UNIVERSITY of WASHINGTON

LEC 15

CSE 121

2D Arrays

Questions during Class?

Raise hand or send here

sli.do   #cse121

Talk to your neighbours:

*What's left on your
Winter bucket list?*

Music: 121 25wi lecture playlist ❄️

Instructor: Matt Wang

TAs:	Ailsa	Alice	Chloë	Christopher
	Ethan	Hanna	Hannah	Hibbah
	Janvi	Judy	Julia	Kelsey
	Lucas	Luke	Maitreyi	Merav
	Ruslana	Samrutha	Sam	Shayna
	Sushma	Vivian		

Announcements, Reminders

- C3 released yesterday, due **Tuesday, Mar 4th**

- R5 due next **Thursday, Mar 6th** (eligible: **P1**, C2, P2)

- Quiz 2 on **Thursday, Mar 6th**
  - can't make it? <u>email me</u> before your quiz!

- Next Wednesday's PCM + class:
  - is *secretly* quiz prep! (array patterns and practice)
  - is a guest lecture! (from our lovely head TA, Hannah)
  - has a question that guides Wed's lecture: **please do this!**

- In the future: final exam on **Tue, March 18th from 12:30-2:20 PM**

PCM Review: 2D Arrays

```
int[][]  a  =  new int[4][3];
```
type   name   array creation code

An array of arrays!

The type of each individual element is another array!

- Your first example of "nested data structures"

- There will be more if you take CSE 122!

```
int[][]          double[][]     String[][]

     boolean[][]          char[][]
```

# PCM Review: 2D Arrays as Rows and Columns

```
int[][] arr = new int[4][3]
```

Can think of the two dimensions as "rows" and "columns".

Individual elements are row-first, then column ("row-major")

`arr[2][1]`

variable: arr
(type: int[][])

	0	1	2
0	0	0	0
1	0	0	0
2	0	0	0
3	0	0	0
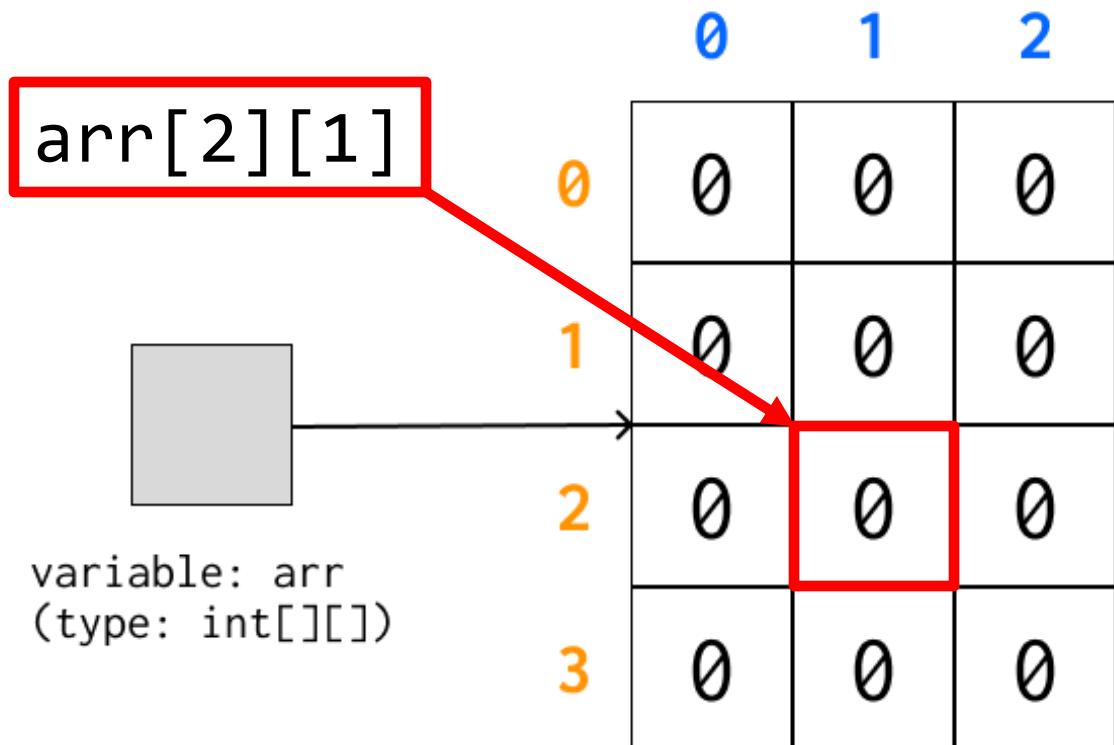
A more accurate view (reference semantics)

`int[][] arr = new int[4][3]`

variable: arr
(type: int[][])
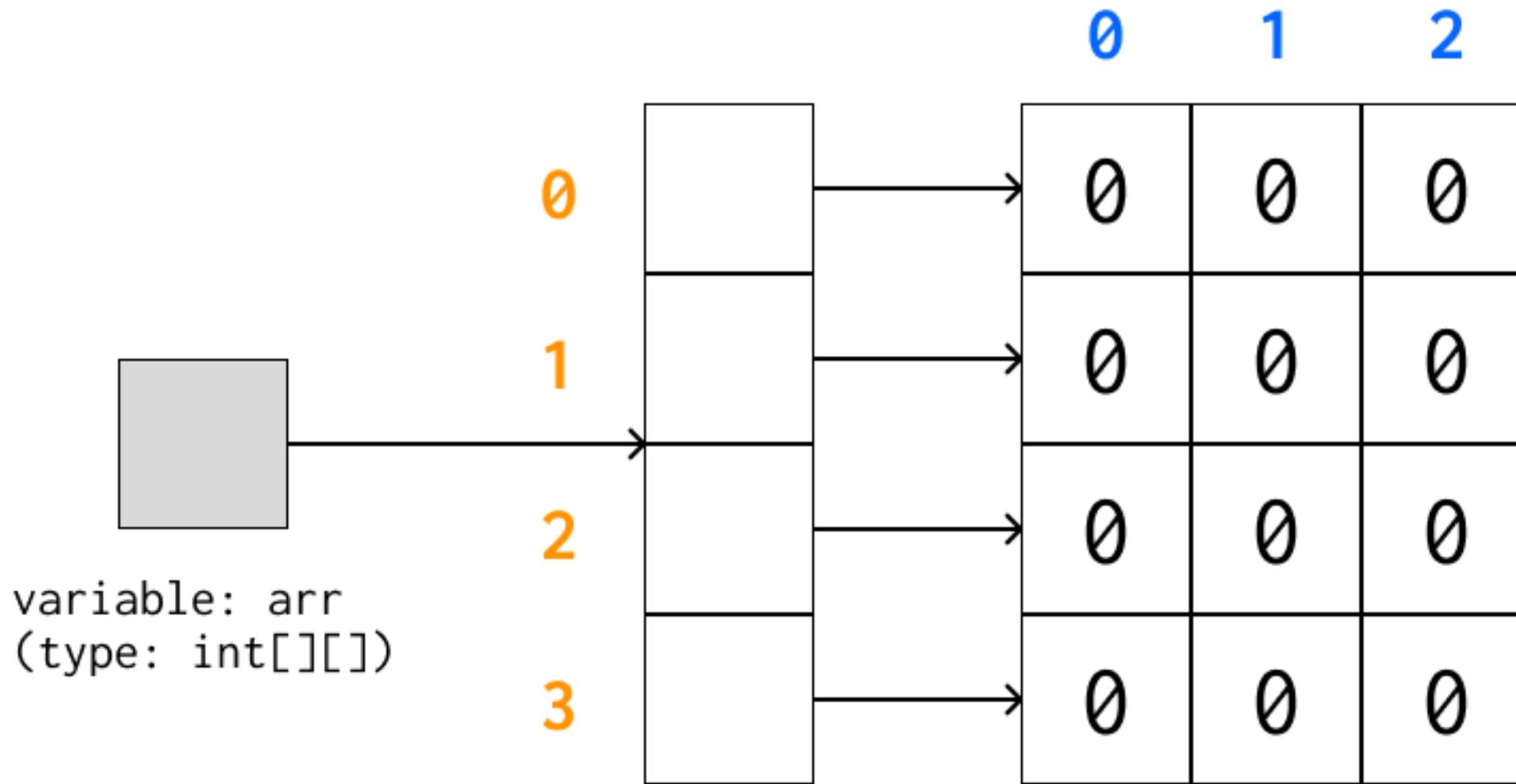
PCM Review: 2D Array Traversals

for each row…

```
for (int i = 0; i < list.length; i++) {
    for (int j = 0; j < list[i].length; j++) {
        // do something with list[i][j]
    }
}
```

for each element within a row…

Arrays Utility Class (and methods)

| Method	Description
`Arrays.toString(array);`	Returns a `String` representing the array, such as `"[10, 30, -25, 17]"`
`Arrays.equals(array1, array2);`	Returns `true` if the two arrays contain the same elements in the same order
`Arrays.deepToString(array);`	Returns a `String` representing the array; if the array contains other arrays as elements, the `String` represents their contents, and so on. For example, `"[[99, 151], [30, 5]]"`
`Arrays.deepEquals(array1, array2);`	Returns `true` if the two arrays contain the same elements in the same order; if the array(s) contain other arrays as elements, their contents are tested for equality, and so on.

Applications of 2D Arrays

- **Matrices**
  - Useful in *so many* applications in math, engineering, and statistics
  - Fundamental to machine learning & AI
  - P3 is one real-life application of this! (bioinformatics)
- Board games
  - e.g. chess, checkers, tic-tac-toe, sudoku
- Tabular or grid-like data
  - e.g. scorekeeping, gradebook, census data
- Image processing

matrixAdd
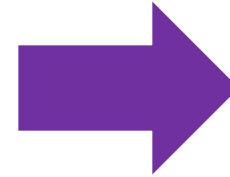
matrixAdd: first row

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

```
i: 0
j: 0
```
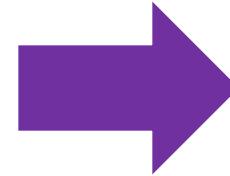
matrixAdd: 0,0

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

```
i: 0
j: 0
```
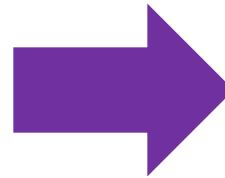
93				

matrixAdd: 0,1

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 0
j: 1
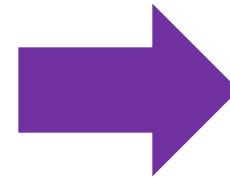
93	169			

matrixAdd: 0,2

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

```
i: 0
j: 2
```
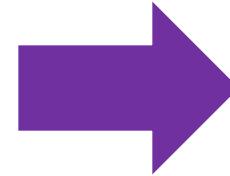
93	169	84		

matrixAdd: 0,3

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

```
i: 0
j: 3
```

➡
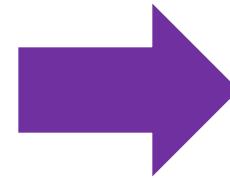
93	169	84	83	

matrixAdd: 0,4

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 0
j: 4
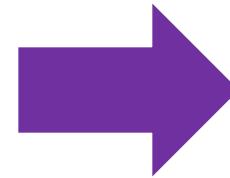
93	169	84	83	103

matrixAdd: 1,0

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 1
j: 0
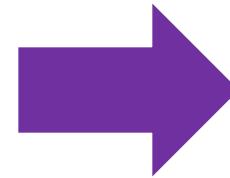
93	169	84	83	103
136				

matrixAdd: 1,1

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 1
j: 1

➡
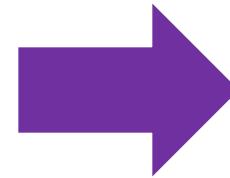
93	169	84	83	103
136	115			

matrixAdd: 1,2

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 1
j: 2
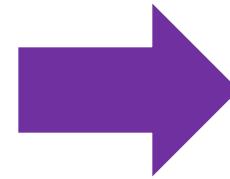
93	169	84	83	103
136	115	91		

matrixAdd: 1,3

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 1
j: 3
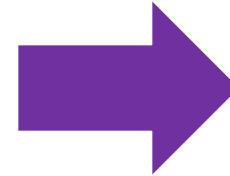
93	169	84	83	103
136	115	91	143	

matrixAdd: 1,4

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+
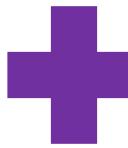
70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 1
j: 4

→
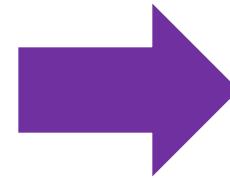
93	169	84	83	103
136	115	91	143	81

matrixAdd: 2,0

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+
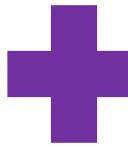
70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 2
j: 0
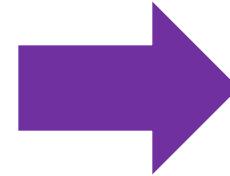
93	169	84	83	103
136	115	91	143	81
119				

matrixAdd: 2,1

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 2
j: 1

→
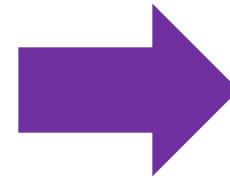
93	169	84	83	103
136	115	91	143	81
119	77			

matrixAdd: 2,2

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

i: 2
j: 2

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1
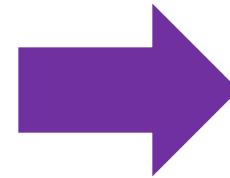
93	169	84	83	103
136	115	91	143	81
119	77	98		

matrixAdd: 2,3

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 2
j: 3

➡
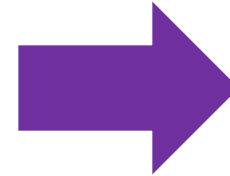
93	169	84	83	103
136	115	91	143	81
119	77	98	105	

matrixAdd: 2,4

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

i: 2
j: 4
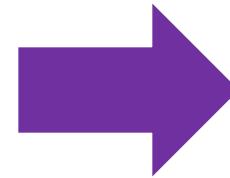
93	169	84	83	103
136	115	91	143	81
119	77	98	105	13

matrixAdd: finished!

23	96	18	4	64
45	40	18	44	34
92	13	77	71	12

+

70	73	66	79	39
91	75	73	99	47
27	64	21	34	1

➡
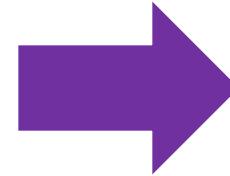
93	169	84	83	103
136	115	91	143	81
119	77	98	105	13

readData: processing input

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
   Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

readData: days

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
   Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1			
2			
3			

readData: 1, Seattle

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
   Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44		
2			
3			

29

readData: 1, Tacoma

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
   Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	
2			
3			

readData: 1, Bothell

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
➡  Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2			
3			

readData: 2, Seattle

```
How many days' data would you like to input? 3
Next day's data:
    Temperature in Seattle? 44
    Temperature in Tacoma? 40
    Temperature in Bothell? 43
Next day's data:
    Temperature in Seattle? 42
    Temperature in Tacoma? 40
    Temperature in Bothell? 44
Next day's data:
    Temperature in Seattle? 42
    Temperature in Tacoma? 41
    Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42		
3			

readData: 2, Tacoma

```
How many days' data would you like to input? 3
Next day's data:
    Temperature in Seattle? 44
    Temperature in Tacoma? 40
    Temperature in Bothell? 43
Next day's data:
    Temperature in Seattle? 42
➡   Temperature in Tacoma? 40
    Temperature in Bothell? 44
Next day's data:
    Temperature in Seattle? 42
    Temperature in Tacoma? 41
    Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42	40	
3			

readData: 2, Bothell

```
How many days' data would you like to input? 3
Next day's data:
    Temperature in Seattle? 44

    Temperature in Tacoma? 40
    Temperature in Bothell? 43
Next day's data:
    Temperature in Seattle? 42

    Temperature in Tacoma? 40
    Temperature in Bothell? 44
Next day's data:
    Temperature in Seattle? 42

    Temperature in Tacoma? 41

    Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42	40	44
3			

readData: 2, Seattle

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
   Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42	40	44
3	42		

readData: 2, Tacoma

```
How many days' data would you like to input? 3
Next day's data:
   Temperature in Seattle? 44
   Temperature in Tacoma? 40
   Temperature in Bothell? 43
Next day's data:
   Temperature in Seattle? 42
   Temperature in Tacoma? 40
   Temperature in Bothell? 44
Next day's data:
   Temperature in Seattle? 42
➡  Temperature in Tacoma? 41
   Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42	40	44
3	42	41	

readData: 2, Bothell

```
How many days' data would you like to input? 3
Next day's data:
  Temperature in Seattle? 44
  Temperature in Tacoma? 40
  Temperature in Bothell? 43
Next day's data:
  Temperature in Seattle? 42
  Temperature in Tacoma? 40
  Temperature in Bothell? 44
Next day's data:
  Temperature in Seattle? 42
  Temperature in Tacoma? 41
  Temperature in Bothell? 43
...
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42	40	44
3	42	41	43

computeAverages

```
How many days' data would you like to input? 3
…
The average values for each location were
[42.66666666666664, 40.33333333333336,
43.33333333333336]
```

	Seattle	Tacoma	Bothell
1	44	40	43
2	42	40	44
3	42	41	43

42.667	40.333	43.333

Average of Seattle
temperatures
(44 + 42 + 42) / 3

Announcements, Reminders (again)

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- R5 due next **Thursday, Mar 6th** (eligible: **P1**, C2, P2)

- Quiz 2 on **Thursday, Mar 6th**

  - can't make it? <u>email me</u> before your quiz!

- Next Wednesday's PCM + class:

  - is *secretly* quiz prep! (array patterns and practice)

  - is a guest lecture! (from our lovely head TA, Hannah)

  - has a question that guides Wed's lecture: **please do this!**

- In the future: final exam on **Tue, March 18th from 12:30-2:20 PM**