ENGAGING SCIENCE

Rotman Institute of Philosophy

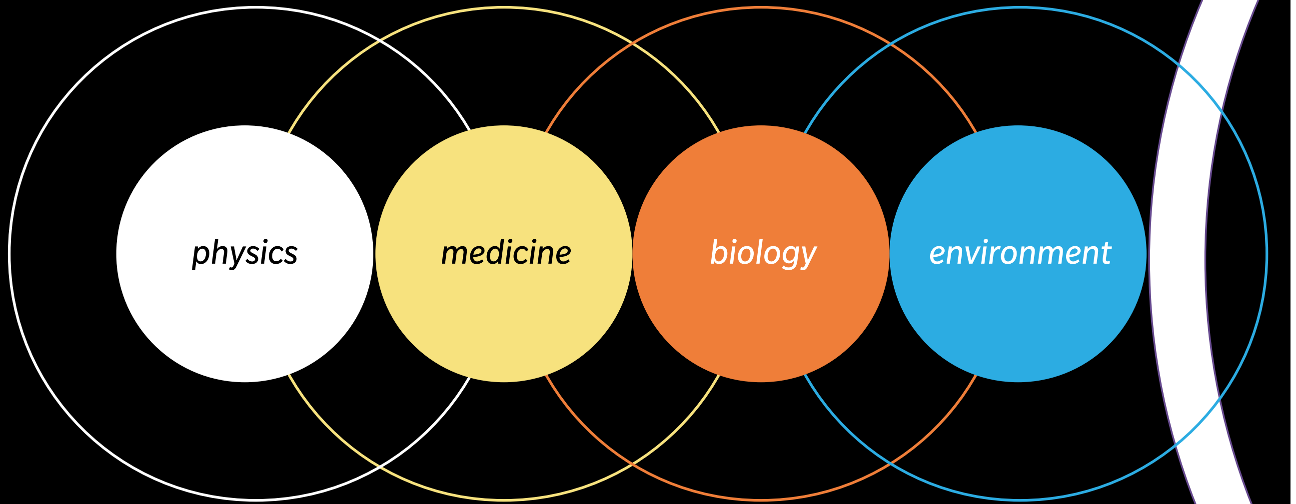
Was Einstein a philosopher?

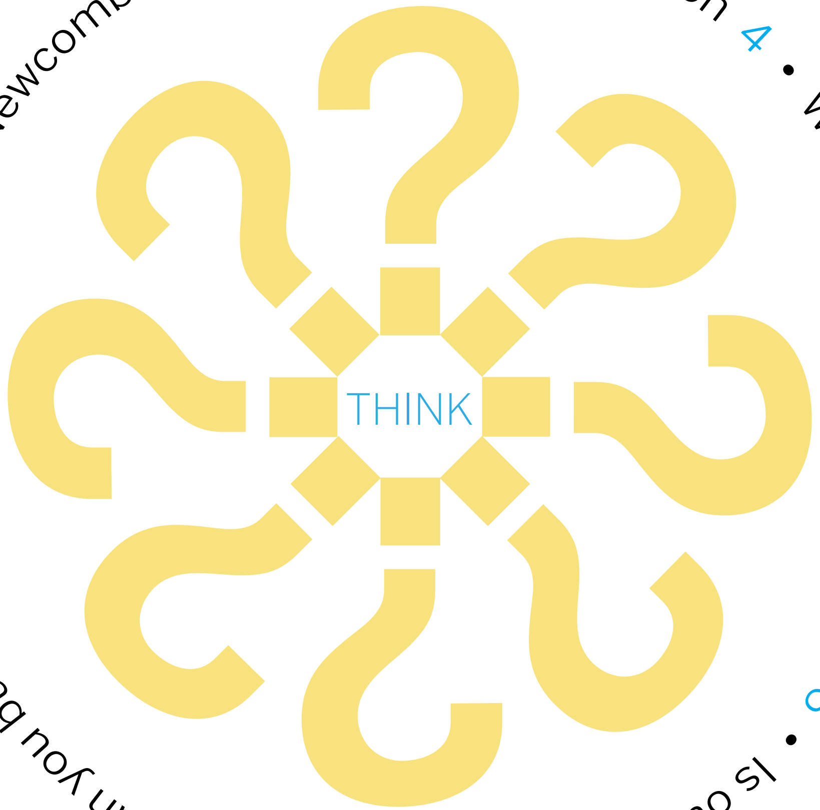
Can you build a time machine?

Would you win $1,000,000?

Is our world irreversible?

SELECTED FOCUS AREAS



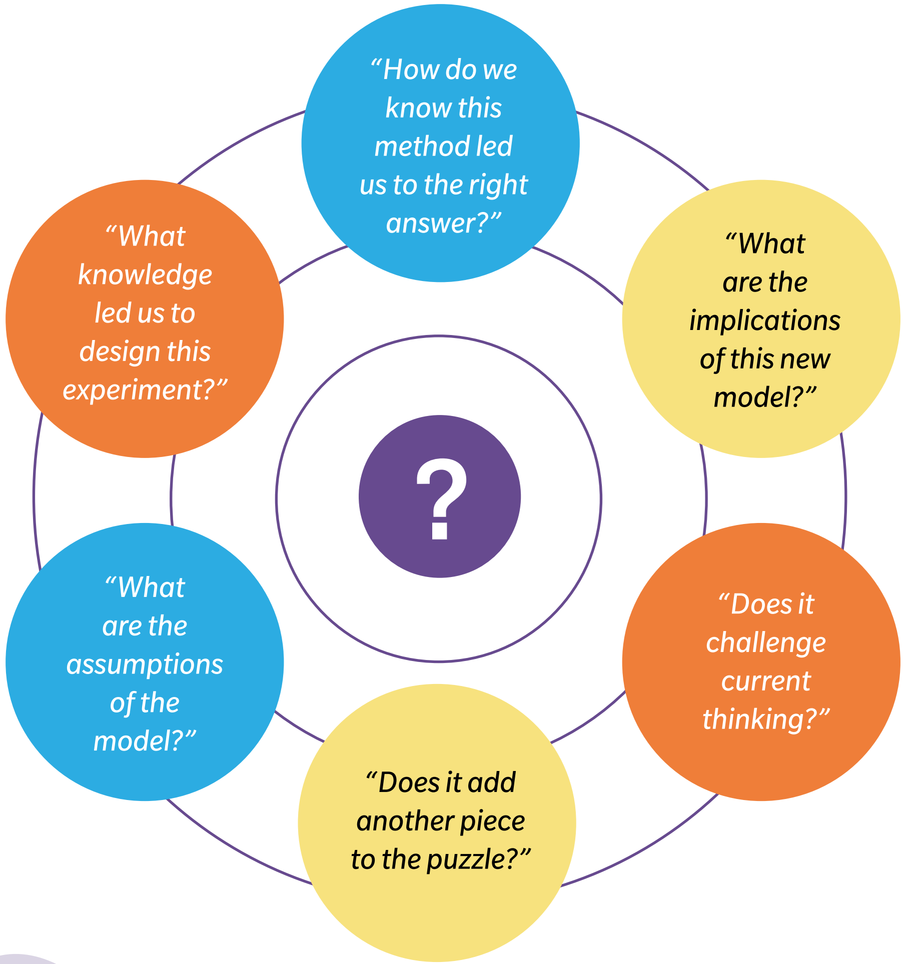


WHO WE ARE

The Rotman Institute of Philosophy at Western University brings together philosophers and scientists to examine some of the most complex issues and most engrossing problems emerging from contemporary science.

Members of the Rotman Institute include scholars who work on the history and philosophy of science, bioethics, neuroscience, biology and ecology, physics, cosmology, and feminist approaches to science, among other things. We come together in a unique collaborative workspace to engage, explore and exchange ideas. This "philosophy laboratory" is the heart of the Rotman Institute.

Philosophers ask **questions**...



that spark our **intellectual curiosity**,
push our thinking,
make us accountable...

If **philosophy** is the study of the fundamental nature of knowledge, reality, and existence – **how we know something to be true** – then it makes sense that philosophy is **a part of science**. The two are intertwined, linked, connected, inseparable.

...and make us understand
the **broader context** in which
science exists.

WAS EINSTEIN A PHILOSOPHER?

What does it mean to “advance” physics, and how does this advancement occur? Philosophers at the Rotman Institute believe that philosophy, along with experimentation and mathematics, drives the advancement of science.

Einstein was celebrated for having the mind of both a physicist and a philosopher. His thought experiments and reflections have helped shape the world of modern physics.

Einstein questioned basic ideas of existing theories, often revealing flaws others had overlooked. Some of his philosophical challenges can be vividly captured with a thought experiment. For one of his famous thought experiments, which he called the “best idea of his life,” he imagined himself riding an elevator in free fall. Thinking about the elevator helped him to see a crack in the foundation of Newton’s theory of gravity.

The weightlessness of being in an elevator that is falling freely “under gravity’s pull”, Einstein realized, was the same as the weightlessness of hovering in deep space far from any planet or star. So Einstein boldly conjectured that both situations are in fact the same - there is no such thing as a “gravitational field”!

Einstein’s insight led him to create a theory in which “falling” is just the natural motion of a body in a curved spacetime. He also connected this idea with an important idea, which he dubbed “Mach’s Principle”, that further guided his thinking in his search for a new theory of gravity.

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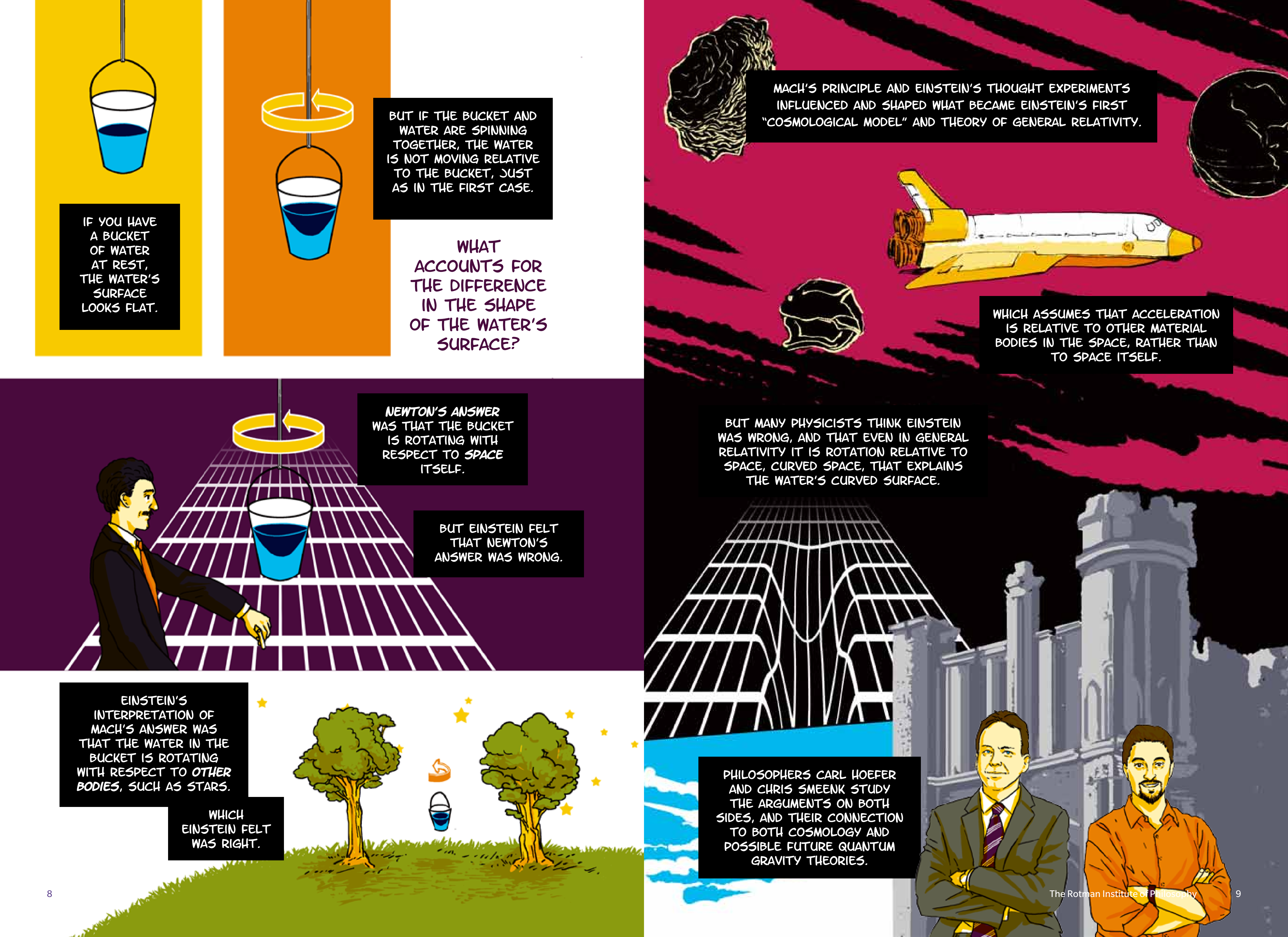

IF YOU HAVE A BUCKET OF WATER AT REST, THE WATER'S SURFACE LOOKS FLAT.
BUT IF THE BUCKET AND WATER ARE SPINNING TOGETHER, THE WATER IS NOT MOVING RELATIVE TO THE BUCKET, JUST AS IN THE FIRST CASE.
WHAT ACCOUNTS FOR THE DIFFERENCE IN THE SHAPE OF THE WATER'S SURFACE?
NEWTON'S ANSWER WAS THAT THE BUCKET IS ROTATING WITH RESPECT TO *SPACE* ITSELF.
BUT EINSTEIN FELT THAT NEWTON'S ANSWER WAS WRONG.
EINSTEIN'S INTERPRETATION OF MACH'S ANSWER WAS THAT THE WATER IN THE BUCKET IS ROTATING WITH RESPECT TO *OTHER BODIES*, SUCH AS STARS.
WHICH EINSTEIN FELT WAS RIGHT.
MACH'S PRINCIPLE AND EINSTEIN'S THOUGHT EXPERIMENTS INFLUENCED AND SHAPED WHAT BECAME EINSTEIN'S FIRST "COSMOLOGICAL MODEL" AND THEORY OF GENERAL RELATIVITY.
WHICH ASSUMES THAT ACCELERATION IS RELATIVE TO OTHER MATERIAL BODIES IN THE SPACE, RATHER THAN TO SPACE ITSELF.
BUT MANY PHYSICISTS THINK EINSTEIN WAS WRONG, AND THAT EVEN IN GENERAL RELATIVITY IT IS ROTATION RELATIVE TO SPACE, CURVED SPACE, THAT EXPLAINS THE WATER'S CURVED SURFACE.
PHILOSOPHERS CARL HOEFER AND CHRIS SMEENK STUDY THE ARGUMENTS ON BOTH SIDES, AND THEIR CONNECTION TO BOTH COSMOLOGY AND POSSIBLE FUTURE QUANTUM GRAVITY THEORIES.

IS OUR WORLD IRREVERSIBLE?

Philosopher Wayne Myrvold has been fascinated by irreversibility since childhood.

When you start thinking about it, irreversible processes are everywhere. Once you cook an egg, you can't uncook it. You can't fuel a car by collecting the exhaust and undoing the process of combustion to extract gasoline. And we are all relentlessly getting older. Why do physical processes go one way and not the other?

Understanding the physical basis of this irreversibility means understanding something very basic to human experience.

The discovery that matter is made of molecules that obey mechanical laws answered a great many question, but it raised some new ones. One of them is the question of explaining irreversibility. The fundamental physical laws that govern the behaviour of things are, insofar as they are relevant to the sorts of processes we're talking about, reversible in time. But for all practical purposes, our world is irreversible.

One way to see this is to watch a video of ordinary events being played backwards. It quickly becomes obvious that it is backwards. Some things just don't happen in reverse. This is a fact so familiar that it's hard to imagine that there would be anything puzzling about it.

But at the sub-microscopic level, these processes are the effects of lots of molecules moving around. Anything these molecules can do, it would seem, they can do in the reverse direction. So why is it that there are so many irreversible processes in the world of our experience?

> *Thinking at the molecular level, it's plain to see that what the Second Law of Thermodynamics says is* ***impossible*** *is really only very* ***improbable.***

A clue to understanding this can be gleaned from thinking about what happens when gases mix. Open a bottle of perfume, and the scent gradually diffuses through the room. We all know that, once out of the bottle, the perfume won't spontaneously go back in.

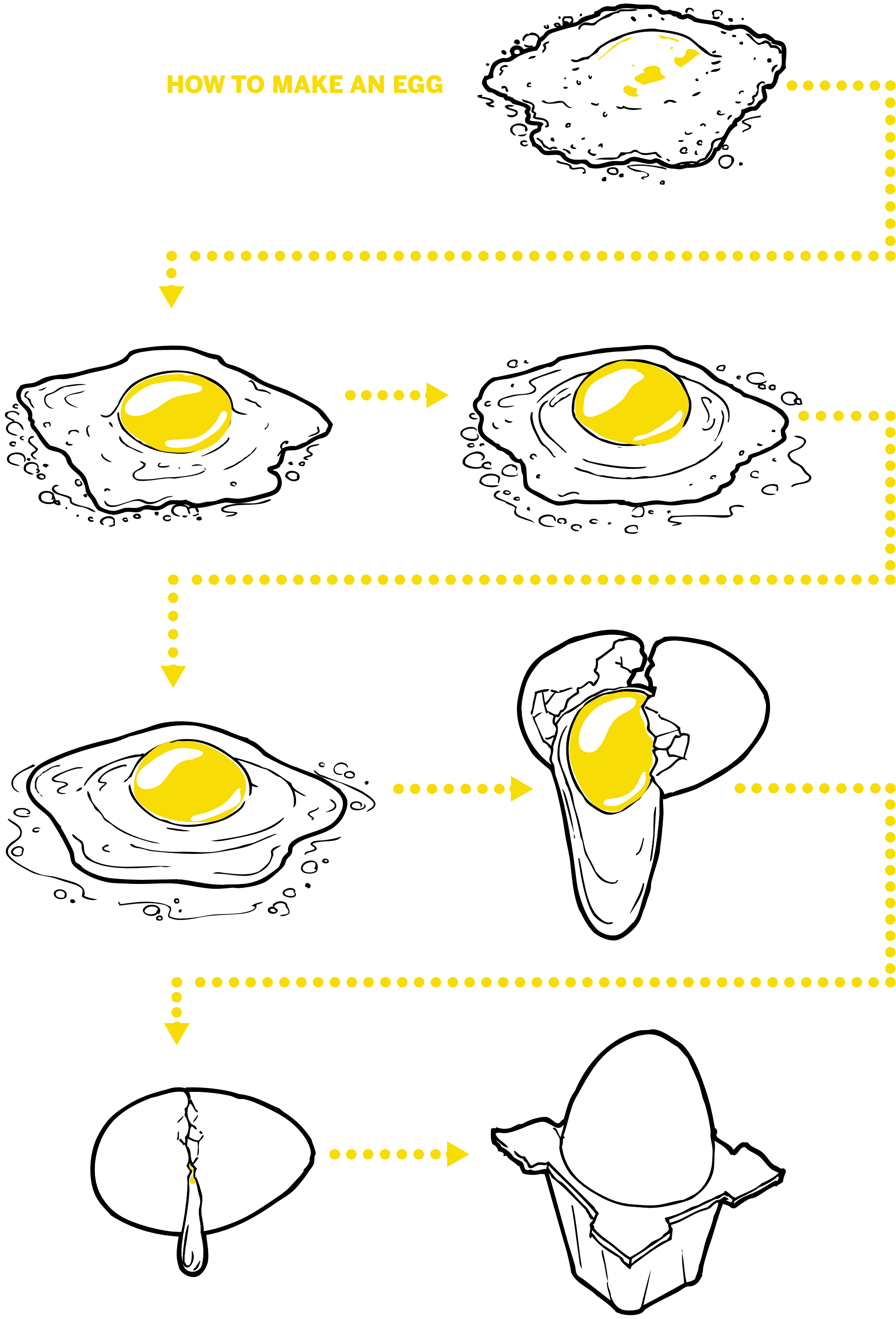
Think of this, now, at the level of molecules. The perfume molecules are being jostled around by air molecules, and are bouncing haphazardly. As time goes on, more and more of them get further and further from the bottle.

The Second Law of Thermodynamics says that certain processes, once they occur, can't be undone without some effort. Although, there's nothing preventing the perfume molecules from spontaneously re-entering the bottle, thinking at the molecular level, it's plain to see that what the Second Law of Thermodynamics says is *impossible* is really only very *improbable*.

This means that we have to make sense of probabilities in physics. The first physicist to clearly see that an explanation of irreversibility would have to involve probability was James Clerk Maxwell.

Philosopher Wayne Myrvold at the Rotman Institute has written an article to make Maxwell's views better-known called "Statistical Mechanics and Thermodynamics: A Maxwellian View" and is working on a book about probabilities in statistical mechanics. His graduate student Joshua Luczak's dissertation project aims at a better understanding of irreversible processes in statistical mechanics.

HOW TO MAKE AN EGG



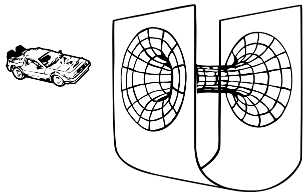
CAN YOU BUILD A TIME MACHINE?

Philosophers Chris Smeenk and Carl Hoefer ponder time travel and determinism.

Wouldn't it be amazing to build a time machine like Doc Brown's DeLorean car in the 80s movie classic *Back To The Future*? Would you change the course of history for the good? What if things changed so that you were never born?! But that's only on TV... or is it?

Before Einstein, space and time were thought to be fixed and unchanging, just a stage for the motion of bodies. But in Einstein's theory of gravity, the geometry of space and time is not fixed. The presence of bodies makes space and time curve. The theory also describes space and time together, as aspects of *spacetime* geometry. It turns out that lots of very different spacetime geometries are "allowed" by Einstein's theories, all satisfying the basic equations for different kinds of matter.

Some of these geometries are quite unusual, including ones with curves representing the path of possible observers looping back on themselves when traveling through spacetime. Such curves, called closed timelike curves (CTCs), would be the path of a time traveler.



A closed timelike curve (CTC).

Time travel?! Could we really manipulate matter and things around us to create such a curve – that is, build a time machine? When Carl Sagan was writing Contact, he reached out to Kip Thorne (a physicist at Caltech) to see if a person could travel through a wormhole. Thorne and others started studying bizarre spacetime geometries that would make time travel possible. Stephen Hawking then argued that quantum mechanical effects would make it impossible.

It turns out that there were some theoretical kinks in the quest for time travel. One of these kinks relates to determinism. Determinism is the idea that the future is fixed based on physical laws and the state of the universe at that moment. For example, you know when you release a ball from your hand, it predictably falls to the floor.

There is a precise way of characterizing which spacetime geometries are compatible with determinism. Spacetimes with unusual geometry like CTCs are not compatible with determinism, where who knows what that ball would do when you released it.

Should we rule out these geometries then? If matter doesn't abide by the deterministic laws of physics while traveling in time, then how can we say that we've "made" a CTC appear?

At the Rotman Institute of Philosophy, Carl Hoefer and Chris Smeenk have thought about time travel because of what it reveals about determinism and the notion of physical possibility. If physics allows for the possibility of CTCs, does this indicate that determinism is false? Or should we instead reconsider Einstein's theory?

Physicists have mostly focused on proving that spacetimes with CTCs are incompatible with other theories, such as quantum mechanics. In assessing what is "physically possible," philosophers at Rotman think we may need to include insights from a variety of theories, rather than only Einstein's theory of gravity.

You have been invited by philosophers CARL HOEFER and BILL HARPER to play a mind-bending game called

NEWCOMB`S PARADOX

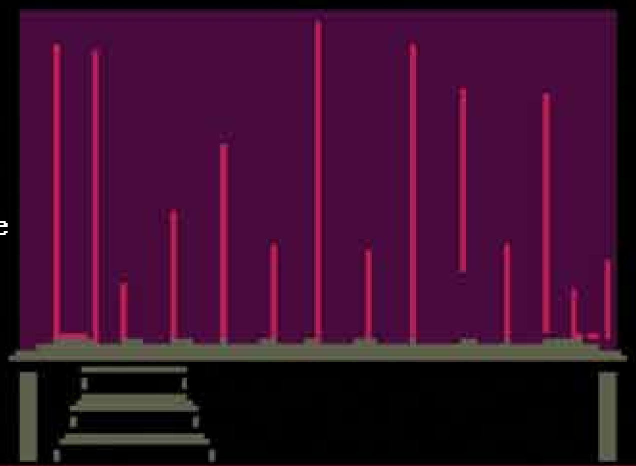
There are two boxes on a stage. One box is clear and has $1,000 in it. The second box [?] is opaque and either has $1 million or nothing in it. You can only guess.

The point of the game is for you to decide if it is smarter (more rational) to take the opaque box [1 BOX] or both of the boxes [2 BOXES].

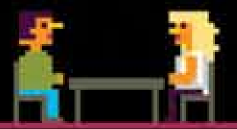
But there`s a catch... you need to factor in the prediction of a psychologist who has an uncanny ability to predict your decision!

This is a strategy game where you choose [2 BOXES] or [1 BOX] where the $$ in one box is always unknown.

You are currently backstage before the game begins.



A psychologist named Cassandra interviews you before you go on stage.



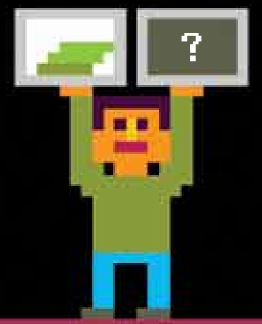
She will make a prediction whether you will choose [2 boxes] or [1 box]. She is right 99% of the time.

You know that based on her prediction, the [?] box will get...

SHE PREDICTS YOU WILL CHOOSE

[2 BOXES]

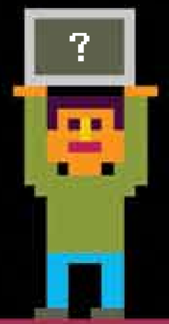
$1,000 $0



SHE PREDICTS YOU WILL CHOOSE

[1 BOX]

$1,000,000



BUT YOU

DON`T KNOW

HER PREDICTION

MAKE YOUR CHOICE

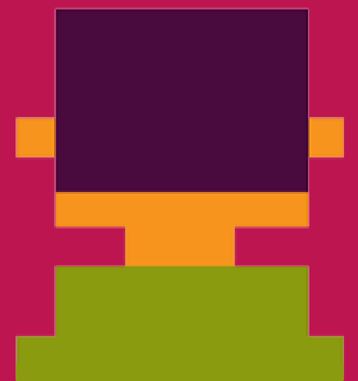
TEST YOUR REASONING

[2 BOXES]

I have no control over what is in the [?] box. I am happy with getting the $1,000 in the clear box. At least it is something. Plus, there is a 1% chance that Cassandra`s prediction is wrong and I will get a million in the [?] box anyway. Either way, I get all the money that is now on stage, and I can`t do any better.

[1 BOX]

I feel confident in choosing [1 BOX]. Choosing [1 box] means I am more likely to win the million than if I choose both boxes, because Cassandra is right 99% of the time. Choosing 1 box, I will only fail to get the million dollars in the rather rare case that Cassandra makes a wrong prediction.



WOULD YOU WIN $1,000,000

<-START GAME

NEWCOMB`S PARADOX

GAME OVER

NEWCOMB`S PARADOX

/ ASK YOURSELF \

Did I choose rationally?

Did I have `free will`
when I made my choice?

Did it make a difference to me
that Cassandra is wrong 1% of the time?

Is it possible to affect the past
with one`s current decisions?

/ CAUSAL DECISION THEORY \

If you are a [2 boxer], your line of reasoning matches that of more philosophers than [1 boxer] reasoning.

This rationale and related thought experiments led to the creation of CAUSAL DECISION THEORY, which advocates calculating the expected benefit based on the `current` state of affairs actually present at the moment of decision.

So if you assume that you can not `affect the past`, then the fact that 99% of [2 boxers] only get $1000 is irrelevant. You get as much money as you possibly can, given the current state of things.

/ EVIDENTIAL DECISION THEORY \

But some philosophers are skeptical about words like `causality` or the `past/present/future distinction`. They would argue that *if* a situation/game like Newcomb`s paradox could be created in real life, the rationale of being a [1 boxer] would make more sense.

/ THE ROTMAN INSTITUTE \

Carl Hoefer has part of a book chapter devoted to the discussion of the Newcomb problem and its relation to the notion of objective probability.

Bill Harper, an Emeritus professor of UWO and member of the Rotman Institute, was one of the founders of Causal Decision Theory. `Counterfactuals and Two Kinds of Expected Utility` by Bill Harper and Alan Gibbard, 1978.

TO LEARN MORE ABOUT THE RESEARCH GOING ON AT THE ROTMAN INSITUTE OF PHILOSOPHY

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physics

biology

medicine

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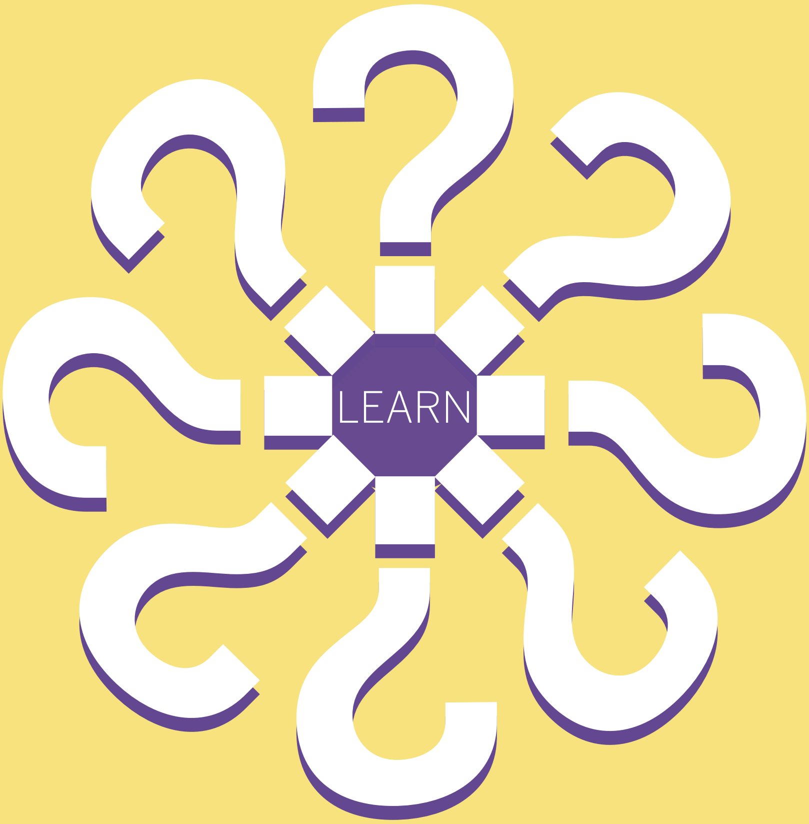

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