Lecture 3

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Northeastern

Aunt

Who knows what an aunt is?

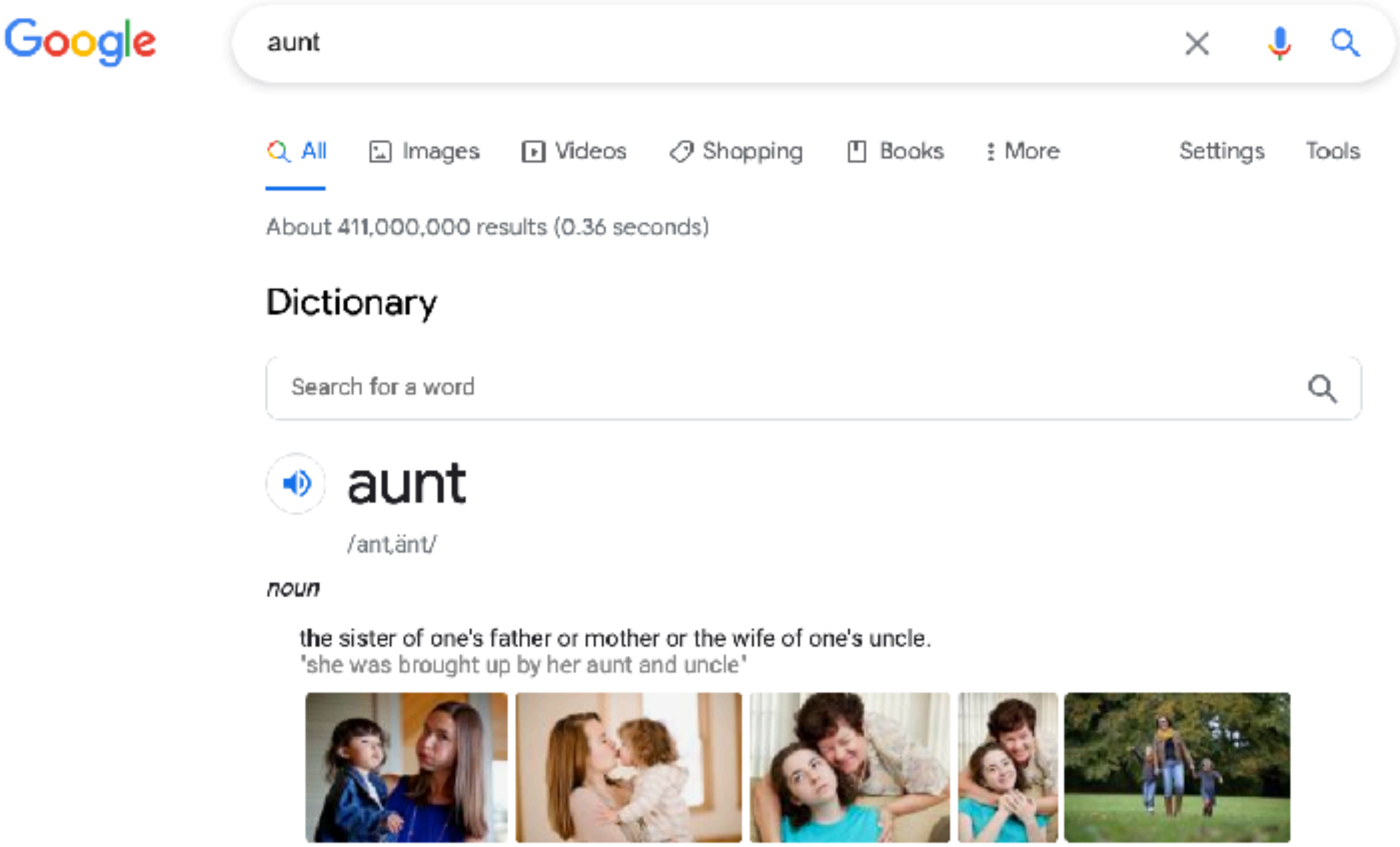
An aunt is …

Aunt May Parker

Real Name	May Parker
First Appearance	Amazing Fantasy #15 (August 1962)

Slides by Pete Manolios for CS4820

Hey, Google



aunt

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About 411,000,000 results (0.36 seconds)

Dictionary

Search for a word

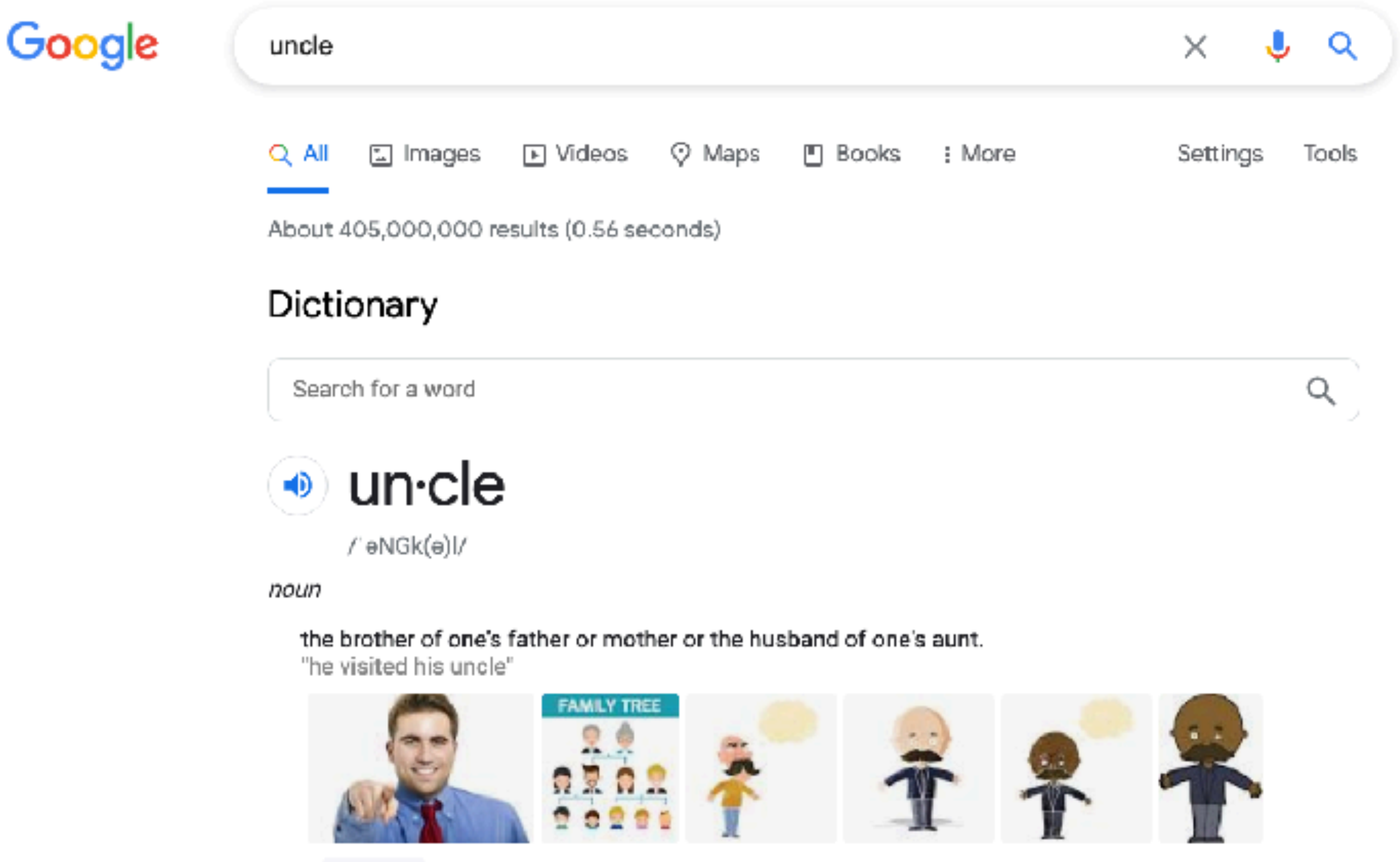
aunt

/ant,änt/

noun

the sister of one's father or mother or the wife of one's uncle.
'she was brought up by her aunt and uncle'

Hey, Google



Google

uncle

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Dictionary

Search for a word

un·cle

/ˈəNGk(ə)l/

noun

the brother of one's father or mother or the husband of one's aunt.
"he visited his uncle"

Aunts and Definitions

- The world according to Goggle
  - Aunt: The sister of one’s father or mother or the wife of one’s uncle.
  - Uncle: The brother of one’s father or mother or the husband of one’s aunt.
  - Google’s definition is circular! So, it is unknowable and requires trust in Google.
- Ignore the circularity for a moment; any other issues?
- What if your mother’s sister is married to a woman?
  - Not an aunt according to Google!
- Wikipedia: An aunt is a woman who is a sibling of a parent or married to a sibling of a parent.
  - What is a sibling? (Adopted? Half?)
  - What about parent? (Biological?)
  - Married? (Legal marriage? What about divorce?)
  - Temporal aspect? (Sure, can’t guess the future)
- Property: If *X* is the aunt of *Y*, then *Y* is not the aunt of *X*. True or Not??
- Logic, mathematics, reasoning requires *real* definitions, allowing *real* inferences

Formalizing Aunts

$$\frac{\alpha P \beta \quad \alpha P x \quad F x \quad \beta P y}{x A y}$$

$$\begin{tikzcd}
\alpha \arrow[d] \arrow[dr] & \\
\beta \arrow[d] & x \\
y &
\end{tikzcd}$$

P: parent-of F: female A: aunt-of

⭕ Female ○ Unspecified sex

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Falsifying the Property

Property: If *X* is the aunt of *Y*, then *Y* is not the aunt of *X*.

$$\frac{\alpha P\beta \quad \alpha Px \quad Fx \quad \beta Py}{xAy} \qquad \frac{\gamma P\delta \quad \gamma Py \quad Fy \quad \delta Px}{yAx}$$

Instantiate

$$\begin{tikzcd}
\alpha \arrow[d] \arrow[dr] & \\
\beta \arrow[d] & x \\
y &
\end{tikzcd}
\qquad
\begin{tikzcd}
\gamma \arrow[d] \arrow[dr] & \\
\delta \arrow[d] & y \\
x &
\end{tikzcd}$$

Merge

$$\begin{tikzcd}
 & \gamma \arrow[d] \arrow[dddl, bend right] \\
\alpha \arrow[d] \arrow[dr] & \delta \arrow[d] \\
\beta \arrow[d] & x \\
y &
\end{tikzcd}$$

P: parent-of F: female A: aunt-of

⭕ Female ◯ Unspecified sex

Pro Reasoning Tip:
Make your own notations &
patterns: xAy is x, 1up, 2down

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Definitions

Mathematics is entirely free in its development, and its concepts are only linked by the necessity of being consistent, and are co-ordinated with concepts introduced previously by means of precise definitions.

Georg Cantor

If any philosopher had been asked for a definition of infinity, he might have produced some unintelligible rigmarole, but he would certainly not have been able to give a definition that had any meaning at all.

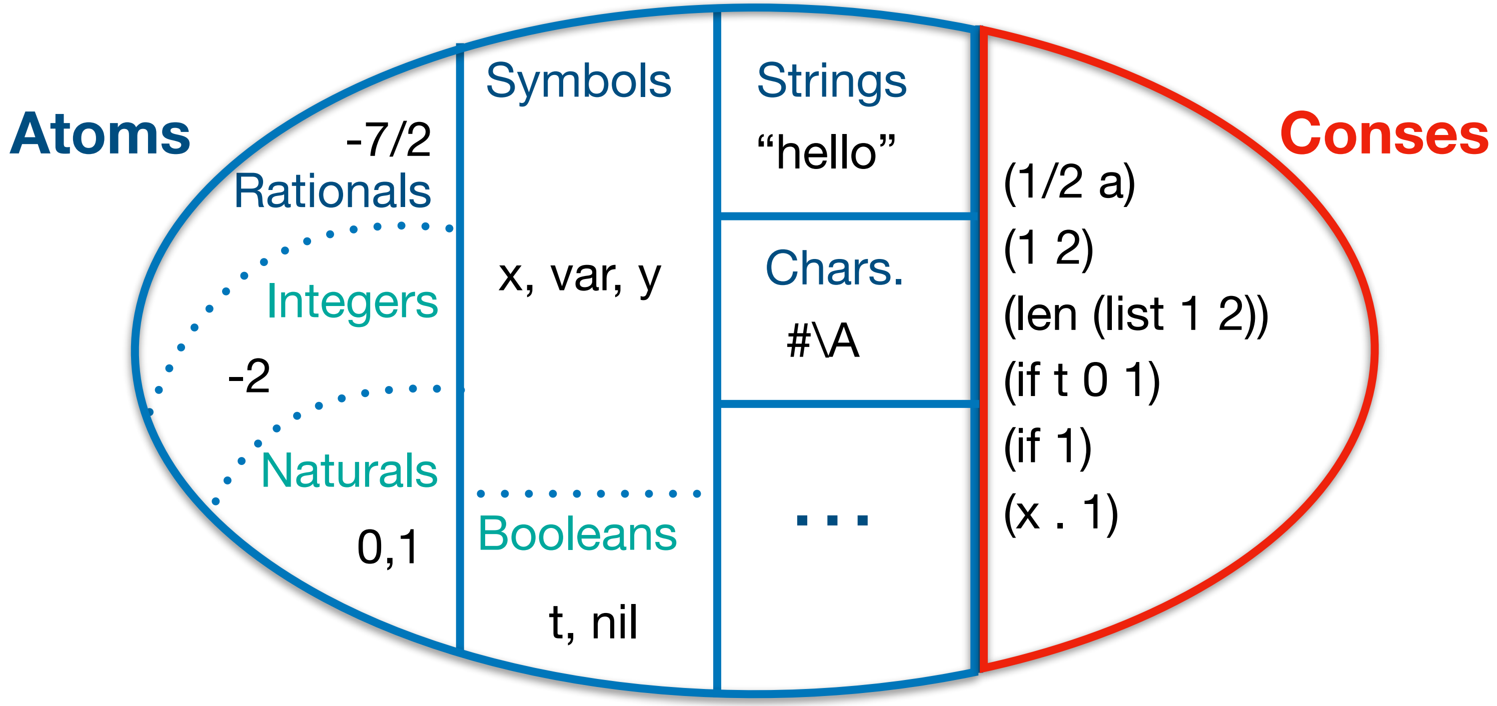
Bertrand Russell

The deepest definition of youth is life as yet untouched by tragedy.

Alfred North Whitehead

ACL2 Universe (Review)

All = Conses ∪ **Atoms**



Lists = Conses ∪ { ( ) }

True-lists = $\cup_{i \in \mathbb{N}} L_i$

L_0 = { ( ) }, L_{i+1} = L_i ∪ {`(cons x l): x ∈ All, l ∈ L`$_i$}

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Expressions

- "Expressions" (or "terms") are elements of a subset of U (the Universe)
- Evaluation maps expressions to ACL2 objects
- ⟦*expr*⟧ denotes the semantics of *expr*
  - or what *expr* evaluates to at the REPL
- Constants are expressions that evaluate to themselves
  - `⟦t⟧ = t`
  - `⟦nil⟧ = nil`
  - `⟦6⟧ = 6`
  - `⟦-21⟧ = -21`

Lazy vs Strict

- Semantics of `if`
  - ⟦(`if` *test then else*)⟧ = ⟦*then*⟧ , when ⟦*test*⟧ ≠ `nil` (Generalized Booleans)
  - ⟦(`if` *test then else*)⟧ = ⟦*else*⟧ , when ⟦*test*⟧ = `nil`
- `if` is lazy:
  - first ACL2s evaluates *test*, i.e., it computes ⟦*test*⟧
  - if ⟦*test*⟧ ≠ `nil` then ACL2s returns ⟦*then*⟧
  - otherwise, it returns ⟦*else*⟧
- So, *test* is always evaluated, but only one of *then*, *else* is
- All other functions are strict
  - ACL2s evaluates all of the arguments to the function
  - Then ACL2s applies the function to evaluated results

Function Definitions

- Why does this definition make sense?
- Because it terminates
- A key idea every time you define a program is to convince yourself that on every recursive call, some parameter decreases in a well-founded way
- Hmm, can lists be circular? then what?
- Lists are non-circular in ACL2s, which is why this works
- Termination is one of the key ideas in CS
- Note that data driven definitions always terminate

```
(definec mlen (l :tl) :nat
  (if (endp l)
      0
    (1+ (mlen (rest l)))))
```

```
(definec mlen (l :tl) :nat
  (if (endp l)
      (1+ (mlen (rest l)))
    0))
```

What if I wrote this?

DEMO

Questions?