

CS 220 / CS319

Dictionary Nesting

Department of Computer Sciences
University of Wisconsin-Madison

Learning Objectives Today

More dictionary operations

- len, in, for loop
- d.keys(), d.values()
- defaults for get and pop

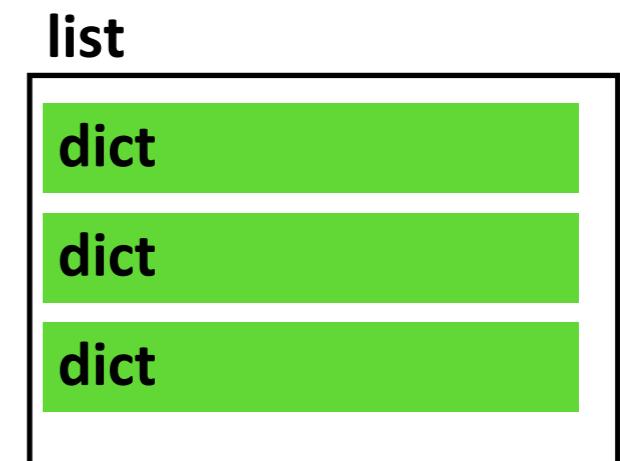
Syntax for nesting (dicts inside dicts, etc)

- indexing/lookup
- step-by-step resolution

Understand common use cases for nesting

- binning/bucketing (`list` in `dict`)
- a more convenient table representation (`dict` in `list`)
- transition probabilities with Markov chains (`dict` in `dict`)

one of the most common
data analysis tasks



we'll generate random
English-like texts

Today's Outline

Dictionary Ops

Binning (dict of list)

Table Representation (list of dict)

Probability Tables and Markov Chains (dict of dict) – self-interest
study; not required for quizzes and exams

Creation of Empty Dict - self-review

Non-empty dict:

```
d = {"a": "alpha", "b": "beta"}
```

Empty dict (way 1):

```
d = {}
```

Empty dict (way 2):

```
d = dict() # special function called constructor
```

similar for lists: L = []

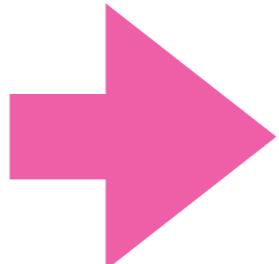
similar for lists: L = list() # special function called constructor

similar for sets: s = set() # special function called constructor

len, in, for - self-review

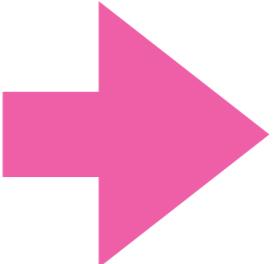
```
num_words = {0:"zero", 1:"one", 2:"two", 3:"three"}
```

```
print(len(num_words))
```



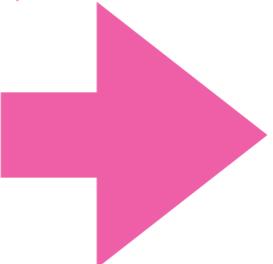
4

```
print(1 in num_words)
```



True

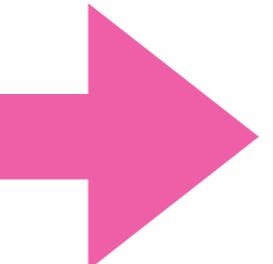
```
print("one" in num_words)
```



False

(it is only checking keys, not vals)

```
for x in num_words:  
    print(x, num_words[x])
```



0 zero

1 one

2 two

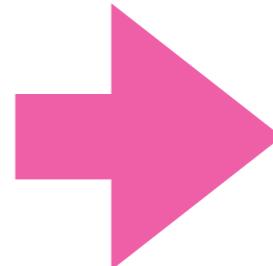
3 three

you can iterate over values
by combining a **for loop** with **lookup**

Extracting keys and values

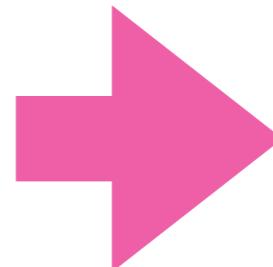
```
num_words = {0:"zero", 1:"one", 2:"two", 3:"three"}
```

```
print(type(num_words.keys()))
```



<class 'dict_keys'>

```
print(type(num_words.values()))
```



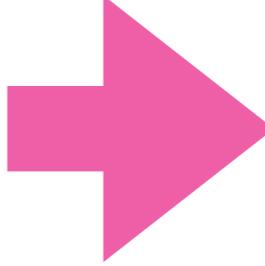
<class 'dict_values'>

don't worry about these
new types, because we
can force them to be lists

Extracting keys and values

```
num_words = {0:"zero", 1:"one", 2:"two", 3:"three"}
```

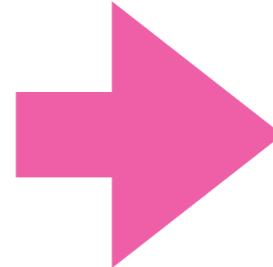
```
print(type(num_words.keys()))
```



```
<class 'dict_keys'>
```



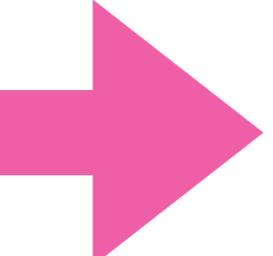
```
print(type(num_words.values()))
```



```
<class 'dict_values'>
```



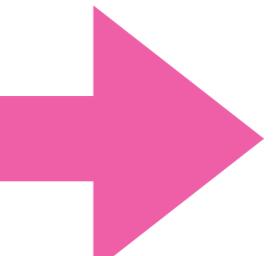
```
print(list(num_words.keys()))
```



```
[0, 1, 2, 3]
```



```
print(list(num_words.values()))
```



```
[ "zero", "one",  
  "two", "three"]
```

Defaults with get and pop

```
suffix = {1:"st", 2:"nd", 3:"rd"}
```

✗ `suffix.pop(0) # delete fails, because no key 0`

✗ `suffix[4] # lookup fails because no key 4`

Defaults with get and pop

```
suffix = {1:"st", 2:"nd", 3:"rd"}
```

specify a default if
key cannot be found

✓ `suffix.pop(0, "th") # returns "th" because no key 0`

✗ `suffix[4] # lookup fails because no key 4`

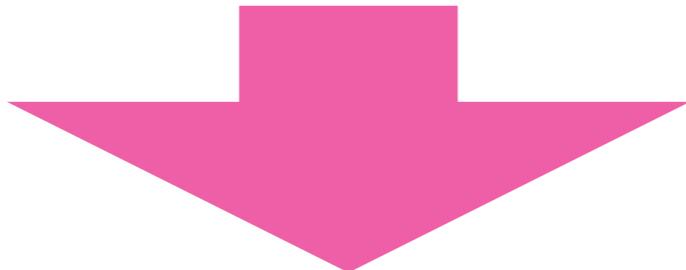
✓ `suffix.get(4, "th") # returns "th" because no key 4`

specify a default if
key cannot be found

Defaults with get and pop

```
suffix = {1:"st", 2:"nd", 3:"rd"}
```

```
for num in range(6):  
    print(str(num) + suffix.get(num, "th"))
```



0th
1st
2nd
3rd
4th
5th

Today's Outline

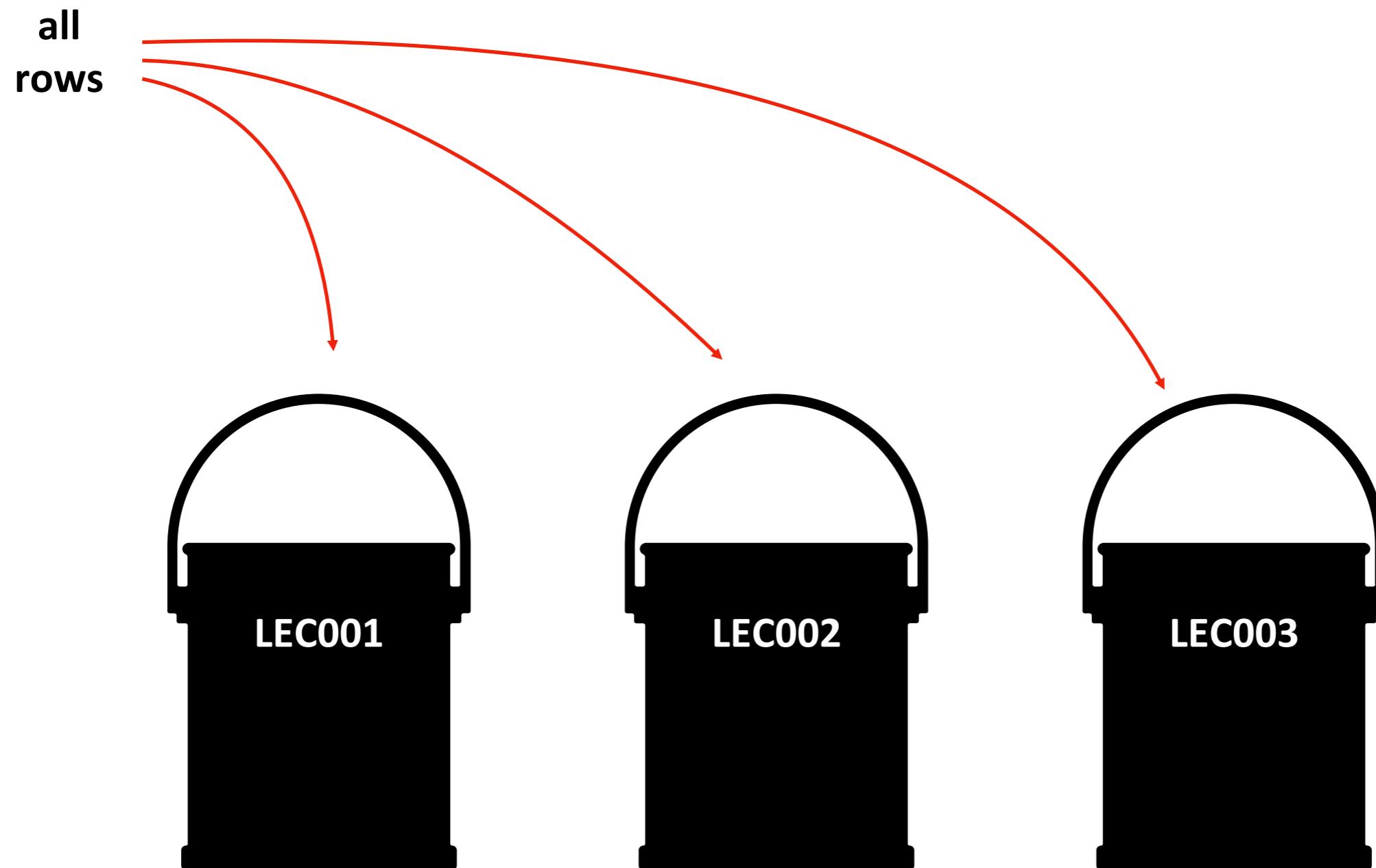
Dictionary Ops

Binning (dict of list)

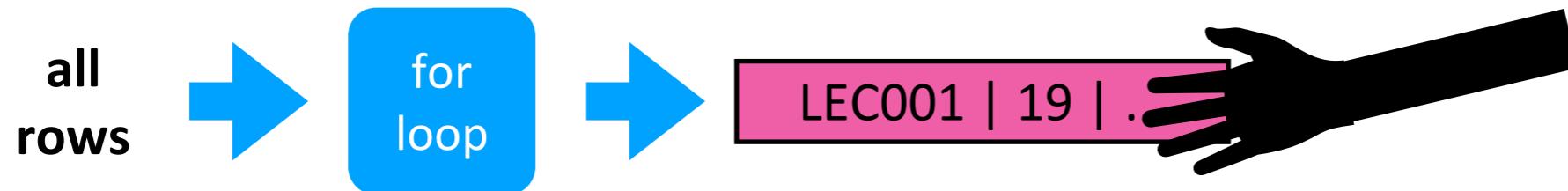
Table Representation (list of dict)

Probability Tables and Markov Chains (dict of dict) – self-interest
study; not required for quizzes and exams

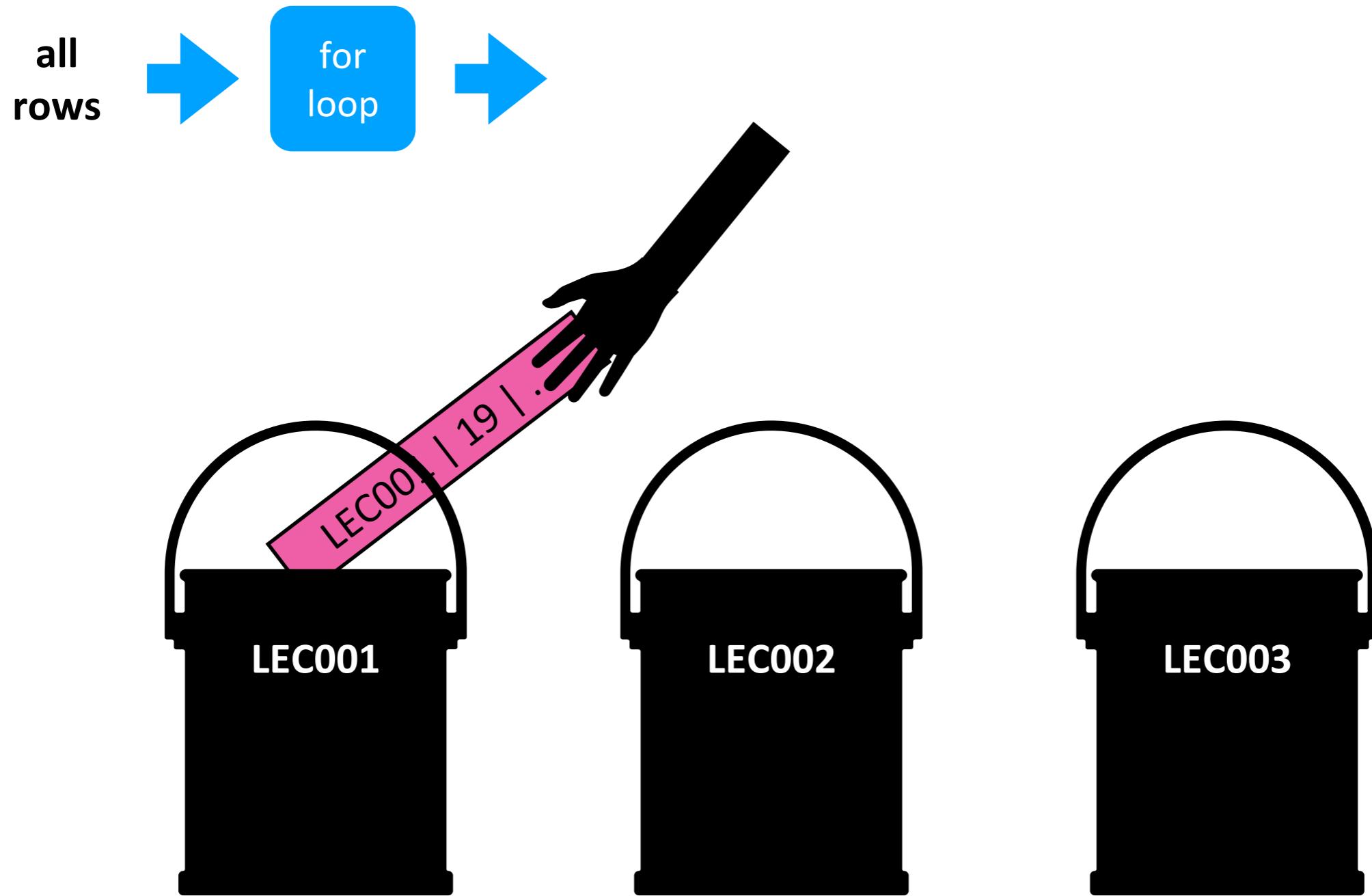
Bucketizing/Binning



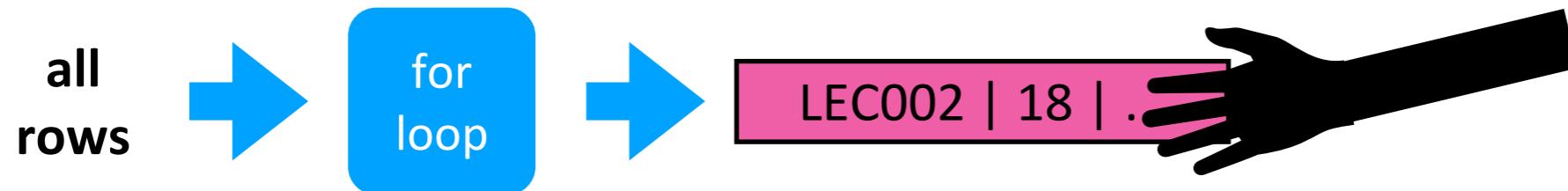
Bucketizing/Binning



Bucketizing/Binning



Bucketizing/Binning

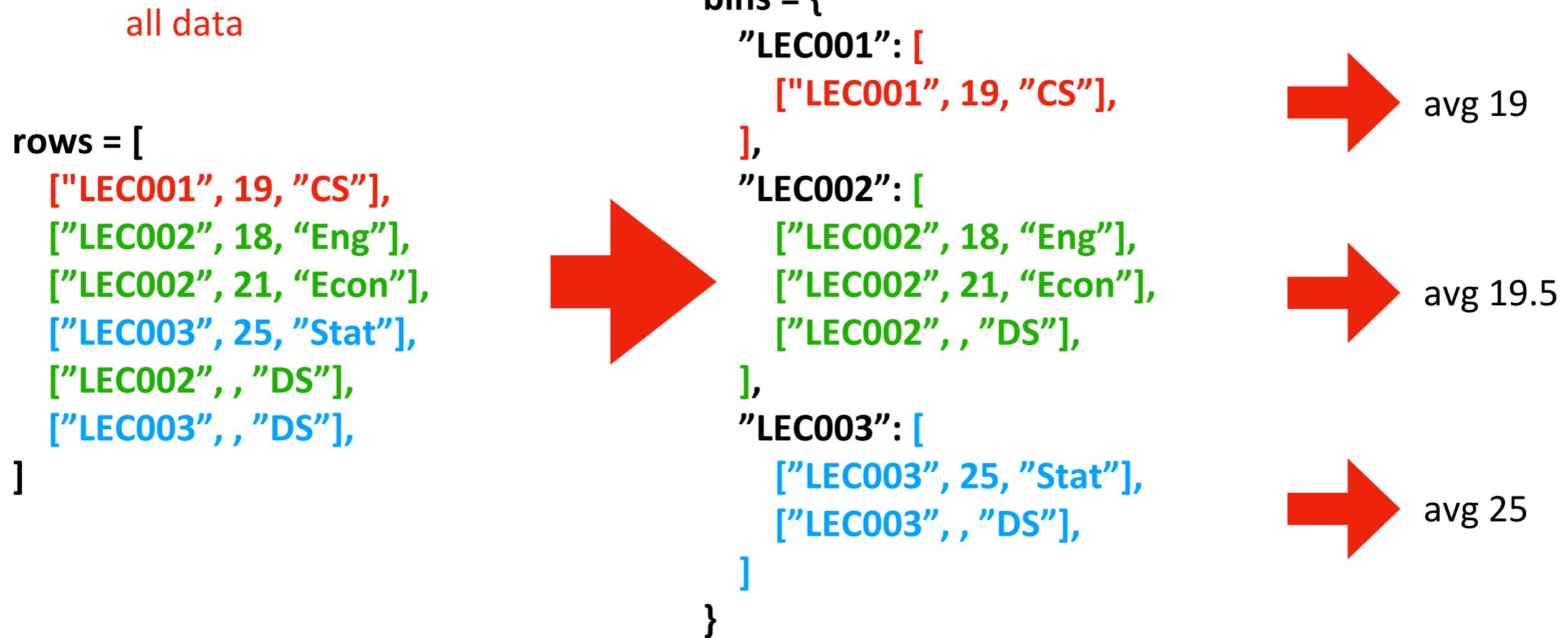


Bucketizing/Binning

all rows → for loop



Bins with lists and dicts



Demo 1: Average Age per Section

Goal: print **average age** of students in each section

Input:

- CS220 Information survey

Output:

- Average age within each section

Example:

SEC001: 19

SEC002: 19.5

SEC003: 25

Today's Outline

Dictionary Ops

Binning (dict of list)

Table Representation (list of dict)

Probability Tables and Markov Chains (dict of dict)

Table Representation

name	x	y
Alice	30	20
Bob	5	11
Cindy	-2	50

list of list representation

```
header = ["name", "x", "y"]
rows = [
    ["Alice", 30, 20],
    ["Bob", 5, 11],
2 → ["Cindy", -2, 50],
]
↑
2
```

rows[2][header.index("y")]

list of dict representation

```
[{"name": "Alice", "x": 30, "y": 20},
 {"name": "Bob", "x": 5, "y": 11},
2 → {"name": "Cindy", "x": -2, "y": 50},
```

↑
"y"

rows[2]["y"]

Demo 2: Table Transform

Goal: create function that transforms list of lists table
to a list of dicts table

Input:

- List of lists (from a CSV)

Output:

- List of dicts

Example:

```
>>> header = ["x","y"]
>>> rows = [[1,2], [3,4]]
>>> transform(header, rows)
[{"x":1, "y":2}, {"x":3, "y":4}]
```

Today's Outline

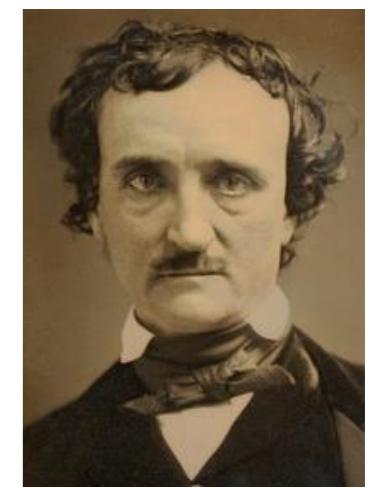
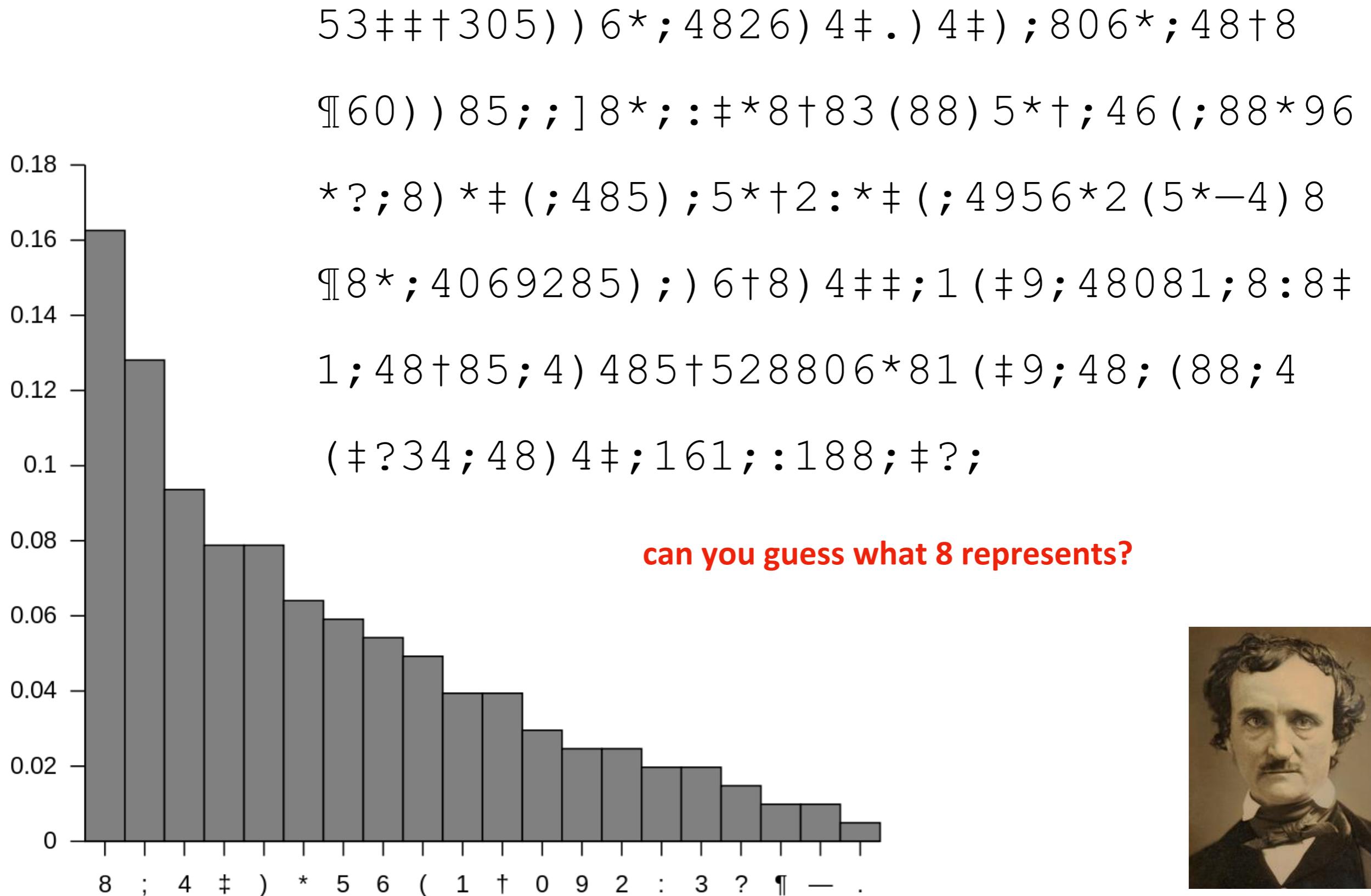
Dictionary Ops

Binning (dict of list)

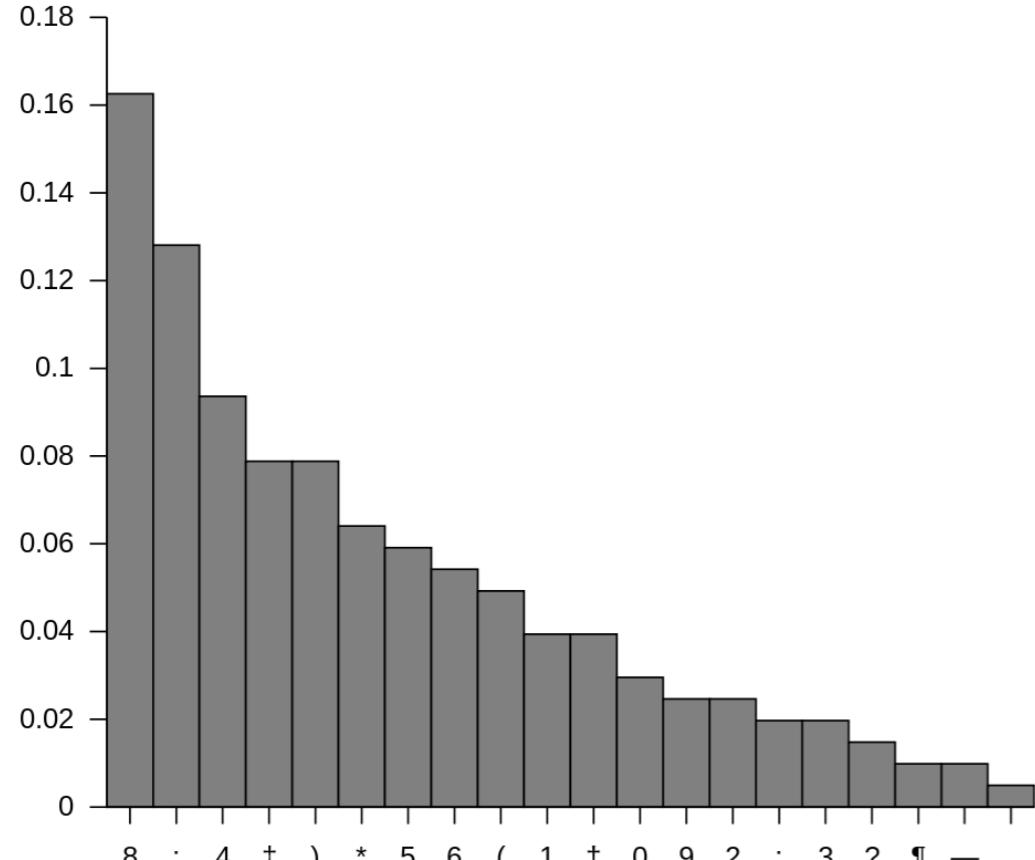
Table Representation (list of dict)

Probability Tables and Markov Chains (dict of dict) – self-interest study; not required for quizzes and exams

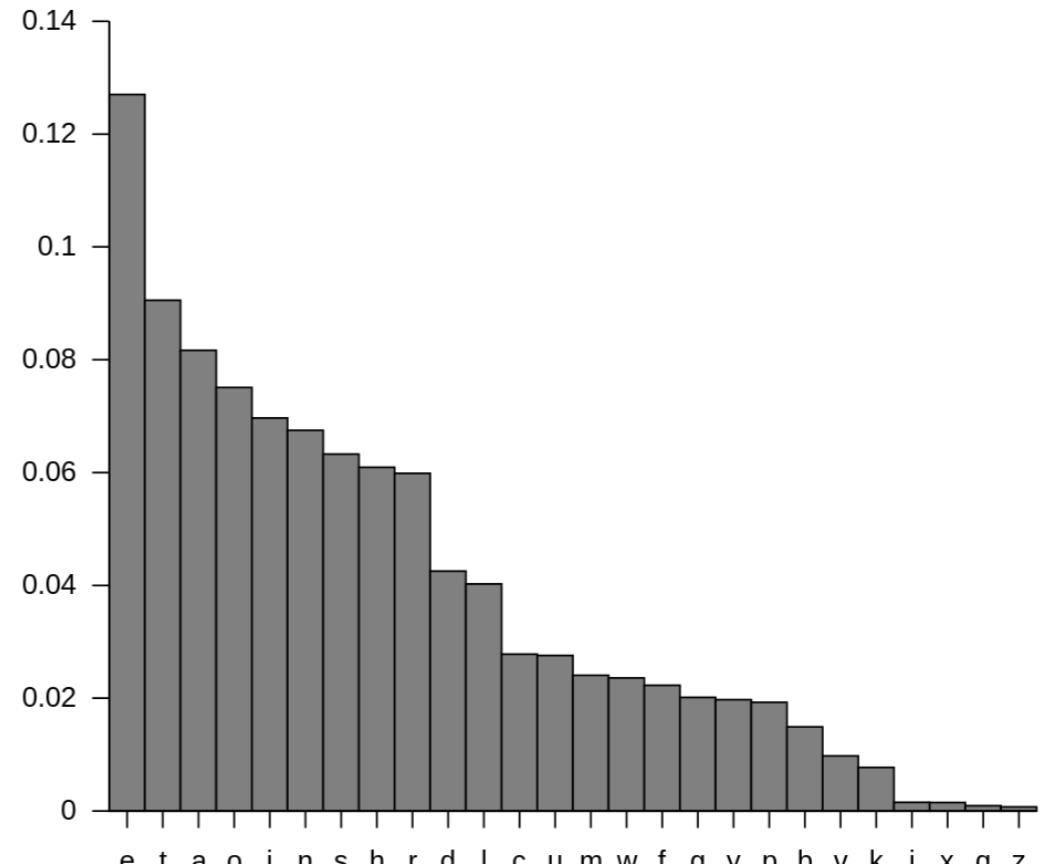
Challenge: Letter Frequency



Challenge: Letter Frequency

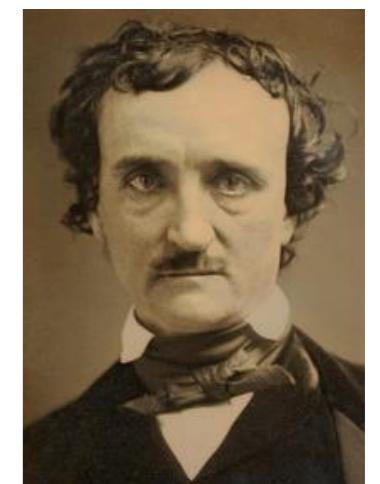


letters



symbols

how to compute these?



Challenge: Letter Frequency

Goal: if we randomly pick a word in a text, what is the probability that it will be a given letter?

Input:

- Plaintext of book (from Project Gutenberg)

Output:

- The portion of letters in the text that are that letter

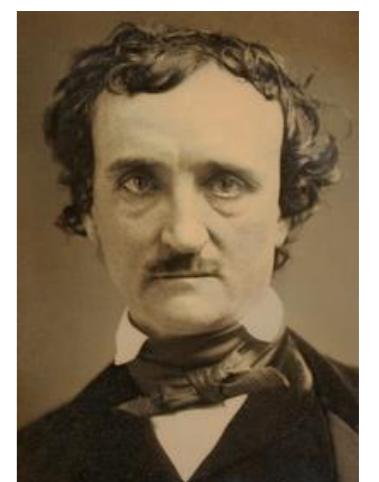
Example:

text: AAAAABBCCC

A: 50%

B: 20%

C: 30%



Sequence Data

Consider this sequence: “the **qu**ick tiger is **qu**iet”

What letter likely comes after “t” in this text?

Next Letter	Probability
h	50%
i	50%
a	0%
...	0%

dict for “t”:

```
{ "h": 0.5, "i": 0.5 }
```

What letter likely comes after “q” in this text?

Next Letter	Probability
u	100%
...	0%

dict for “q”:

```
{ "u": 1.0 }
```

Sequence Data

Organize all the dicts with a dict:

```
probs = {  
    "u": {"i": 1.0},  
}  
}
```

Imagine a next-letter probability dictionary for every letter

dict for "u":

```
{"i": 1.0}
```

dict for "t":

```
{"h": 0.5, "i": 0.5}
```

dict for "i":

```
{"c": 0.25, "g": 0.25,  
"s": 0.25, "e": 0.25}
```

dict for "q":

```
{"u": 1.0}
```

...

Sequence Data

Organize all the dicts with a dict:

```
probs = {  
    "u": {"i": 1.0},  
    "t": {"h": 0.5, "i": 0.5}  
    "i": {"c": 0.25, "g": 0.25,  
          "s": 0.25, "e": 0.25},  
    "q": {"u": 1.0},  
    ...  
}
```

probs["i"]

Imagine a next-letter probability dictionary for every letter

dict for "u":

```
{ "i": 1.0 }
```

dict for "t":

```
{ "h": 0.5, "i": 0.5 }
```

dict for "i":

```
{ "c": 0.25, "g": 0.25,  
  "s": 0.25, "e": 0.25 }
```

dict for "q":

```
{ "u": 1.0 }
```

...

Sequence Data

Organize all the dicts with a dict:

```
probs = {  
    "u": {"i": 1.0},  
    "t": {"h": 0.5, "i": 0.5}  
    "i": {"c": 0.25, "g": 0.25,  
          "s": 0.25, "e": 0.25},  
    "q": {"u": 1.0},  
    ...  
}
```

probs["i"]["e"] → 0.25

There is a 25% probability that
the letter following an “i” is an “e”

Imagine a next-letter probability
dictionary for every letter

dict for “u”:

```
{ "i": 1.0 }
```

dict for “t”:

```
{ "h": 0.5, "i": 0.5 }
```

dict for “i”:

```
{ "c": 0.25, "g": 0.25,  
  "s": 0.25, "e": 0.25 }
```

dict for “q”:

```
{ "u": 1.0 }
```

...

Vocabulary

```
probs = {  
    "u": {"i": 1.0},  
    "t": {"h": 0.5, "i": 0.5}  
    "i": {"c": 0.25, "g": 0.25,  
          "s": 0.25, "e": 0.25},  
    "q": {"u": 1.0},  
    ...  
}
```

The collection of transition probabilities like this is sometimes called a “stochastic matrix”

Processes that make probabilistic transitions like this (e.g., from one letter to the next) are called “Markov chains”

Random Text Generation

which looks
closest to
English?

1

XFOML RXKHRJFFJUJ
ZLPWCFWKCYJ FFJEYVKCQSGHYD
QPAAMKBZAACIBZLHJQD.

2

OCRO HLI RGWR NMIELWIS EU LL
NBNSEBYA TH EEI ALHENHTTPA
OOBTTVA NAH BRL.

3

ON IE ANTSOUTINYS ARE T
INCTORE ST BE S DEAMY ACHIN D
ILONASIVE TUOOWE AT
TEASONARE FUSO TIZIN ANDY
TOBE SEACE CTISBE.

Random Text Generation

all letters equally likely

XFOML RXKHRJFFJUJ
ZLPWCFWKCYJ FFJEYVKCQSGHYD
QPAAMKBZAACIBZLHJQD.

weighted random, based
on frequency in a text
(implement with dict)

OCRO HLI RGWR NMIELWIS EU LL
NBNSEBYA TH EEI ALHENHTTPA
OOBTTVA NAH BRL.

probability of each letter
based on previous letter
(implement with dict of dicts)

ON IE ANTSOUTINYS ARE T
INCTORE ST BE S DEAMY ACHIN D
ILONASIVE TU COOWE AT
TEASONARE FUSO TIZIN ANDY
TOBE SEACE CTISBE.

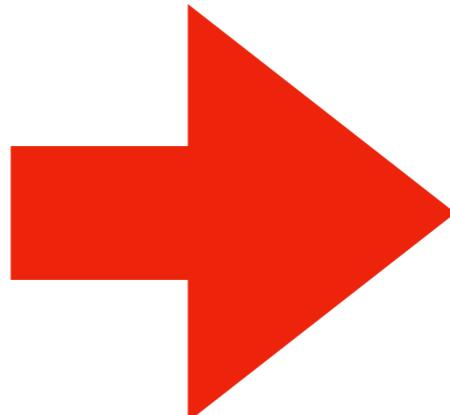
Hypothetical Use Case

DNA sequences

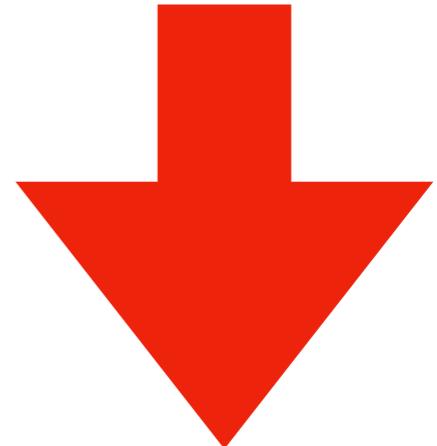
GATACAGATA~~CAGATA~~CA

GCTATAGCTATAGCGCGC

AAAATTTAAAATTTAAAAA



stochastic model



BIOINFORMATICS APPLICATIONS NOTE

Vol. 22 no. 12 2006, pages 1534–1535
doi:10.1093/bioinformatics/btl113

Sequence analysis

GenRGenS: software for generating random genomic sequences and structures

Yann Ponty¹, Michel Termier² and Alain Denise^{1,*}

¹LRI, UMR CNRS 8623, Université Paris-Sud 11, F91405 Orsay cedex, France and ²IGM, UMR CNRS 8621, Université Paris-Sud 11, F91405 Orsay cedex, France

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Associate Editor: Martin Bishop

CATCATC?TC?TCATC?TCAT
CATCATCATCATCATCATCAT

**synthetic sequences,
filling in gaps**

Challenge: Conditional Letter Frequency

Goal: if we look at given letter, what is the next letter likely to be?

Input:

- Plaintext of book (from Project Gutenberg)

Output:

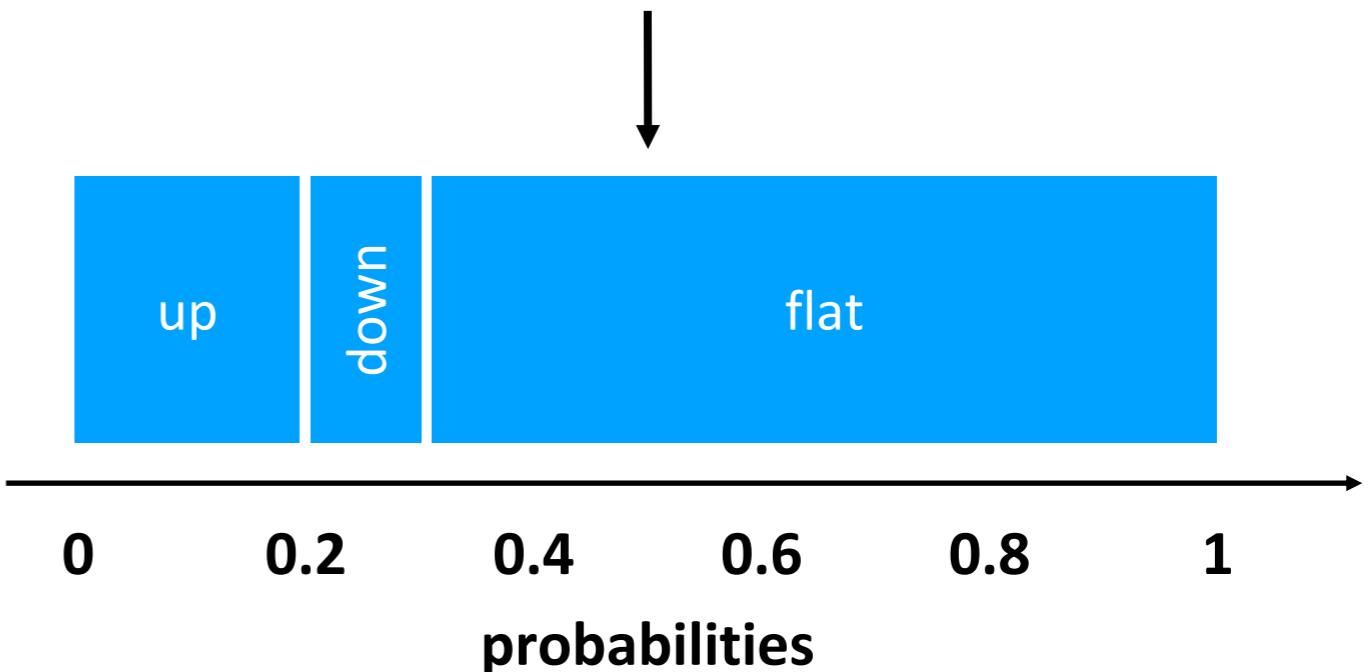
- Transition probabilities
- Randomly generated text, based on probabilities

Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.5
```

flat “wins”

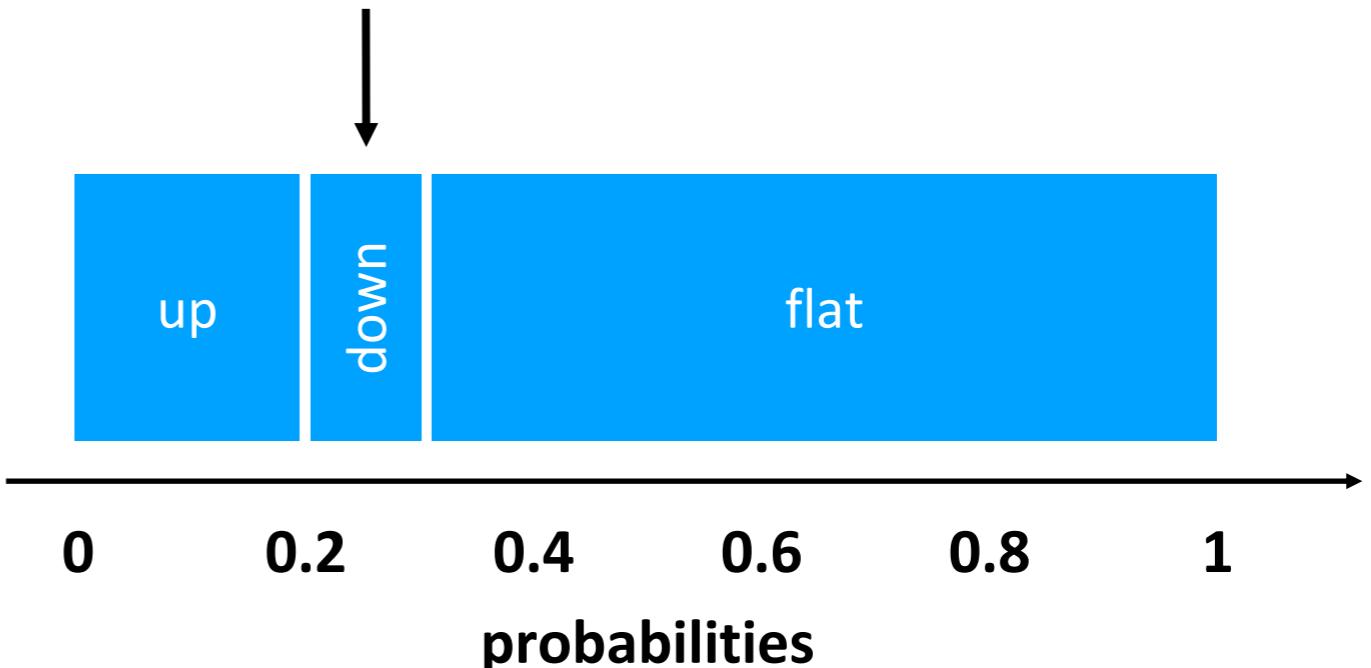


Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

down “wins”

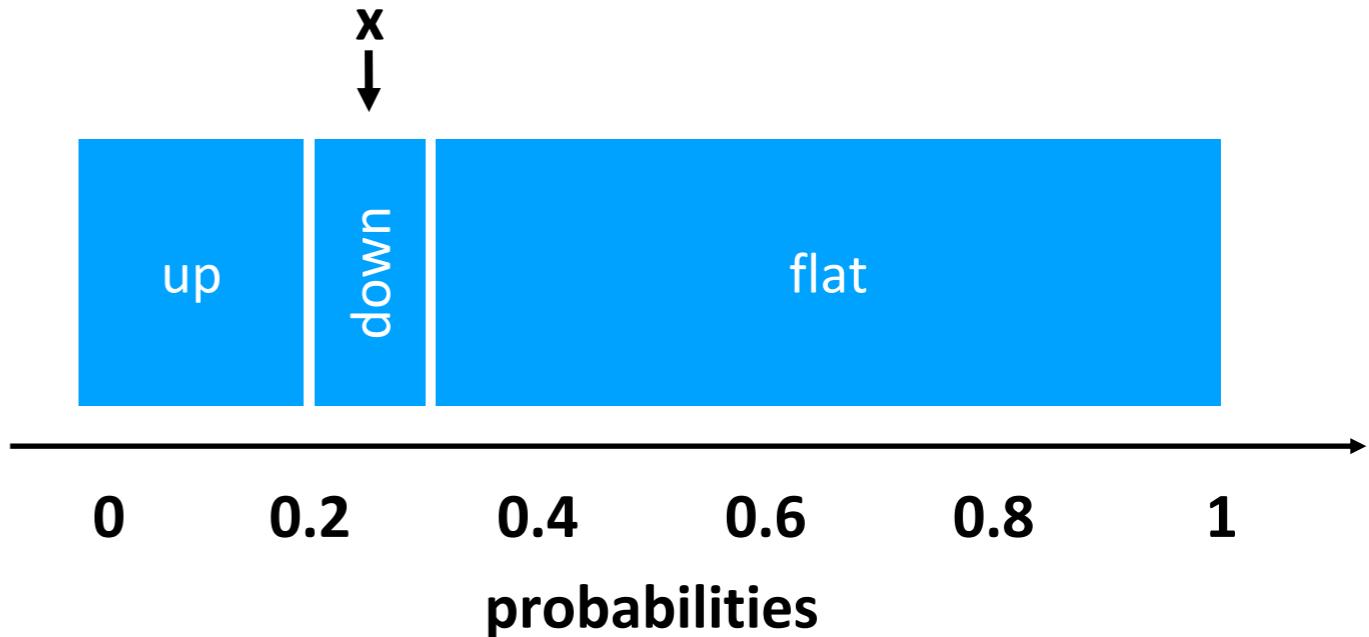


Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
for key in keys:  
    end += transitions[key]  
    if end >= x:  
        winner = key  
        break
```

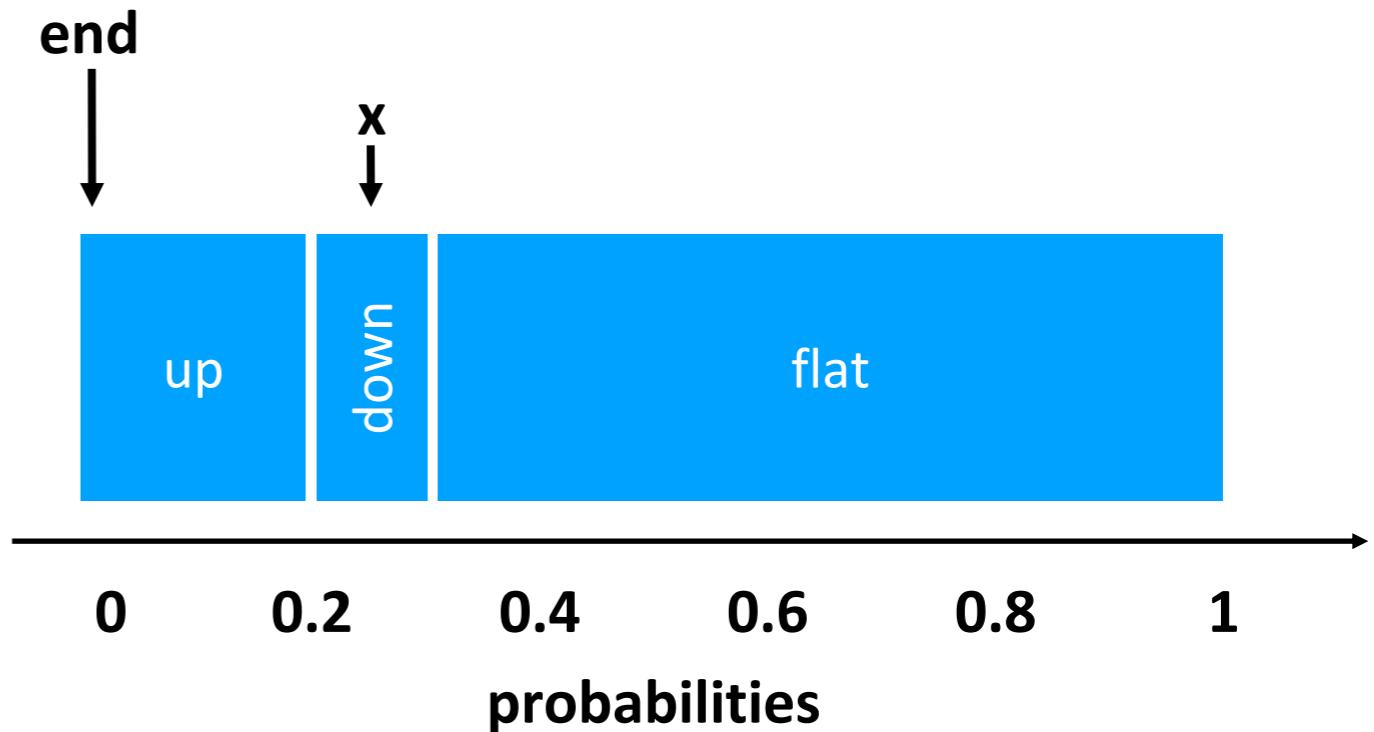


Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
for key in keys:  
    → end += transitions[key]  
    if end >= x:  
        winner = key  
        break
```



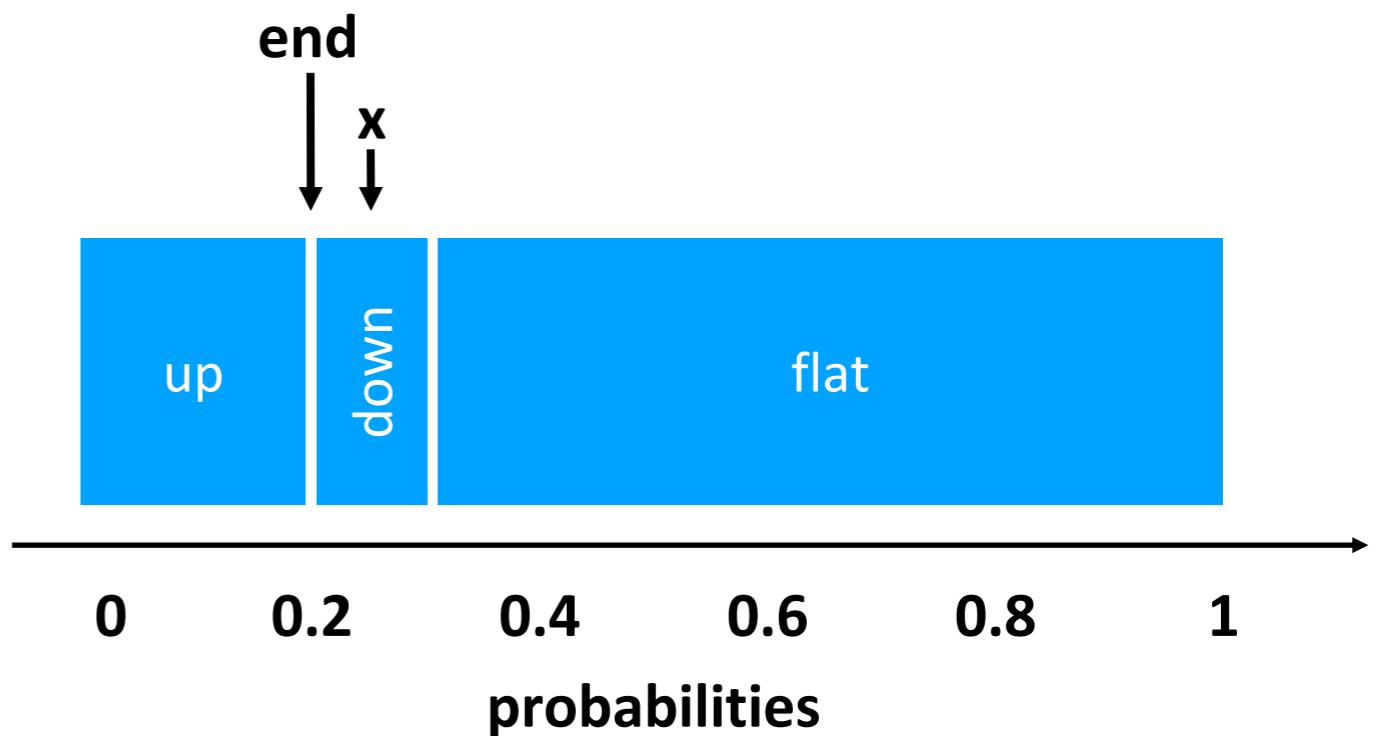
key up
end 0

Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
for key in keys:  
    end += transitions[key]  
    if end >= x:  
        winner = key  
        break
```

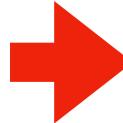


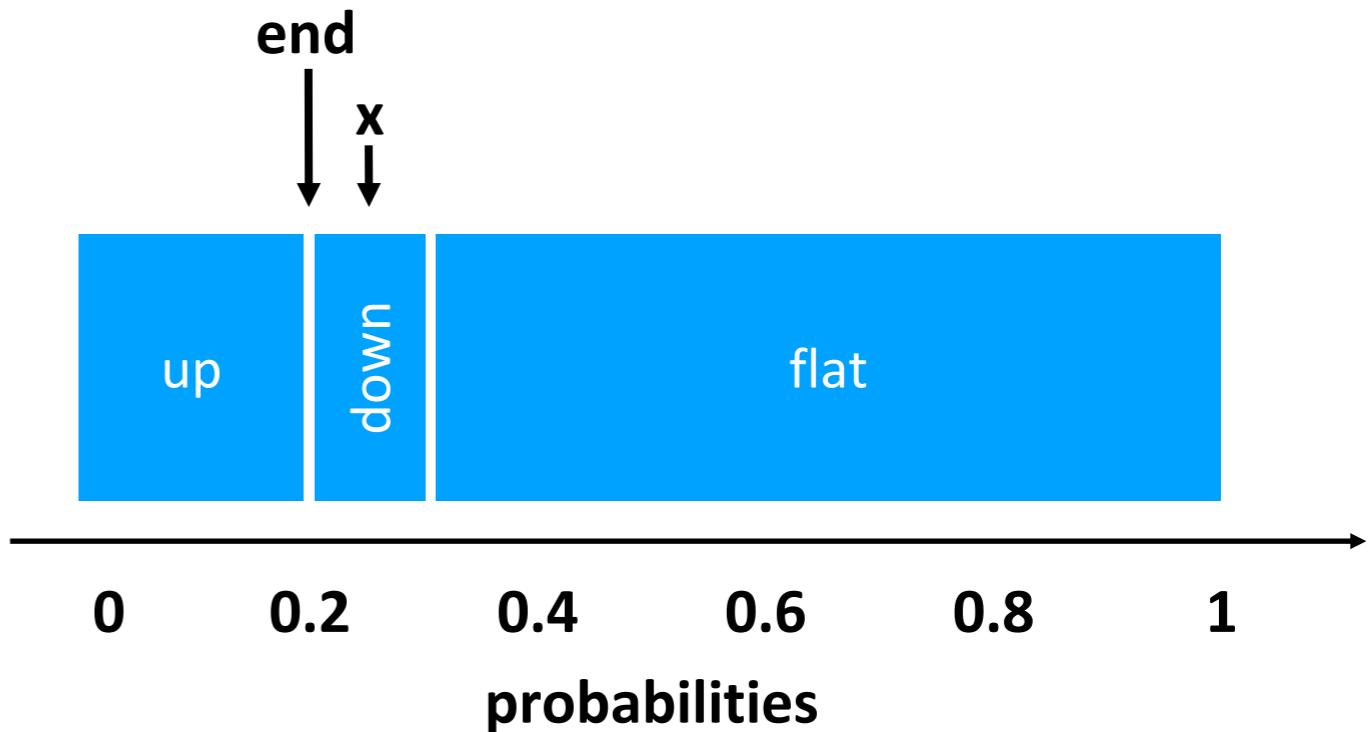
key up
end 0.2

Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
  
for key in keys:  
    end += transitions[key]  
    if end >= x:  
        winner = key  
        break
```



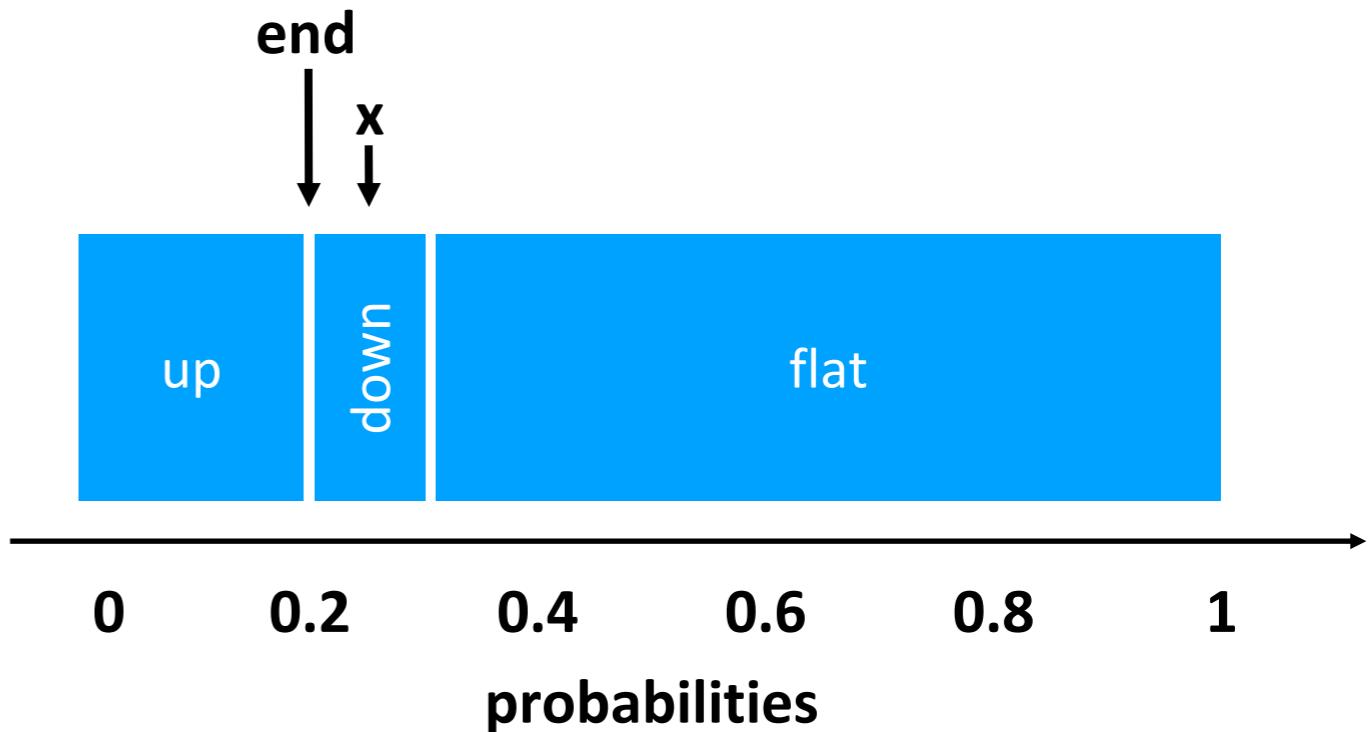
key up
end 0.2

Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
for key in keys:  
    → end += transitions[key]  
    if end >= x:  
        winner = key  
        break
```



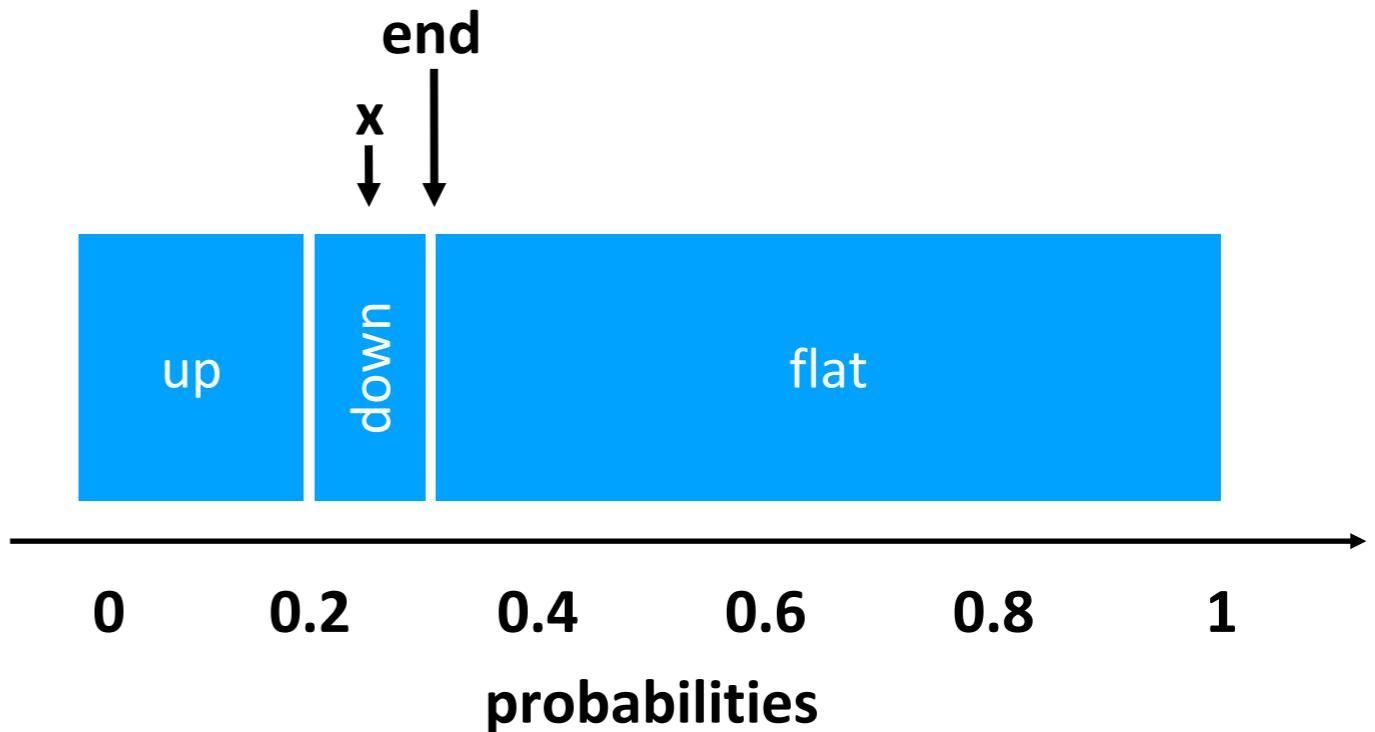
key down
end 0.2

Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
for key in keys:  
    end += transitions[key]  
    if end >= x:  
        winner = key  
        break
```



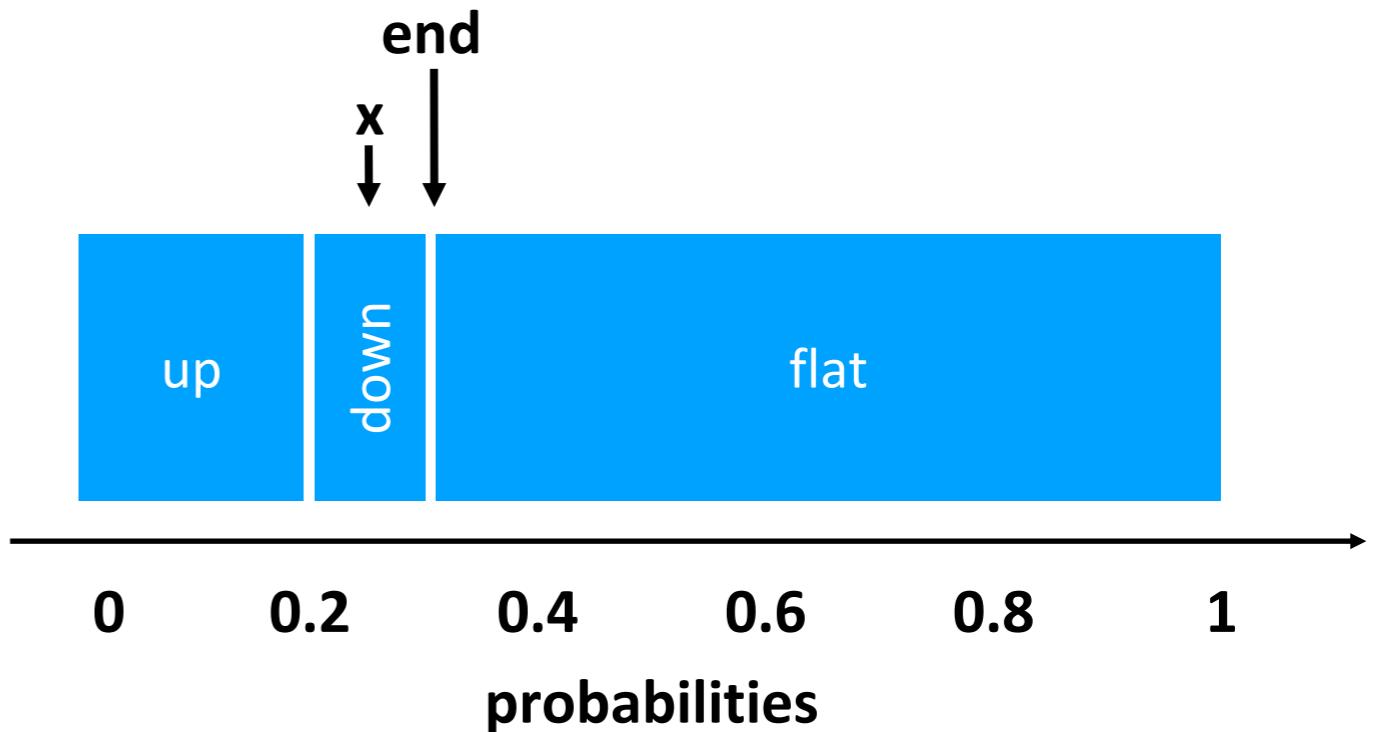
key down
end 0.3

Weighted Random

```
transitions = {  
    "up": 0.2,  
    "down": 0.1,  
    "flat": 0.7  
}
```

```
x = random.random()  
# assume 0.25
```

```
end = 0  
keys = ["up", "down", "flat"]  
winner = None  
for key in keys:  
    end += transitions[key]  
    if end >= x:  
        → winner = key  
        break
```



key down
end 0.3

we randomly chose "down"