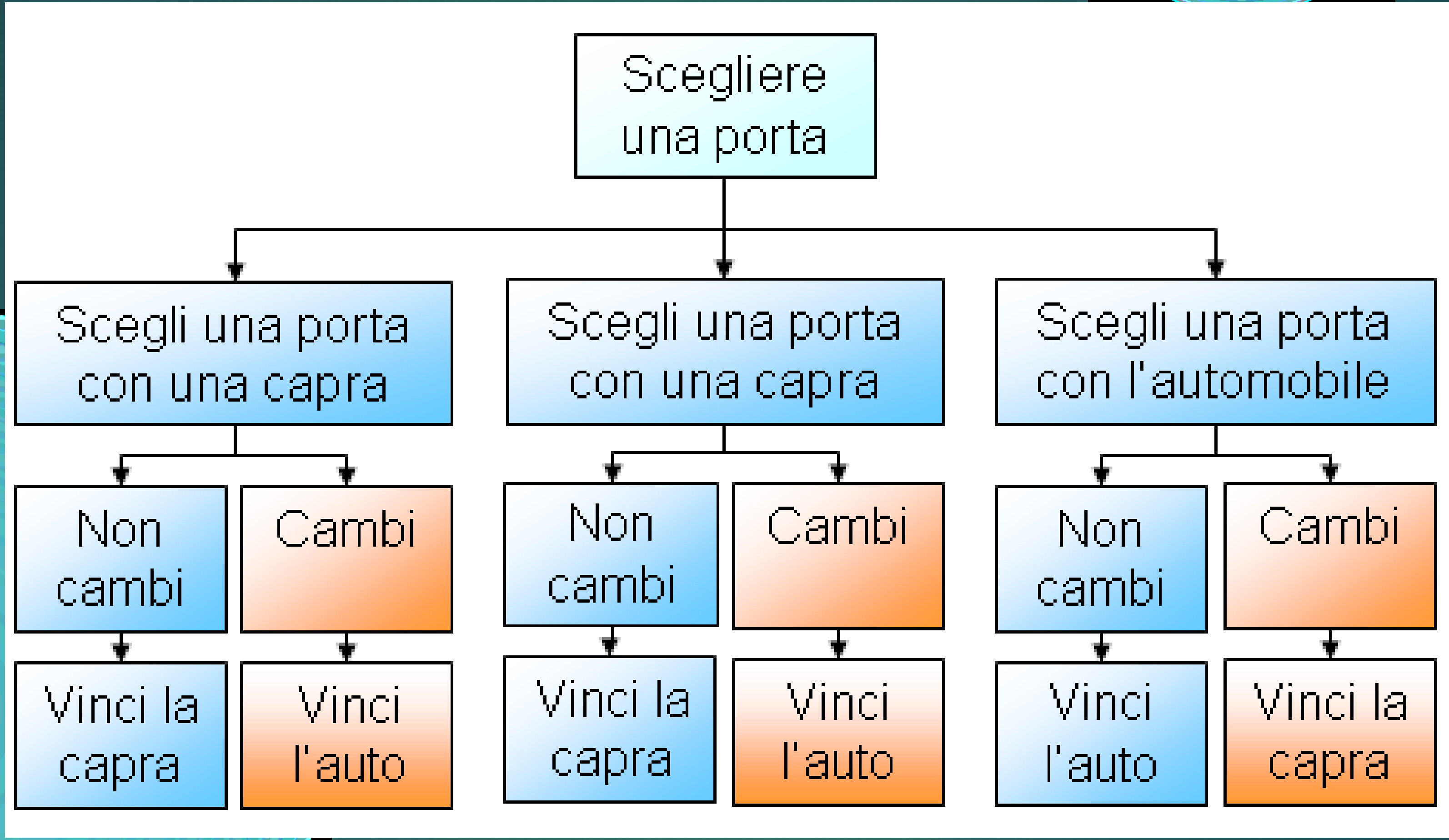


Problem…

A FRIEND OF MINE HAS TWO NON-TWIN CHILDREN. KNOWING THAT ONE IS MALE, WHAT IS THE PROBABILITY THAT THE OTHER IS FEMALE?

The Monty Hall problem

Solution



Scegliere una porta
Scegli una porta con una capra
Scegli una porta con una capra
Scegli una porta con l'automobile
Non cambi
Cambi
Non cambi
Cambi
Non cambi
Cambi
Vinci la capra
Vinci l'auto
Vinci la capra
Vinci l'auto
Vinci l'auto
Vinci la capra

of observing and without regard to each other.

Bayes' theorem

A and B = EVENTS

P(A) and P(B) = probabilities of observing A and B without regard to each other

P(A | B) = conditional probabillity (the probability of observing A given that B is true)

$$P(A \mid B) = \frac{P(B \mid A)\, P(A)}{P(B)},$$

where A and B are events and $P(B) \neq 0$.

- $P(A)$ and $P(B)$ are the probabilities of observing A and B without regard to each other.
- $P(A \mid B)$, a conditional probability, is the probability of observing event A given that B is true.
- $P(B \mid A)$ is the probability of observing event B given that A is true.

example

- Afternoon practical session

https://www.bayes.it/#teorema

Rivediamo il problema di Monty Hall…

Mettiamo che la porta 3 sia stata aperta dal conduttore mostrando una capra e che il concorrente abbia selezionato la porta 1.
La probabilità che l'automobile si trovi dietro la porta 2 (ovvero la probabilità di trovare l'auto dopo aver cambiato la scelta iniziale) è :

$$1-P(A1|C3)$$

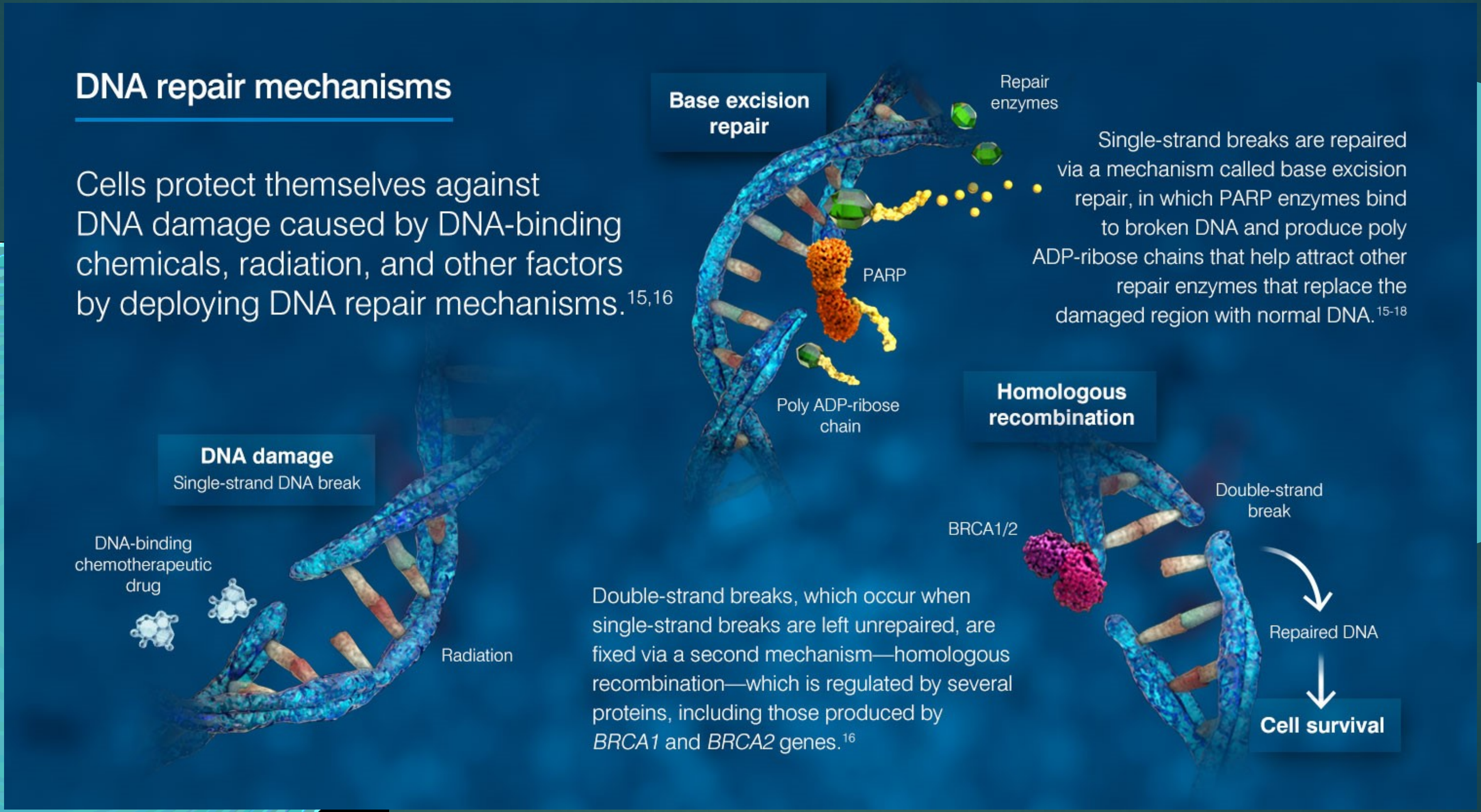
dove A1 = l'auto si trova dietro alla porta 1;
C3 = il conduttore seleziona una capra dietro la porta 3.

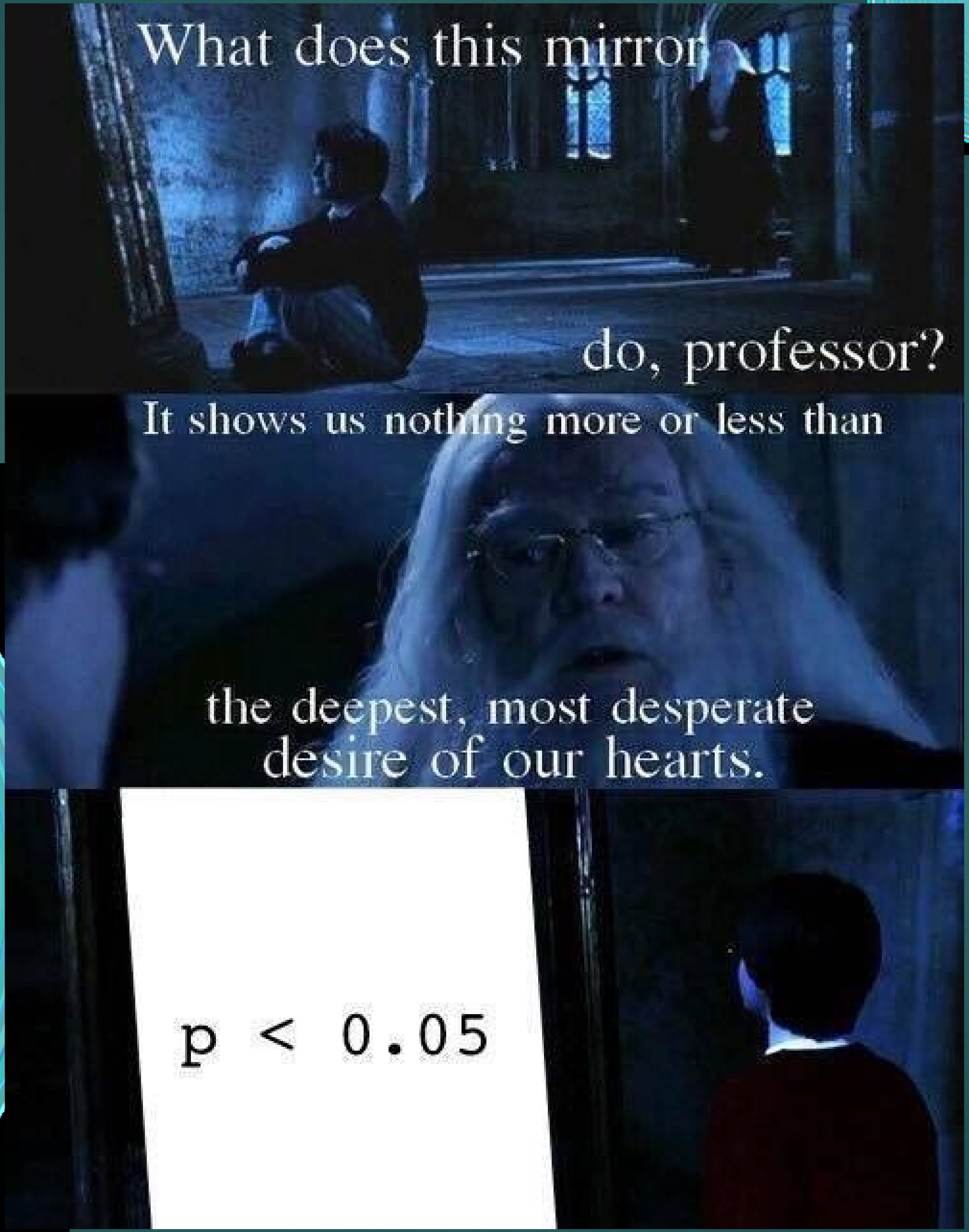
La probabilità a priori che l'automobile si trovi dietro la porta 1, P(A1), = 1/3
La probabilità che il conduttore trovi una capra dietro la porta 3, P(C3) , è = 1, (il conduttore sa in anticipo dove è l'automobile)
La probabilità che il conduttore selezioni una porta con dietro la capra posto ("a posteriori") che l'automobile sia dietro la porta 1, P(C3|A1) = è 1.
Pertanto, sfruttando il teorema di Bayes la probabilità di trovare l'auto cambiando la scelta iniziale, dopo che il conduttore (onnisciente) ha mostrato una porta con dietro la capra è:

$$1-P(A1-C3) = 1 - \frac{P(C3|A1)P(A1)}{P(C3)} = \frac{1-1*1/3}{1} = \frac{2}{3}$$

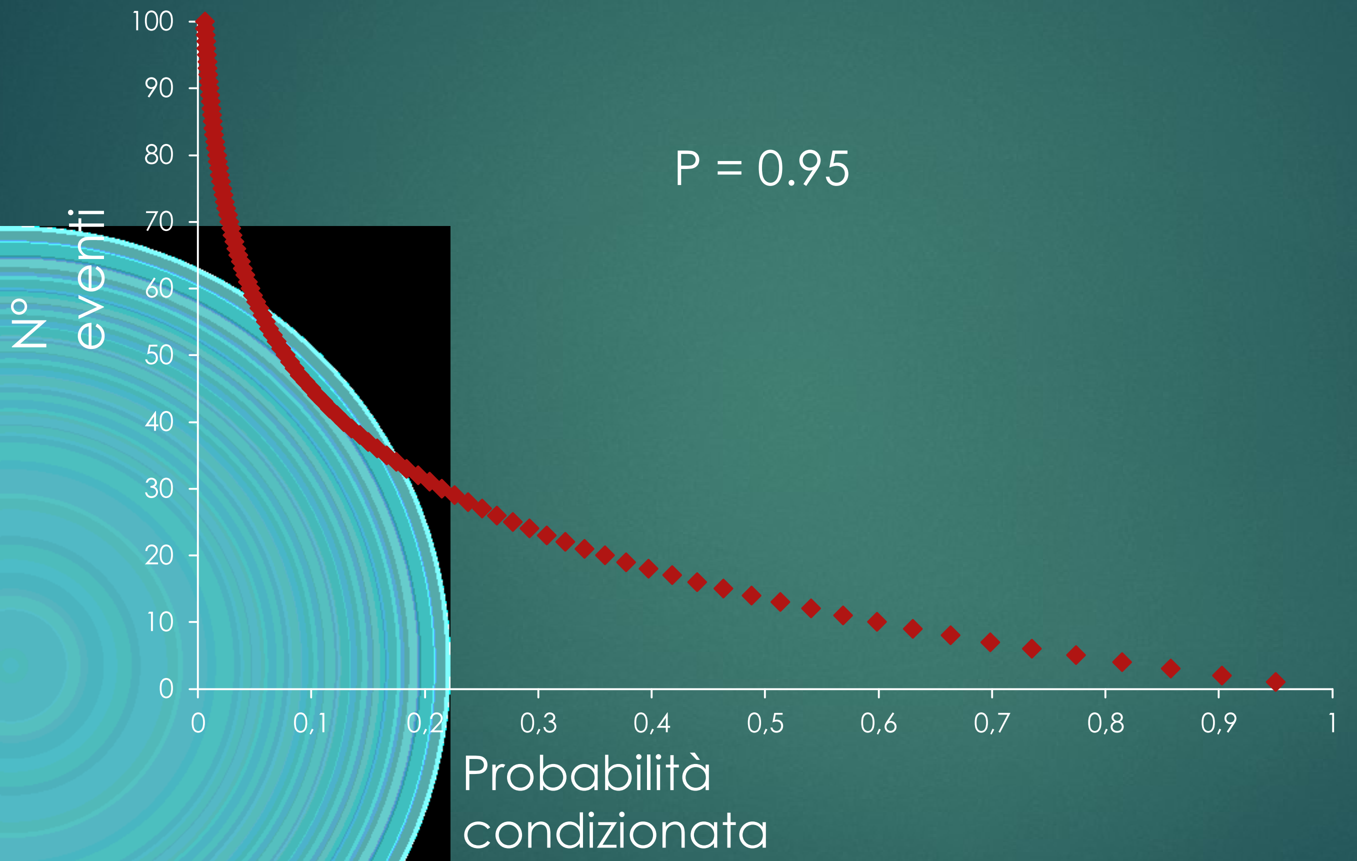
http://montyhallproblem.com/
http://www.youtube.com/watch?v=mhlc7peGlGg

Probability and biology

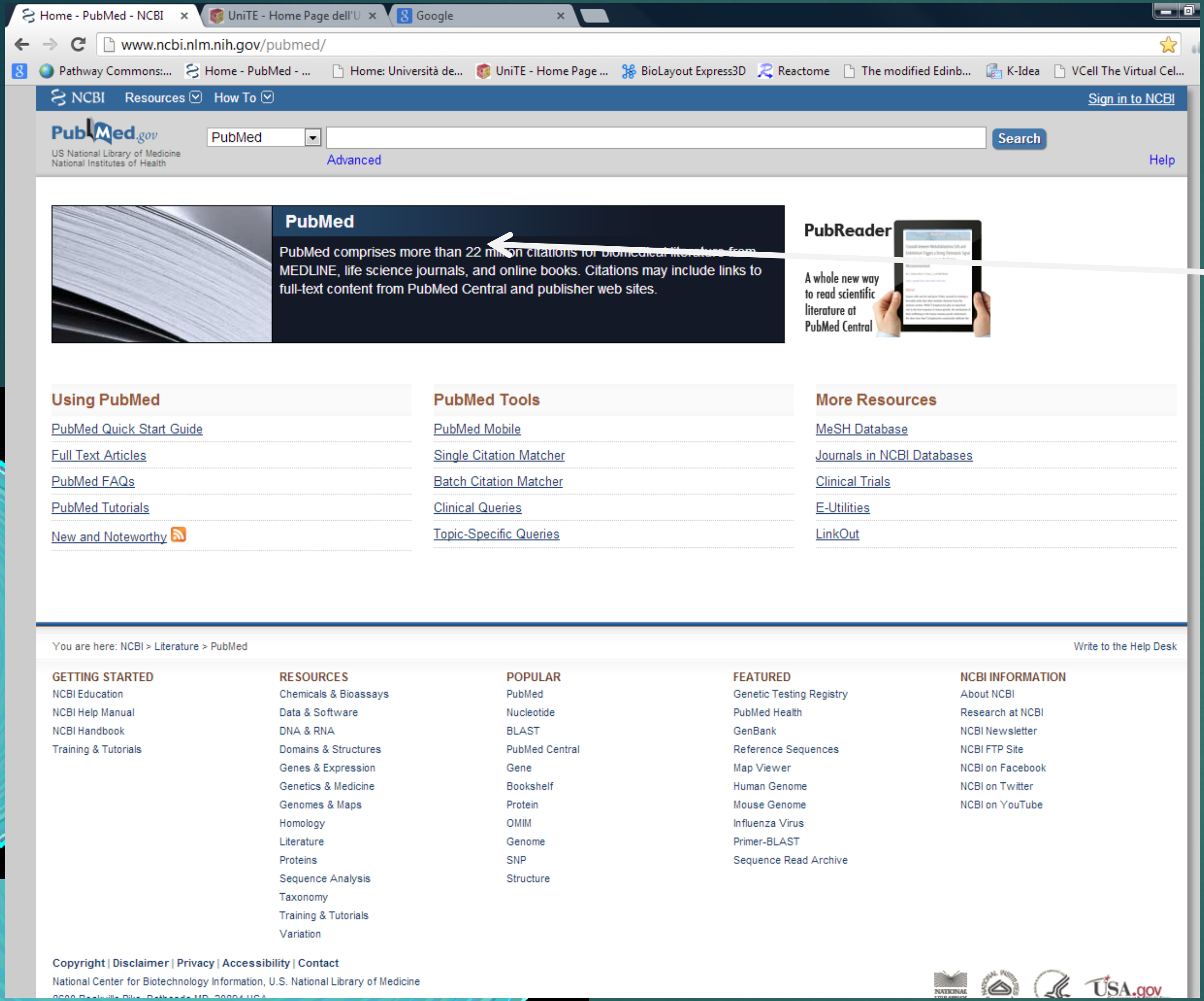



What does this mirror
do, professor?
It shows us nothing more or less than
the deepest, most desperate desire of our hearts.
p < 0.05

P = 0.95



p	eventi
0,95	1
0,9025	2
0,857375	3
0,814506	4
0,773781	5
0,735092	6
0,698337	7
0,66342	8
0,630249	9
0,598737	10
0,5688	11
0,54036	12
0,513342	13
0,487675	14
0,463291	15
0,440127	16
0,41812	17
0,397214	18
0,377354	19
0,358486	20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A whole new way to read scientific literature at PubMed Central
Using PubMed
PubMed Quick Start Guide
Full Text Articles
PubMed FAQs
PubMed Tutorials
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PubMed Tools
PubMed Mobile
Single Citation Matcher
Batch Citation Matcher
Clinical Queries
Topic-Specific Queries
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DNA & RNA
Domains & Structures
Genes & Expression
Genetics & Medicine
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Map Viewer
Human Genome
Mouse Genome
Influenza Virus
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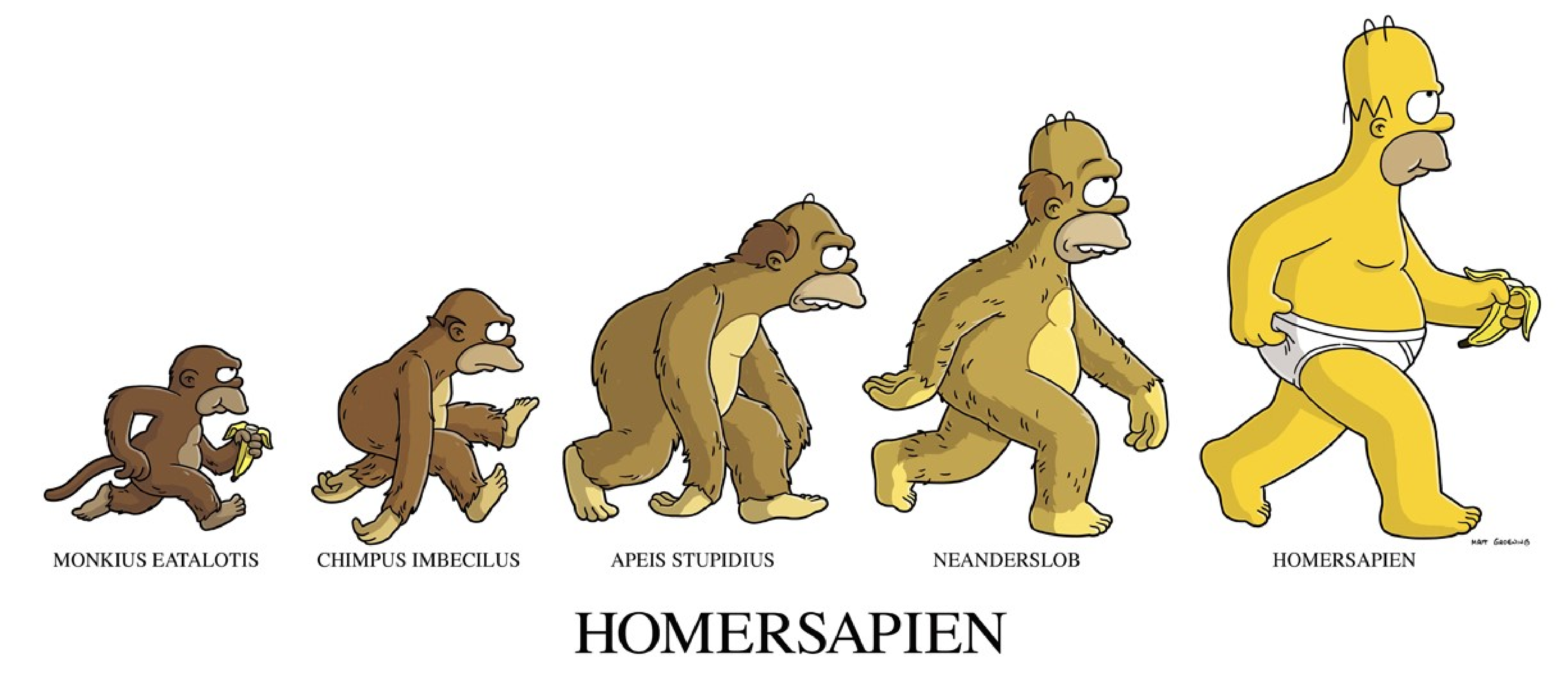
National Center for Biotechnology Information, U.S. National Library of Medicine
USA.gov

5% = 1.100.000

P evento raro (1/10.000)

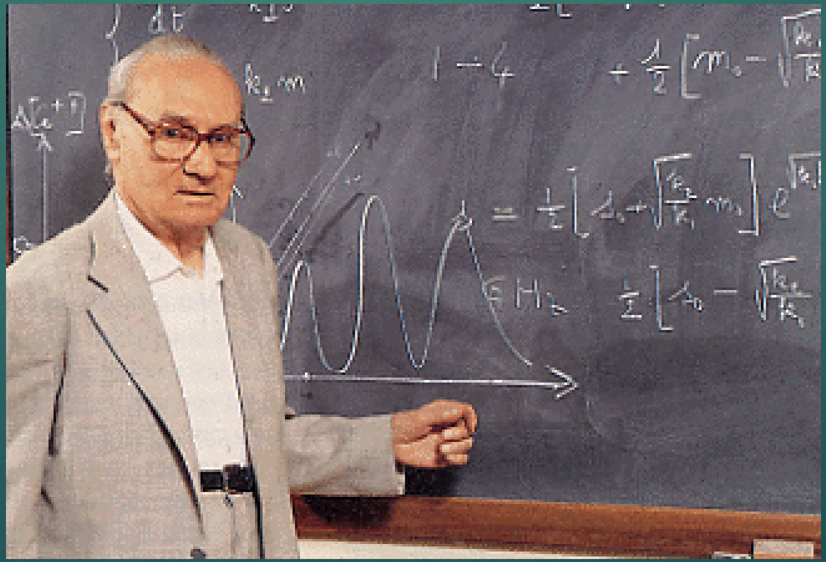
events	p
1	0,0001
2	0,00000001
3	1E-12
4	1E-16
5	1E-20
6	1E-24
7	1E-28
8	1E-32
9	1E-36
10	1E-40

… but …


MONKIUS EATALOTIS
CHIMPUS IMBECILUS
APEIS STUPIDIUS
NEANDERSLOB
HOMERSAPIEN
HOMERSAPIEN

Probabilità per unità di tempo

«Il concetto di *probabilità per unità dì tempo* risulta essenziale quando si tratti di spiegare come mai sia possibile il verificarsi di un certo esito, che di fatto richiede la concorrenza concertata di un gran numero di eventi casuali diversi. È la difficoltà di fronte alla quale molti capitolano, quando si tratta di giustificare in qualche modo il formarsi spontaneo di un sistema chimico appropriato di una prima cellula vivente. Sembra loro che il numero di eventi casuali concorrenti che debbono verificarsi sia talmente elevato, da rendere la probabilità della comparsa spontanea della vita un evento di probabilità evanescente» (Mario Ageno)



Some calculations...

1/100 sec.

1/1000
p=0,001

1	0,001
2	0,000001
3	0,000000001
4	1E-12
5	1E-15

1 year	31536000 sec.
1 year	3,1536E-06
1000 years	0,0031536
1 Bilion years	3153,6

How life on Earth really got its start.

Randomization