How’d We Arrive Here?

(Selmer’s Leibnizian Whirlwind History of Logic)

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Intro to Logic
1/24/2019

RAIR
Rensselaer AI and Reasoning Lab

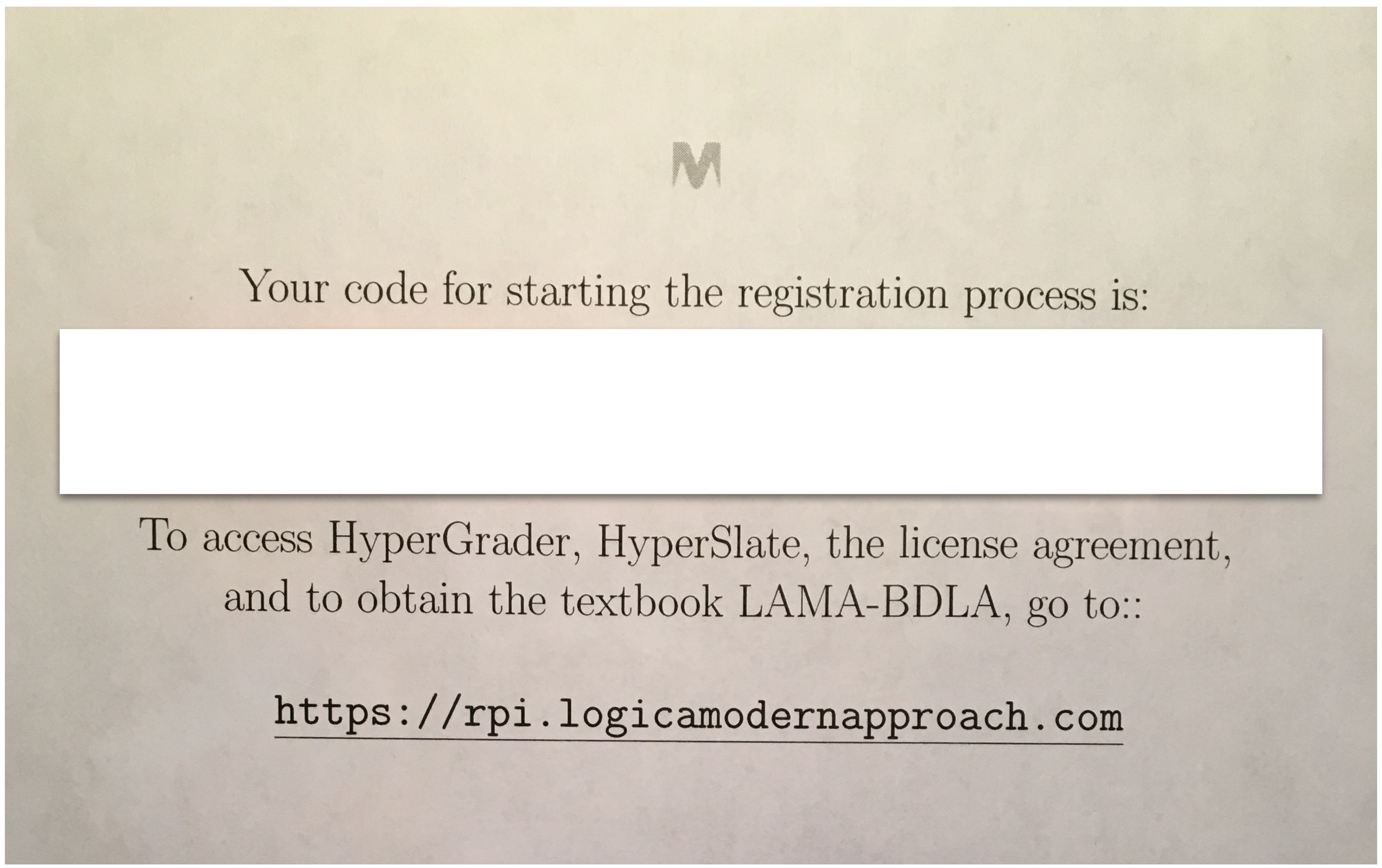
The Starting Code to Purchase in Bookstore

Your code for starting the registration process is:

To access HyperGrader, HyperSlate, the license agreement, and to obtain the textbook LAMA-BDLA, go to::

https://rpi.logicamodernapproach.com

The Starting Code to Purchase in Bookstore



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Once seal broken on envelope, no return. Remember from first class, any reservations, opt for "Stanford" paradigm, with its software instead of LAMA™ paradigm!

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Intro to Logic
1/29/2018

Caveat; Apology; Rain Check

Caveat; Apology; Rain Check

LAMA–BDLA

Caveat; Apology; Rain Check

LAMA–BDLA

Caveat; Apology; Rain Check

LAMA–BDLA

Caveat; Apology; Rain Check

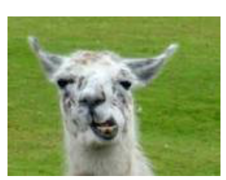
LAMA–BDLA

LAMA–BIL, a bit.

The Monty Hall Problem

$1M

The Monty Hall Problem



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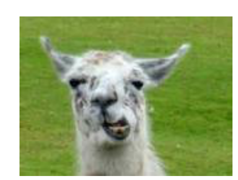

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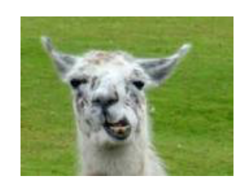

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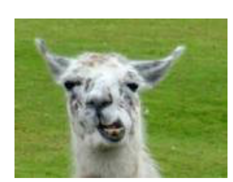

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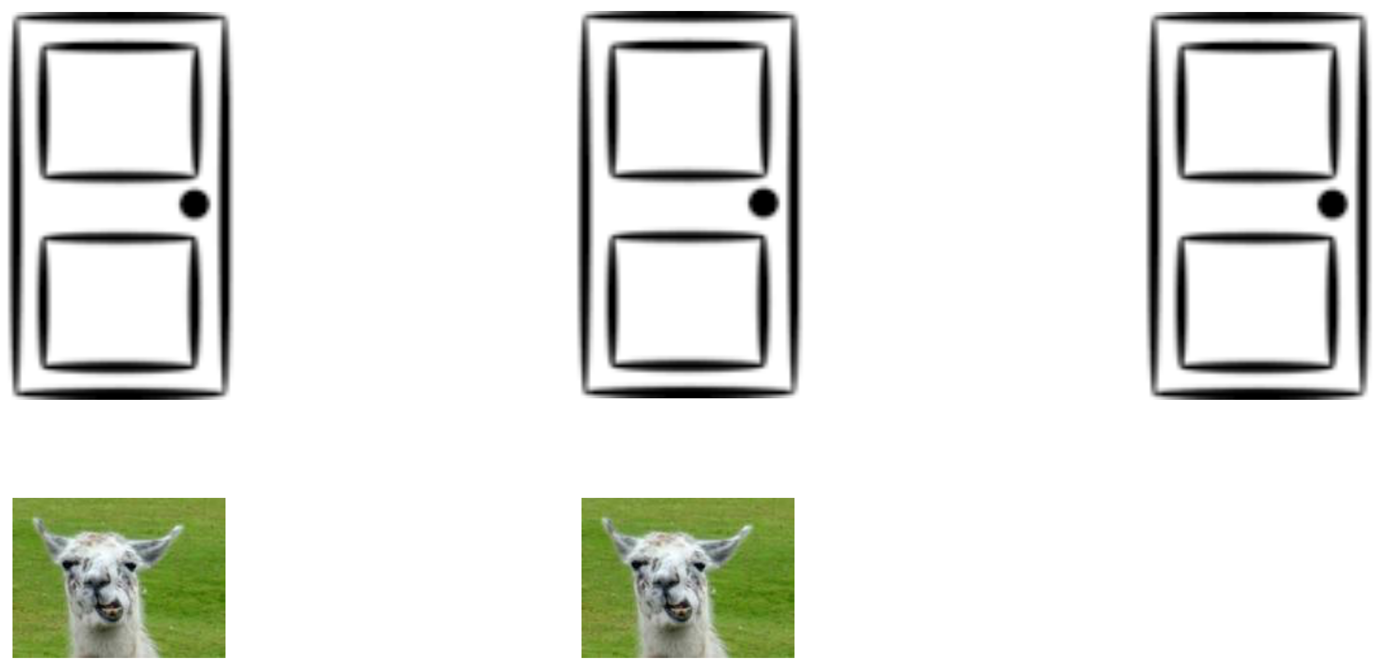

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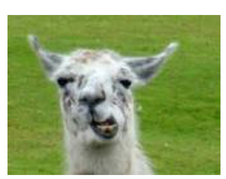
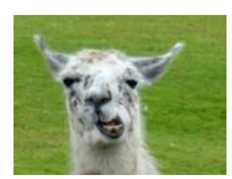
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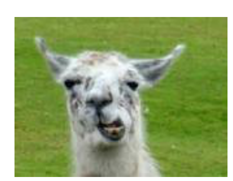
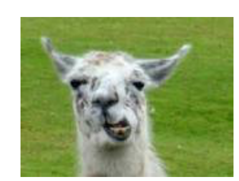
The Monty Hall Problem

$1M

MHP Defined

Jones has come to a game show, and finds himself thereon selected to play a game on national TV with the show's suave host, Full Monty. Jones is told correctly by Full that hidden behind one of three closed, opaque doors facing the two of them is $1,000,000, while behind each of the other two is a feculent, obstreperous llama whose value on the open market is charitably pegged at $1. Full reminds Jones that this is a game, and a fair one, and that if Jones ends up selecting the door with $1M behind it, all that money will indeed be his. (Jones' net worth has nearly been exhausted by his expenditures in traveling to the show.) Full also reminds Jones that he (= Full) knows what's behind each door, fixed in place until the game ends.

Full asks Jones to select which door he wants the contents of. Jones says, "Door 1." Full then says: "Hm. Okay. Part of this game is my revealing at this point what's behind one of the doors you didn't choose. So ... let me show you what's behind Door 3." Door 3 opens to reveal a very unsavory llama. Full now to Jones: "Do you want to switch to Door 2, or stay with Door 1? You'll get what's behind the door of your choice, and our game will end." Full looks briefly into the camera, directly.

(P1.1) What should Jones do if he's rational?

(P1.2) Prove that your answer is correct. (Diagrammatic proofs are allowed.)

(P1.3) A quantitative hedge fund manager with a PhD in finance from Harvard zipped this email off to Full before Jones made his decision re. switching or not: "Switching would be a royal waste of time (and time is money!). Jones hasn't a doggone clue what's behind Door 1 or Door 2, and it's obviously a 50/50 chance to win whether he stands firm or switches. So the chap shouldn't switch!" Is the fund manager right? Prove that your diagnosis is correct.

(P1.4) Can these answers and proofs be exclusively Bayesian in nature?

2019

2019

$\mathcal{DCEC}^*$

Syntax

$$S ::= \begin{array}{l} \textsf{Object} \mid \textsf{Agent} \mid \textsf{Self} \sqsubset \textsf{Agent} \mid \textsf{ActionType} \mid \textsf{Action} \sqsubseteq \textsf{Event} \mid \\ \textsf{Moment} \mid \textsf{Boolean} \mid \textsf{Fluent} \mid \textsf{Numeric} \end{array}$$

$$f ::= \begin{array}{l} \mathit{action} : \textsf{Agent} \times \textsf{ActionType} \rightarrow \textsf{Action} \\ \mathit{initially} : \textsf{Fluent} \rightarrow \textsf{Boolean} \\ \mathit{holds} : \textsf{Fluent} \times \textsf{Moment} \rightarrow \textsf{Boolean} \\ \mathit{happens} : \textsf{Event} \times \textsf{Moment} \rightarrow \textsf{Boolean} \\ \mathit{clipped} : \textsf{Moment} \times \textsf{Fluent} \times \textsf{Moment} \rightarrow \mathit{Boolean} \\ \mathit{initiates} : \textsf{Event} \times \textsf{Fluent} \times \textsf{Moment} \rightarrow \textsf{Boolean} \\ \mathit{terminates} : \textsf{Event} \times \textsf{Fluent} \times \textsf{Moment} \rightarrow \textsf{Boolean} \\ \mathit{prior} : \textsf{Moment} \times \textsf{Moment} \rightarrow \textsf{Boolean} \\ \mathit{interval} : \textsf{Moment} \times \textsf{Boolean} \\ * : \textsf{Agent} \rightarrow \textsf{Self} \\ \mathit{payoff} : \textsf{Agent} \times \textsf{ActionType} \times \textsf{Moment} \rightarrow \textsf{Numeric} \end{array}$$

$$t ::= x : S \mid c : S \mid f(t_1, \ldots, t_n)$$

$$\phi ::= \begin{array}{l} t : \textsf{Boolean} \mid \neg\phi \mid \phi \wedge \psi \mid \phi \vee \psi \mid \\ \mathbf{P}(a,t,\phi) \mid \mathbf{K}(a,t,\phi) \mid \mathbf{C}(t,\phi) \mid \mathbf{S}(a,b,t,\phi) \mid \mathbf{S}(a,t,\phi) \\ \mathbf{B}(a,t,\phi) \mid \mathbf{D}(a,t,\mathit{holds}(f,t')) \mid \mathbf{I}(a,t,\mathit{happens}(\mathit{action}(a^*,\alpha),t')) \\ \mathbf{O}(a,t,\phi,\mathit{happens}(\mathit{action}(a^*,\alpha),t')) \end{array}$$

Rules of Inference

$$\frac{}{\mathbf{C}(t,\mathbf{P}(a,t,\phi) \rightarrow \mathbf{K}(a,t,\phi))}\ [R_1] \qquad \frac{}{\mathbf{C}(t,\mathbf{K}(a,t,\phi) \rightarrow \mathbf{B}(a,t,\phi))}\ [R_2]$$

$$\frac{\mathbf{C}(t,\phi)\ t \leq t_1 \ldots t \leq t_n}{\mathbf{K}(a_1,t_1,\ldots \mathbf{K}(a_n,t_n,\phi)\ldots)}\ [R_3] \qquad \frac{\mathbf{K}(a,t,\phi)}{\phi}\ [R_4]$$

$$\frac{}{\mathbf{C}(t,\mathbf{K}(a,t_1,\phi_1 \rightarrow \phi_2)) \rightarrow \mathbf{K}(a,t_2,\phi_1) \rightarrow \mathbf{K}(a,t_3,\phi_2)}\ [R_5]$$

$$\frac{}{\mathbf{C}(t,\mathbf{B}(a,t_1,\phi_1 \rightarrow \phi_2)) \rightarrow \mathbf{B}(a,t_2,\phi_1) \rightarrow \mathbf{B}(a,t_3,\phi_2)}\ [R_6]$$

$$\frac{}{\mathbf{C}(t,\mathbf{C}(t_1,\phi_1 \rightarrow \phi_2)) \rightarrow \mathbf{C}(t_2,\phi_1) \rightarrow \mathbf{C}(t_3,\phi_2)}\ [R_7]$$

$$\frac{}{\mathbf{C}(t,\forall x.\ \phi \rightarrow \phi[x \mapsto t])}\ [R_8] \qquad \frac{}{\mathbf{C}(t,\phi_1 \leftrightarrow \phi_2 \rightarrow \neg\phi_2 \rightarrow \neg\phi_1)}\ [R_9]$$

$$\frac{}{\mathbf{C}(t,[\phi_1 \wedge \ldots \wedge \phi_n \rightarrow \phi] \rightarrow [\phi_1 \rightarrow \ldots \rightarrow \phi_n \rightarrow \psi])}\ [R_{10}]$$

$$\frac{\mathbf{B}(a,t,\phi)\ \ \phi \rightarrow \psi}{\mathbf{B}(a,t,\psi)}\ [R_{11a}] \qquad \frac{\mathbf{B}(a,t,\phi)\ \ \mathbf{B}(a,t,\psi)}{\mathbf{B}(a,t,\psi \wedge \phi)}\ [R_{11b}]$$

$$\frac{\mathbf{S}(s,h,t,\phi)}{\mathbf{B}(h,t,\mathbf{B}(s,t,\phi))}\ [R_{12}]$$

$$\frac{\mathbf{I}(a,t,\mathit{happens}(\mathit{action}(a^*,\alpha),t'))}{\mathbf{P}(a,t,\mathit{happens}(\mathit{action}(a^*,\alpha),t))}\ [R_{13}]$$

$$\frac{\begin{array}{l}\mathbf{B}(a,t,\phi)\ \ \mathbf{B}(a,t,\mathbf{O}(a^*,t,\phi,\mathit{happens}(\mathit{action}(a^*,\alpha),t'))) \\ \mathbf{O}(a,t,\phi,\mathit{happens}(\mathit{action}(a^*,\alpha),t'))\end{array}}{\mathbf{K}(a,t,\mathbf{I}(a^*,t,\mathit{happens}(\mathit{action}(a^*,\alpha),t')))}\ [R_{14}]$$

$$\frac{\phi \leftrightarrow \psi}{\mathbf{O}(a,t,\phi,\gamma) \leftrightarrow \mathbf{O}(a,t,\psi,\gamma)}\ [R_{15}]$$

2019

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2019


2019

2019


350 BC
2019

350 BC

2019

Euclid

Euclidean "Magic"

Theorem: There are infinitely many primes.

Proof: We take an indirect route. Let $\Pi = p_1 = 2, p_2 = 3, p_3 = 5, \ldots, p_k$ be a finite, exhaustive consecutive sequence of prime numbers. Next, let $\mathbf{M}_\Pi$ be $p_1 \times p_2 \times \cdots \times p_k$, and set $\mathbf{M}'_\Pi$ to $\mathbf{M}_\Pi + 1$. Either $\mathbf{M}'_\Pi$ is prime, or not; we thus have two (exhaustive) cases to consider.

C1 Suppose $\mathbf{M}'_\Pi$ is prime. In this case we immediately have a prime number beyond any in Π — contradiction!

C2 Suppose on the other hand that $\mathbf{M}'_\Pi$ is *not* prime. Then some prime p divides $\mathbf{M}'_\Pi$. (Why?) Now, p itself is either in Π, or not; we hence have two sub-cases. Supposing that p is in Π entails that p divides $\mathbf{M}_\Pi$. But we are operating under the supposition that p divides $\mathbf{M}'_\Pi$ as well. This implies that p divides 1, which is absurd (a contradiction). Hence the prime p is outside Π.

Hence for *any* such list Π, there is a prime outside the list. That is, there are infinitely many primes. **QED**

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350 BC

2019

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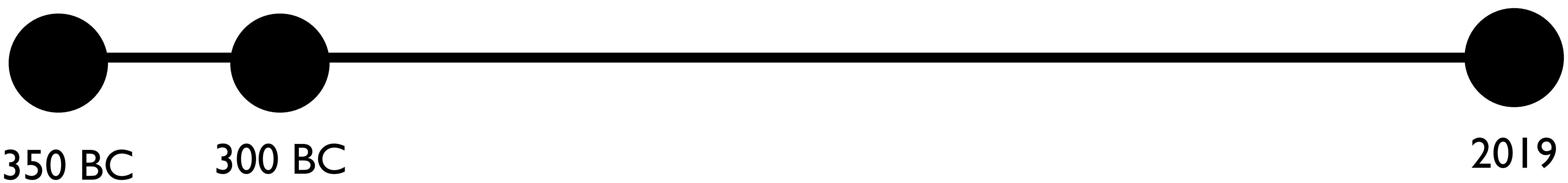
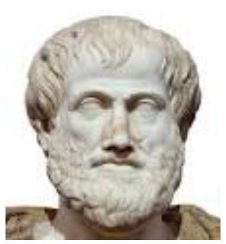
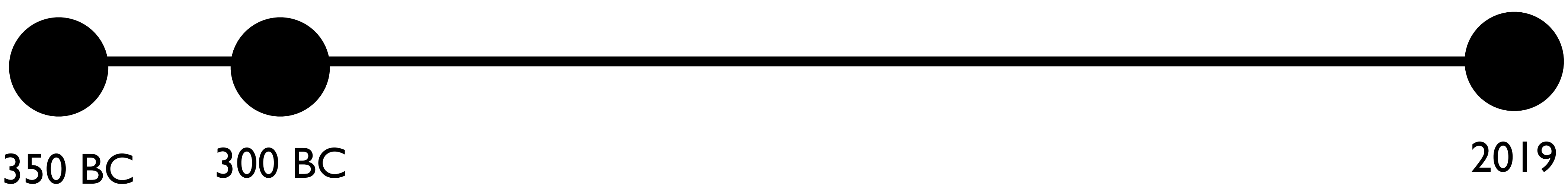
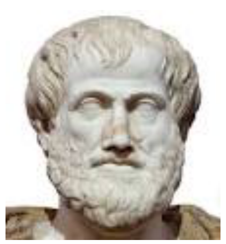




Euclid

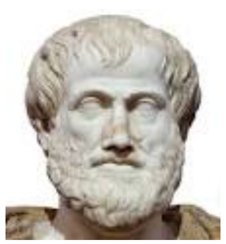




I don’t believe in magic! Why exactly is that so convincing? What exactly is he doing?!?

Euclid

350 BC 300 BC 2019



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Euclid *Organon*

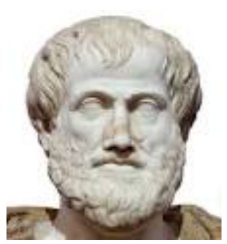
He's using syllogisms!

E.g.,

All As are Bs.
All Bs are Cs.

All As are Cs.

350 BC — 300 BC — 2019



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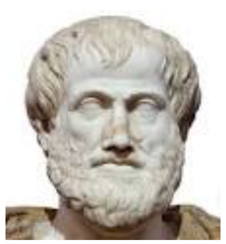

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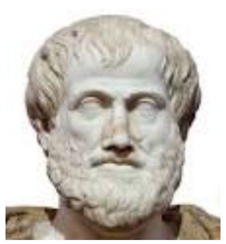
350 BC

300 BC

2019



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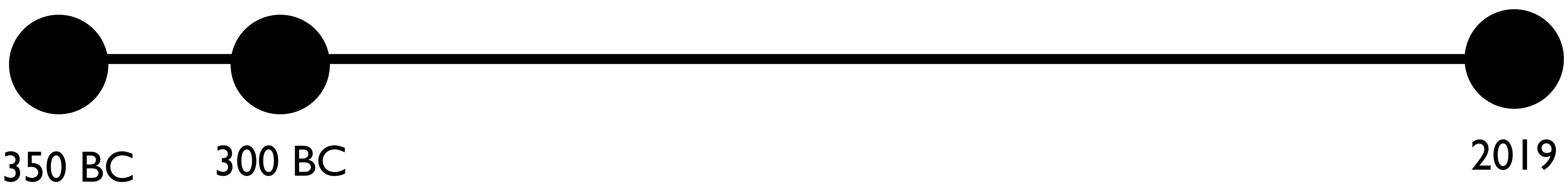

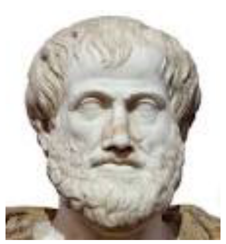

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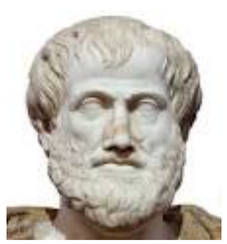
350 BC
300 BC
Euclid
Organon

350 BC | 300 BC | 1666

Euclid



Organon

350 BC

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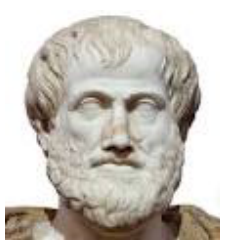

Organon

1666

Leibniz

350 BC | 300 BC | 1666

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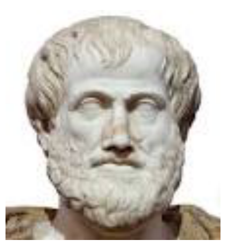
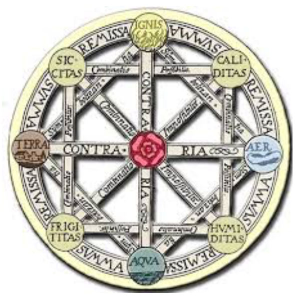


Organon

Leibniz

$\int$

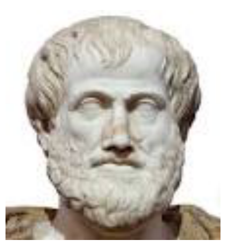
"Universal Computational Logic"



350 BC

Euclid

300 BC



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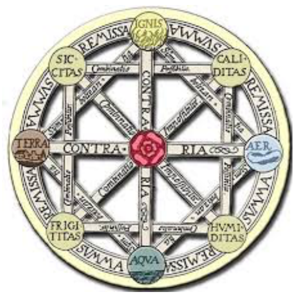

350 BC

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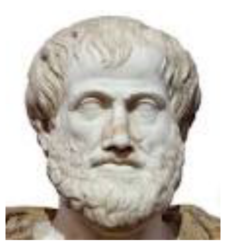

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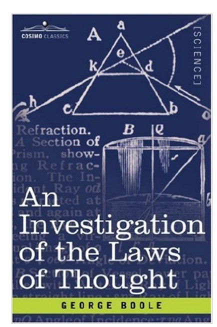
1854



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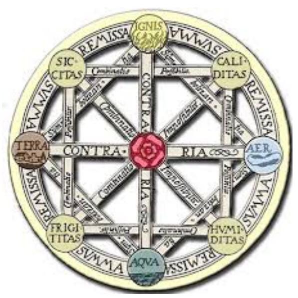
"Universal Computational Logic"



350 BC

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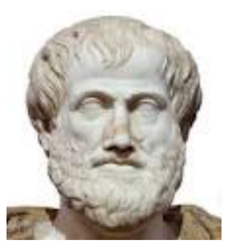

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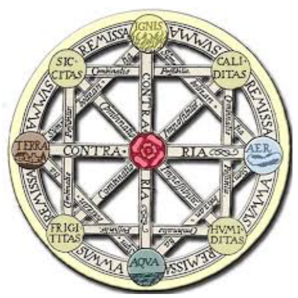
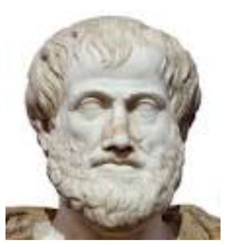


Logic Theorist
(birth of modern logicist AI)

350 BC

Euclid

300 BC



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1666

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1854

1956

Simon

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“Astonishing” Logic Theorist Proof @ Dawn of AI

"Astonishing" Logic Theorist Proof @ Dawn of AI

1	$(\phi \vee \phi) \rightarrow \phi$	axiom
2	$(\neg\phi \vee \neg\phi) \rightarrow \neg\phi$	substitution
3	$(\phi \rightarrow \neg\phi) \rightarrow \neg\phi$	a "replacement rule"
4	$(A \rightarrow \neg A) \rightarrow \neg A$	substitution

“Astonishing” Logic Theorist Proof @ Dawn of AI

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At dawn of AI: 10 seconds.

“Astonishing” Logic Theorist Proof @ Dawn of AI

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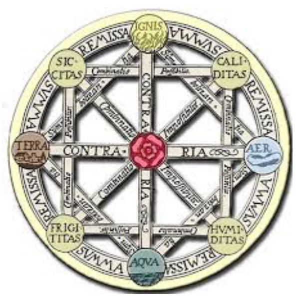
At dawn of AI: 10 seconds.

AI of today: vanishingly small amount of time.

"Universal Computational Logic"



Logic Theorist
(birth of modern logicist AI)

350 BC

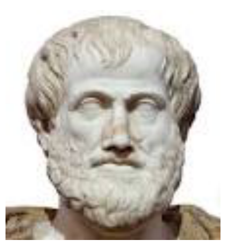
300 BC

1854

1956

2019

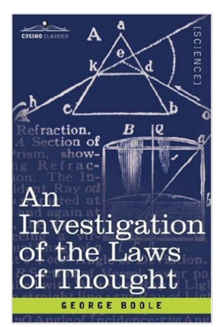
Euclid



Organon

Leibniz

$\int$



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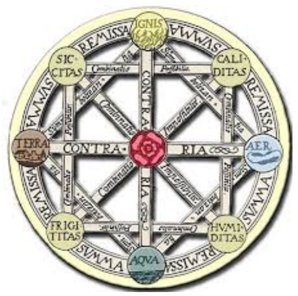
"Universal Computational Logic"



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350 BC — 300 BC — 1666 — 1854 — 1956 — 2019

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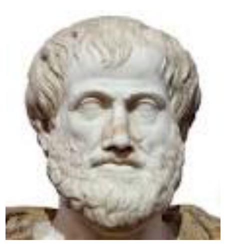

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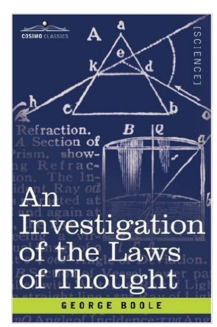

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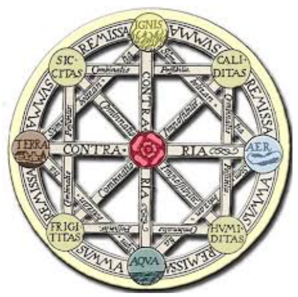

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	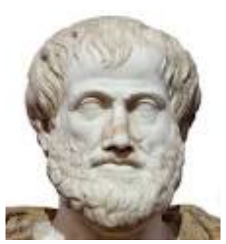				
Euclid	*Organon*	Leibniz $\int$		Simon	

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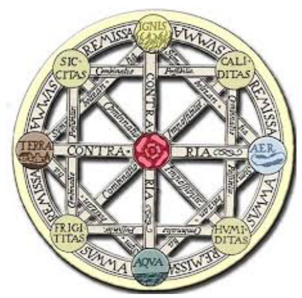

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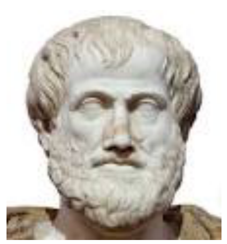

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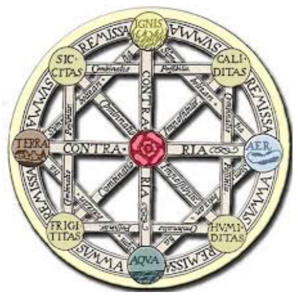

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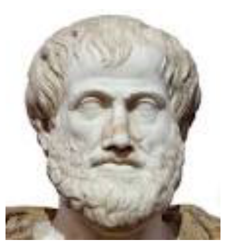

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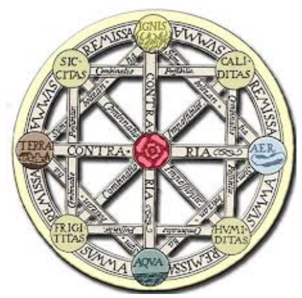
TheSingularity?

Entscheidungsproblem

"Universal Computational Logic"



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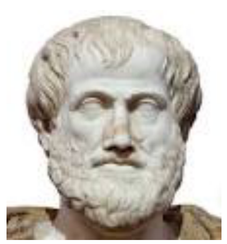

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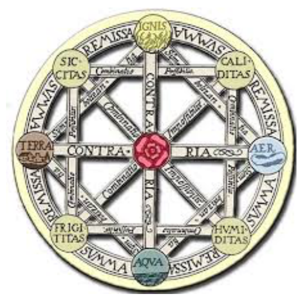

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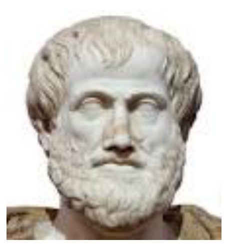

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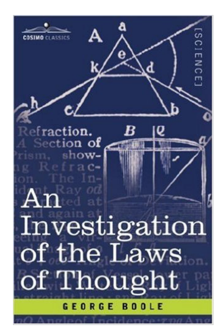

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The Singularity?

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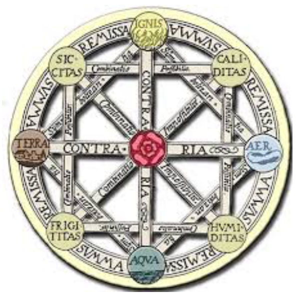

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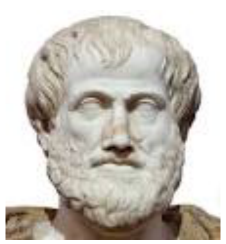

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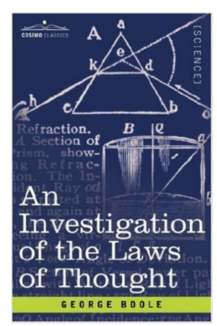

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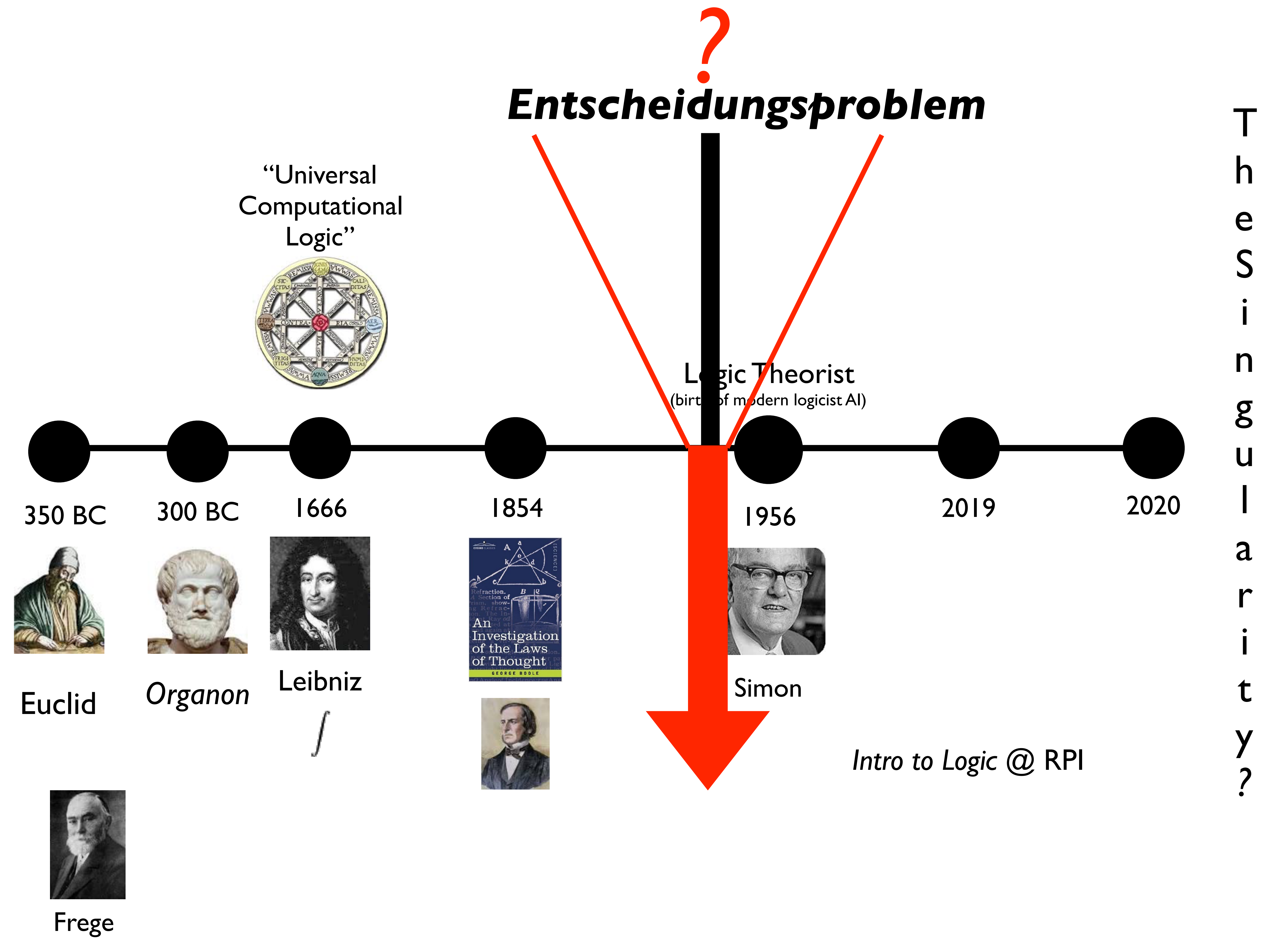
The Singularity?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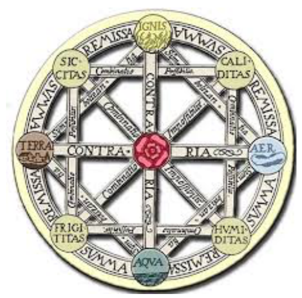

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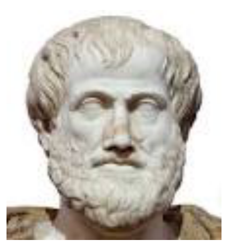

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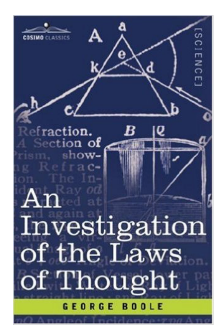

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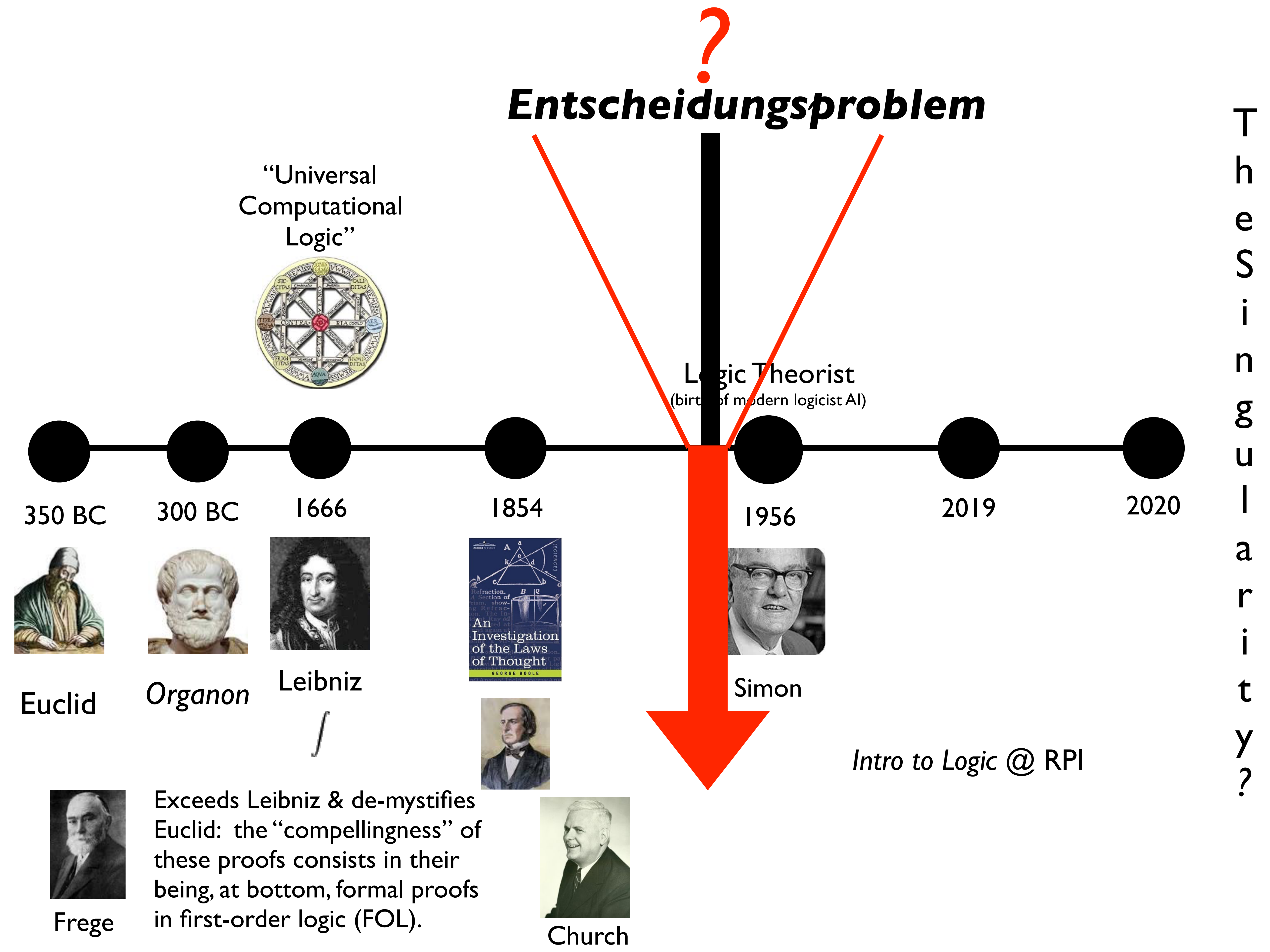
Frege

Exceeds Leibniz & de-mystifies Euclid: the "compellingness" of these proofs consists in their being, at bottom, formal proofs in first-order logic (FOL).

The Singularity?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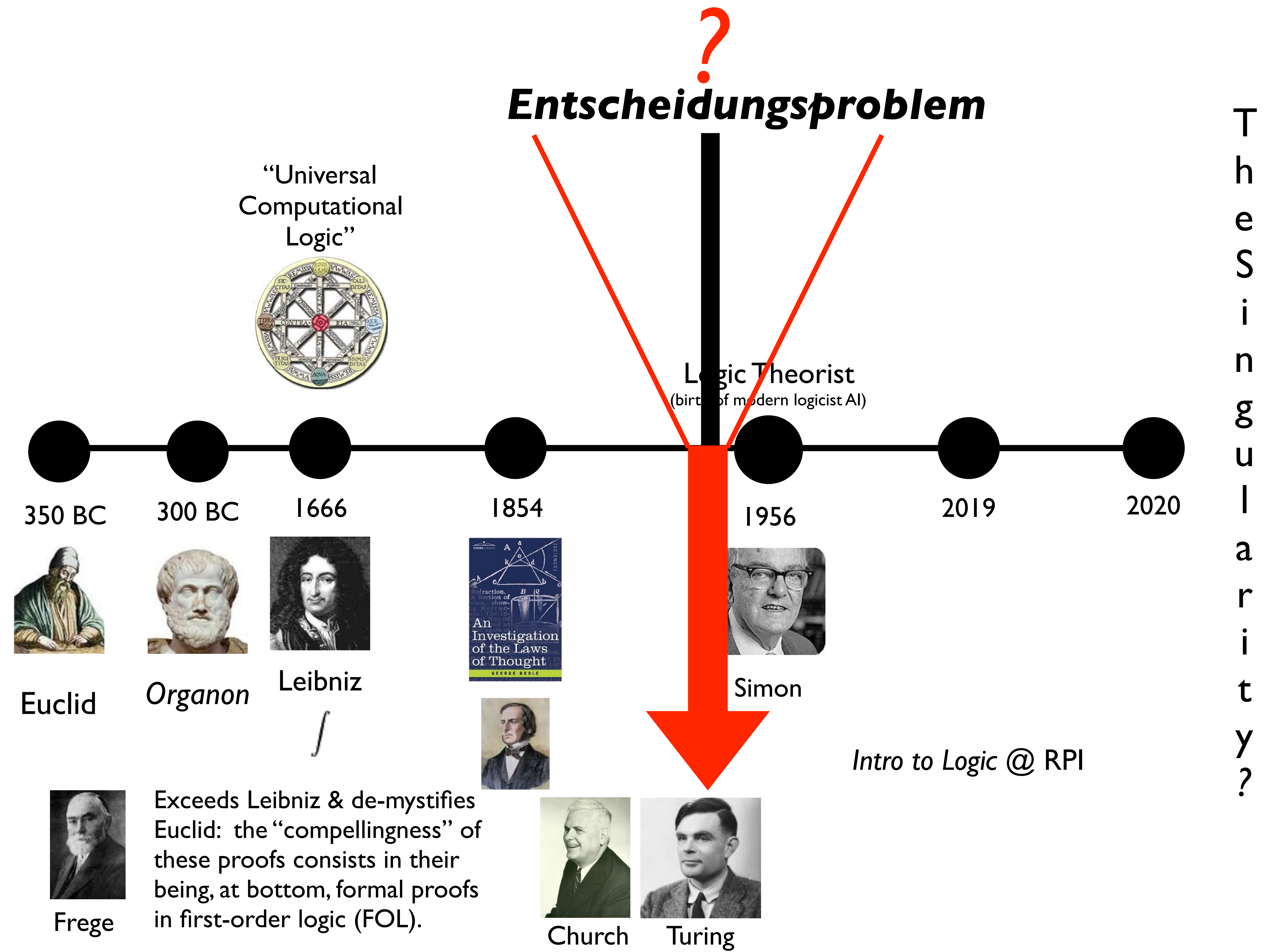
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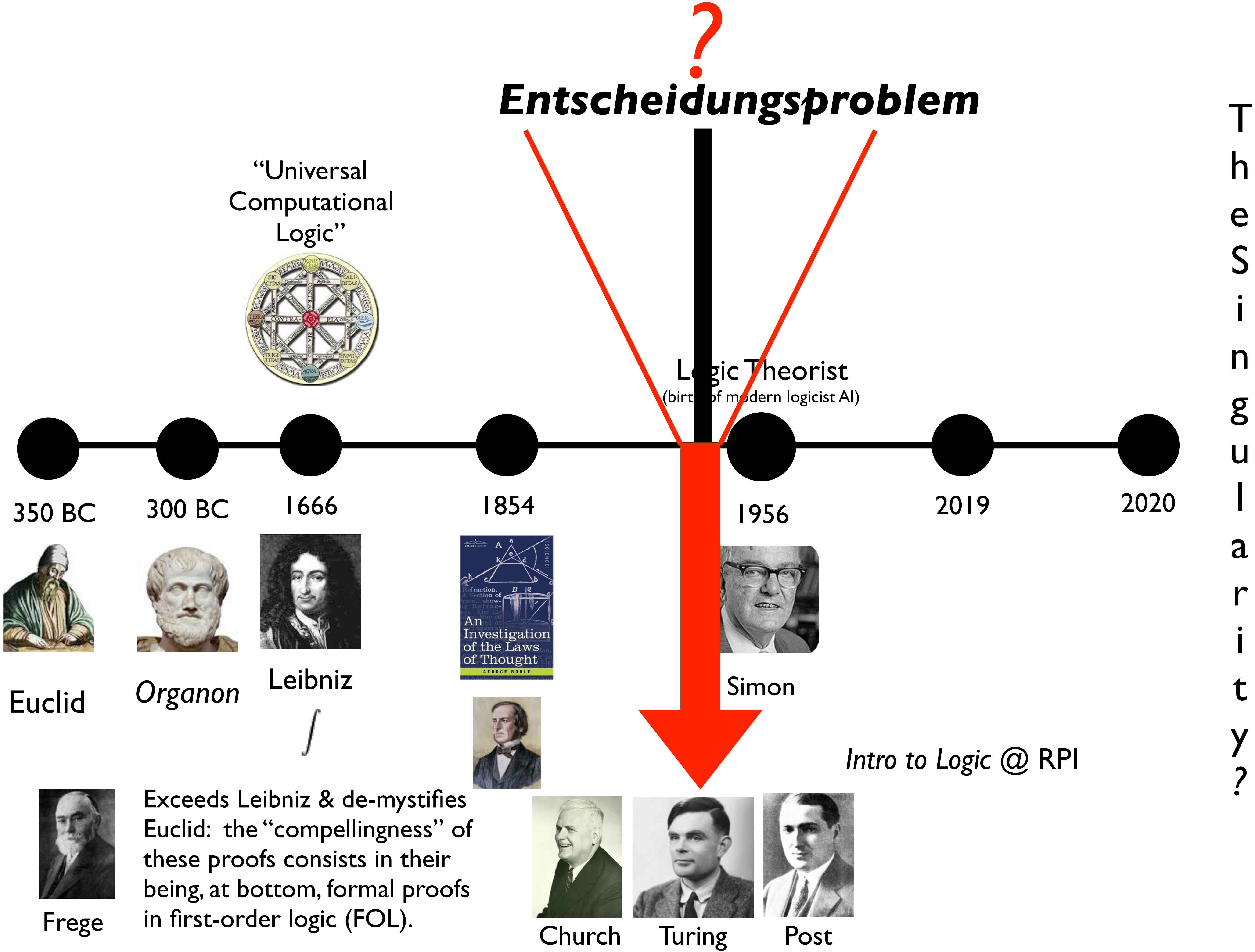
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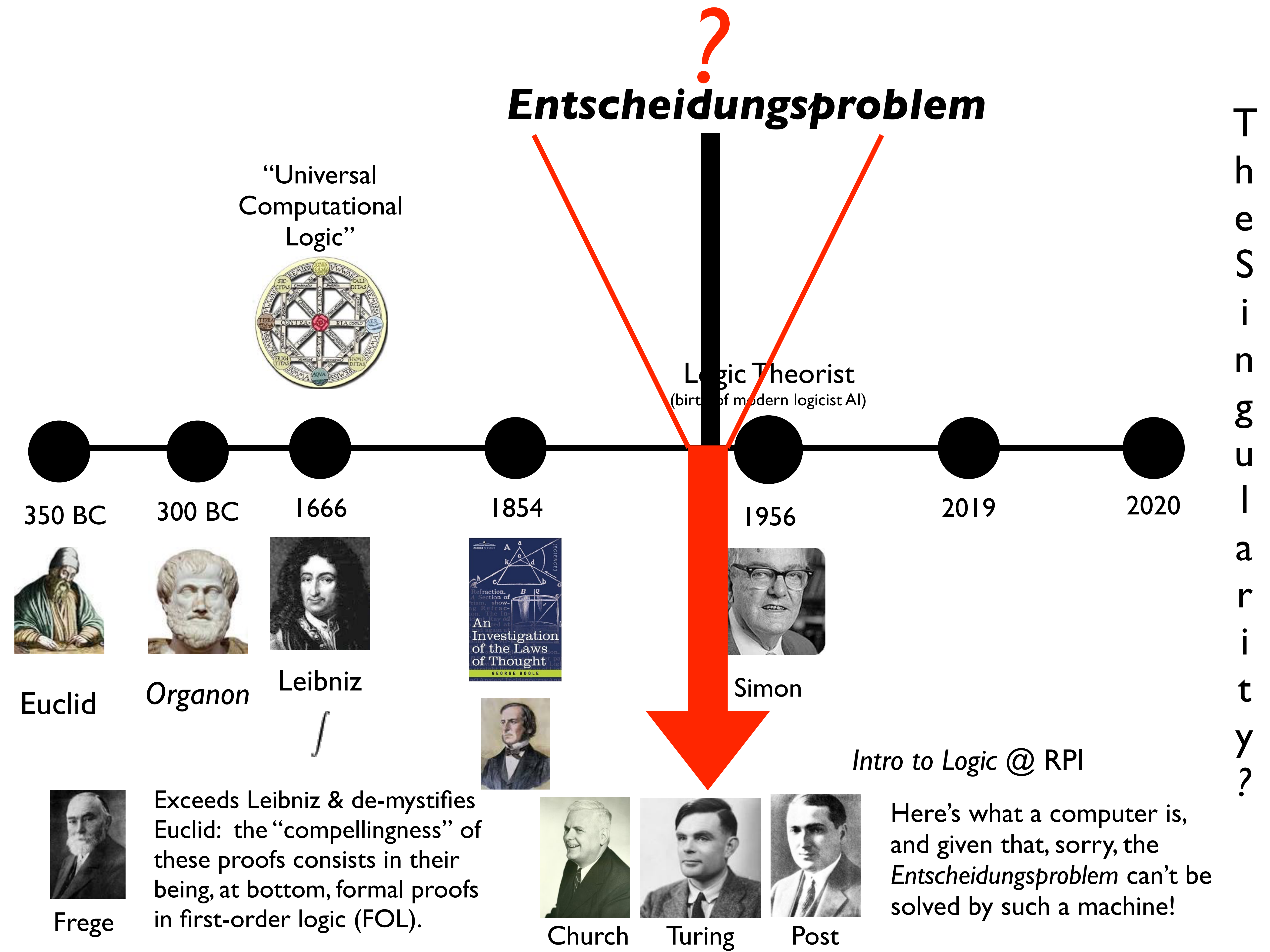
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Post
Here's what a computer is, and given that, sorry, the Entscheidungsproblem can't be solved by such a machine!
The Singularity?

First, the Theoremhood Decision Problem ($\text{THEOREM}_{\text{PC}}$) for the Propositional Calculus

First, the Theoremhood Decision Problem (THEOREM$_{PC}$) for the Propositional Calculus

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Hard!! — for apparently no polynomial-time algorithm for this!

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$$((K \to A) \land \neg A) \to \neg K$$

Hard!! — for apparently no polynomial-time algorithm for this!

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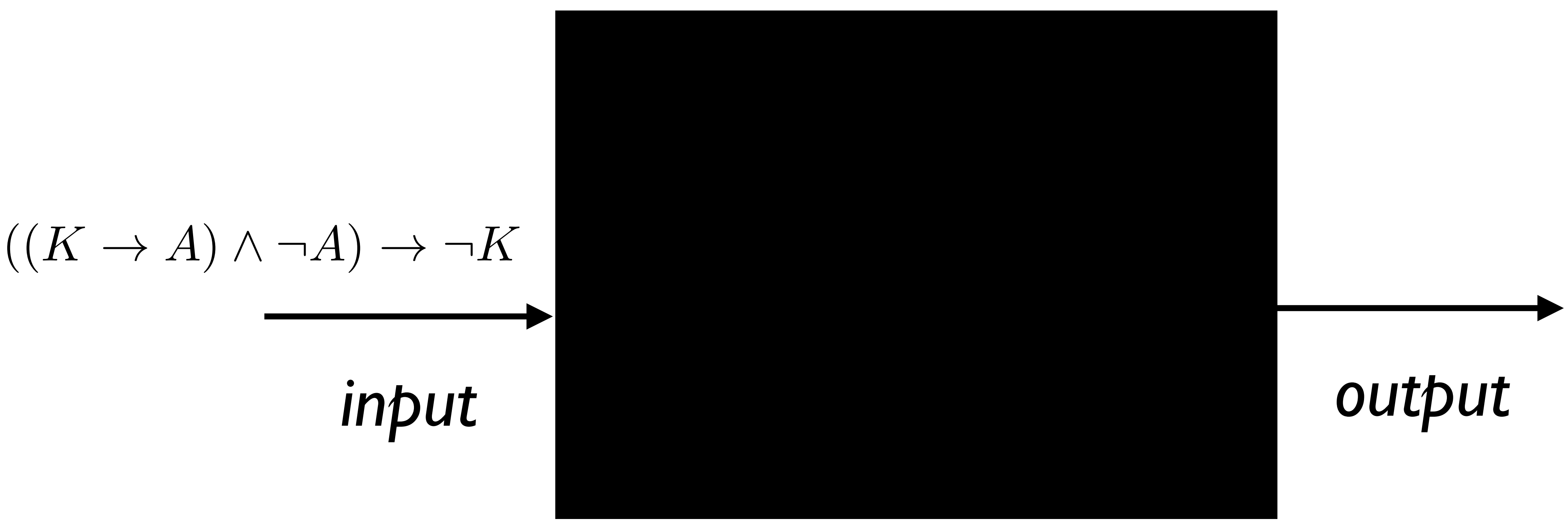

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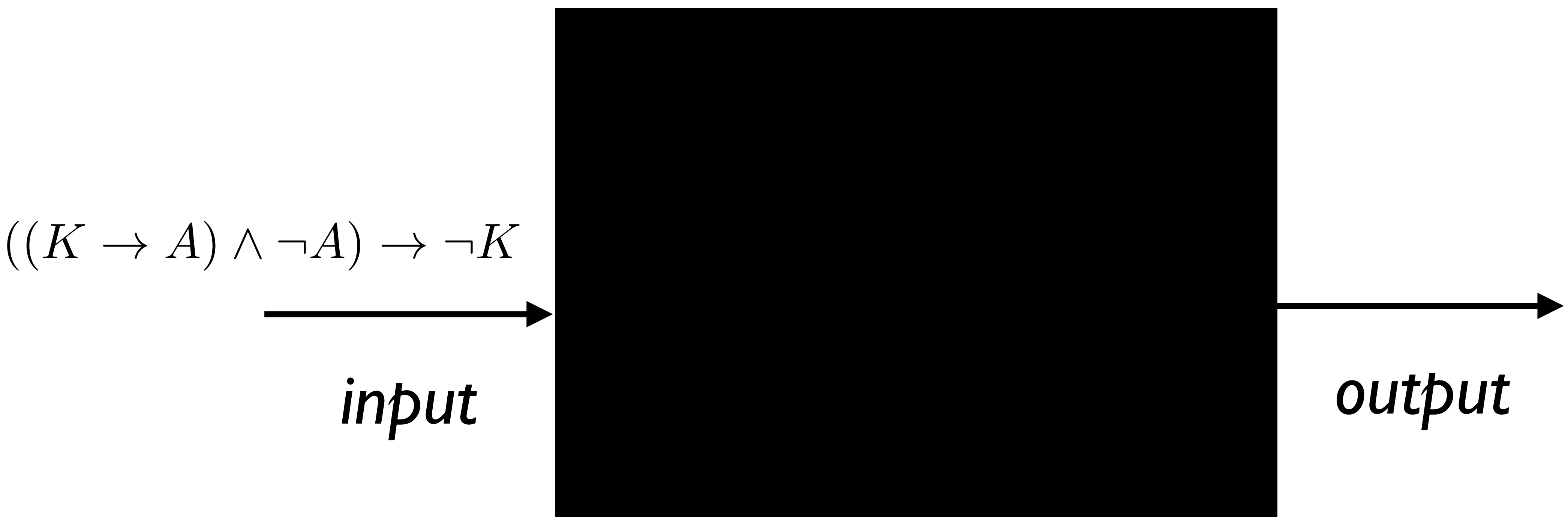

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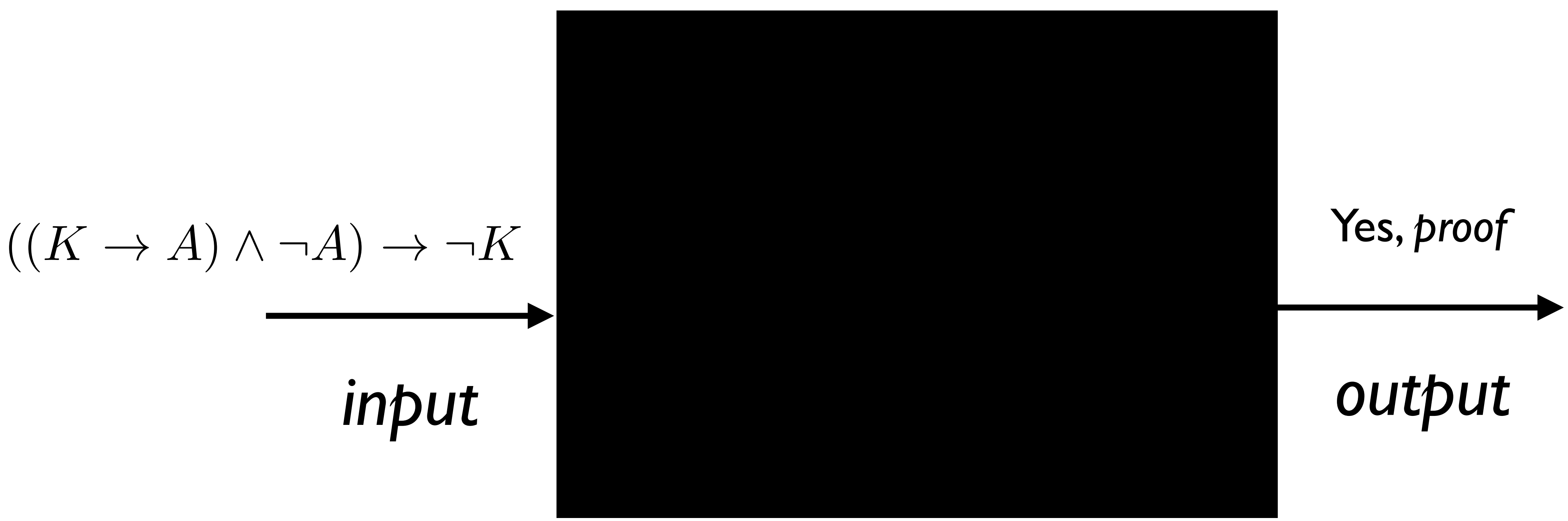

Hard!! — for apparently no polynomial-time algorithm for this!

And now, the Theoremhood Decision Problem,
i.e., the *Entscheidungsproblem*,
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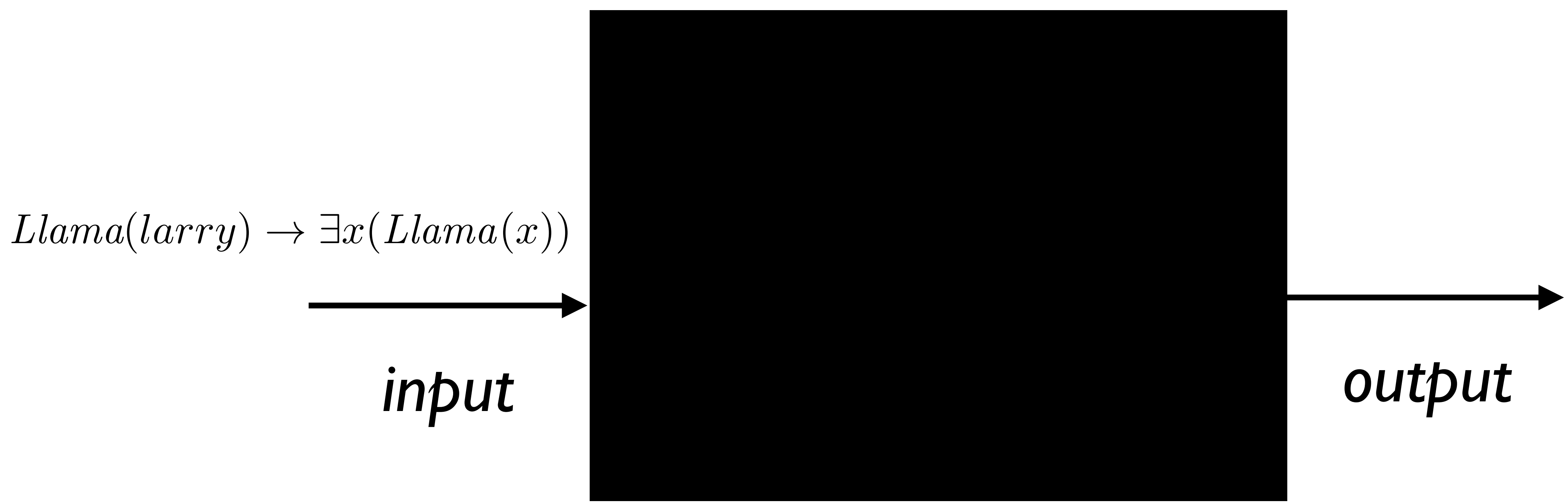

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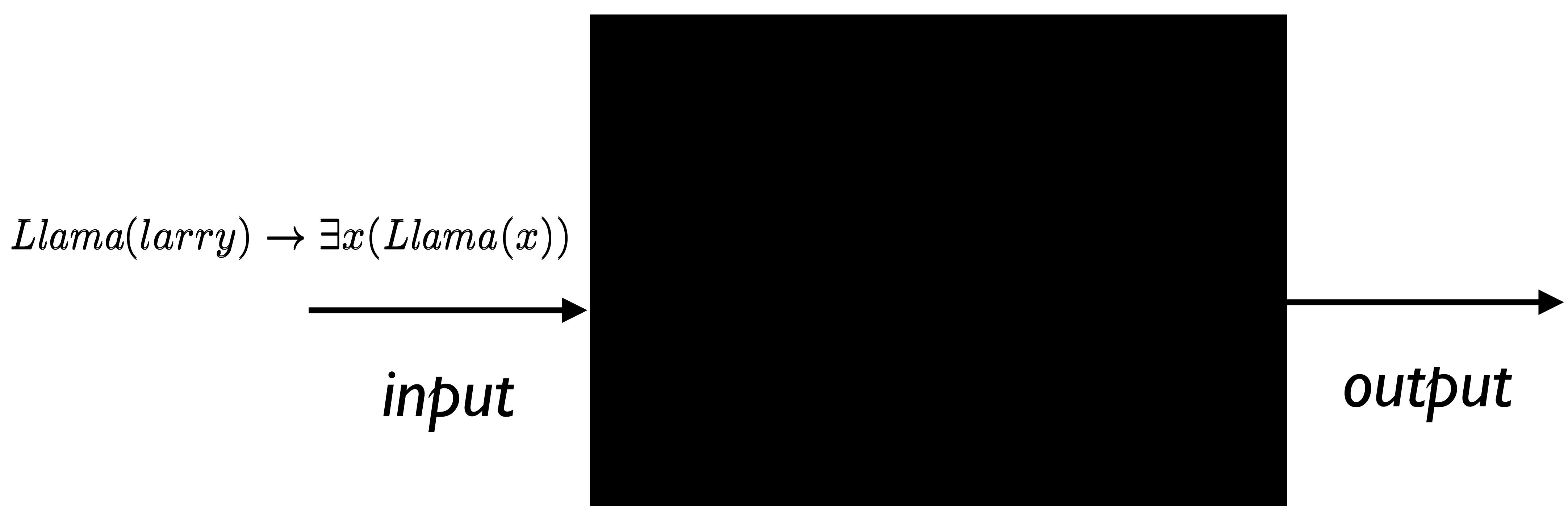

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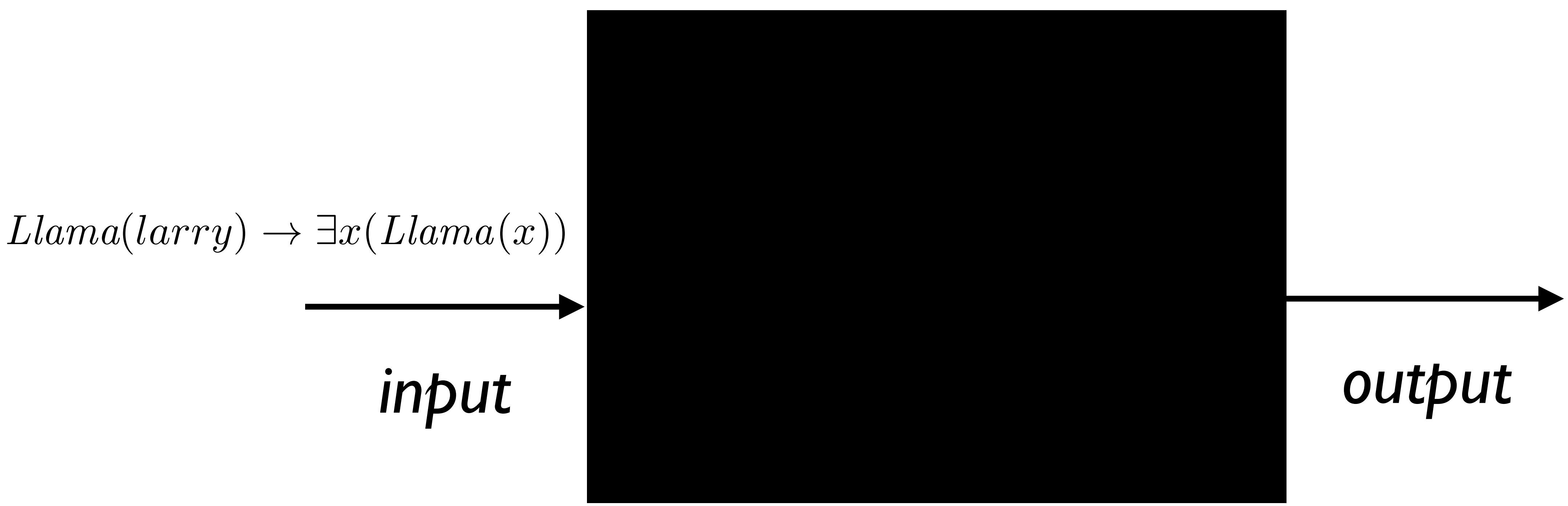

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$$Llama(larry) \rightarrow \exists x(Llama(x))$$

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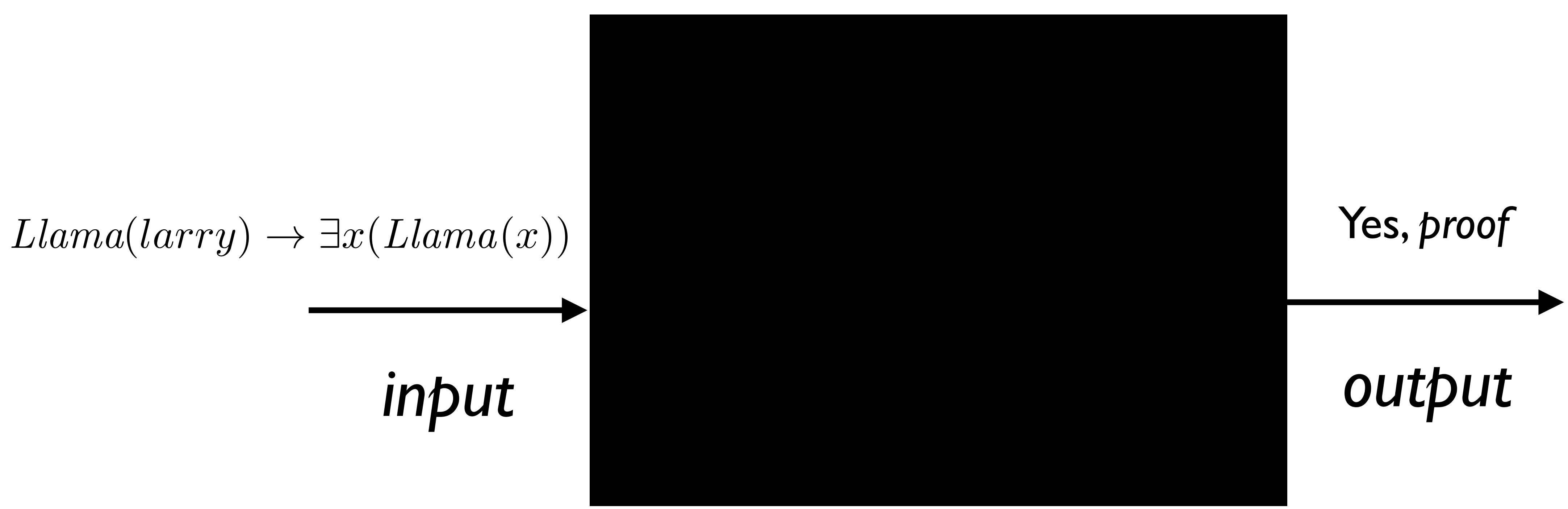

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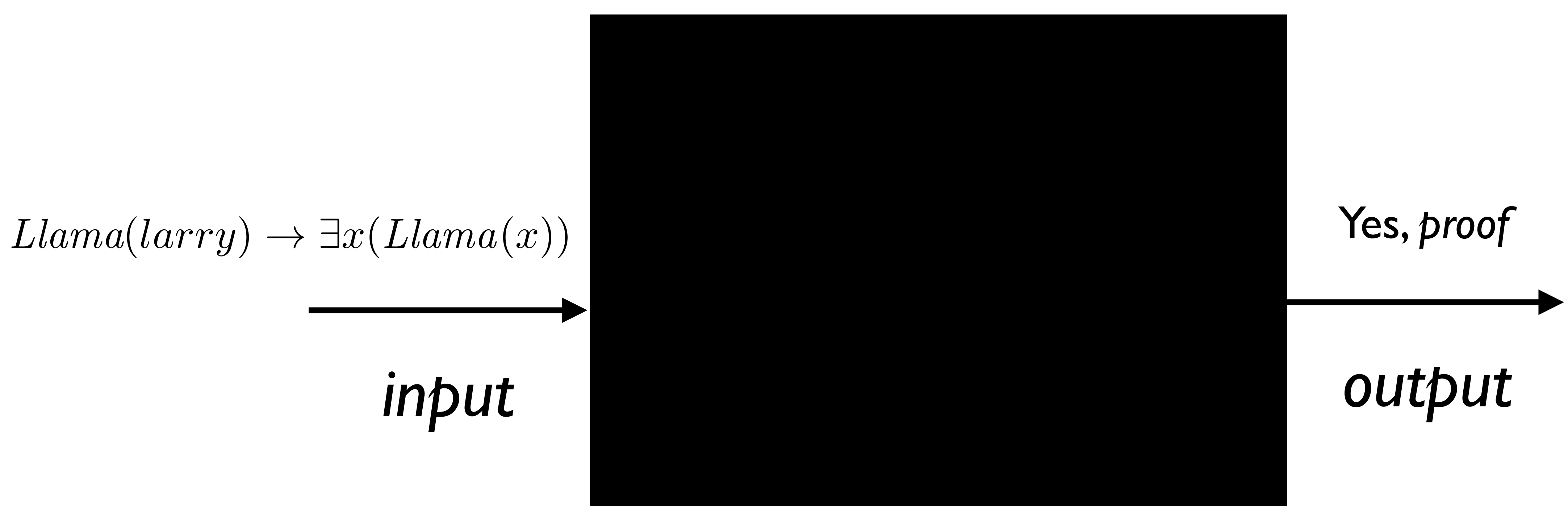

Not just hard: *impossible* for a (and this needed to be *invented* in the course of clarifying and solving the problem) standard computing machine.

Applying this to …
The Singularity Question

Applying this to …
The Singularity Question

$\mathcal{A}$:

	Premise 1	There will be AI (created by HI and such that AI = HI).
	Premise 2	If there is AI, there will be AI^+ (created by AI).
	Premise 3	If there is AI^+, there will be AI^{++} (created by AI^+).
$\therefore$	**S**	There will be AI^{++} ($= \mathcal{S}$ will occur).

(Good-Chalmers Argument)

(Kurzweil is an "extrapolationist.")

Applying this to …
The Singularity Question

So, these super-smart machines that will be built by human-level-smart machines, they can't *possibly* be smart enough to solve the *Entscheidungsproblem*. Hence they'll be just faster at solving problems we can routinely solve? What's so super-smart about *that*?