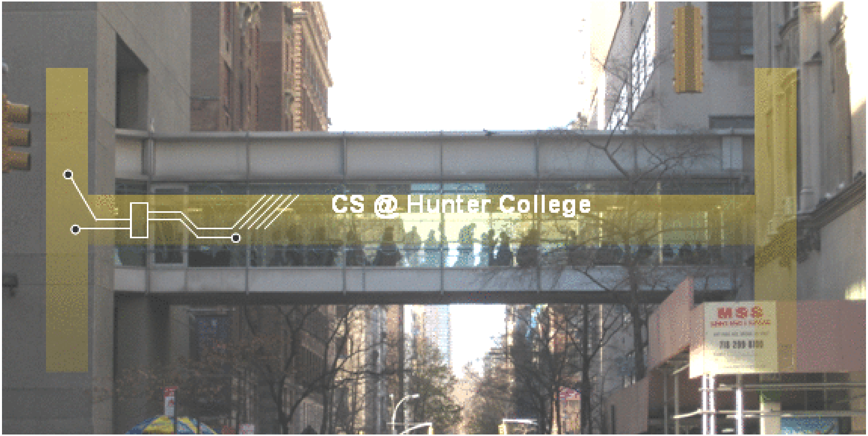
CSci 127: Introduction to Computer Science



hunter.cuny.edu/csci

Announcements

- Welcome back!
  Next holiday is Thanksgiving.

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- Each lecture includes a survey of computing research and tech in NYC.

  Today: Prof. Katherine St. John (computational biology)

Frequently Asked Questions

From lecture slips & recitation sections.

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  1) it's fundamental, and
  2) the same ideas are used for accessing formatted data (today's topic).
- Is it okay to work ahead?
  Yes! It's great to try things before lecture/lab (builds a "mental scaffold" to hold new material covered).
  All the labs are up for the rest of the semester, and programs open on gradescope 4 weeks before the deadline.

Today's Topics

- Recap: Logical Expressions & Circuits
- Design: Cropping Images
- Accessing Formatted Data
- CS Survey: Computational Biology

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Recap: Logical Operators

and

in1		in2	*returns:*
False	and	False	False
False	and	True	False
True	and	False	False
True	and	True	True

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`in1`		`in2`	*returns:*
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`False`	`and`	`True`	`False`
`True`	`and`	`False`	`False`
`True`	`and`	`True`	`True`

or

`in1`		`in2`	*returns:*
`False`	`or`	`False`	`False`
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not

	in1	*returns:*
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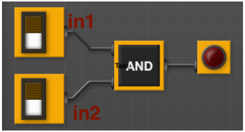
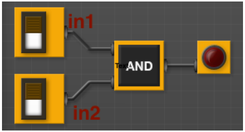
not	True	False

Logical Operators & Circuits



- Each logical operator (`and`, `or`, & `not`) can be used to join together expressions.

Logical Operators & Circuits



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  Example: `in1 and in2`

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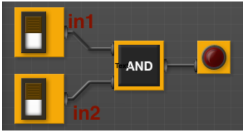

- Each logical operator (`and`, `or`, & `not`) can be used to join together expressions.

  Example: `in1 and in2`
- Each logical operator (`and`, `or`, & `not`) has a corresponding logical circuit that can be used to join together inputs.

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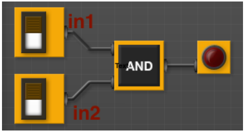

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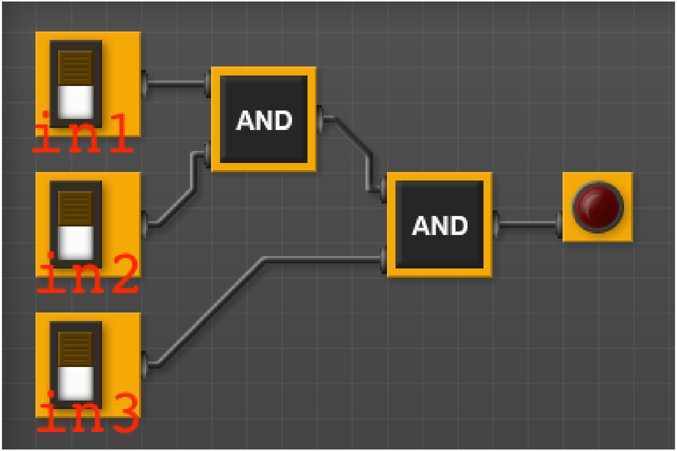
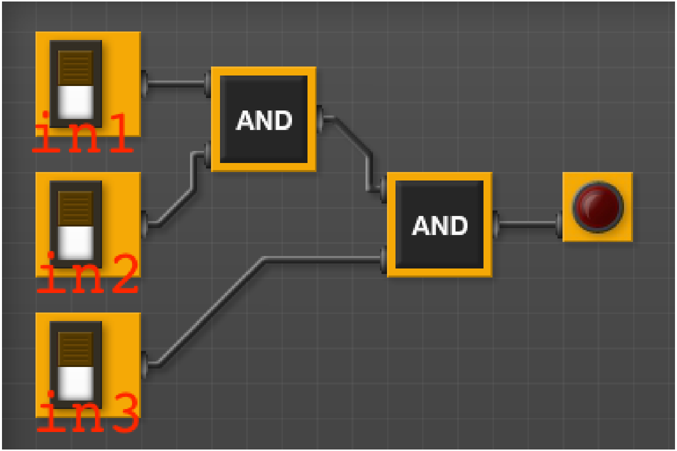
Examples: Logical Circuit



Examples: Logical Circuit



`(in1 and in2) and in3`

Examples: Logical Expressions

Examples from last lecture:

```
origin = "Indian Ocean"
winds = 100
if (winds > 74):
    print("Major storm, called a ", end="")
    if origin == "Indian Ocean" or origin == "South Pacific":
        print("cyclone.")
    elif origin == "North Pacific":
        print("typhoon.")
    else:
        print("hurricane.")

visibility = 0.2
winds = 40
conditions = "blowing snow"
if (winds > 35) and (visibility < 0.25) and \
    (conditions == "blowing snow" or conditions == "heavy snow"):
    print("Blizzard!")
```

In Pairs or Triples:

Predict what the code will do:

- ```
  x = 6
  y = x % 4
  w = y**3
  z = w // 2
  print(x,y,w,z)
  x,y = y,w
  print(x,y,w,z)
  x = y / 2
  print(x,y,w,z)
  ```
- ```
  sports = ["Field Hockey","Swimming","Water Polo"]
  mess = "Qoauxca BrletRce crcx qvBnqa ocUxk"
  result = ""
  for i in range(len(mess)):
      if i % 3 == 0:
          print(mess[i])
          result = result + mess[i]
  print(sports[1], result)
  ```

Python Tutor

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(Demo with `pythonTutor`)

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In Pairs or Triples: Design Question

From Final Exam, Fall 2017, V4, #6.

Design an algorithm that reads in an image and displays the lower left corner of the image.

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Input:
Output:
Process: *(Brainstorm for a "To Do" list to accomplish this.)*

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6. Display the new image.
   ```
   plt.imshow(img2) #Load our new image into pyplot
   plt.show() #Show the image (waits until closed to continue)
   ```

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Structured Data

	Undergraduate		
College	**Full-time**	**Part-time**	**Total**
Baruch	11,288	3,922	15,210
Brooklyn	10,198	4,208	14,406
City	10,067	3,250	13,317
Hunter	12,223	4,500	16,723
John Jay	9,831	2,843	12,674
Lehman	6,600	4,720	11,320
Medgar Evers	4,760	2,059	6,819
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- See end of Lab 6 for directions on downloading it to your home machine.
- To use, add to the top of your file:

```
import pandas as pd
```

CSV Files

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- Excel .xls files have much extra formatting.

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nycHistPop.csv

Reading in CSV Files

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- It also has **Series**, that is perfect for holding a row or column of data.

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`nycHistPop.csv`

In Lab 6

Example: Reading in CSV Files

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nycHistPop.csv

In Lab 6

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`nycHistPop.csv`

In Lab 6

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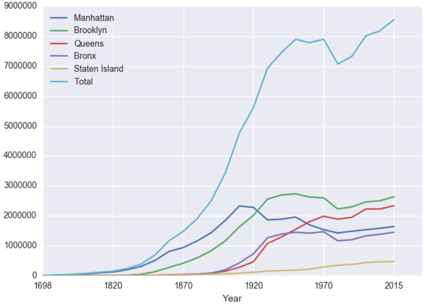
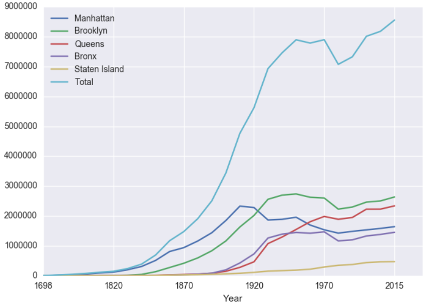
nycHistPop.csv

In Lab 6



Series in Pandas



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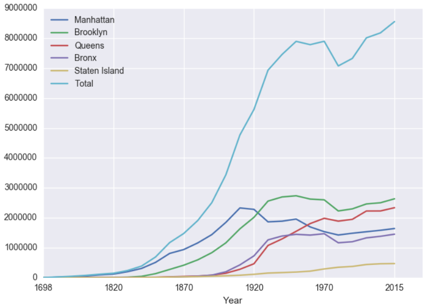
Series in Pandas



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- Example: `pop["Manhattan"]` is the Series corresponding to the column of Manhattan data.

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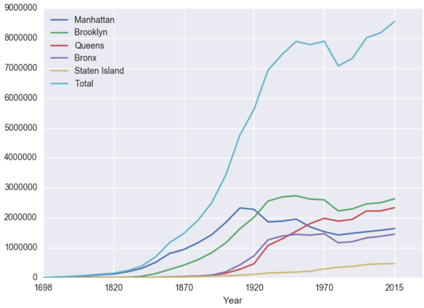

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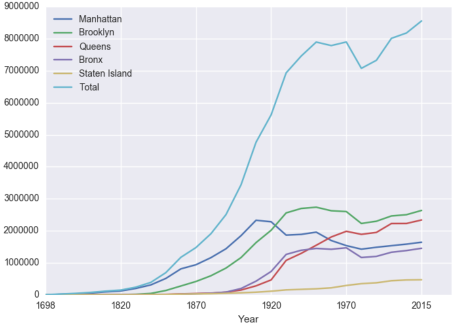
- Example: `pop["Manhattan"]` is the Series corresponding to the column of Manhattan data.
- Example:
  ```
  print("The largest number living in the Bronx is",
  pop["Bronx"].max())
  ```

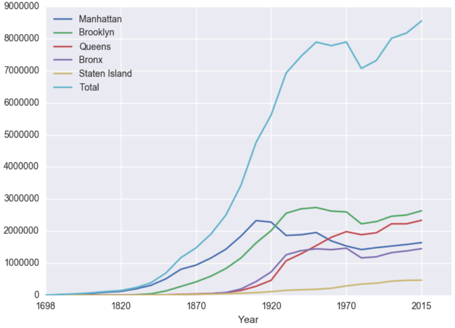
In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`

In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`

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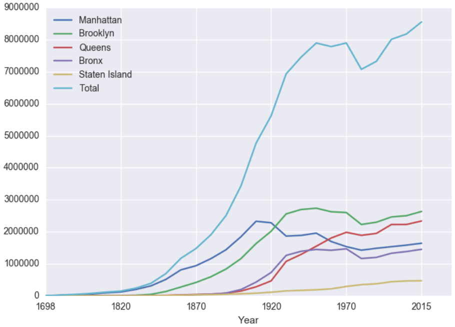

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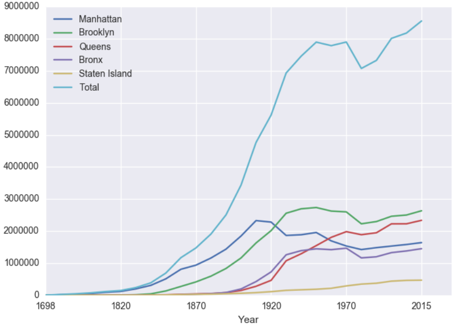

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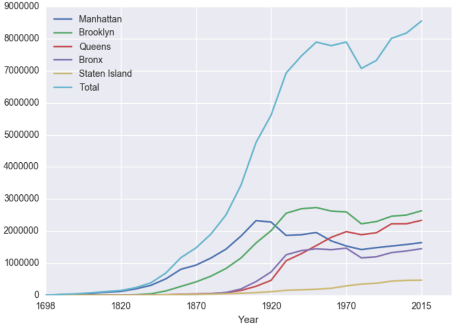

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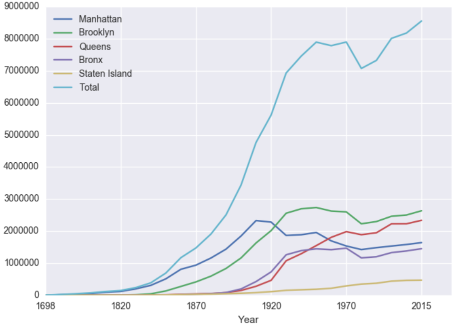
- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`
- `pop.plot.bar(x="Year")`
- `pop.plot.scatter(x="Brooklyn", y= "Total")`

In Pairs or Triples



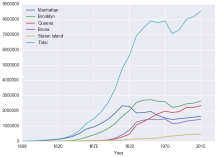
Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`
- `pop.plot.bar(x="Year")`
- `pop.plot.scatter(x="Brooklyn", y= "Total")`
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`

Solutions

Predict what the following will do:

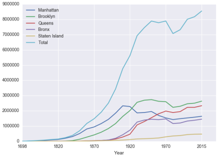
- `print("Queens:", pop["Queens"].min())`



Solutions

Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
  Minimum value in the column with label "Queens".



Solutions

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- `print("Queens:", pop["Queens"].min())`
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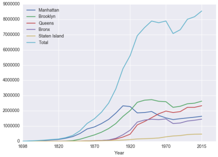
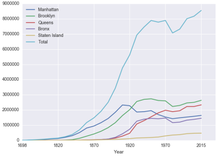


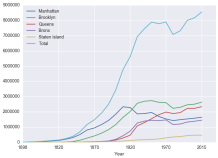
Solutions



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
  Minimum value in the column with label "Queens".
- `print("S I:", pop["Staten Island"].mean())`
  Average of values in the column "Staten Island".

Solutions



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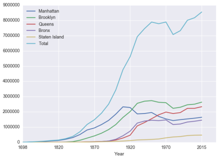
- `print("S I :", pop["Staten Island"].std())`

Solutions



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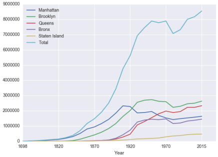
Solutions



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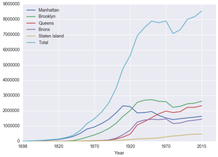
  Average of values in the column "Staten Island".
- `print("S I :", pop["Staten Island"].std())`
  Standard deviation of values in the column "Staten Island".
- `pop.plot.bar(x="Year")`

Solutions



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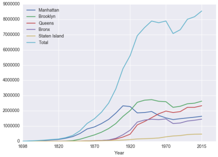
  Standard deviation of values in the column "Staten Island".
- `pop.plot.bar(x="Year")`
  Bar chart with x-axis "Year".

Solutions



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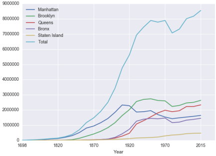
- `pop.plot.bar(x="Year")`
  Bar chart with x-axis "Year".
- `pop.plot.scatter(x="Brooklyn", y= "Total")`

Solutions



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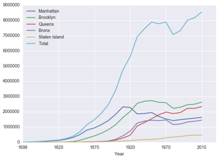
  Standard deviation of values in the column "Staten Island".
- `pop.plot.bar(x="Year")`
  Bar chart with x-axis "Year".
- `pop.plot.scatter(x="Brooklyn", y= "Total")`
  Scatter plot of Brooklyn versus Total values.

Solutions



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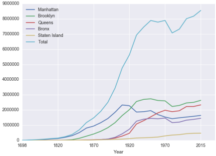
  Standard deviation of values in the column "Staten Island".
- `pop.plot.bar(x="Year")`
  Bar chart with x-axis "Year".
- `pop.plot.scatter(x="Brooklyn", y= "Total")`
  Scatter plot of Brooklyn versus Total values.
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`

Solutions



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- `print("S I :", pop["Staten Island"].std())`
  Standard deviation of values in the column "Staten Island".
- `pop.plot.bar(x="Year")`
  Bar chart with x-axis "Year".
- `pop.plot.scatter(x="Brooklyn", y= "Total")`
  Scatter plot of Brooklyn versus Total values.
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`
  New column with the fraction of population that lives in the Bronx.

In Pairs or Triples

	Undergraduate		
College	Full-time	Part-time	Total
Baruch	11,288	3,922	15,210
Brooklyn	10,198	4,208	14,406
City	10,067	3,250	13,317
Hunter	12,223	4,500	16,723
John Jay	9,831	2,843	12,674
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York	5,066	3,192	8,258

`cunyF2016.csv`

Write a complete Python program that reads in the file, `cunyF2016.csv`, and produces a scatter plot of full-time versus part-time enrollment.

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Solution:

1. *Include pandas & pyplot libraries.*
2. *Read in the CSV file.*
3. *Set up a scatter plot.*
4. *Display plot.*

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   import pandas as pd
   ```
2. *Read in the CSV file.*
   ```
   pop=pd.read_csv('cunyF2016.csv',skiprows=1)
   ```
3. *Set up a scatter plot.*

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2. *Read in the CSV file.*
```
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```
3. *Set up a scatter plot.*
```
pop.plot(x="Full-time",y="Part-time")
```
4. *Display plot.*

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   ```
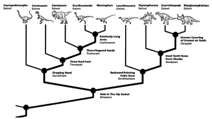
3. *Set up a scatter plot.*
   ```
   pop.plot(x="Full-time",y="Part-time")
   ```
4. *Display plot.*
   ```
   plt.show()
   ```

Today's Topics

- Recap: Logical Expressions & Circuits
- Design: Cropping Images
- Accessing Formatted Data
- **CS Survey: Computational Biology**

CS Survey: Prof. St. John, computational biology



(American Museum of Natural History)

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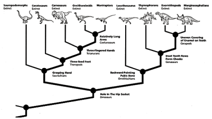

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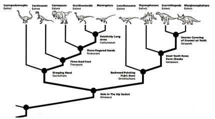

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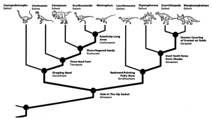
BRIDGE UP STEM

CS Survey: Prof. St. John, computational biology



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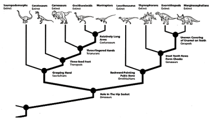
BRIDGE UP STEM

- Finding optimal evolutionary histories for biological data.

CS Survey: Prof. St. John, computational biology



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- Finding optimal evolutionary histories for biological data.
- Computationally hard questions.

BRIDGE UP STEM

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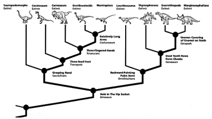

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- Collaborate with biologists & anthropologists at AMNH, & team of undergraduate researchers.

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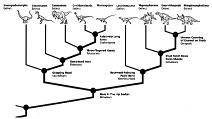

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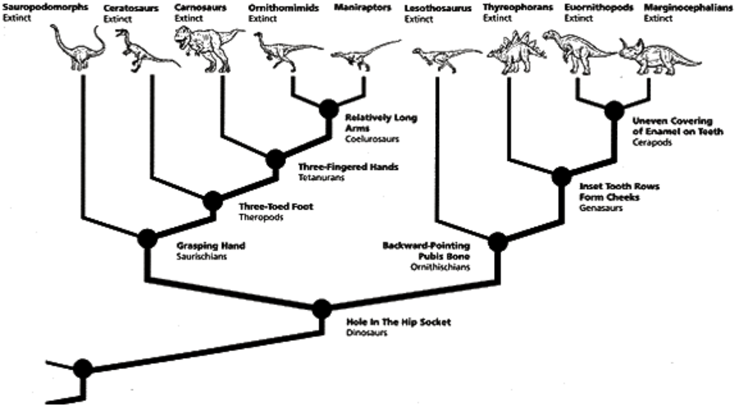
- Challenge today from BridgeUp:STEM.

Evolutionary History: Dinosaurs



(American Museum of Natural History)

Where Do Turtles Fit in the Tree of Life?

Green Turtle, Kona, Hawai'i (wiki: Inaglory)

Where Do Turtles Fit in the Tree of Life?

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- Lack of consensus about where turtles fit into the tree of life.

Where Do Turtles Fit in the Tree of Life?

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- Recent papers: Lyson *et al.* 2013, Crawford *et al.* 2015, Schoch & Sues 2016

Where Do Turtles Fit in the Tree of Life?

Turtle

(Inaglory, wiki)

Green sea turtle

Chelonia mydas

Squamate

(Bac Luong, wiki)

Tokyo gecko

Gekko gecko

Amphibian

(WA Djatmiko, wiki)

Common tree frog

Polypedates leucomystax

Bird

(S Nygaard, wiki)

Ostrich

Struthio camelus

Mammal

(Proc Zoo London 1863)

Shrew opossum

Caenolestes fuliginosus

Your Turn: Draw an evolutionary history.

Fill in the evolutionary history with the 5 species as tips/leaves of the tree:

Turtle

(Inaglory, wiki)

Squamate

(Bac Luong, wiki)

Amphibian

(WA Djatmiko, wiki)

Bird

(S Nygaard, wiki)

Mammal

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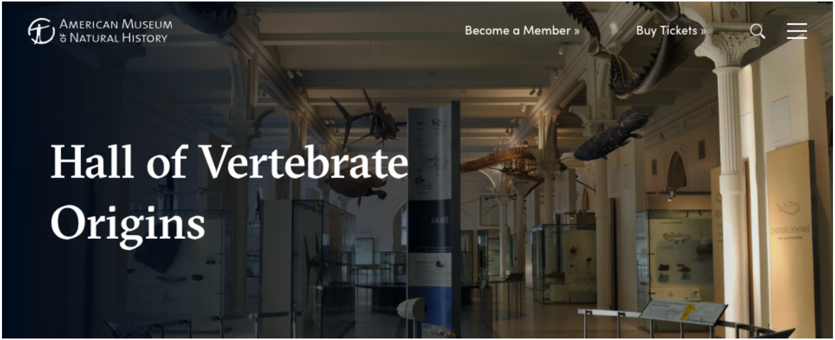
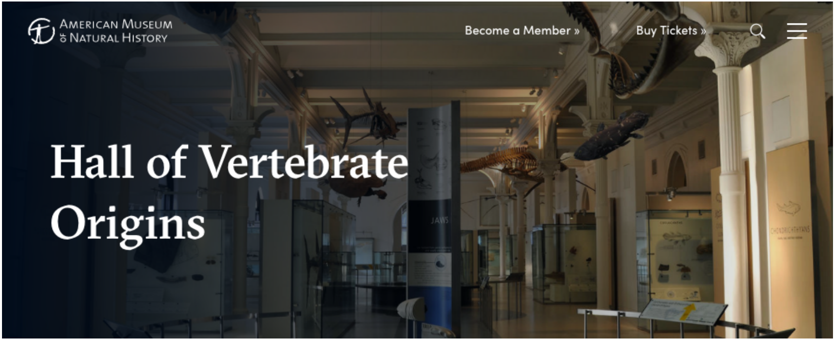
Collecting Characters



- Before we can evaluate a tree, we need to have a set of characters/traits for our species.

Collecting Characters



- Before we can evaluate a tree, we need to have a set of characters/traits for our species.
- Students visited the AMNH's Hall of Vertebrate Origins to fill in the character matrix.

Collecting Characters

Species →	**Higher taxonomy**	Sarcopterygii	Testudinata	Lepidosauria	Amphibia	Aves	Mammalia
	Species name	Protopterus dolloi	Chelonia mydas	Gekko gecko	Polypedates leucomystax	Struthio camelus	Caenolestes fuliginosus
	Common name	Lungfish	Green sea turtle	Tokay gecko	Common tree frog	Ostrich	Shrew opossum
Character ↓	Vertebral column						
	Tetrapod (four limbs)						
	Amniotic egg						
	Palatal opening						
	Diapsids (openings in skull for jaw muscles)						
	Feathers						
	Shed skin + specialized ear						
	Fused rib bones form carapace						
	Fur, lactation						
	Gas exchange across skin + large openings in mouth						

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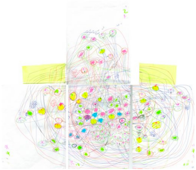
	Palatal opening	0	1	1	0	1	0
	Diapsids (openings in skull for jaw muscles)	0	0	1	0	1	0
	Feathers	0	0	0	0	1	0
	Shed skin + specialized ear	0	0	1	0	0	0
	Fused rib bones form carapace	0	1	0	0	0	0
	Fur, lactation	0	0	0	0	0	1
	Gas exchange across skin + large openings in mouth	0	0	0	1	0	0

Choosing the Best

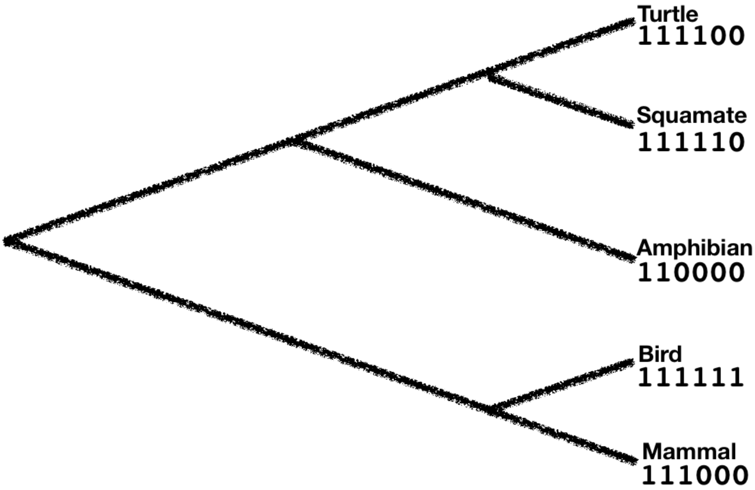


Given a set of organisms, which tree is optimal?

- Two standard criteria for optimality:
  - Maximum Parsimony: find tree with fewest changes.
  - Maximum Likelihood: find most likely tree (with respect to a model of evolution)
- Idea: pick a criteria; choose the tree that scores the best under it.

Maximum Parsimony

- For each tree, measure the minimal number of substitutions across branches:



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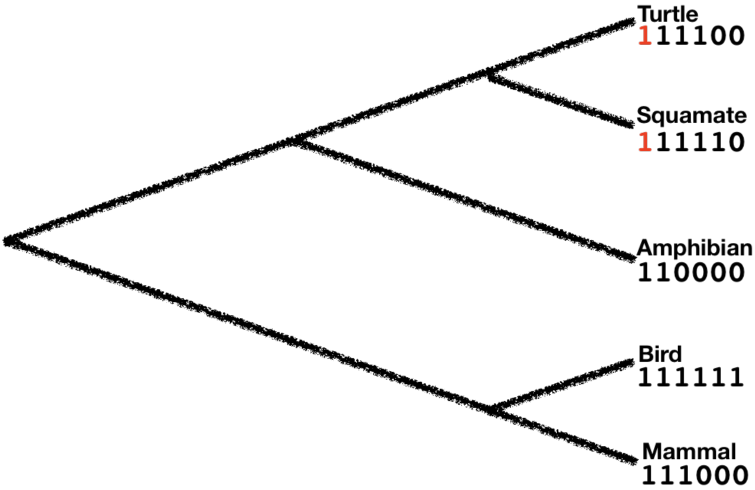

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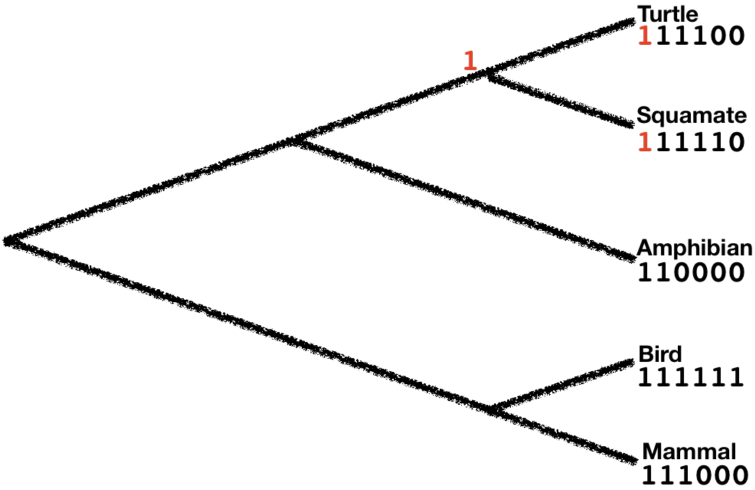

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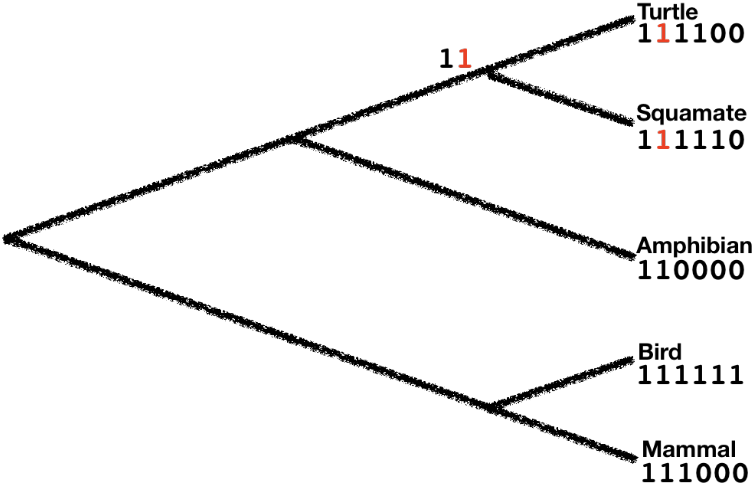

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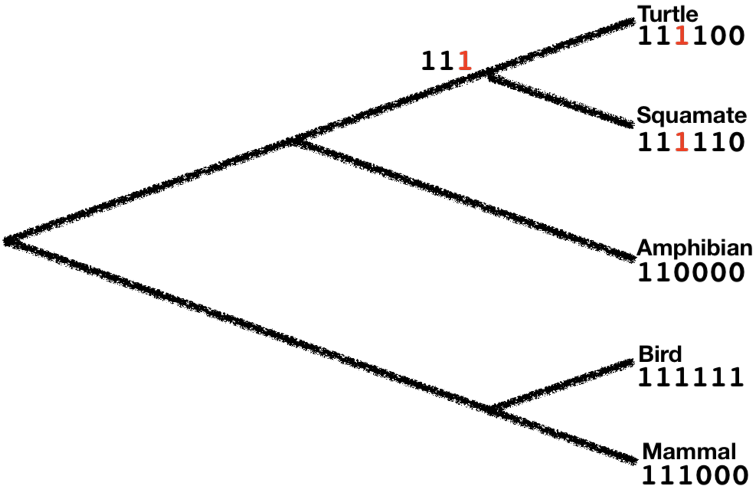

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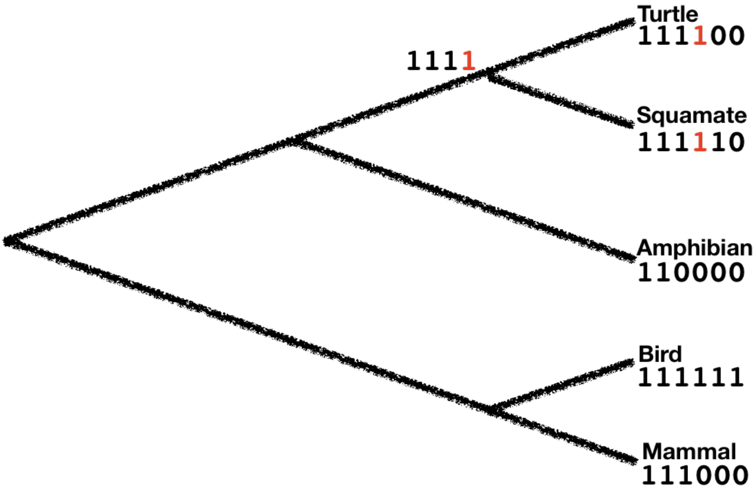

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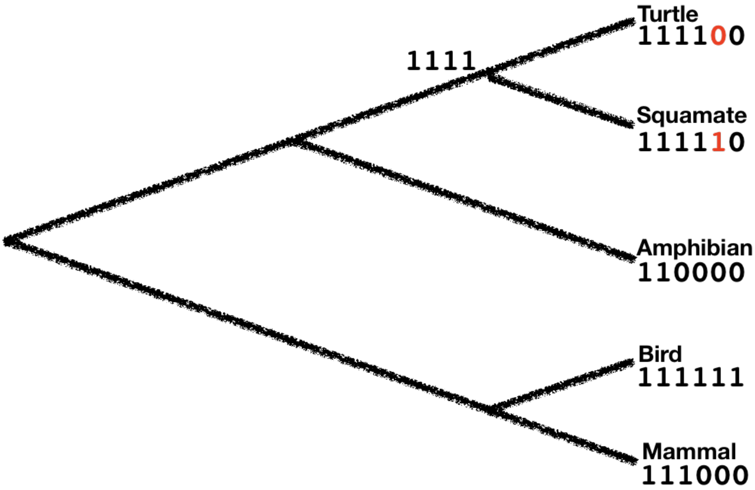

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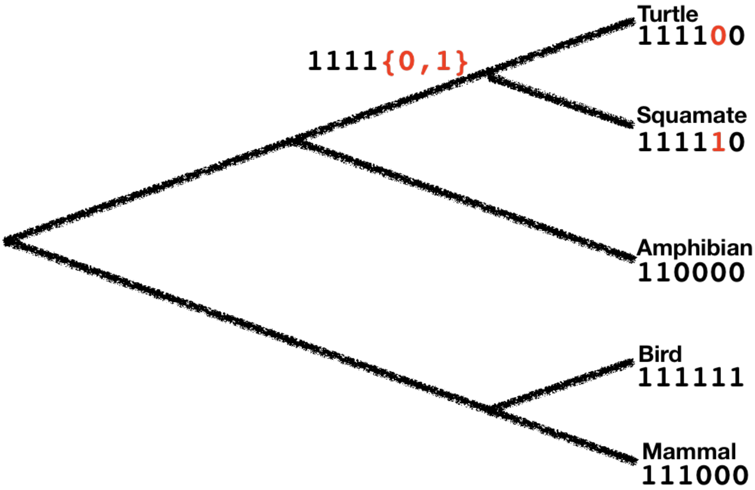

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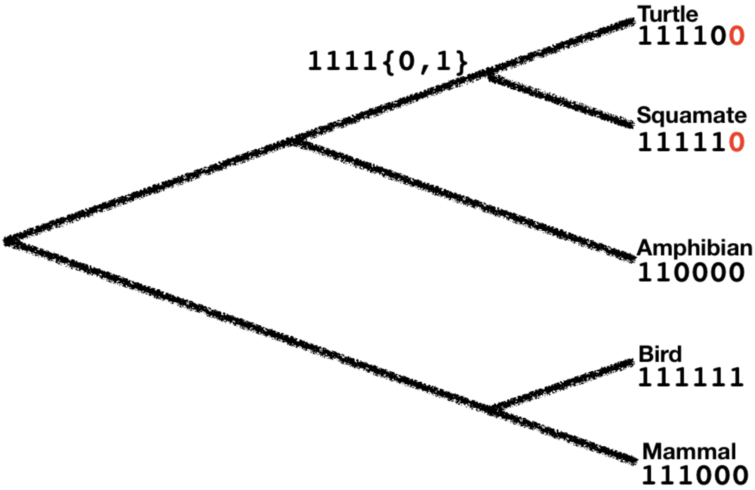

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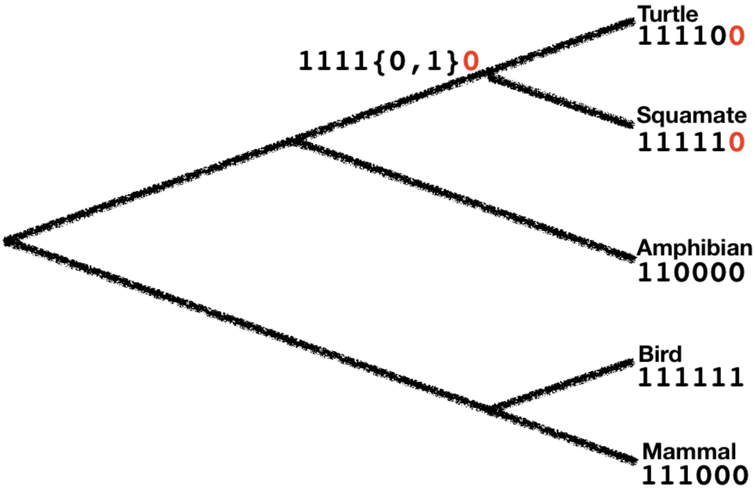

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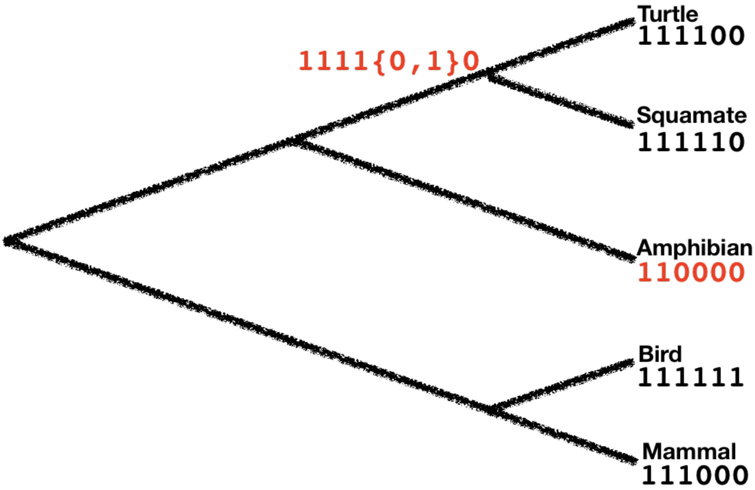

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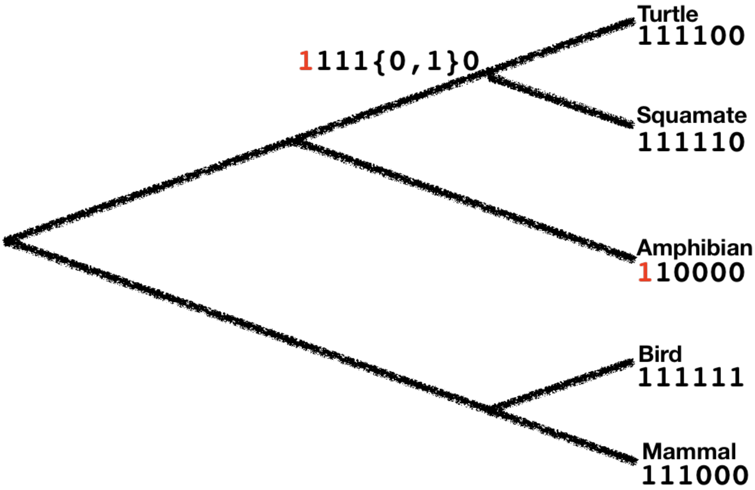

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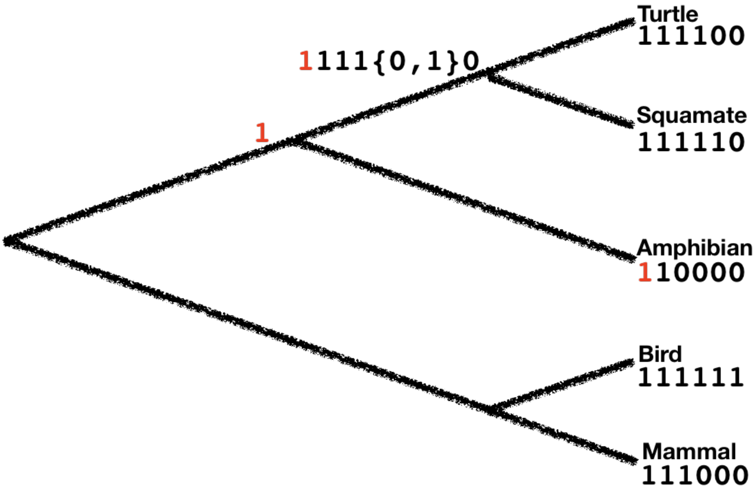

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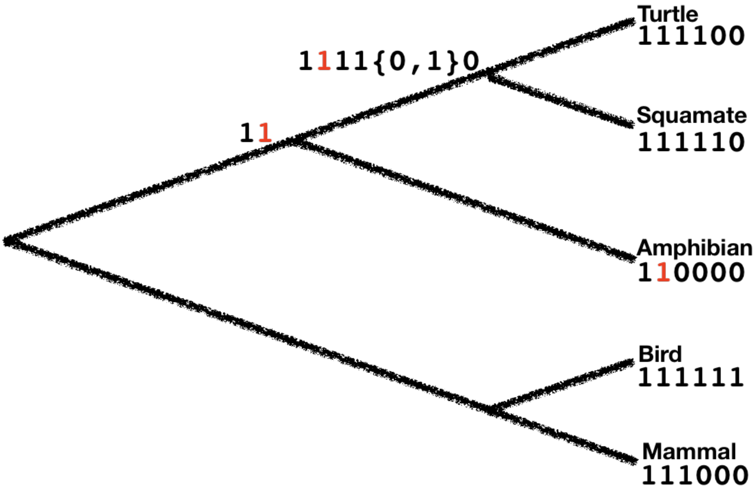

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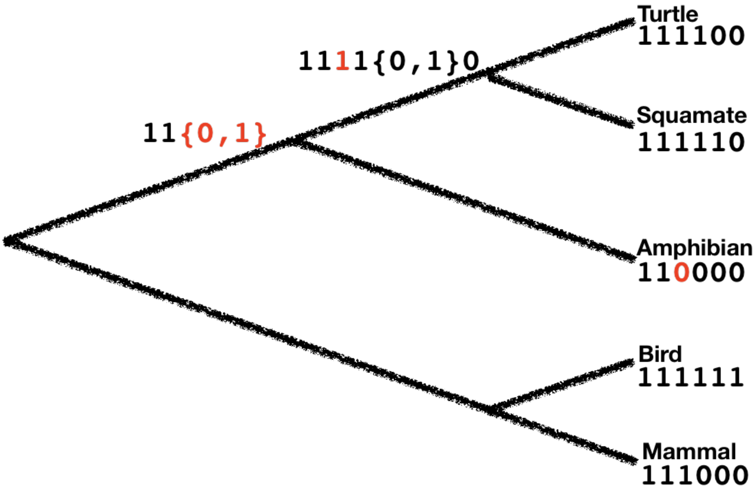

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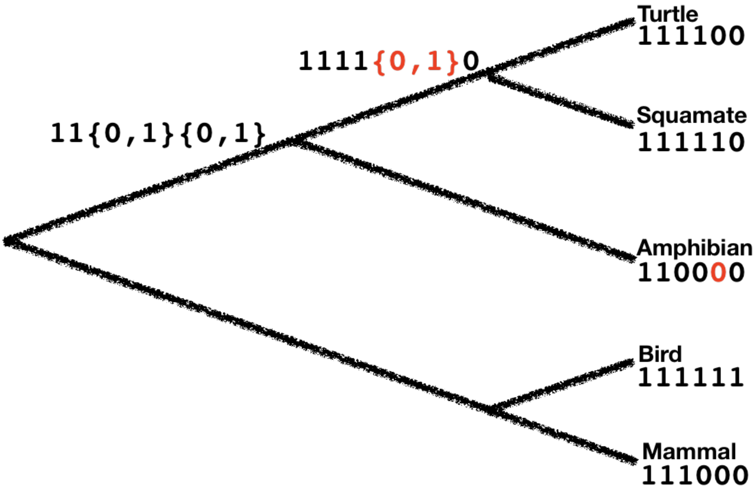

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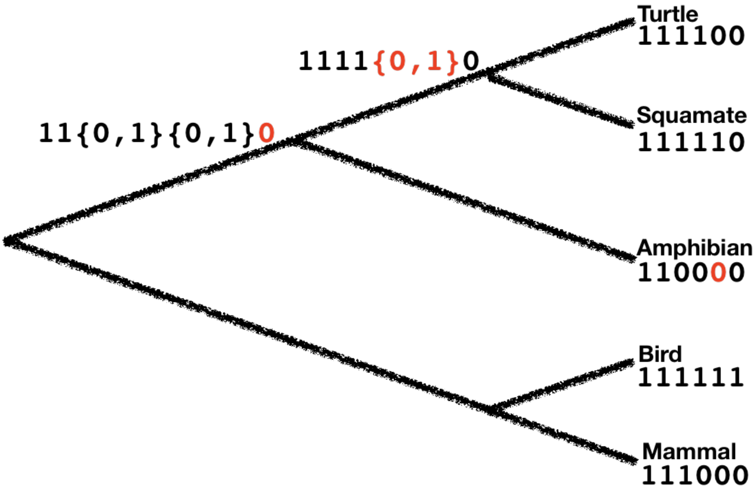

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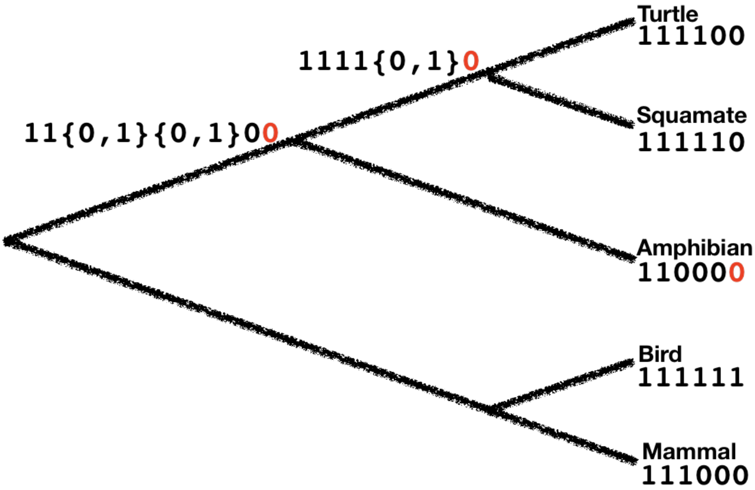

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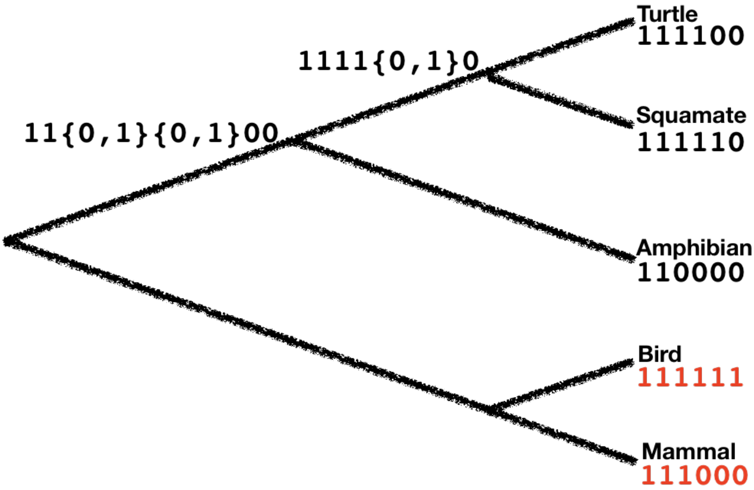

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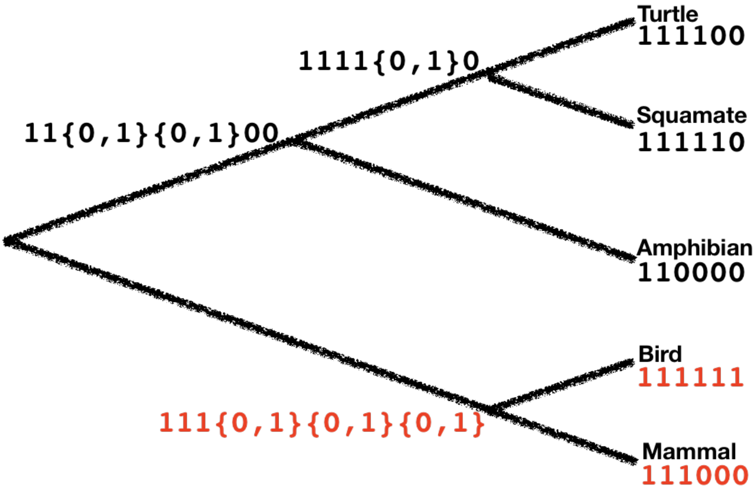

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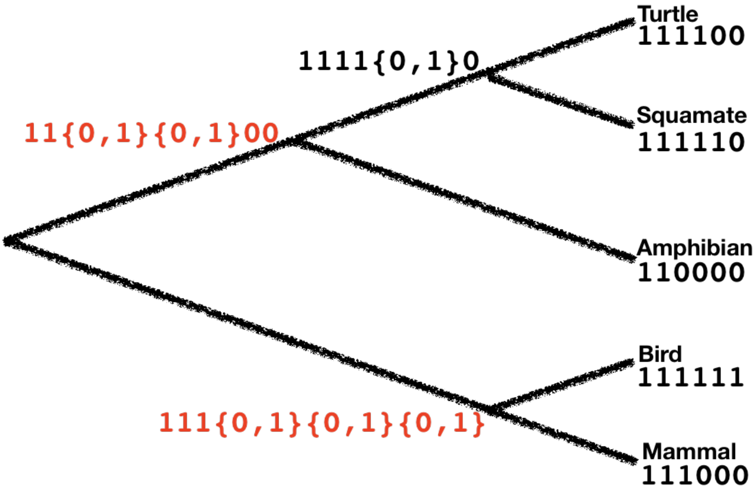

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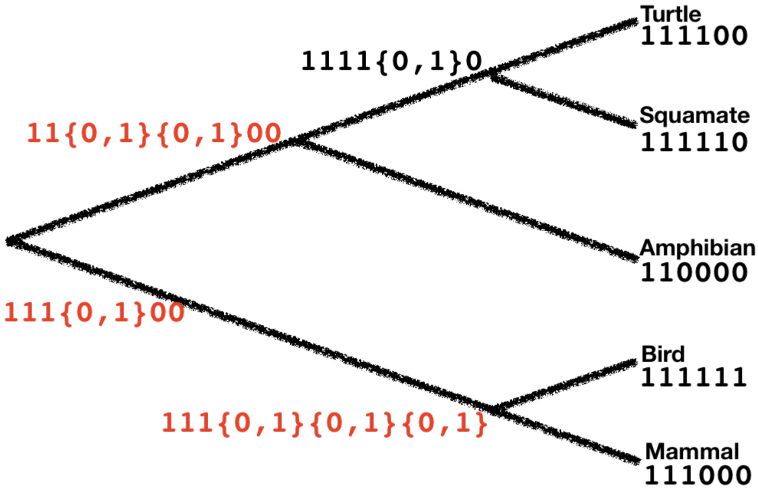

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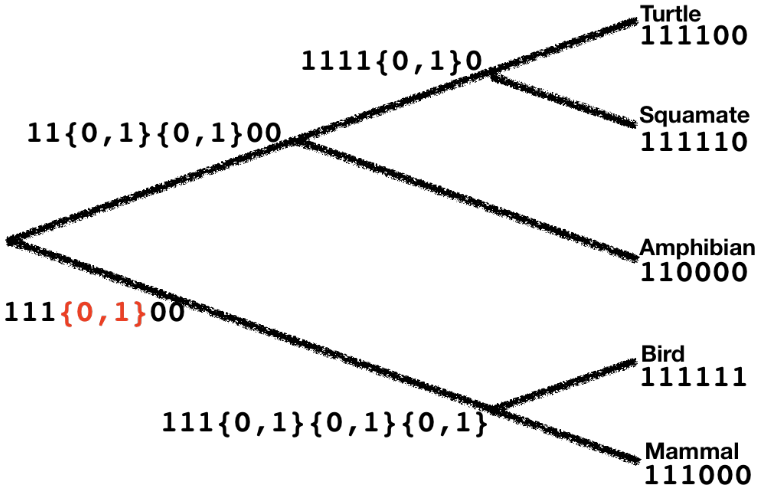

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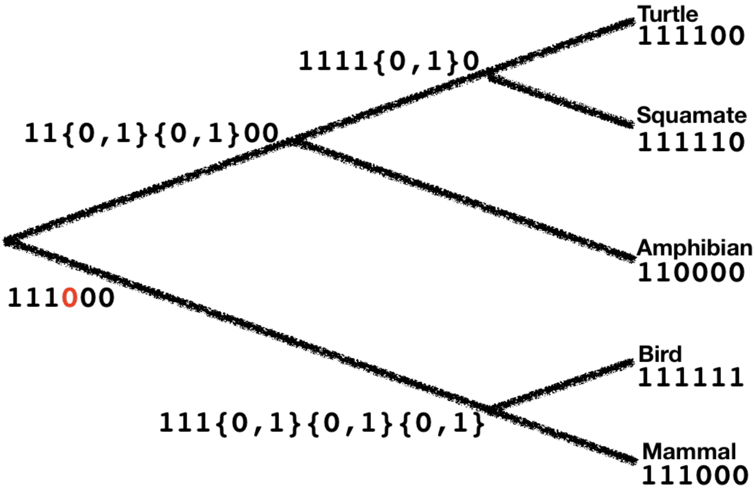

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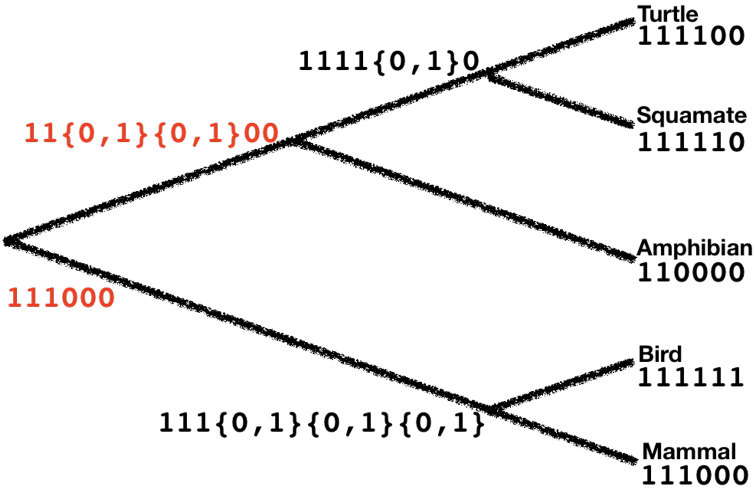

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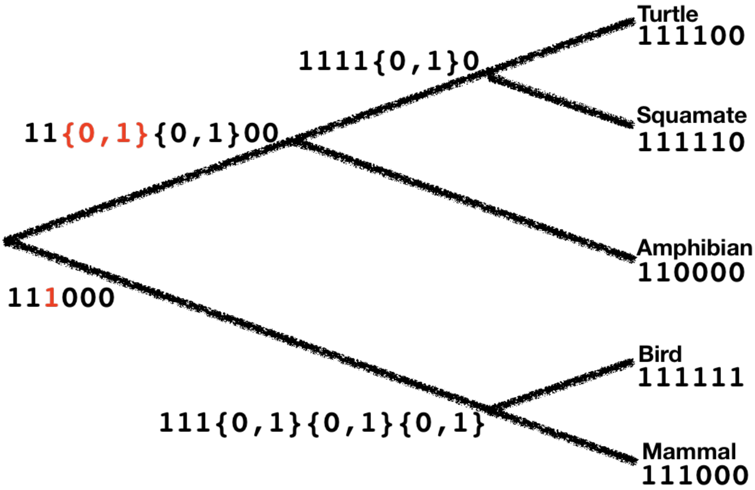

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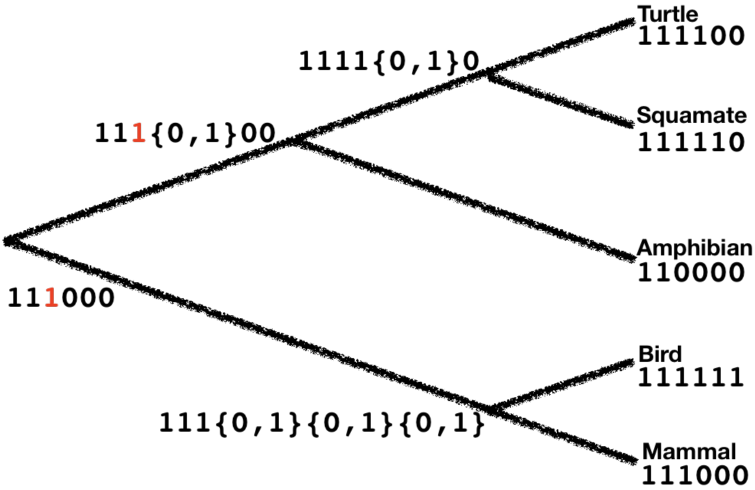

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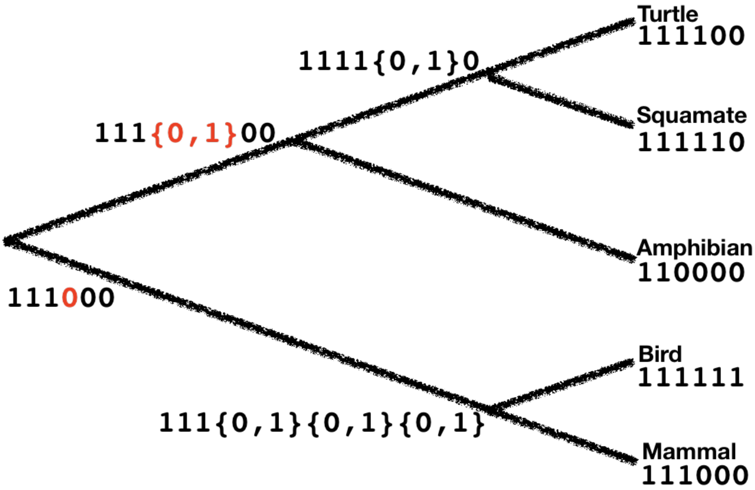

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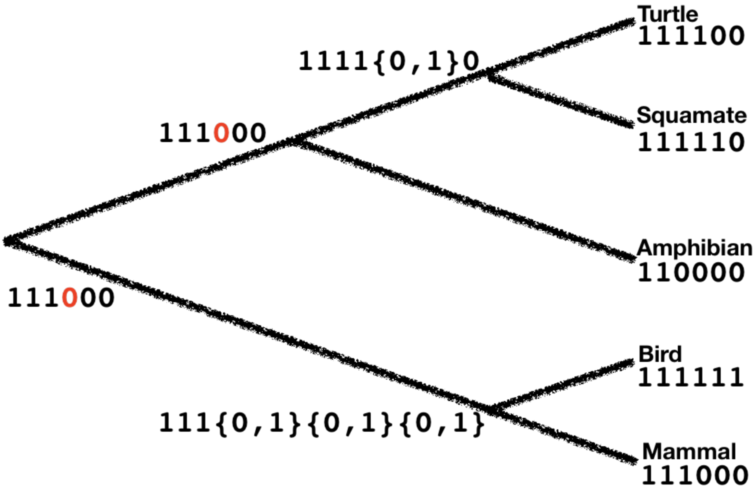

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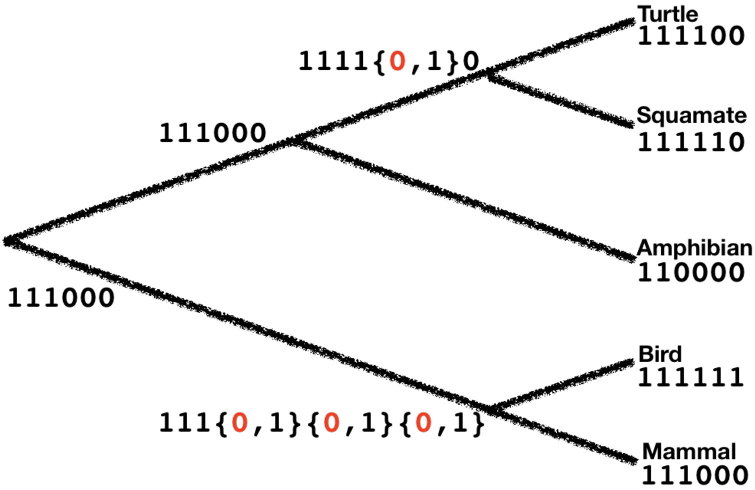

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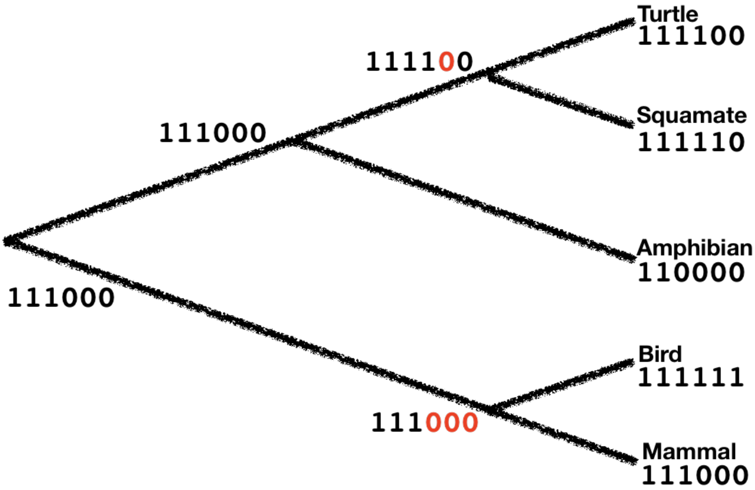

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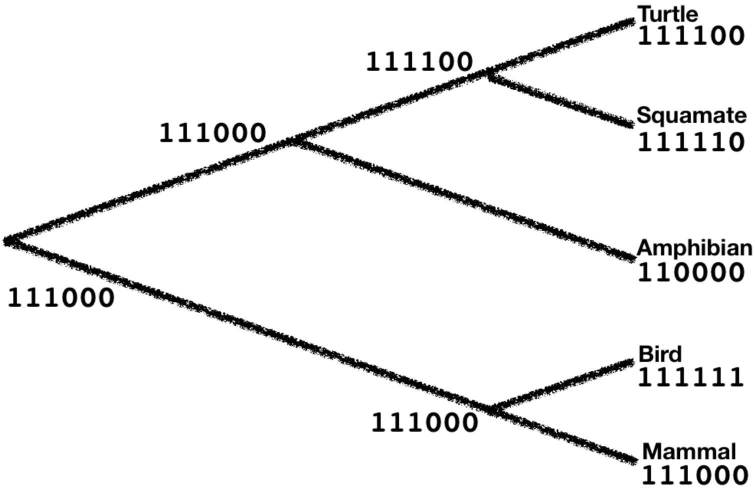

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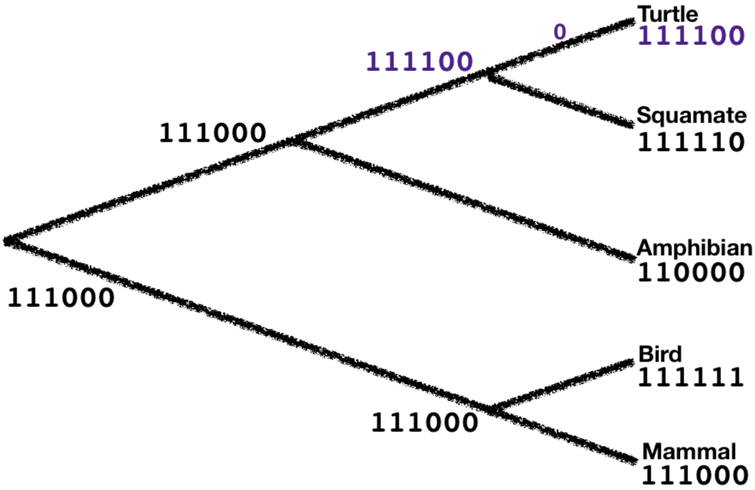

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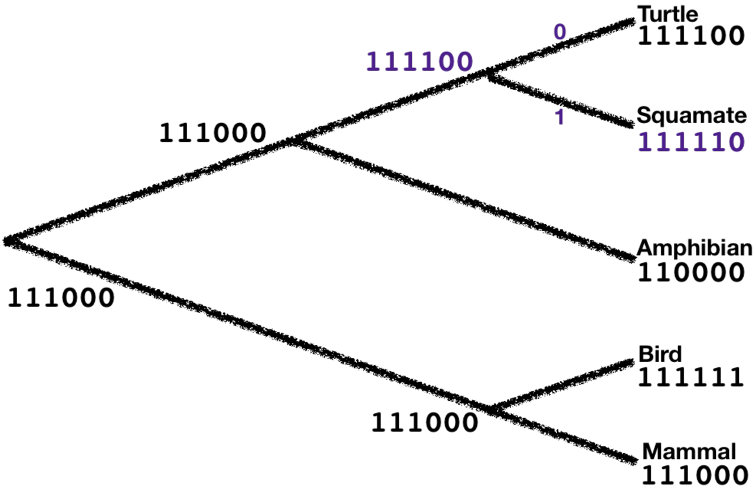

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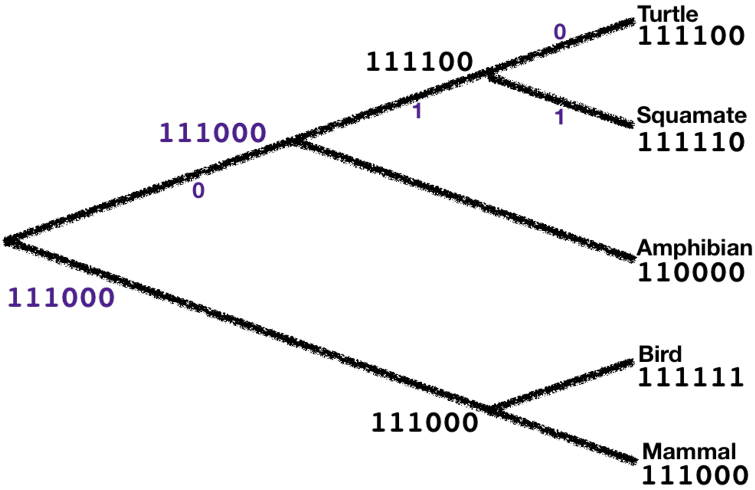

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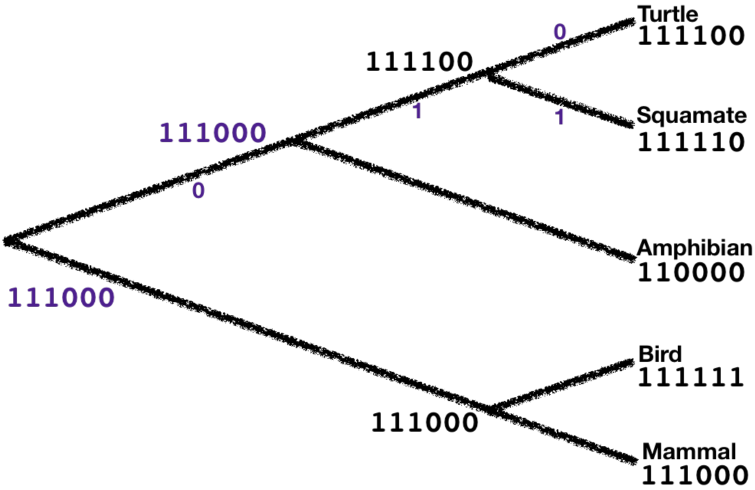

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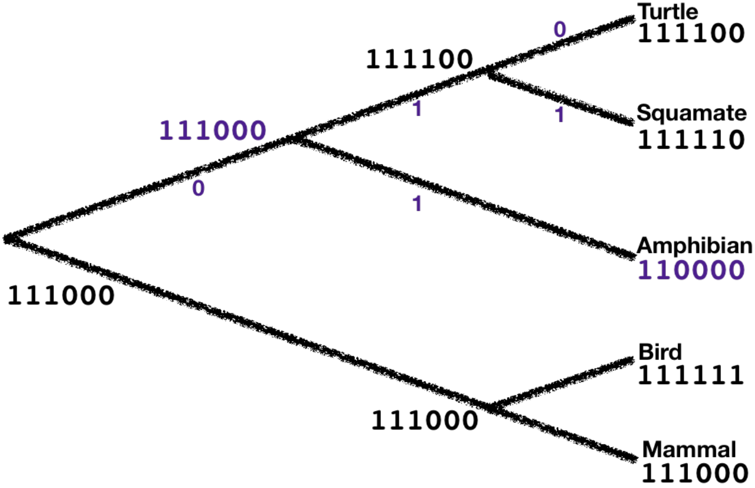

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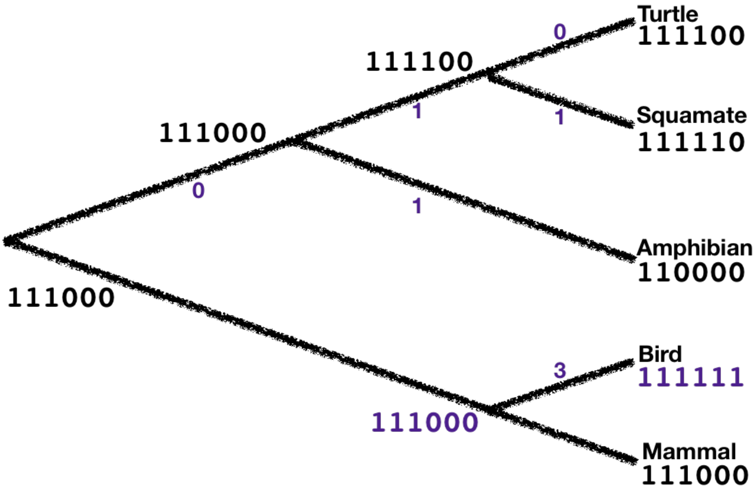

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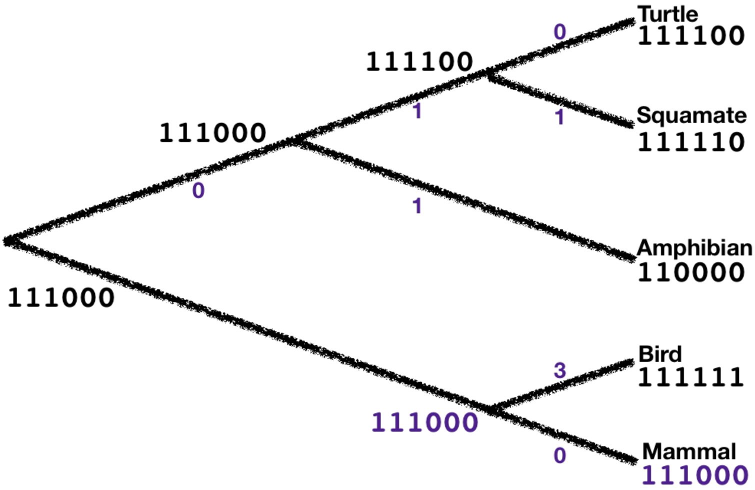

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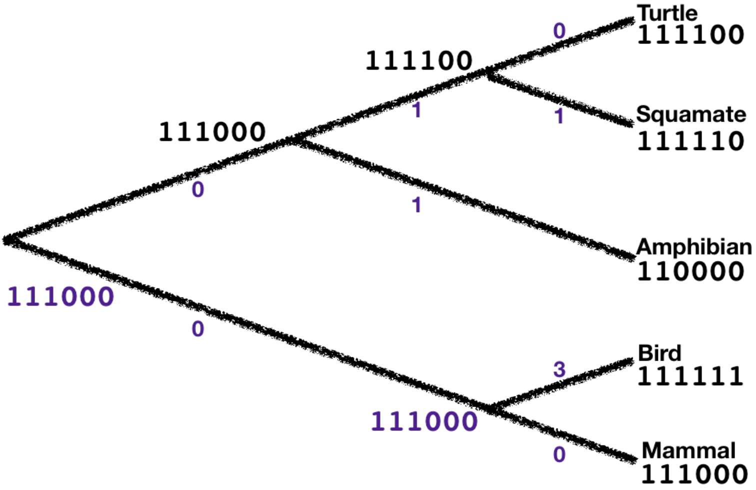
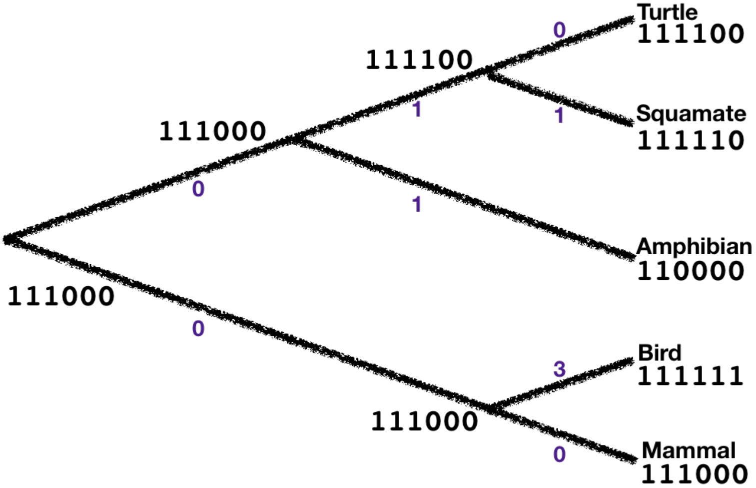
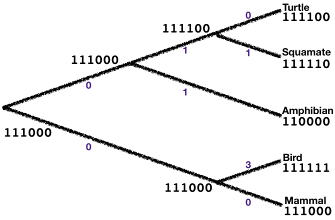


Maximum Parsimony

- Count the number of changes across each branch: 6 changes.



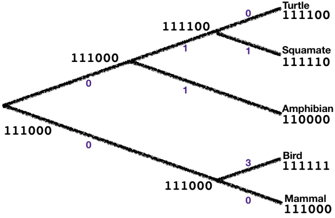
Your turn: score your tree



Species	Characters					
Amphibian	1	1	0	0	0	0
Bird	1	1	1	1	1	1
Mammal	1	1	1	0	0	0
Squamate	1	1	1	1	1	0
Turtle	1	1	1	1	0	0

1. Score the tree you drew.

Your turn: score your tree



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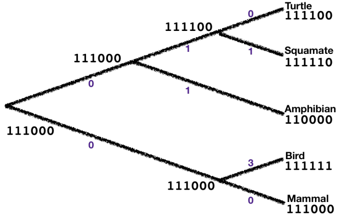
1. Score the tree you drew.
2. Is there a better scoring tree?

Your turn: score your tree



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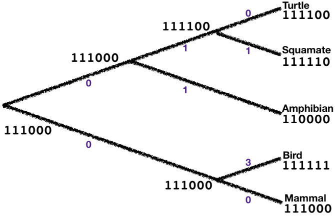
1. Score the tree you drew.
2. Is there a better scoring tree?
3. Why or why not?

Your turn: score your tree



Species	Characters					
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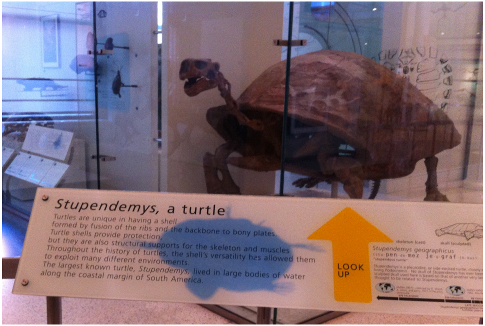
Squamate	1	1	1	1	1	0
Turtle	1	1	1	1	0	0

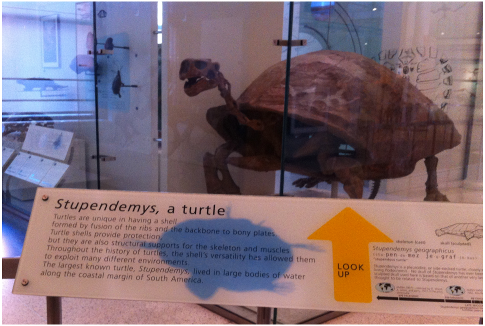
1. Score the tree you drew.
2. Is there a better scoring tree?
3. Why or why not?

Wrap-up



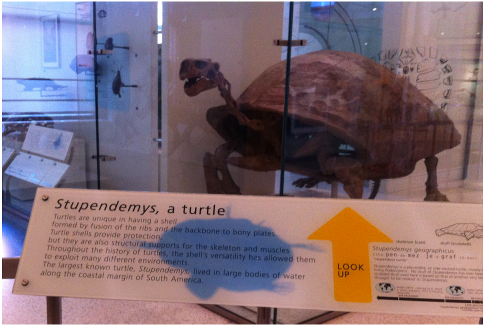
- For 6 taxa, there are 105 possible trees.

Wrap-up



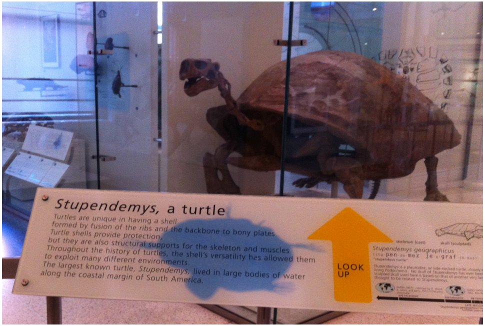
- For 6 taxa, there are 105 possible trees.
  General formula: for n taxa, $\#$ trees $= (2n-5)!!$
- Finding the best tree is computationally hard (NP-hard).

Wrap-up



- For 6 taxa, there are 105 possible trees.
  General formula: for n taxa, # trees $= (2n-5)!!$
- Finding the best tree is computationally hard (NP-hard).
- But, for small number of taxa, can exhaustively search.

Wrap-up



- For 6 taxa, there are 105 possible trees.
  General formula: for n taxa, $\#$ trees $= (2n-5)!!$
- Finding the best tree is computationally hard (NP-hard).
- But, for small number of taxa, can exhaustively search.
- With high schoolers, we did both:
  - by hand for morphological data, and
  - using bioPython and student-written code code to download genetic sequences, score trees, and choose the best.

Recap

- On lecture slip, write down a topic you wish we had spent more time (and why).

pandas
$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$

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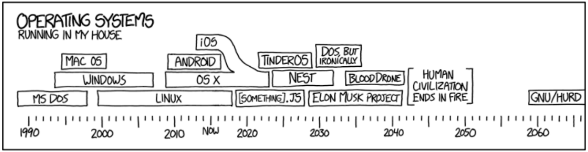
Practice Quiz & Final Questions



xkcd #1508

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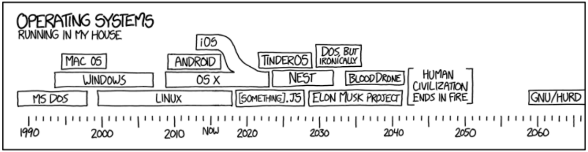

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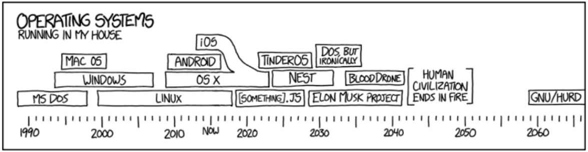

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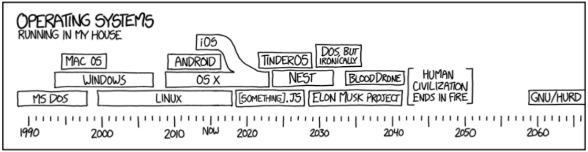

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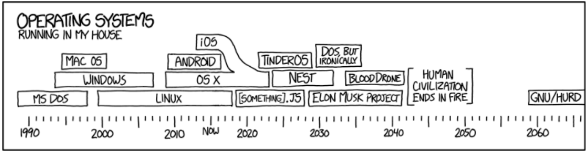

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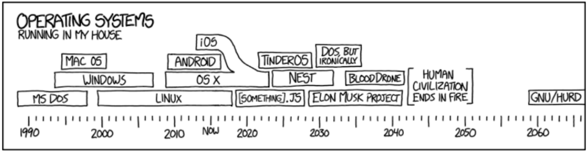

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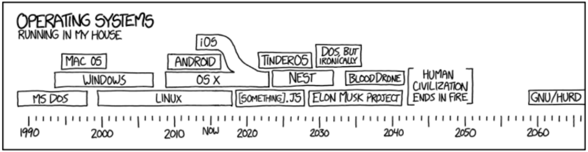

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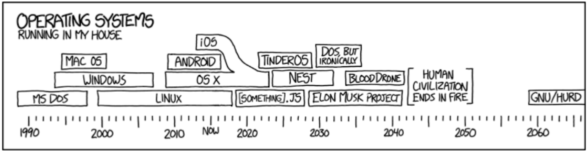

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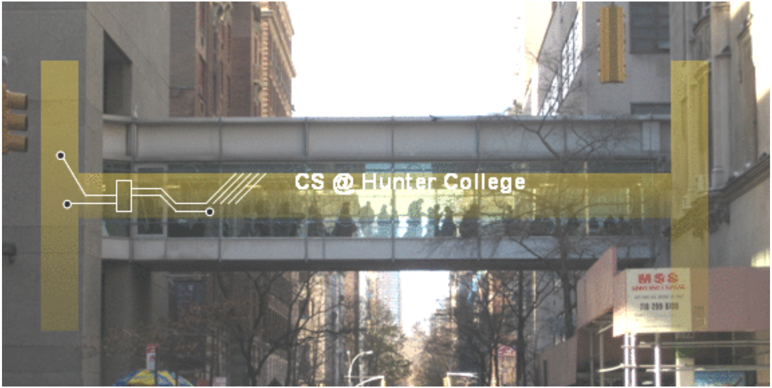
- Theme: Unix commands!

Writing Boards



- Return writing boards as you leave...