Pure Predicate Calculus = $\mathscr{L}_0$; *Toward* Quantification

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Intro to Logic
2/11/2019

Logistics …

Logistics …

Any questions?

Logistics …

Any questions?

Phase 2 of class mtg today …

What *is* Logic?

- The key to becoming rational.
- "The science of reasoning." — so the not-unreasonable slogan goes.
- The only invincible subject there is.
- The basis for the formal sciences (from mathematics to game theory to decision theory to probability calculi to axiomatic physics ….) — and hence the basis for disciplines based on the formal sciences (e.g., engineering, computer science).
- The way of escape from shallow content and context to pure, immaterial, and immortal form and structure (which is why the exotic, imaginary, and seemingly non-sensical is so pedagogically useful).
- The most challenging subject there is.
- One of the chief differentiators between dogs and monkeys versus you (let alone bears and you); and mindless machines (like Deep Blue & Watson) versus you.
- A key to riches.
- The key to divining the meaning of life (and other such big questions).
- The better way to program computers; and fundamentally the *only* way to *reliably* program computers.
- One of two fundamental approaches to studying minds, and replicating/simulating minds in machines…
- The thing many creatures of fiction have mastered — have you (as a New Yorker)?…

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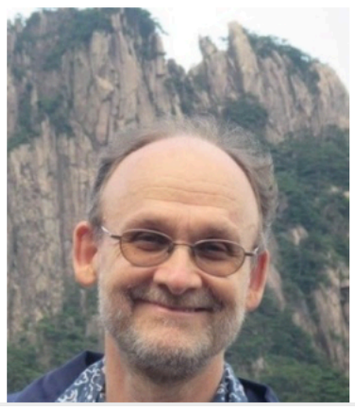
Watch brainy zoo animals figure out a box puzzle to get at food

(https://www.newscientist.com/article/2075151-watch-brainy-zoo-animals-figure-out-a-box-puzzle-to-get-at-food/)

ANIMAL SENTIENCE

AN INTERDISCIPLINARY JOURNAL ON ANIMAL FEELING

Chapman, Colin A. and Huffman, Michael A. (2018) Why do we want to think humans are different?. *Animal Sentience* 23(1)



AUTHOR WEBSITE

http://chapmancolin.com/

https://www.pri.kyoto-u.ac.jp/sections/social_systems_evolution/huffman/index-j.html

ABSTRACT

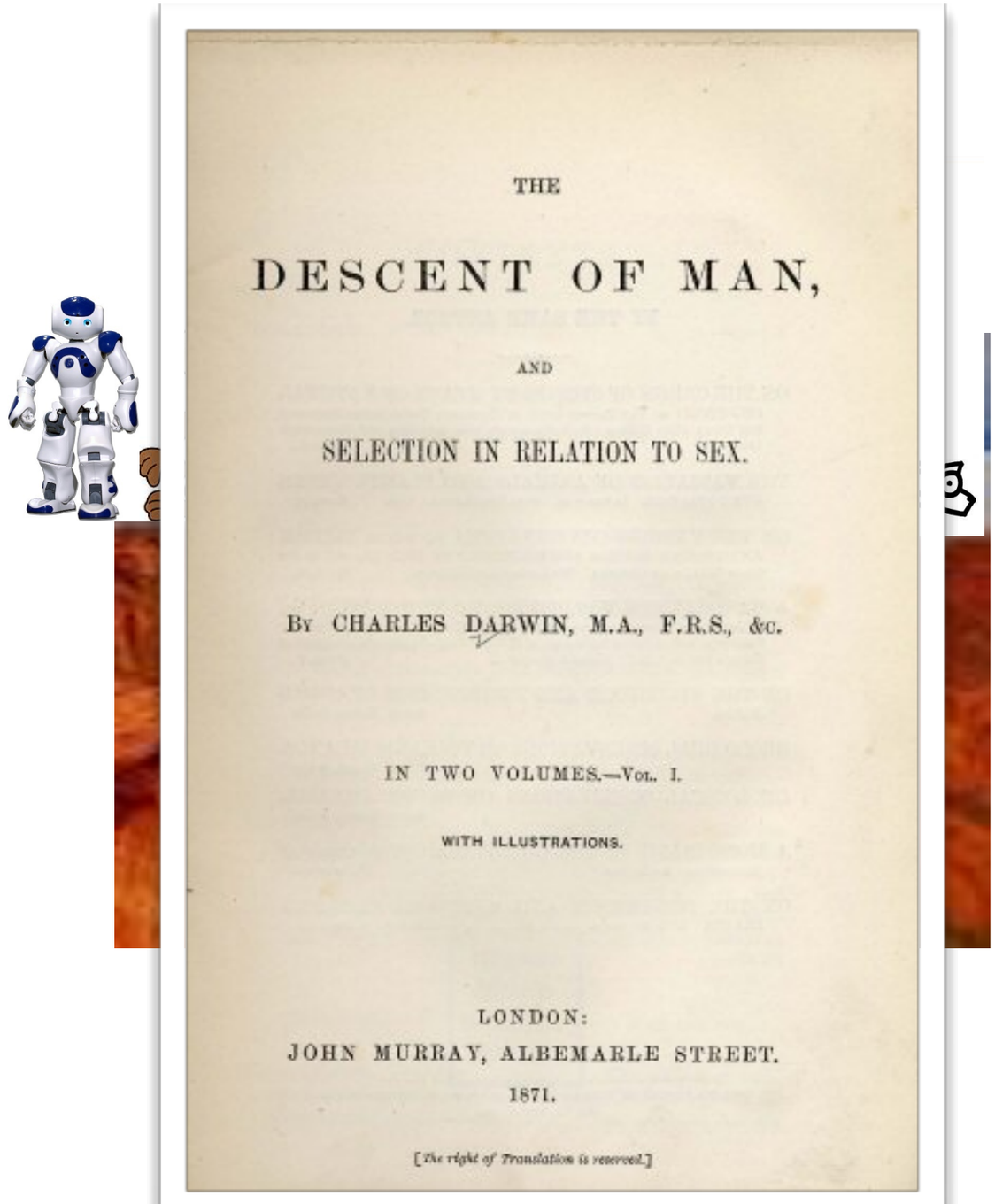
One harmful consequence of creating categories where one group is unique and superior to others is that it justifies committing negative, often atrocious, acts on the members of the inferior group. Correcting divisive human categorizations (racial superiority, gender superiority) has bettered society. Scholars have often claimed that humans are unique and superior to nonhuman animals. These claims need to be reevaluated. Many have already been refuted. Animals have been shown to outperform humans in many tasks, including cognitive ones. Here we raise the question: Has the false sense of superiority been used to justify human cruelty to animals?

AUTHOR BIOGRAPHY

Colin A. Chapman has conducted research in Kibale National Park in Uganda for 30

https://animalstudiesrepository.org/animsent/vol3/iss23/1/

The Canyon of Discontinuity (or Darwin's Dread)



THE

DESCENT OF MAN,

AND

SELECTION IN RELATION TO SEX.

By CHARLES DARWIN, M.A., F.R.S., &c.

IN TWO VOLUMES.—Vol. I.

WITH ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1871.

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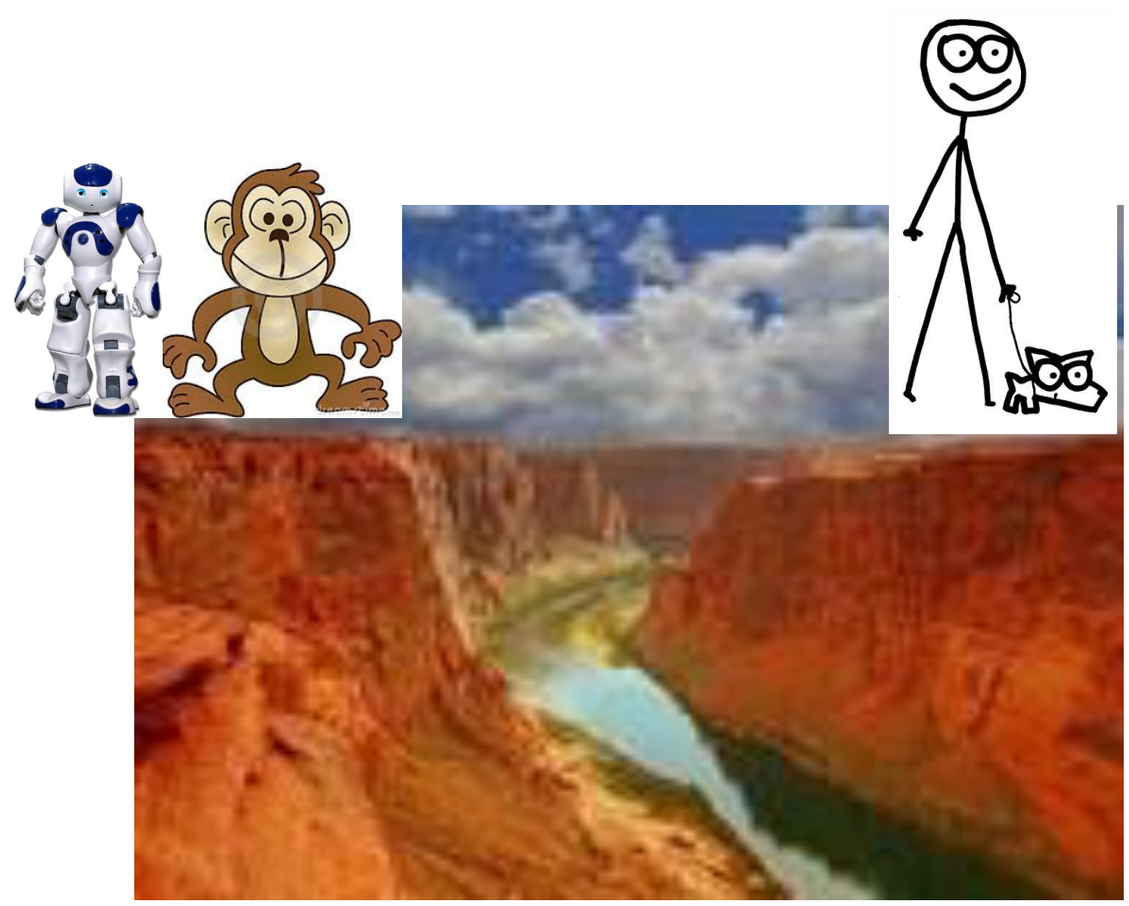

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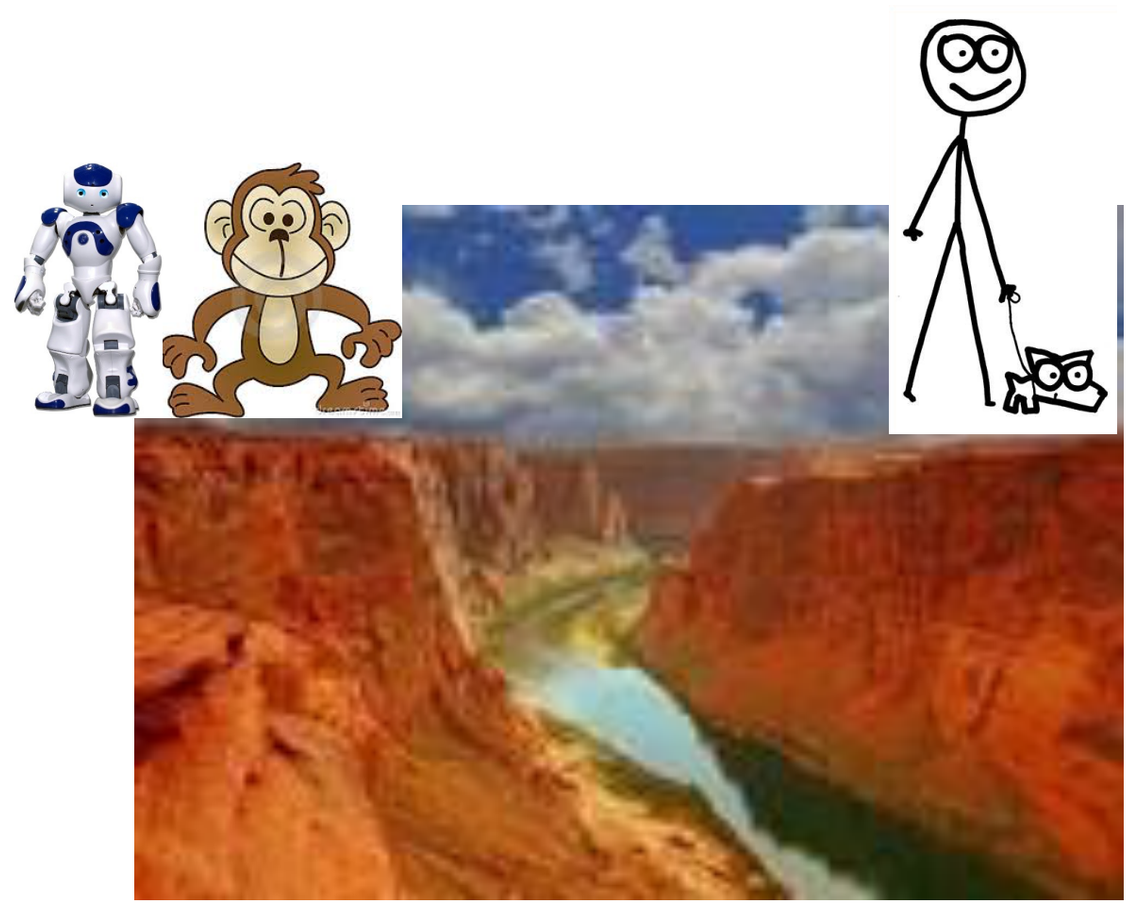

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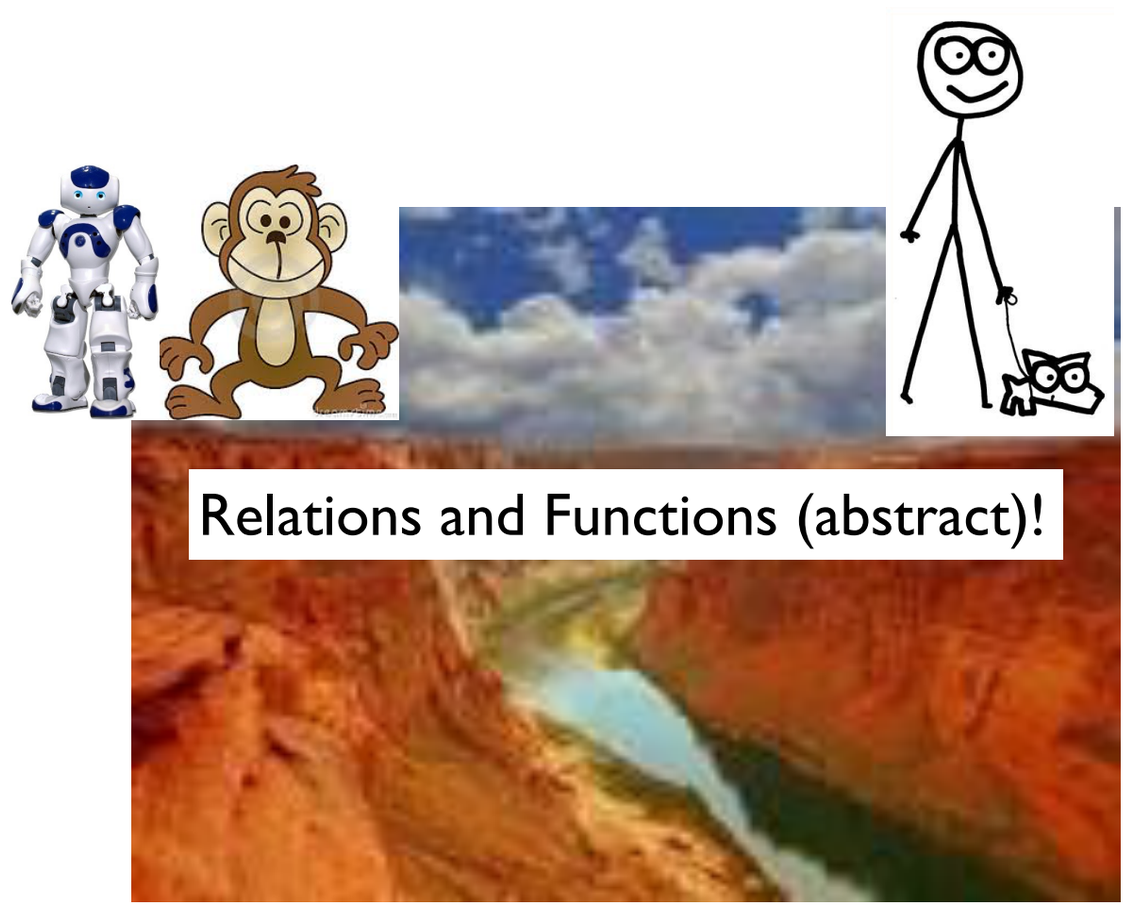

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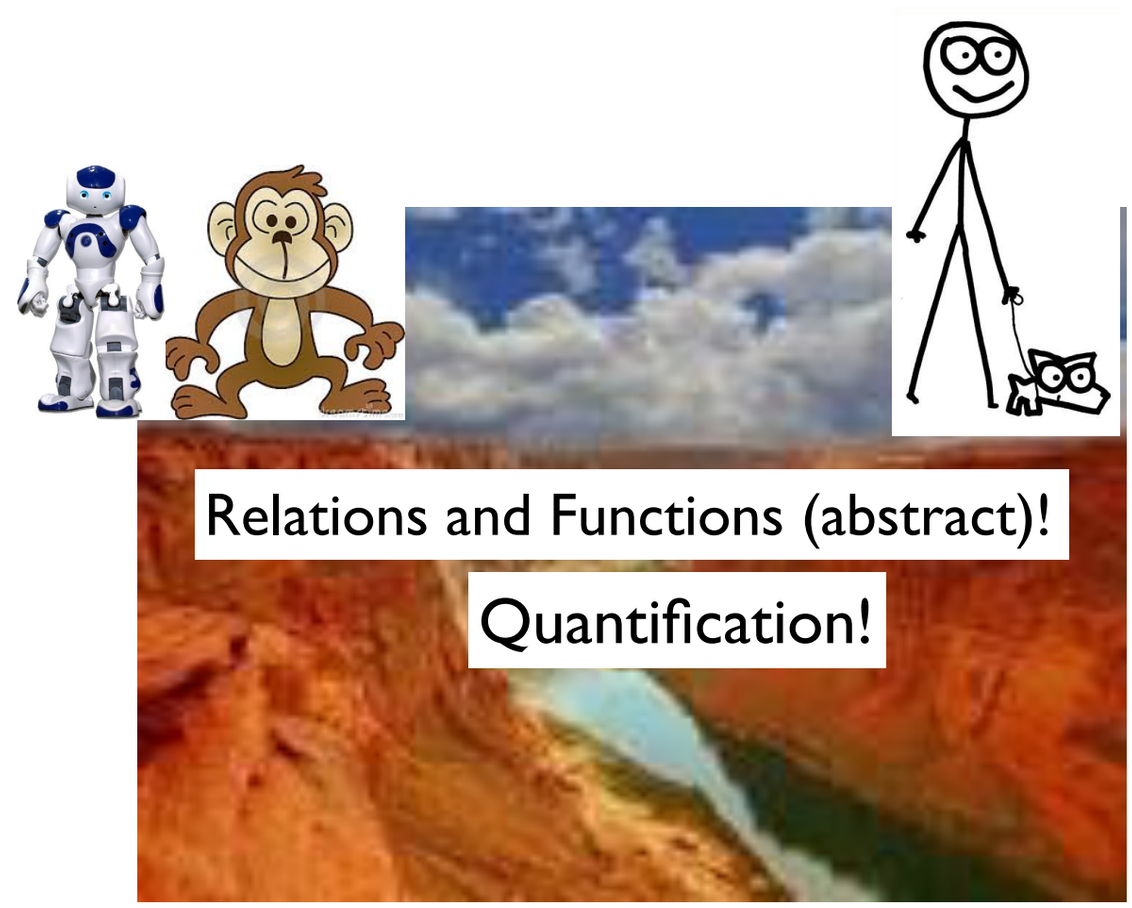

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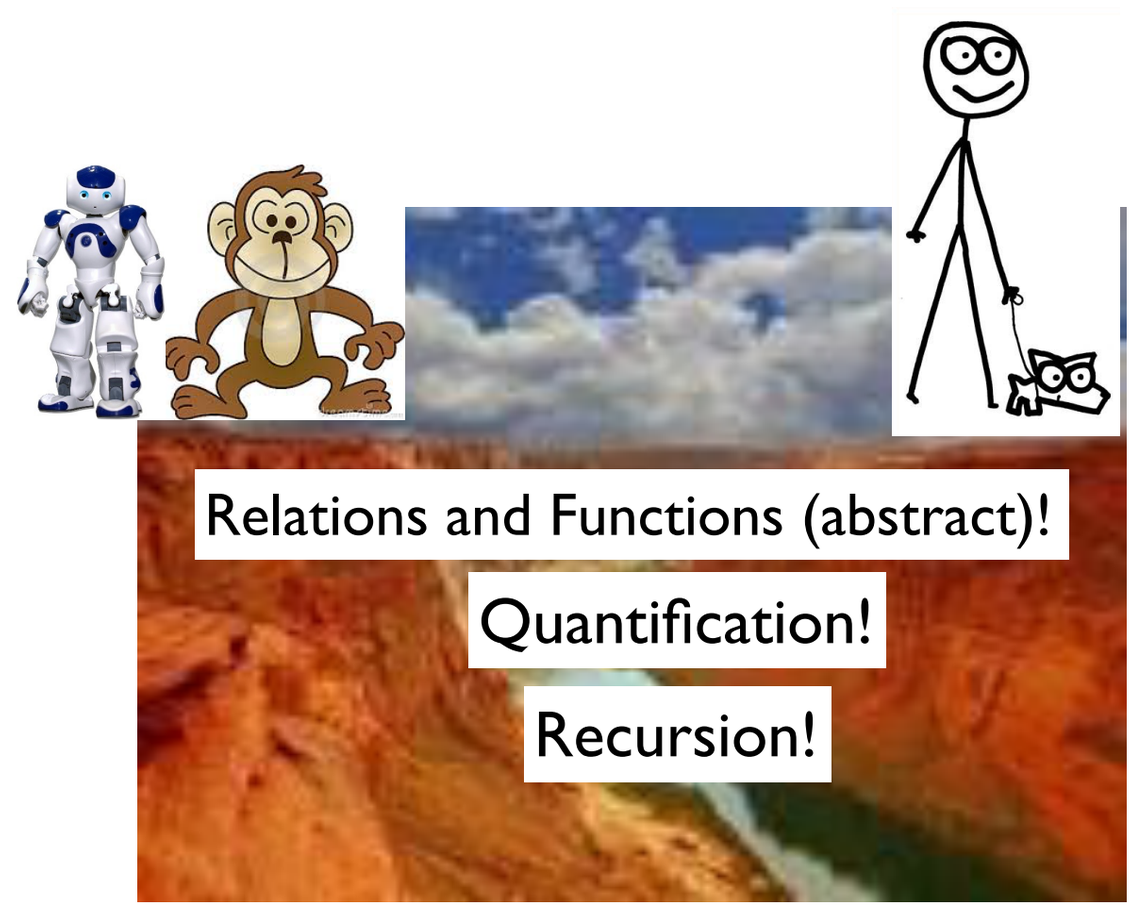

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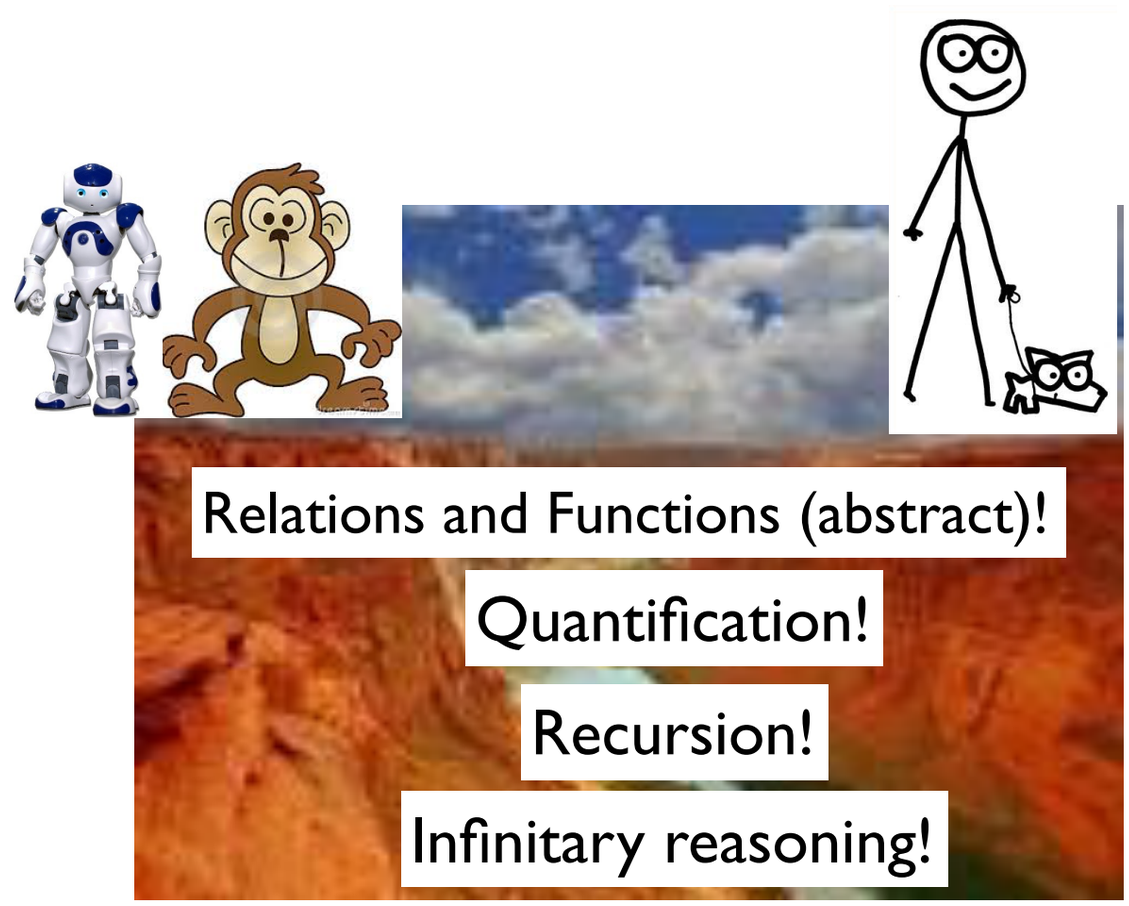

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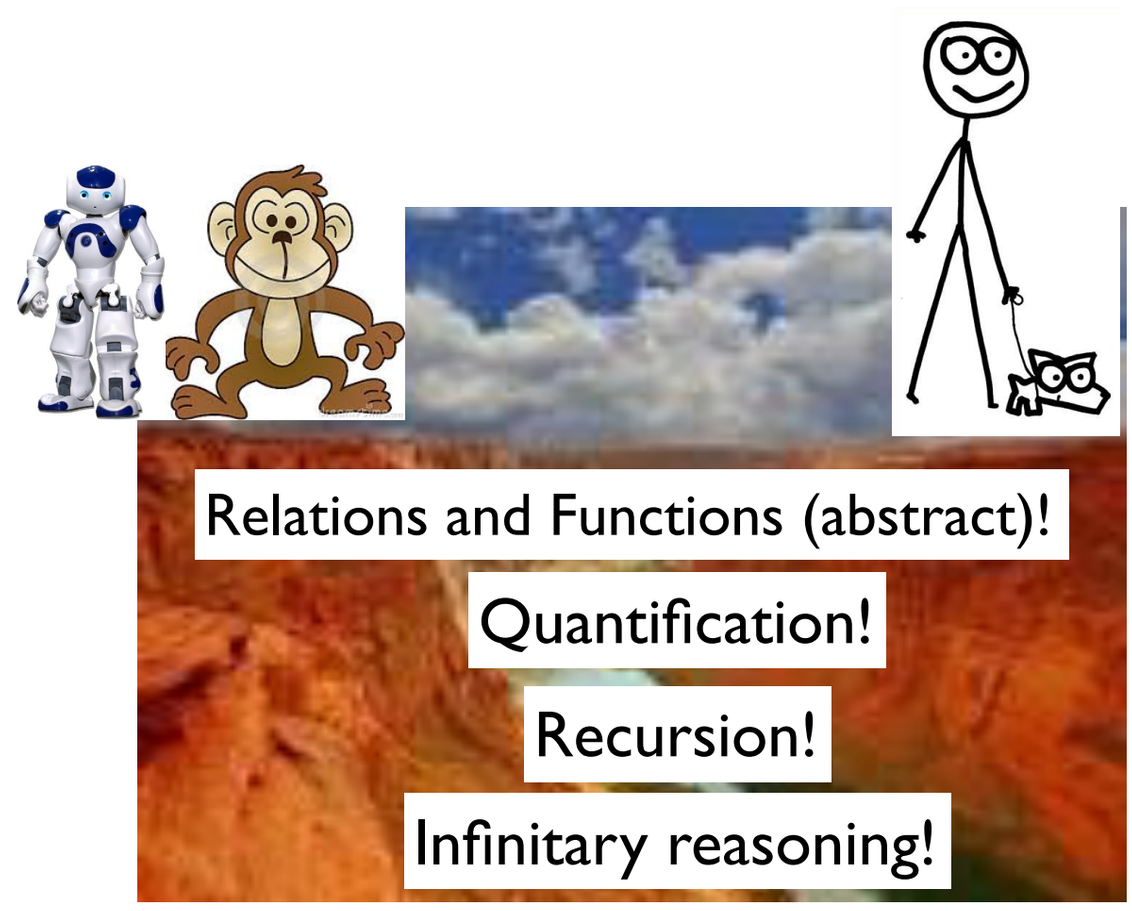

(Thinking ahead to our next topic (quantification), Interesting paper: http://idiom.ucsd.edu/~ivano/SemBabble_old/LogicSeminar_15W/Material/Partee_2013_History-of-Quantifiers.pdf.)

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Everyone karkooks anyone who karkooks someone.

Alvin karkooks Bill.

Can you infer that everyone karkooks Bill?

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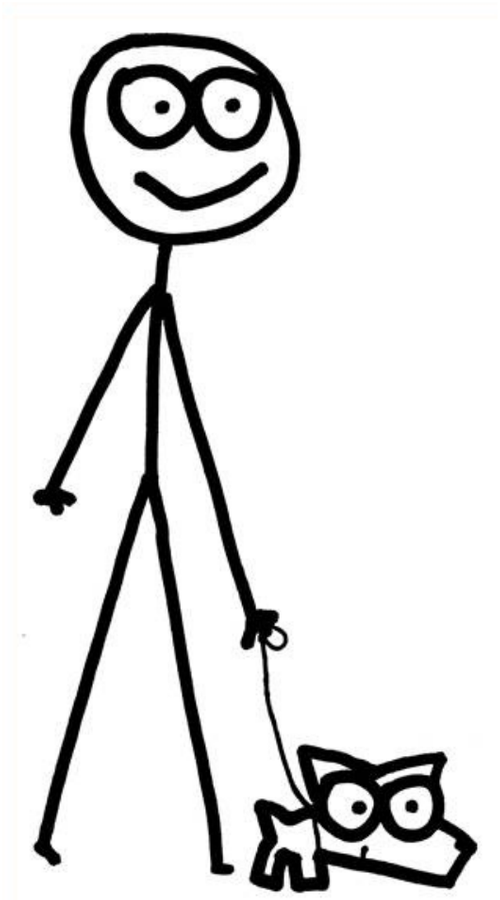
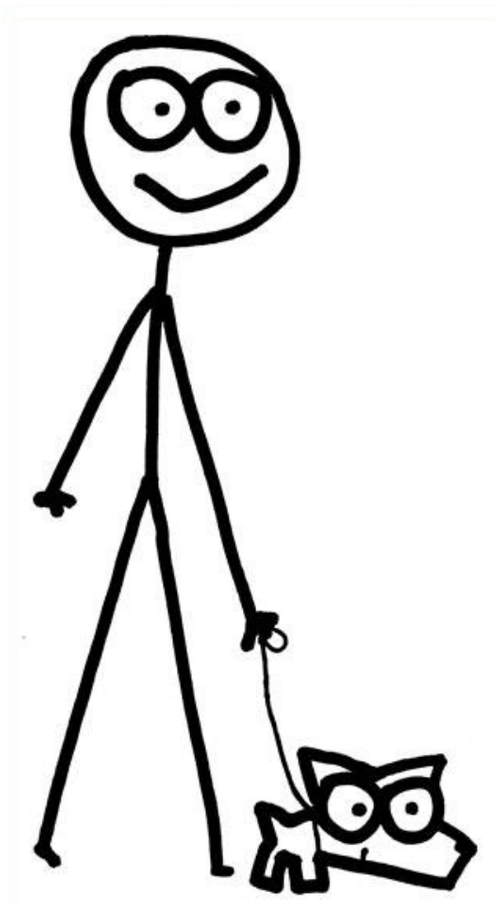
Relations and Functions!

Quantification!

Recursion!

Infinitary Reasoning!





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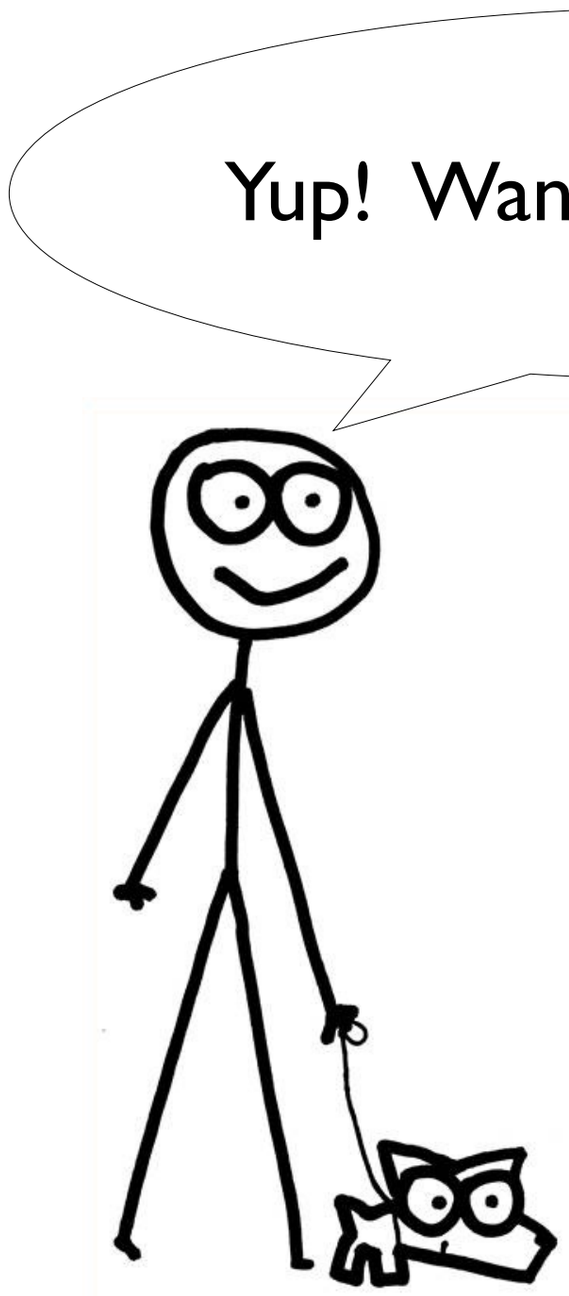

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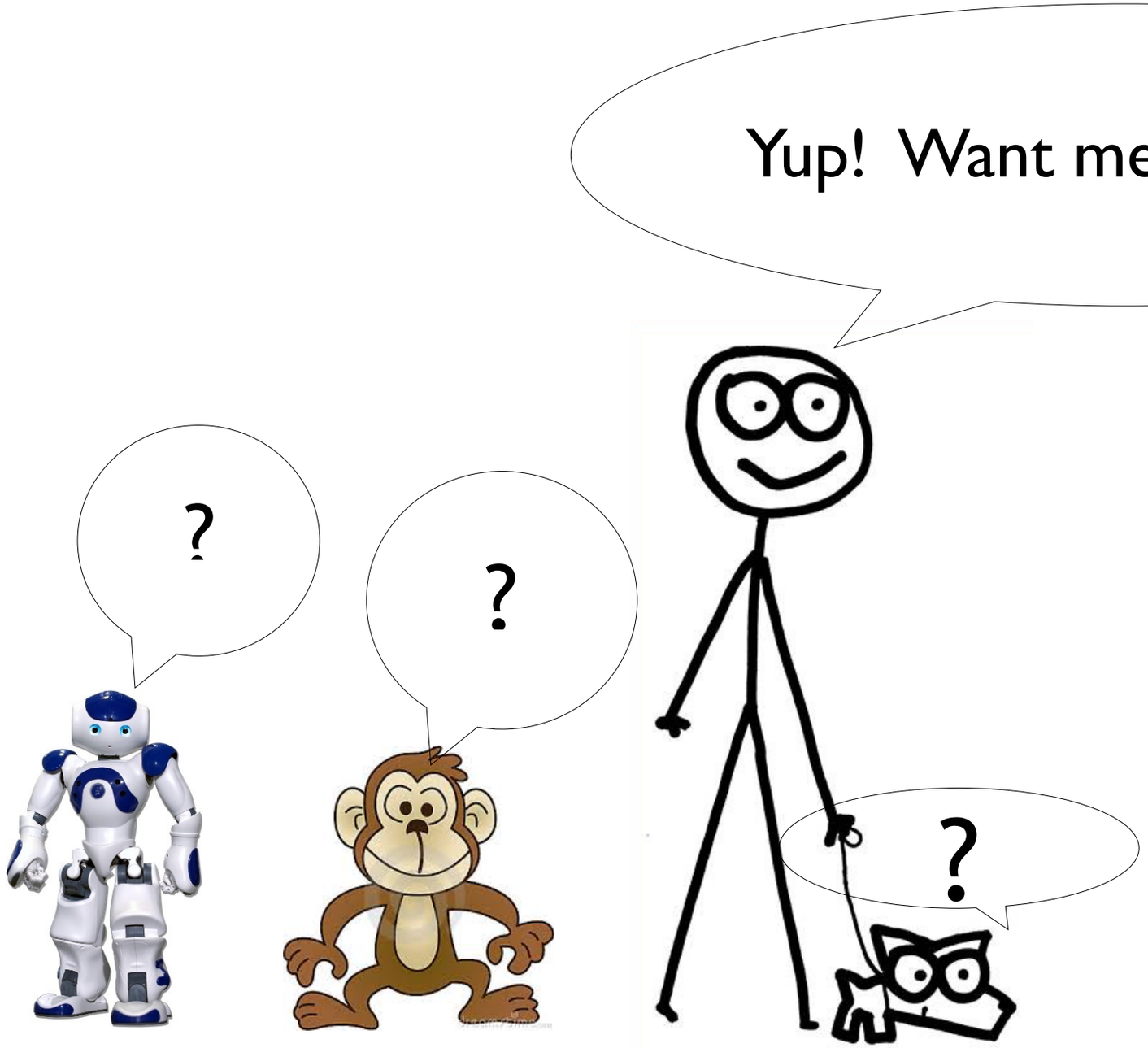

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Larry

Larry attended Hotchkiss before entering Harvard, from which he graduated with a degree in Scandinavian Studies. He aspires to be a Diplomat representing the United States to Sweden. Larry is from a rather wealthy family: his trust fund is valued at $7 billion; his father collects exotic islands, his mother precursor-to-Impressionism masterpieces, and his three bachelor brothers, fast, classic European luxury sedans capable of heart-pounding top speeds. Larry's command of math never exceeded what is covered on the SAT, and he has long forgotten even this material. He does not understand what a computer or computer program is, but nonetheless makes continuous use of social networking technology, including specifically **facebook**, on which he is liked by four people, all in his nuclear family, save for one, and that one is a brilliant female with a penchant for driving fast European sedans *really* fast. Say what you will about Larry, he is arrestingly eloquent without notes of any kind when speaking about geopolitics, in any venue; knows perhaps more about the history of Northern Europe (including its mythology) than any man alive; and while in keeping with his upbringing is a Hayekian capitalist, is rumored to generously donate millions each year to Big Brothers Big Sisters, AA, and Samaritan's Purse.

Lucy

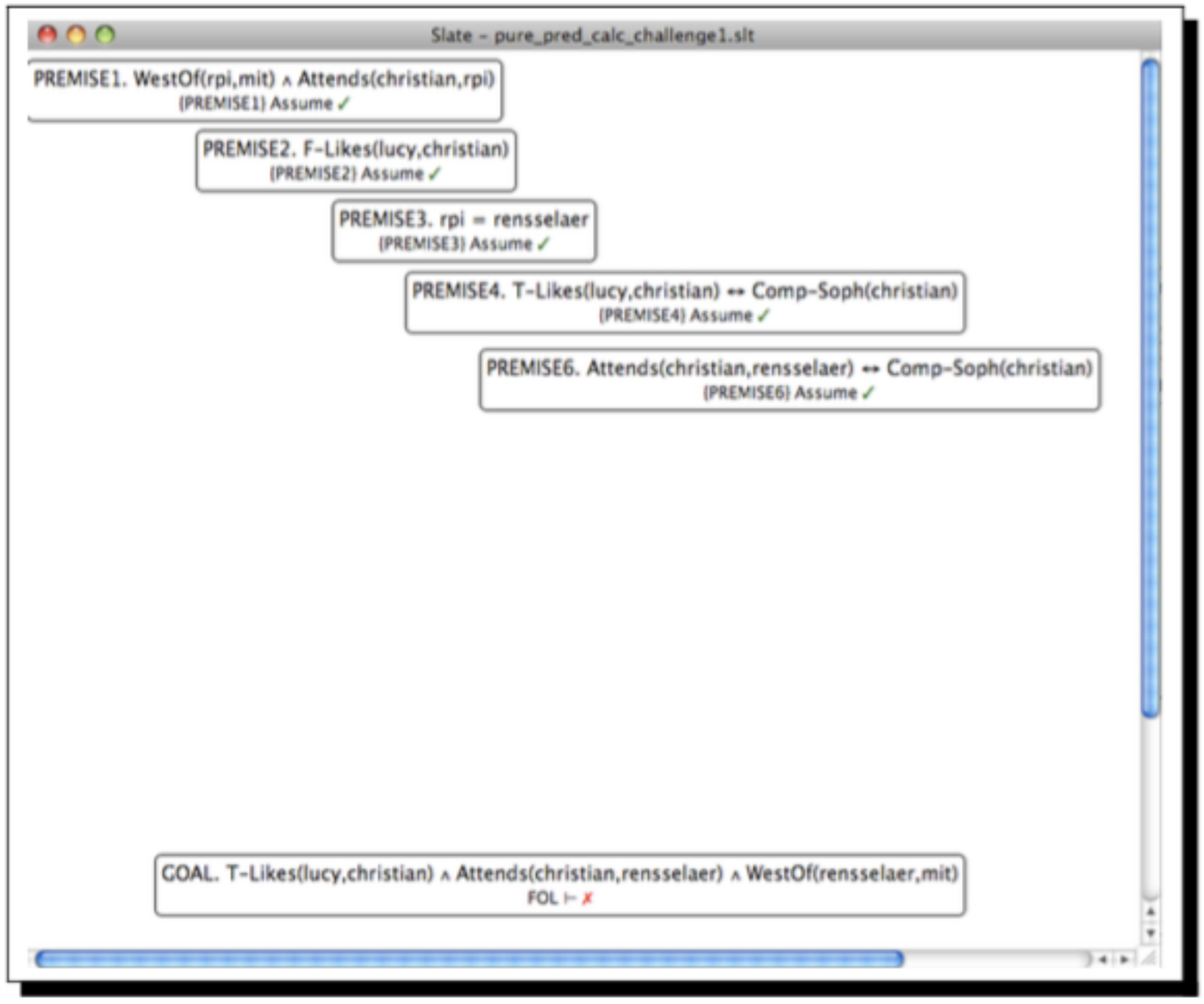
Lucy is a brilliant but poor hacker from a broken, impoverished home in Buffalo NY. A motherless only child raised by a single, devoted father who made ends meet (between binges on the bottle) as a brilliant but itinerant Daimler mechanic, she saw more heartache in her youth than that catalogued in a thousand country-song sagas. As a sophomore at MIT, she (successfully) petitioned to move directly to the PhD program in computer science without having to suffer the — to use her words — "torturous tedium" of the junior and senior years. This rapid "ascension" was all the more remarkable because her first year in college was not spent at MIT, but at Erie Community College, where on day one of *Java 101*, the professor insisted she come to her office after class, whereupon was launched a tutor-student relationship that initially centered not around not Java, but the language for which Professor Kuth has a secret passion: Prolog. Lucy has consistently rebuffed the overtures of all males at MIT, a group she disdains for their universally poor command of matters computational. Lucy stays in touch with her father by email (and as of this writing has managed to maintain her atheism despite his conversion and testimony), and with but five friends on **facebook**, one of whom has attended an Ivy-League institution, and one of whom, an entrepreneur co-running a startup company in the mobile computing space, attends a likewise techie university 2.5-hrs-drive to-the-west-of MIT.

Key

'Larry' :: `larry`
'Lucy' :: `lucy`
'Virginia' :: `virginia`
'Prescott' :: `prescott`
'Hank' :: `hank`
'Abe' :: `abe`
'Ben' :: `ben`
'Charles' :: `charles`
'Christian' :: `christian`
'Harvard' :: `harvard`
'MIT' :: `mit`
'RPI' :: `rpi`
'Rensselaer' :: `rensselaer`
`father-of` is a function; eg we can say: `(father-of lucy)`
`brother-of` is a function; eg we can say: `(brother-of larry)`
x is rich iff `(Rich x)`
x is employed at *y* iff `(EmployedAt x y)`
x is west of *y* iff `(WestOf x y)`
x attends *y* iff `(Attends x y)`
x had i-contact with *y* iff `(IContact x y)`
x facebook-likes *y* iff `(F-Likes x y)`
x truly likes *y* iff `(T-Likes x y)`
x is an alum of *y* iff `(Alum x y)`
x is a hacker iff `(Hacker x)`
x is computationally sophisticated iff `(Comp-Soph x)`
x is a female iff `(Female x)`
x is a generous iff `(Generous x)`
x is eloquent iff `(Eloquent x)`
x is a brother of *y* iff `(Brother x y)`
x knows Norse mythology iff `(K-Norse-Myth x)`
x knows who Huginn and Muninn are iff `(K-H-M x)`

Work through this example from the book!

Figure 3.1: A Proof Challenge in the Pure Predicate Calculus



Provably

Subsuming

Prolog …

?

Entscheidungsproblem

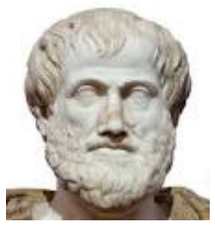
"Universal Computational Logic"

Logic Theorist
(bi[illegible] of modern logicist AI)

350 BC

Euclid

300 BC



Organon

1666

Leibniz

$\int$

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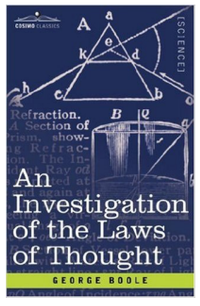

1956

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2020

The Singularity?

Intro to Logic @ RPI

Frege

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

Church

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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!

New: Functional = Church; Procedural = Turing. Where is logicist computation?

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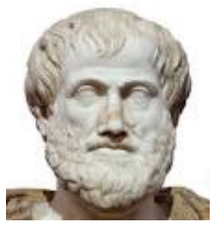

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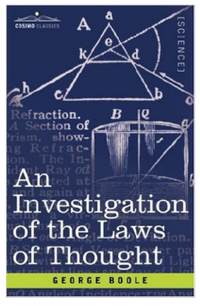

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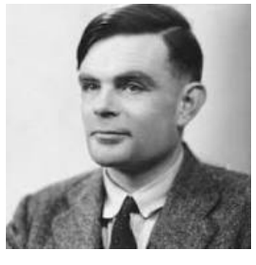

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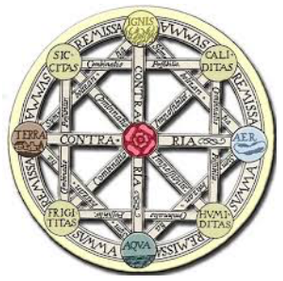

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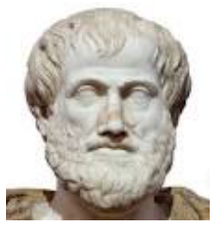

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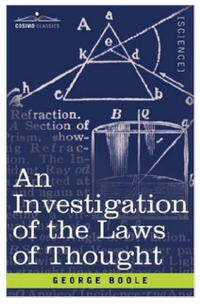

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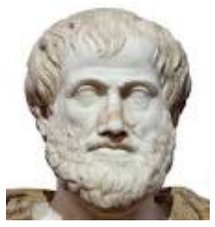

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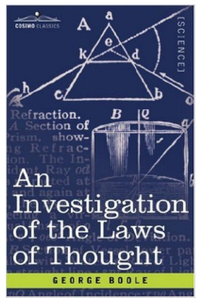

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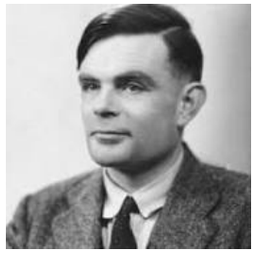

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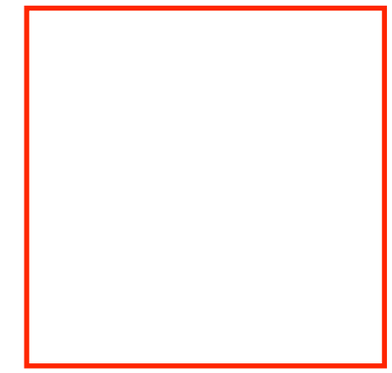

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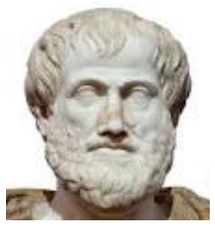

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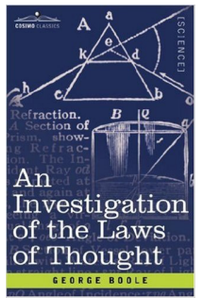

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Two Logicist Branches; B1:

Frege (remember him?), 1893:
"Aha! Currying! I recast multiple-arity operations with functions into a unary affair!"

Schönfinkel, 1920's:
"Aha! I can do this stuff using combinatory logic!"

Church, 1920's & 30's:
"Aha! The lambda calculus!

•••

Haskell

Our Logicist Branch: B2:

Our Logicist Branch: B2:

The AI Branch: Automated Reasoning

Our Logicist Branch: B2:

The AI Branch: Automated Reasoning

Leibniz

Our Logicist Branch: B2:

The AI Branch: Automated Reasoning

Leibniz

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Prolog?

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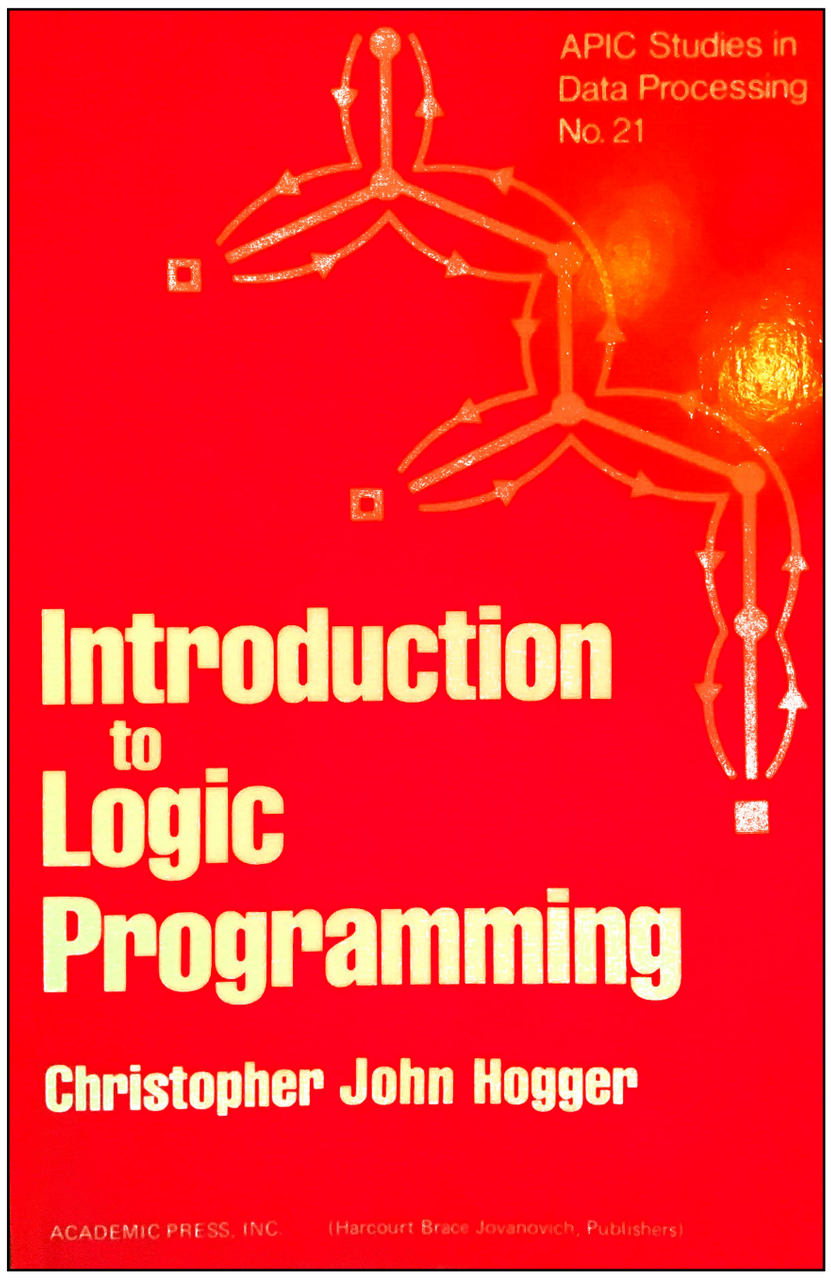
…

PGLP

Ok, but how do we *know* PGLP can subsume Prolog?

Here's how …



Show $\mathscr{L}_0 + \mathbb{R}$ can handle quantifier-free functions.

Later: $\mathscr{L}_1$ for rest of functions.

Enden — for i dag.