Data Structures

CS 106A, May 14, 2018

Julia Daniel

Collections we've seen

aka data structures

• `Arrays`	• fixed size, indexed values
• `ArrayLists`	• changing size, indexed values
• `Matrices`	• fixed size, indexed lists of arrays
• `HashMaps`	• changing size, not indexed, keys & values

How do these play together?

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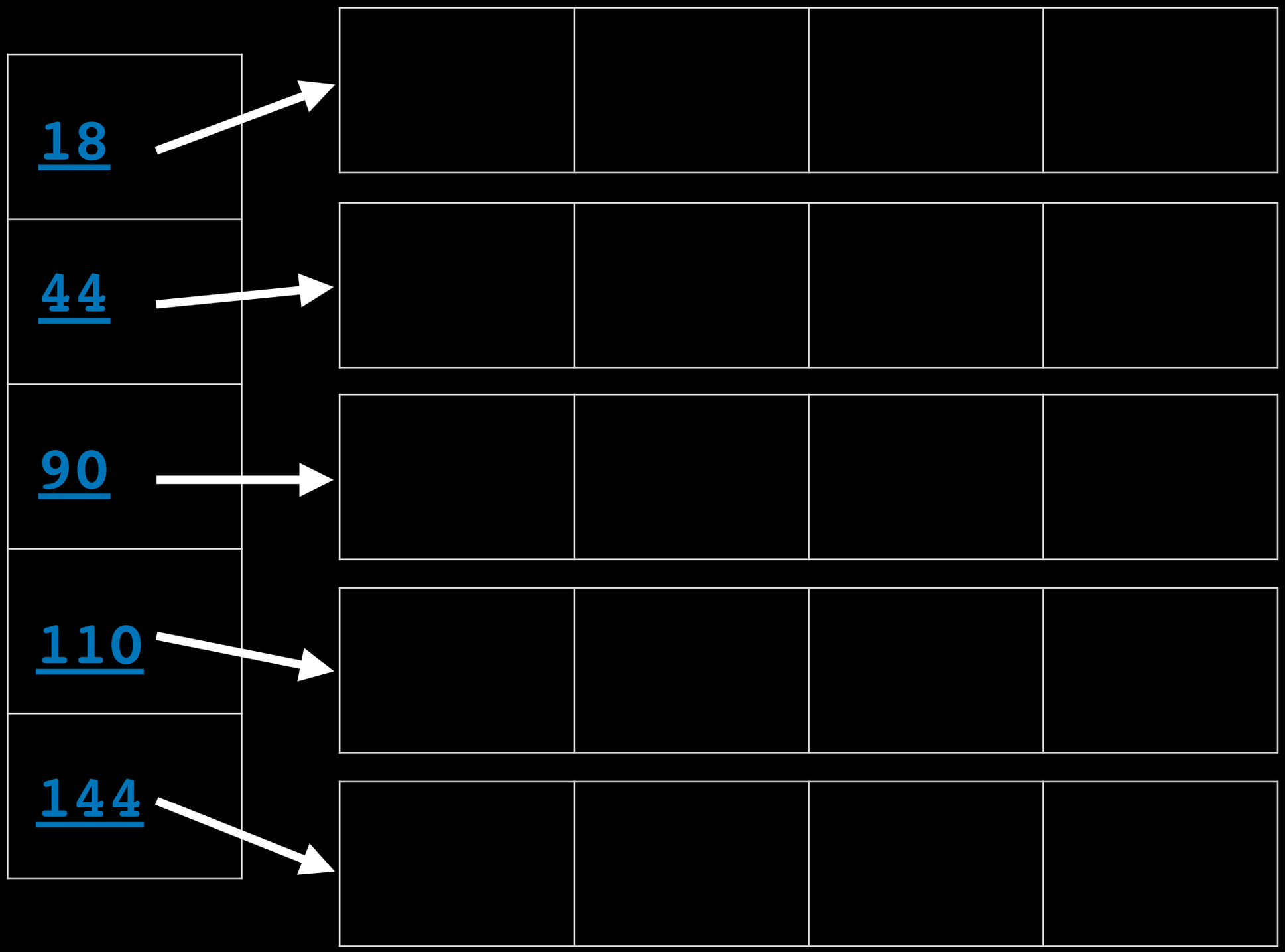
• `Matrices`	• `arrays` of `arrays`!
• `HashMaps`	• changing size, not indexed, keys & values

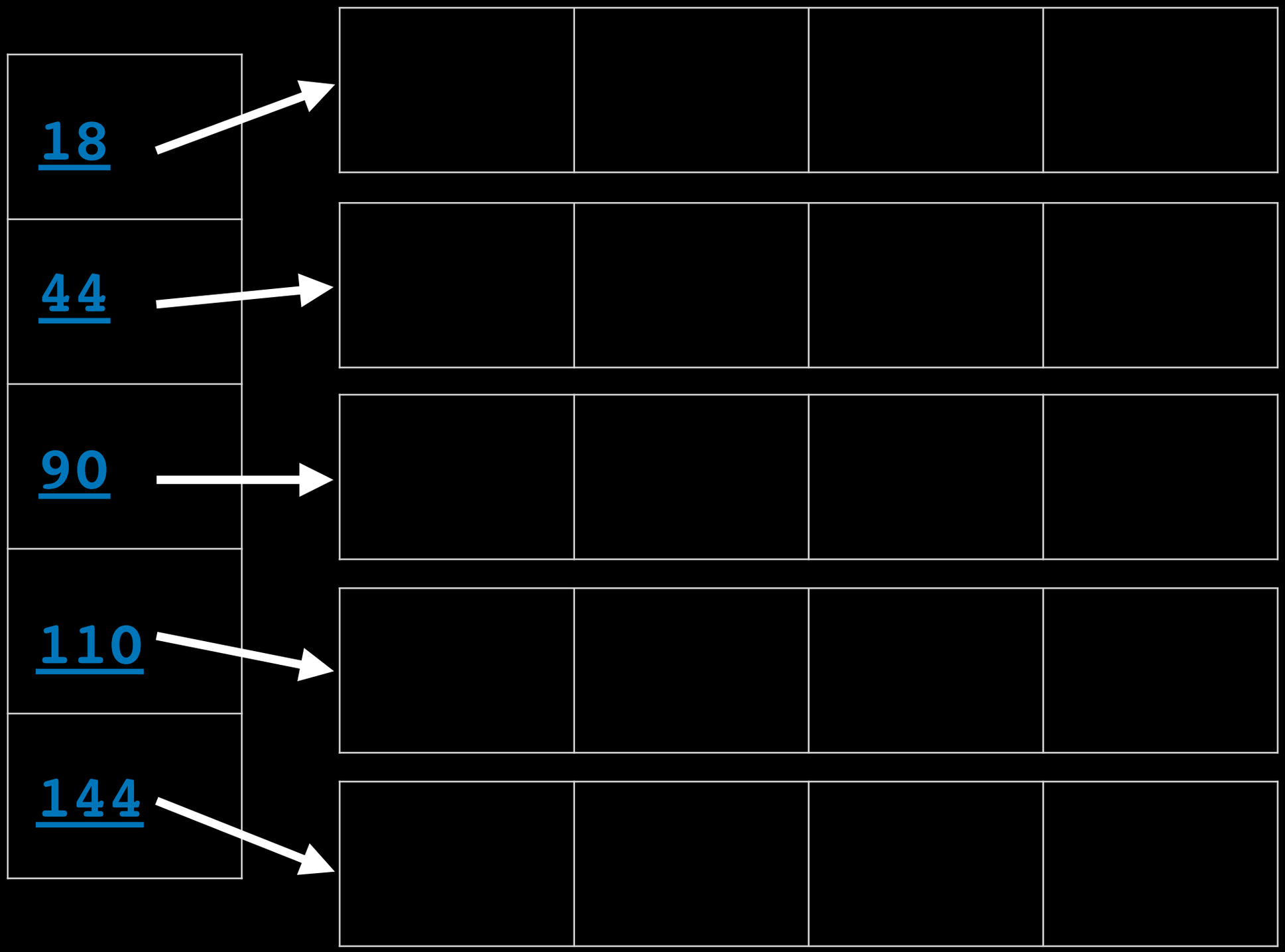
Matrix Mechanics



Under the hood

- Objects are represented in the program by their address
- Addresses are small
- Addresses can redirect to other addresses
- So we can get as many layers as we want without worrying if things will “fit”!

Matrix Mechanics



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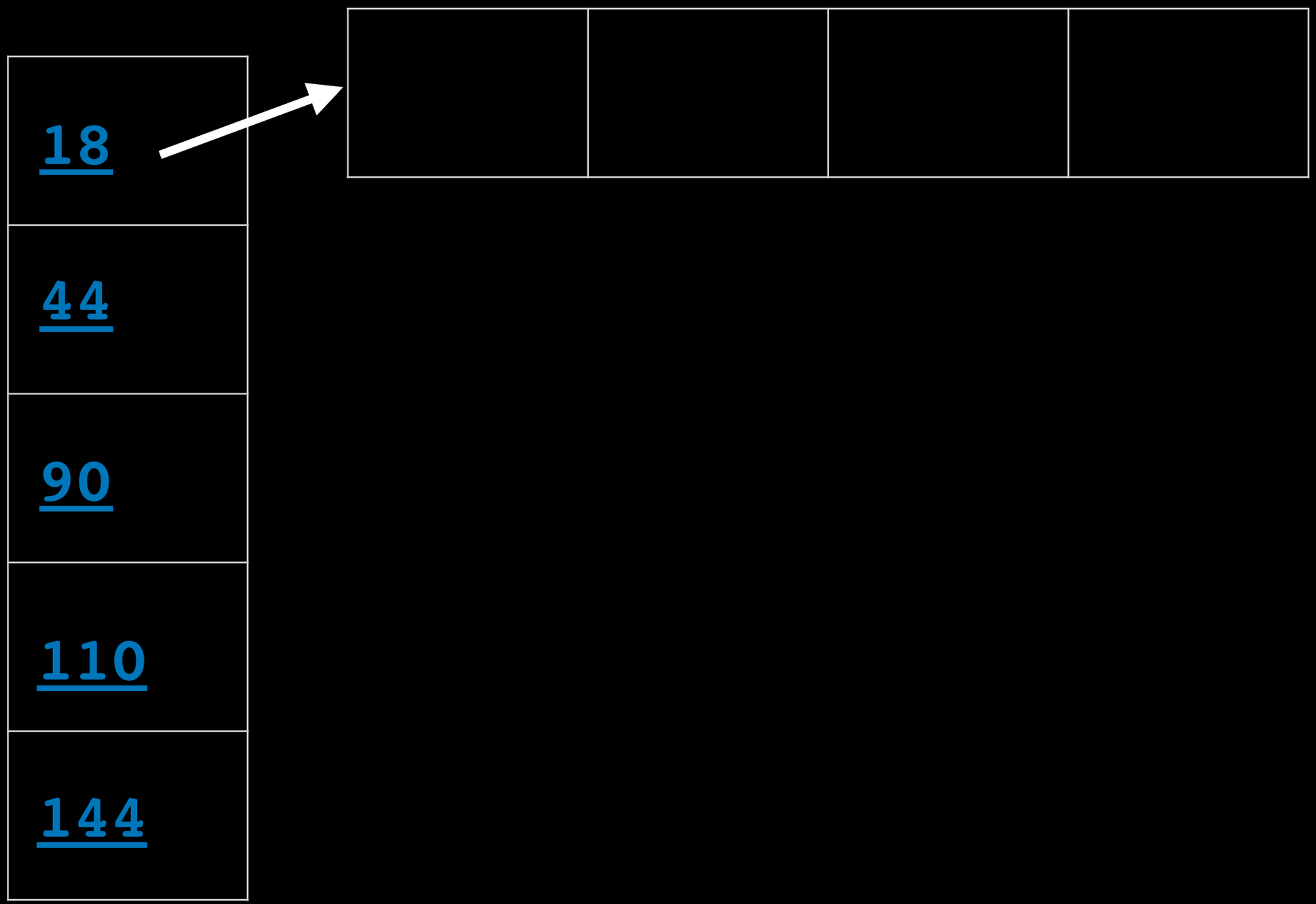

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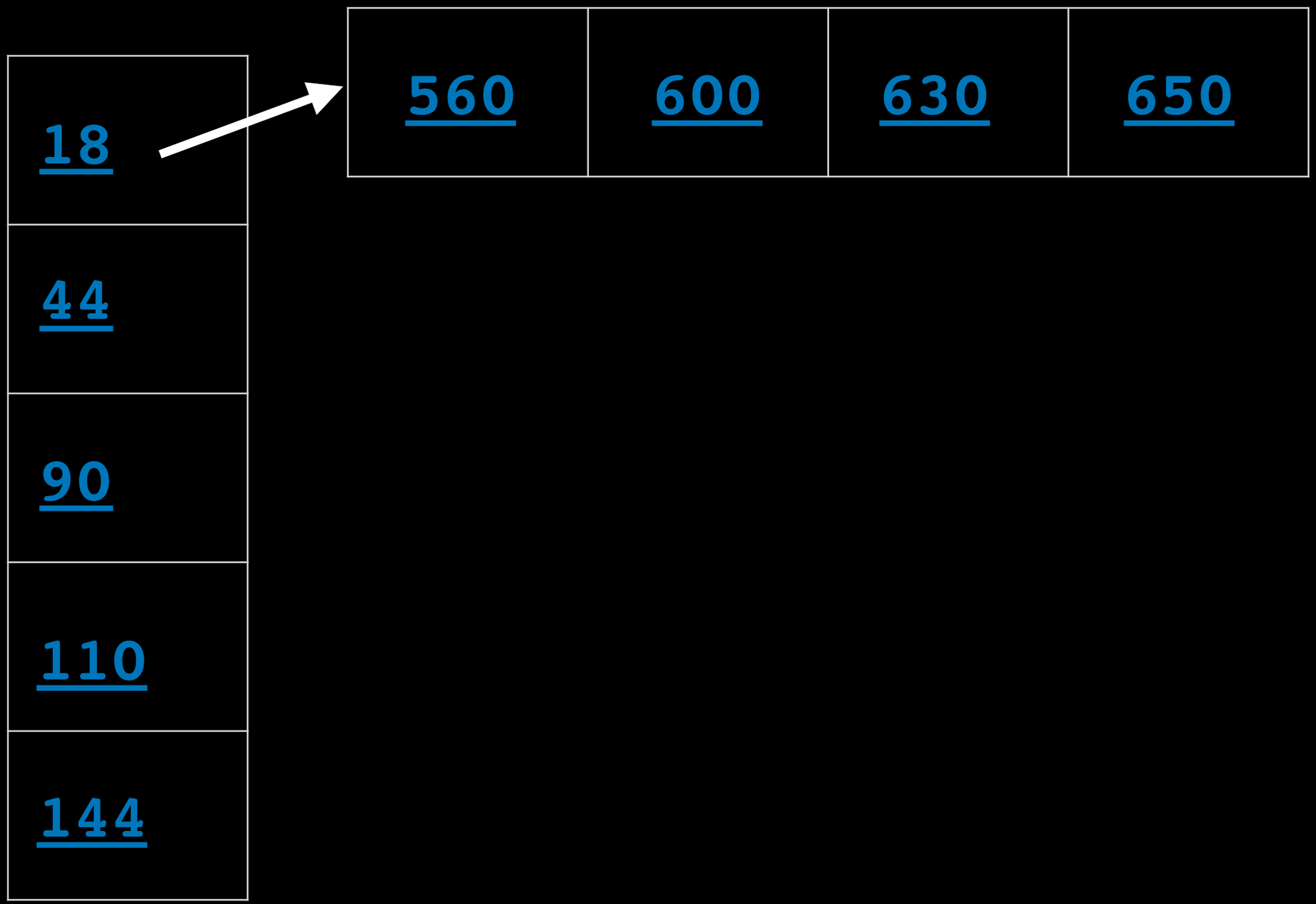

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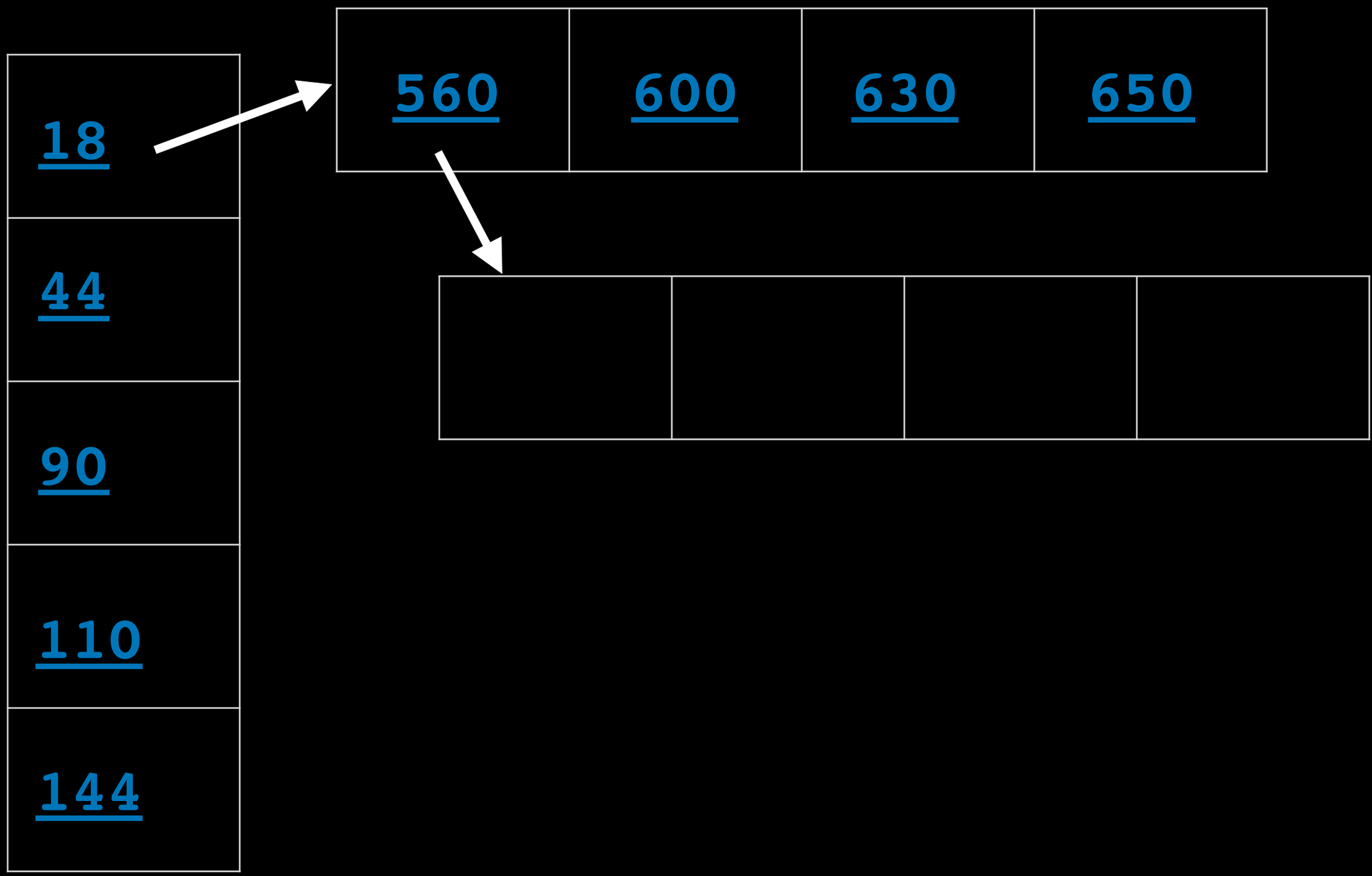

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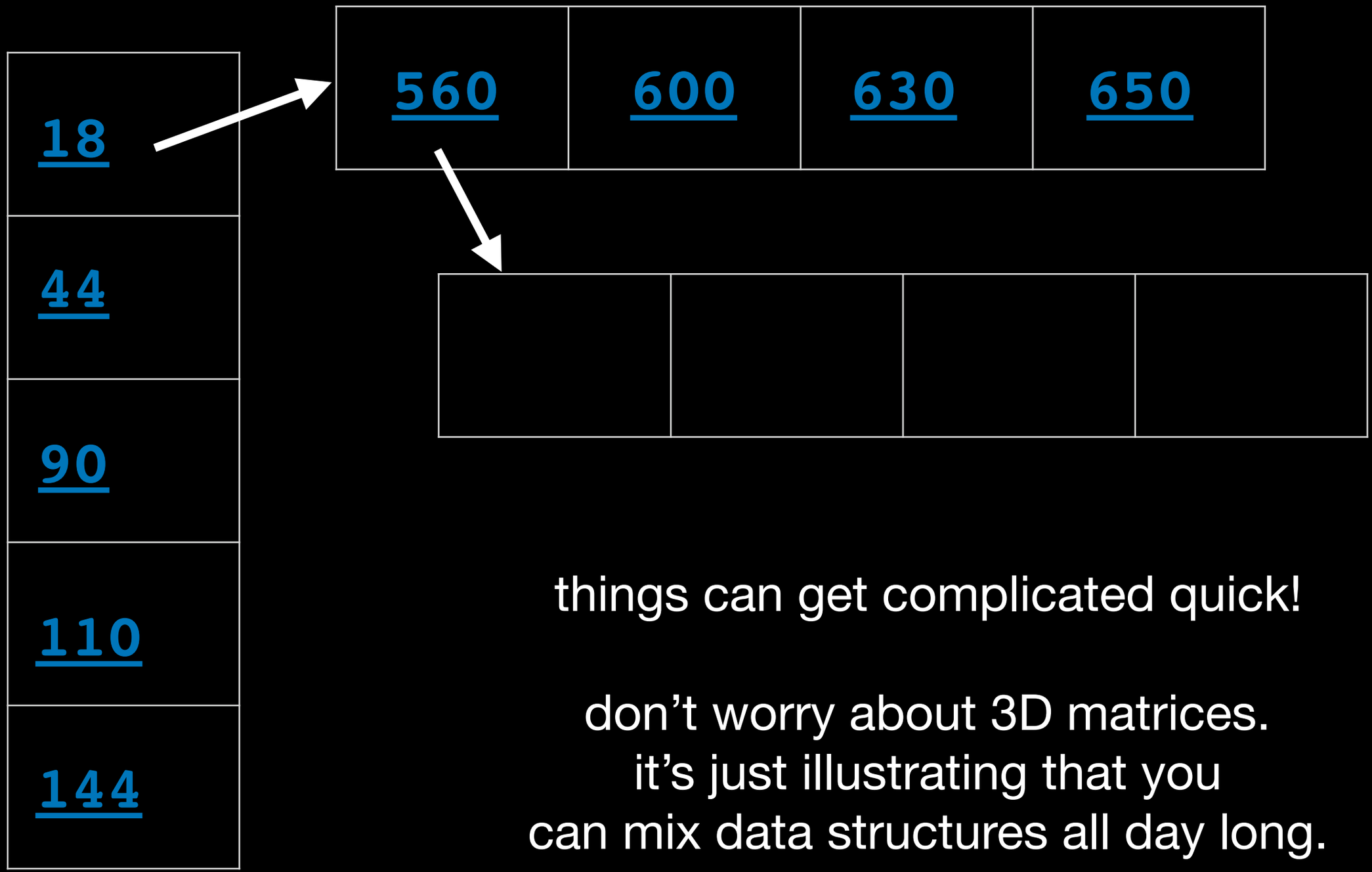


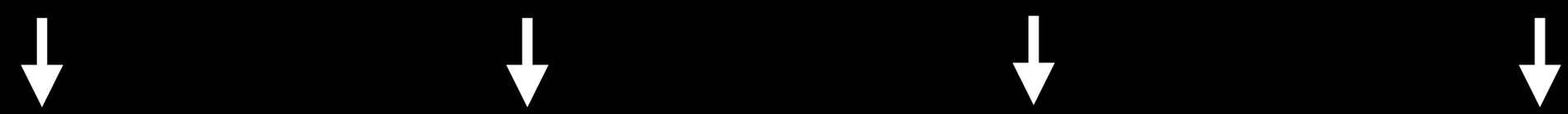
things can get complicated quick!

don’t worry about 3D matrices.
it’s just illustrating that you
can mix data structures all day long.

A `HashMap` of pets

A `HashMap` of pets

“Chris” **“Julia”** **“Brahm”** **“Annie”**



“dog” **“cat”** **“parrot”** **“dog”**

A HashMap of pets

```
HashMap<String, String> pets
```

“Chris”	“Julia”	“Brahm”	“Annie”
↓	↓	↓	↓
“dog”	“cat”	“parrot”	“dog”

A `HashMap` of pets

`HashMap<String, String> pets`

- Each member of the course staff has one pet
- We have a `HashMap` from people to their pet type (all `Strings`):

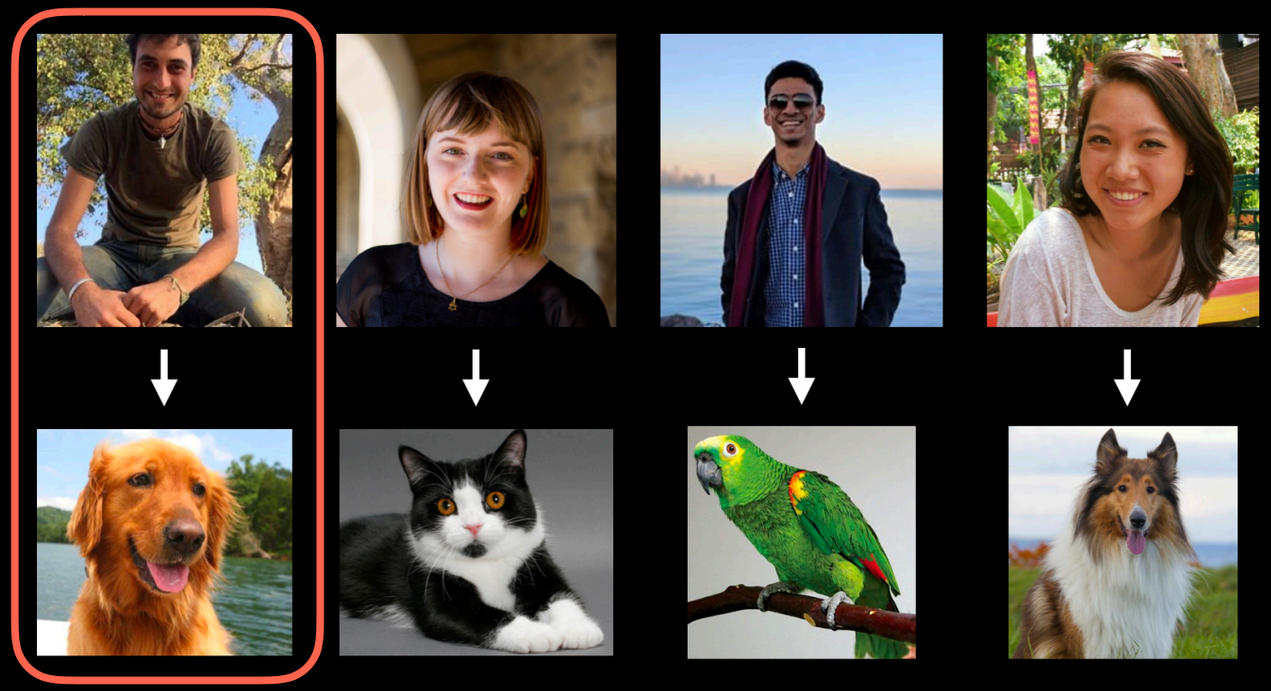
```
"Julia" -> "cat"
"Chris" -> "dog"
"Brahm" -> "parrot"
"Annie" -> "dog"
```

- How do we find and print all the people who have dogs?

A `HashMap` of pets

Approach 1: the “needle in a haystack”

check each item in the HashMap, and print it out
as you go if it matches what you’re looking for



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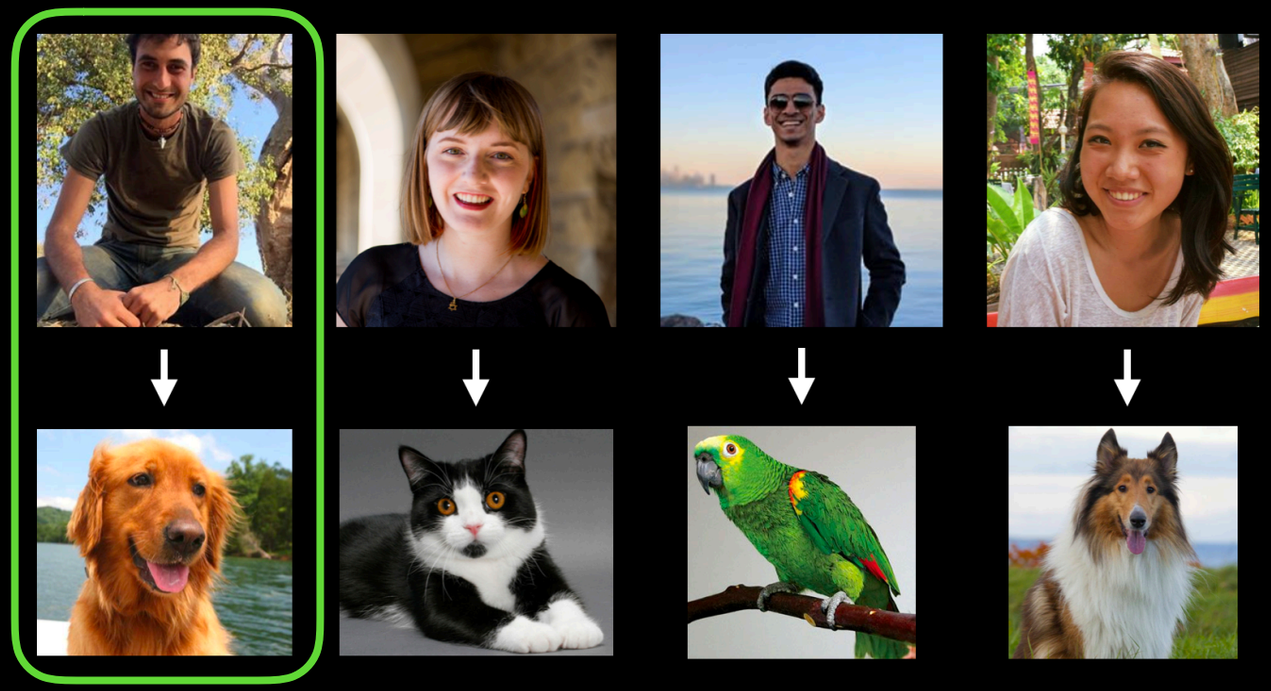

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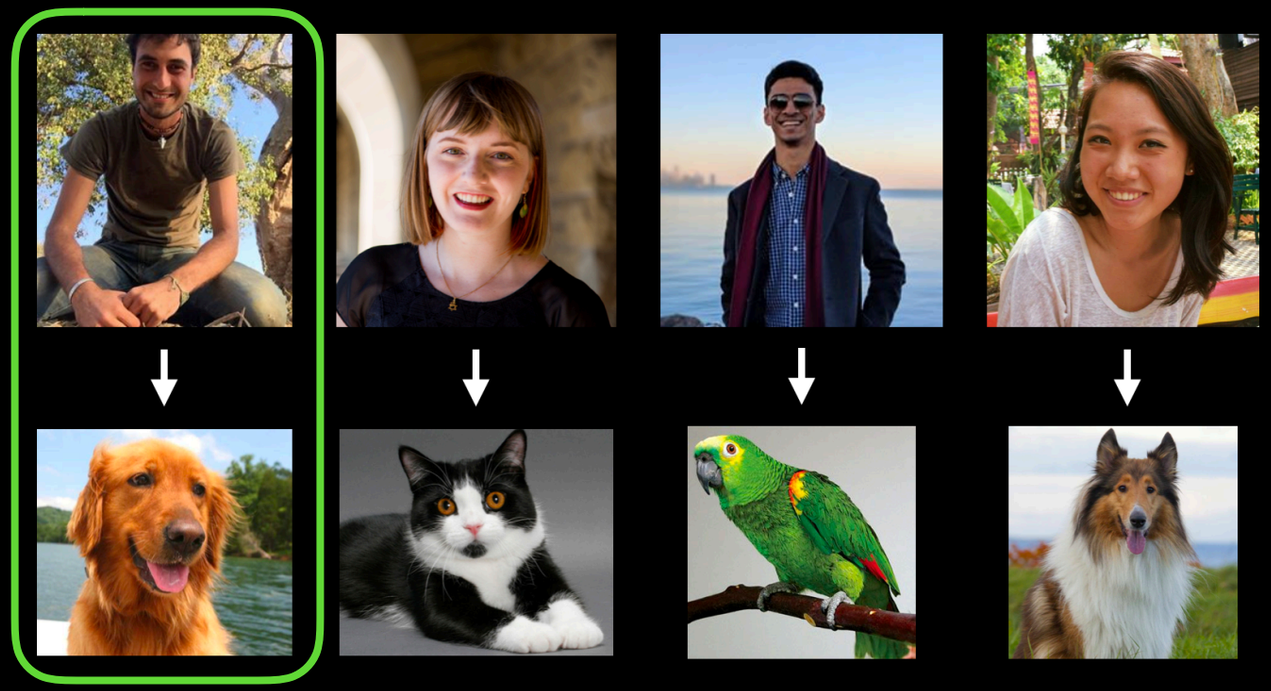

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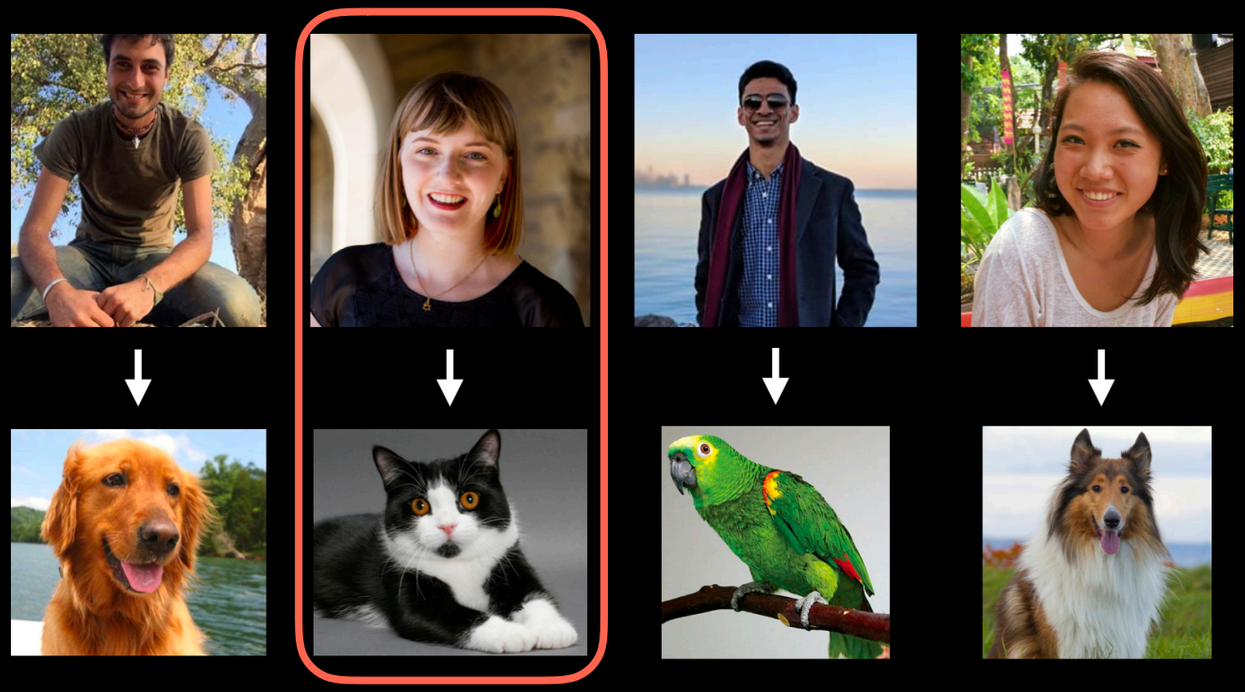

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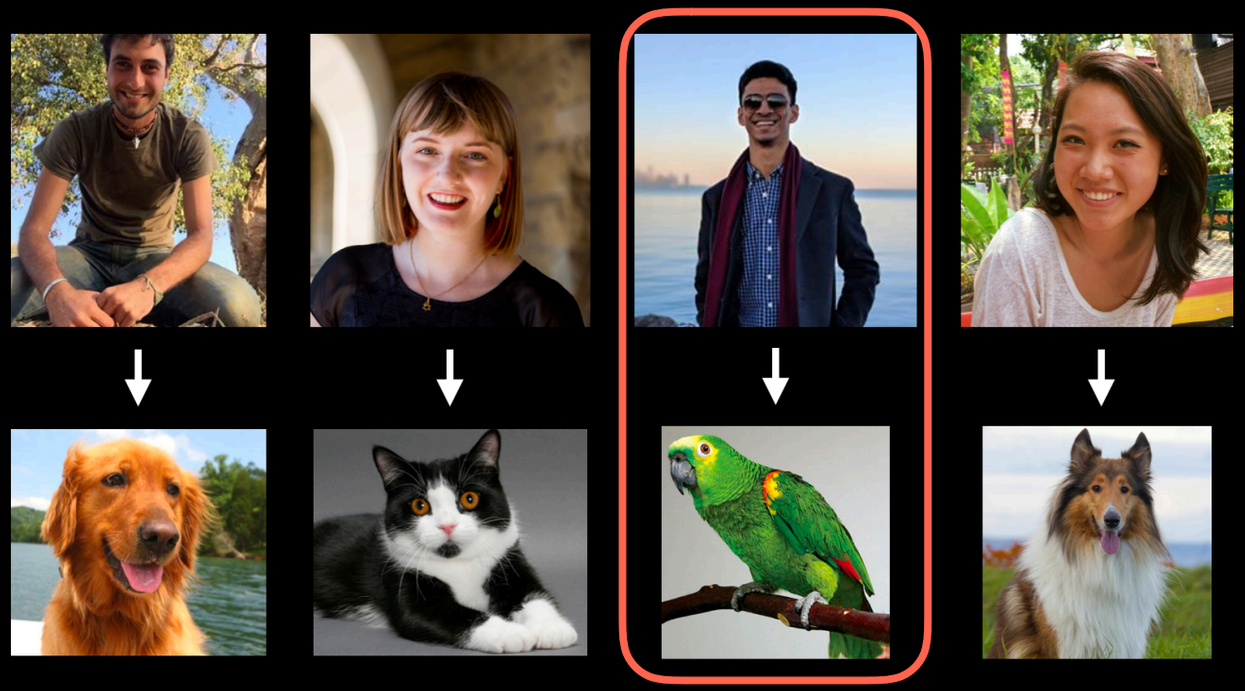

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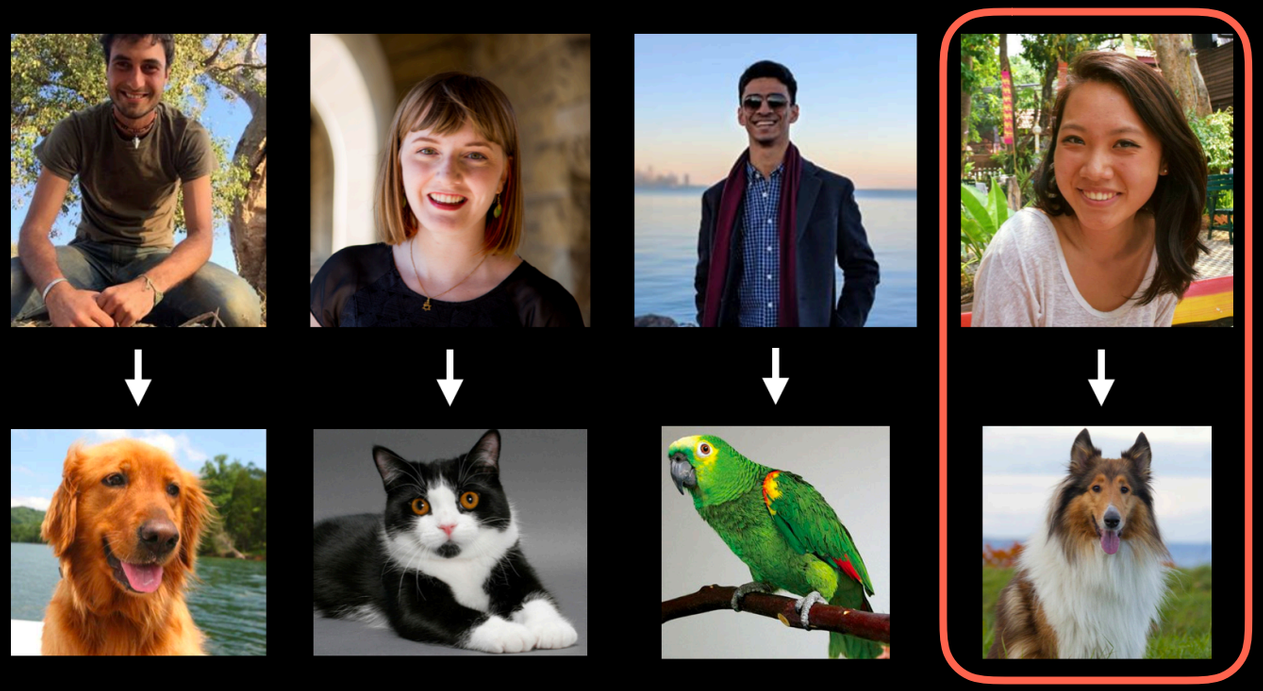

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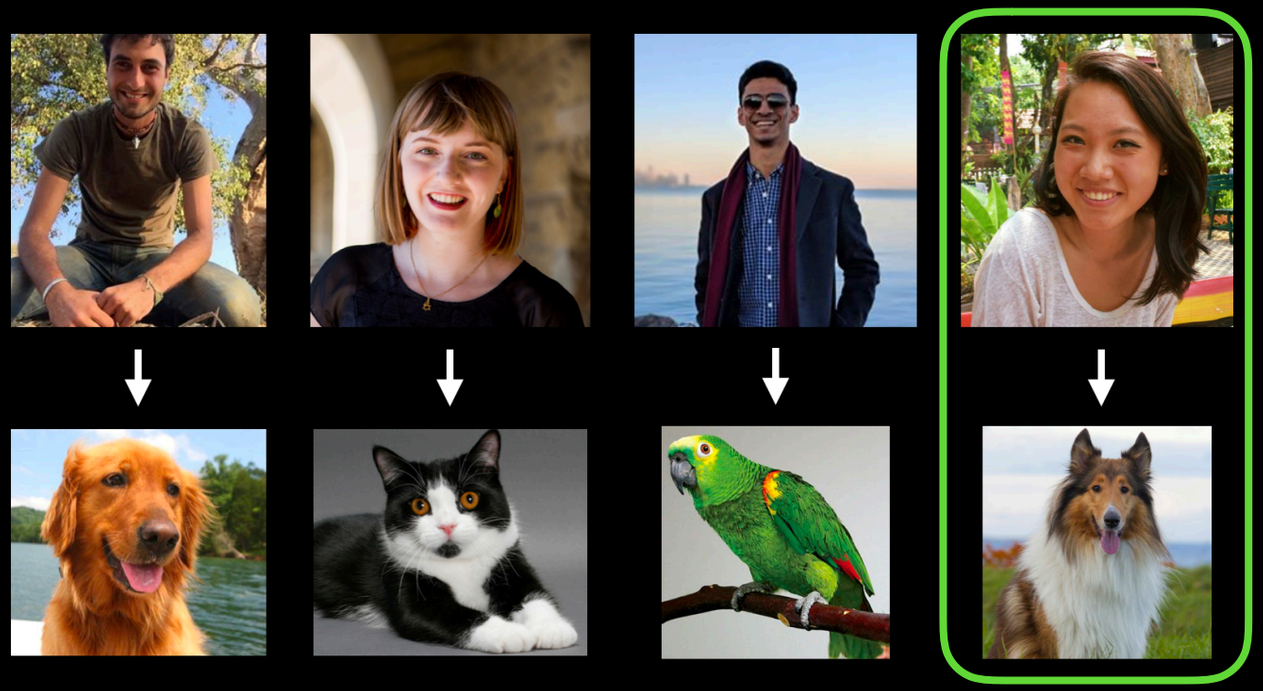

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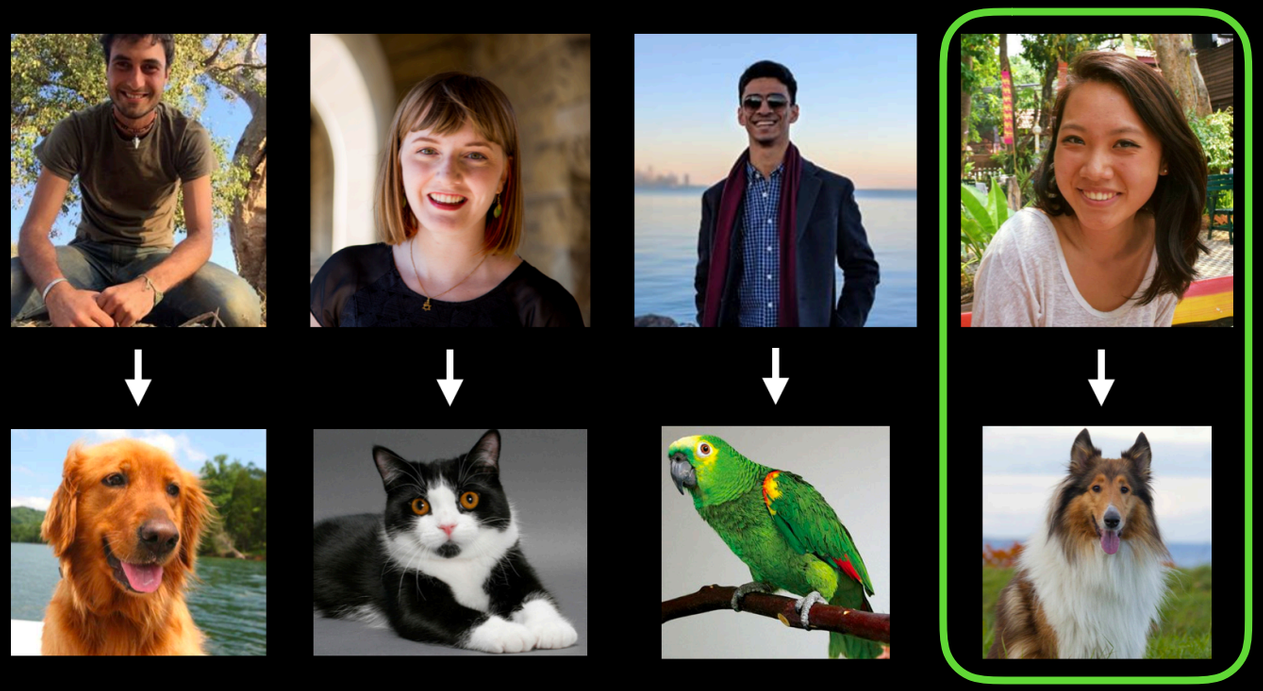

Chris
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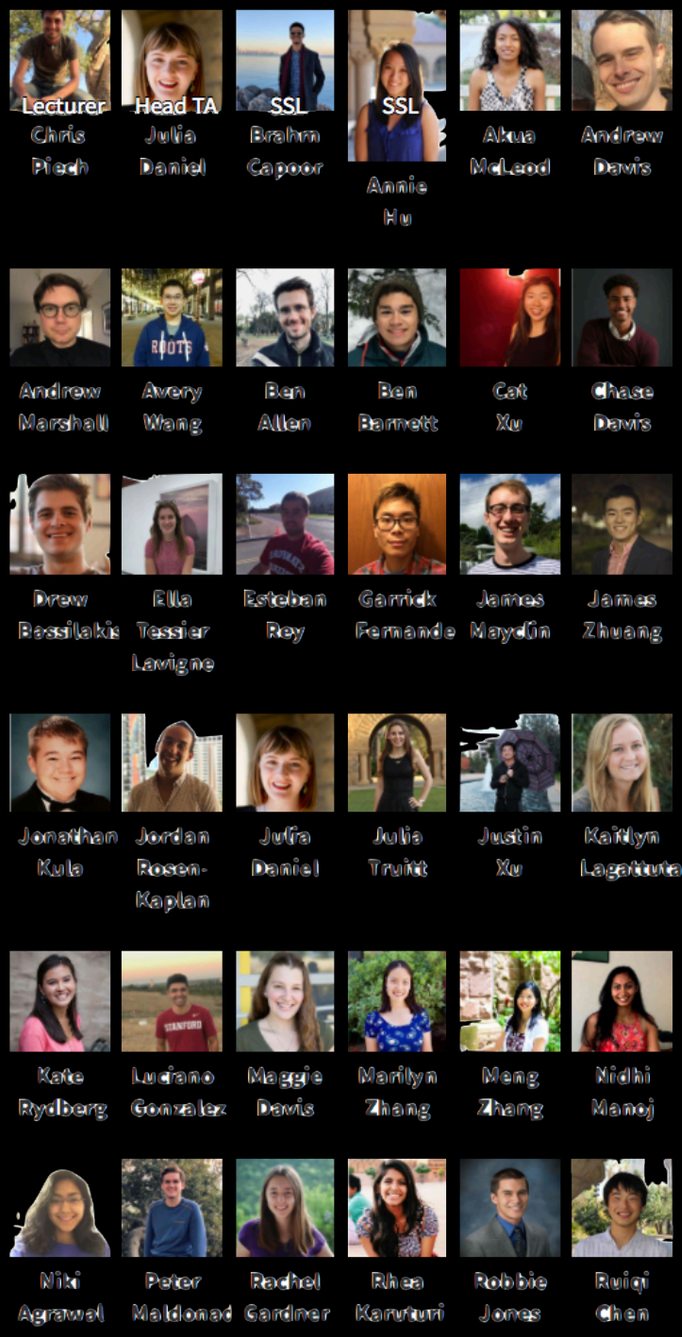
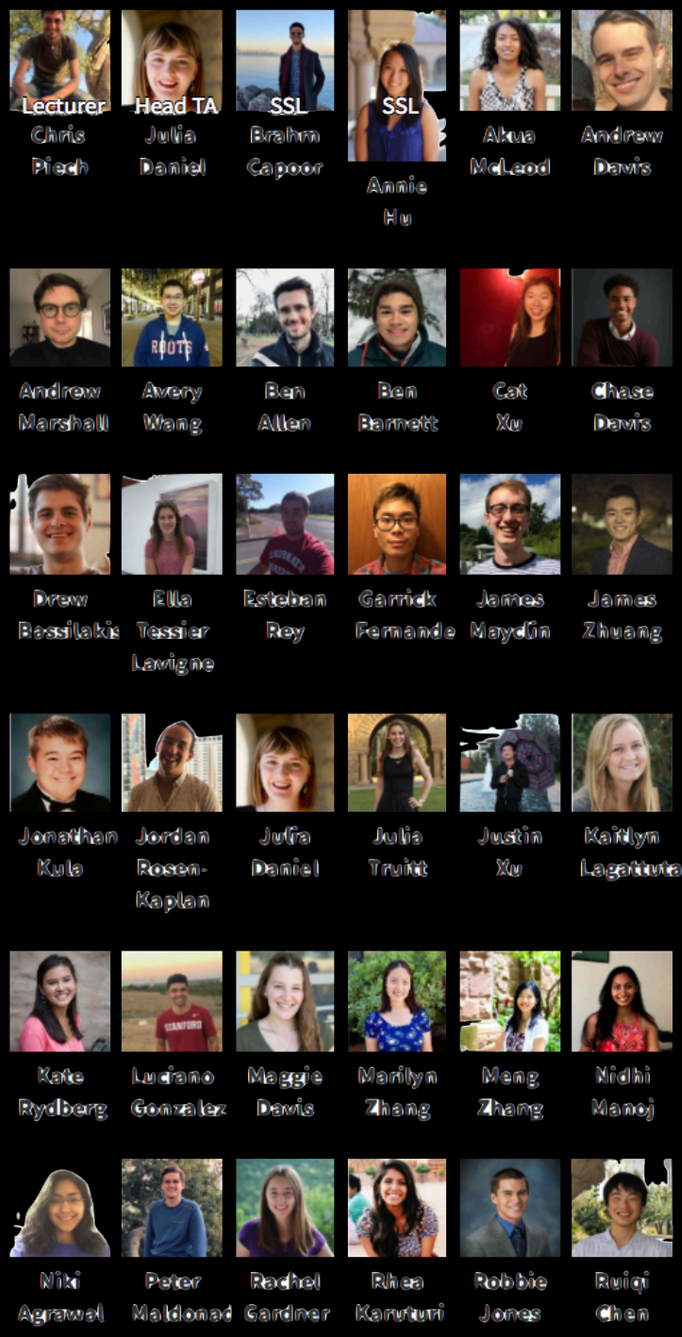
A `HashMap` of pets



What if we have a huge list of course staff?

And what if we want to be able to look up any type of pet, and quickly get back all the staff who have that pet without searching through everyone each time?

A `HashMap` of pets



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We need to use a data structure

A `HashMap` of pets

We have:

A `HashMap<String, String> pets`
that maps names to pet types

```
“Julia” -> “cat”
“Chris” -> “dog”
```

We need:

A data structure of some kind
that maps pet types to names

```
“parrot” -> “Brahm”
“dog” -> “Chris”, “Annie”
```

Approach 2:

the “build it once, use it forever”

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Approach 2:

the “build it once, use it forever”

a HashMap can only store one value per key, but we might have multiple people for the same type of pet

A `HashMap` of pets

We build:

A data structure of some kind
that maps pet types to multiple names

```
“parrot” -> “Brahm”
“dog” -> “Chris”, “Annie”
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A `HashMap` of pets

We build:

A `HashMap<String, ArrayList<String>>`
that maps pet types to a list of names

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Nested collections

Every data structure we've learned is at our disposal!

HashMaps

ArrayLists

Arrays

mix 'em together

the possibilities are endless!

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- Ultimate tic tac toe?

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- Shazam - song lookup by notes?

Nested collections

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- Ultimate tic tac toe - matrix of matrices, or 9 x 9 matrix

- Shazam - `HashMap` where key is pair of notes, value is every song with that pair

Mapping Genomes

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  - an x value
  - a y value
  - (*and some other data)*

```
22  Spain,SP,136,-0.0243,-0.0321,4
23  Portugal,PT,128,-0.0282,-0.0332,4
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26  Slovakia,SK,1,-0.0495,0.0355,5
27  Swiss-French,SW,125,0.00575,-0.0028,6
28  Swiss-German,SW,84,0.01,0.00224,6
29  Swiss-Italian,SW,13,-0.0173,0.00806,6
30  France,FR,91,0.00219,-0.0138,7
```

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- How do we store this data so we can plot each country's points?

Mapping Genomes

`HashMap<country code, country points>`

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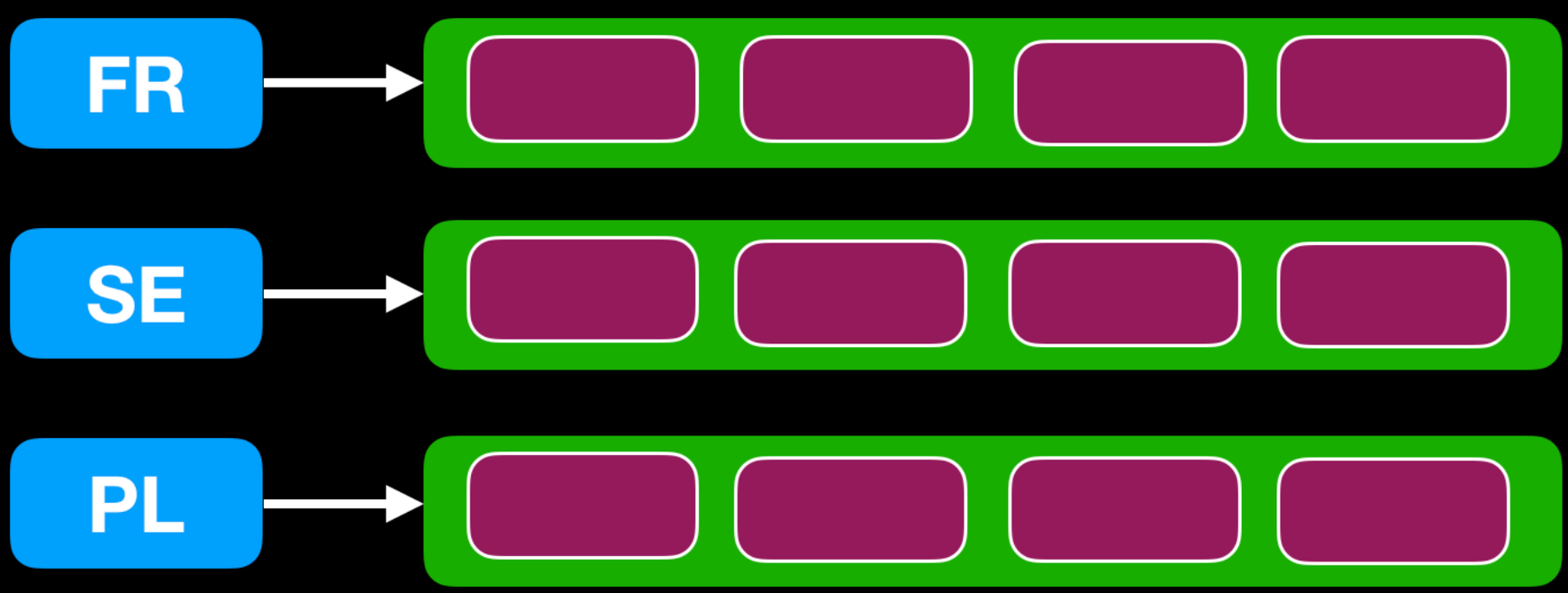
`HashMap<country code, country points>`

`HashMap<String, ArrayList<points>>`



Mapping Genomes

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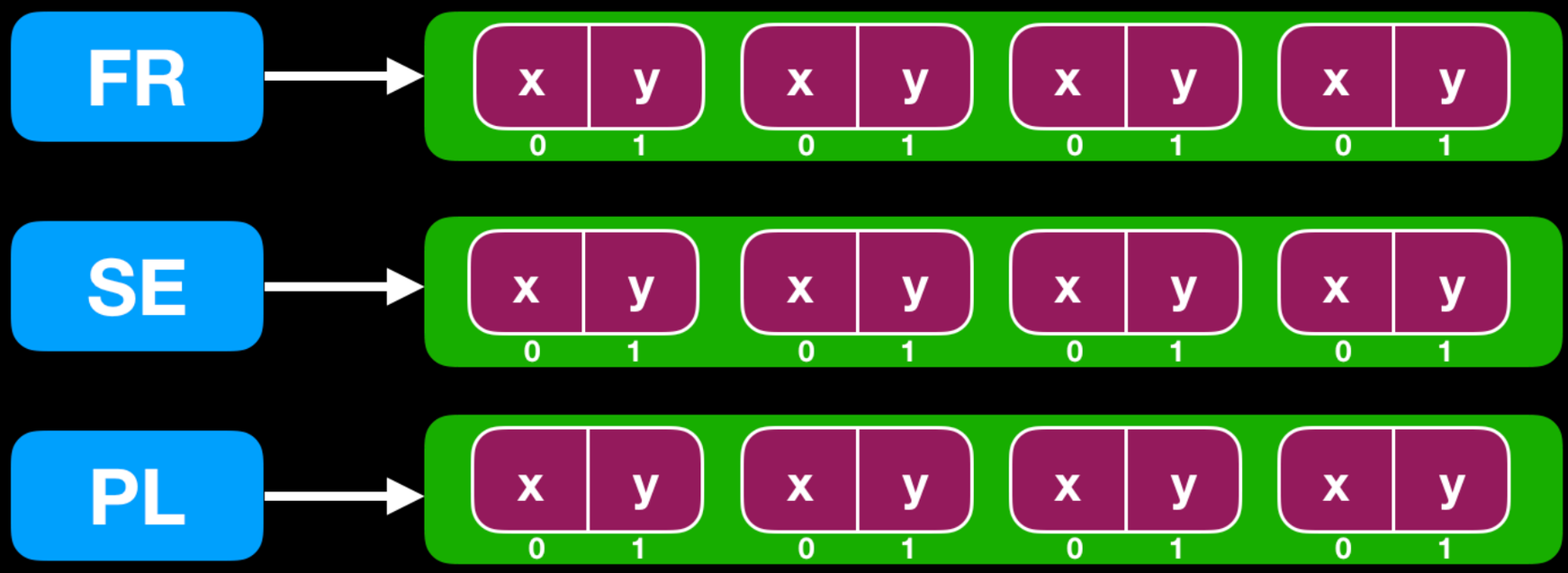
HashMap<String, ArrayList<x, y pairs>>



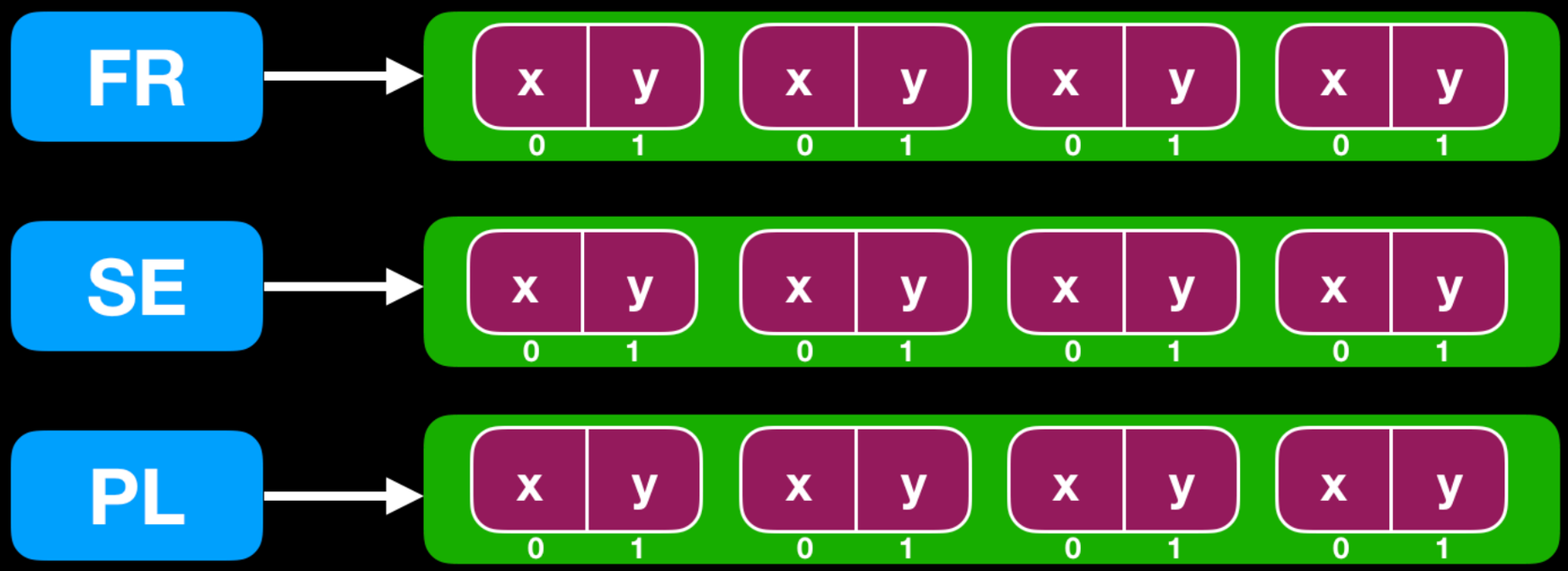
Mapping Genomes

HashMap<country code, country points>

HashMap<String, ArrayList<points>>

HashMap<String, ArrayList<x, y pairs>>

HashMap<String, ArrayList<Double[]>>



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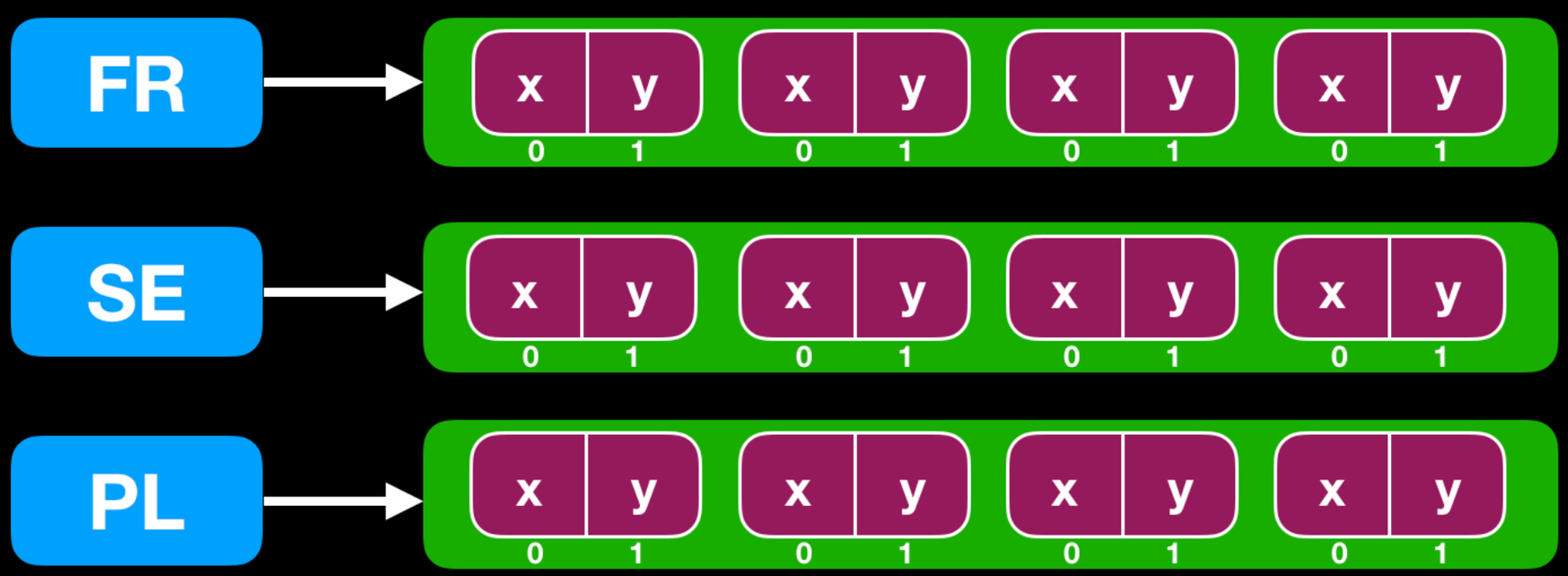

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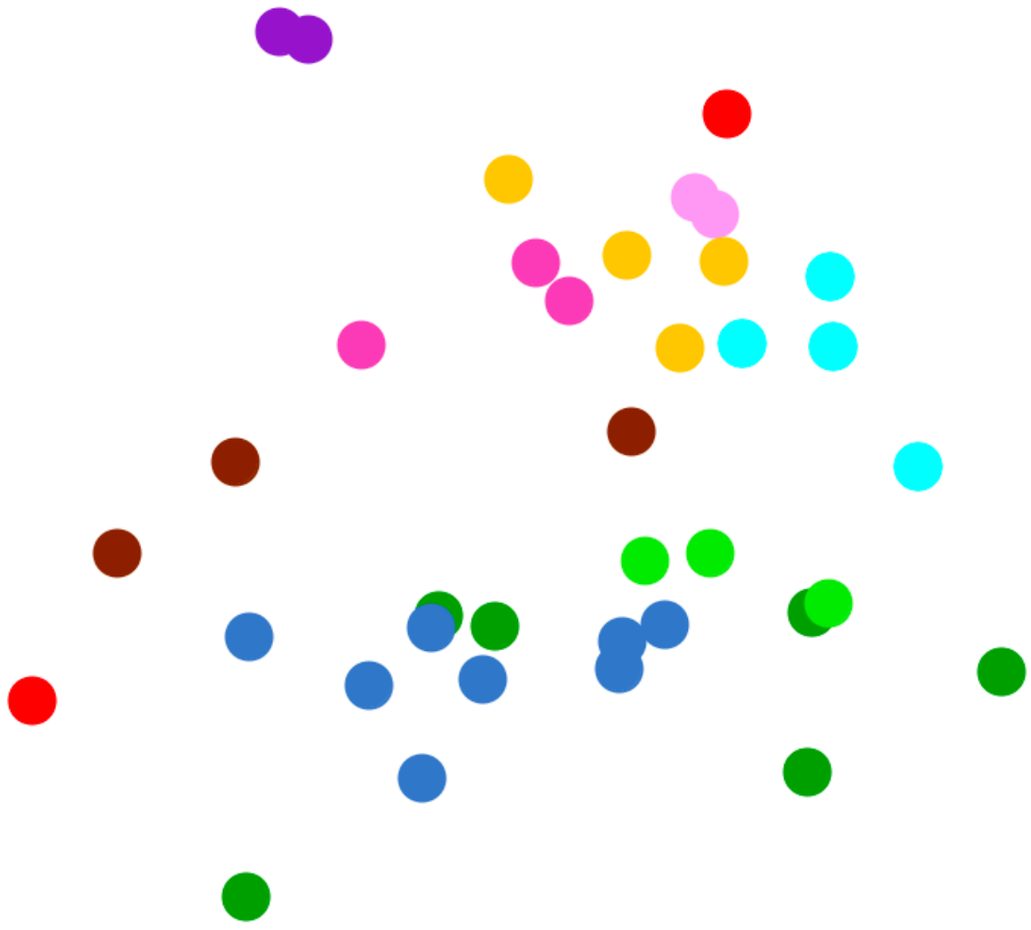
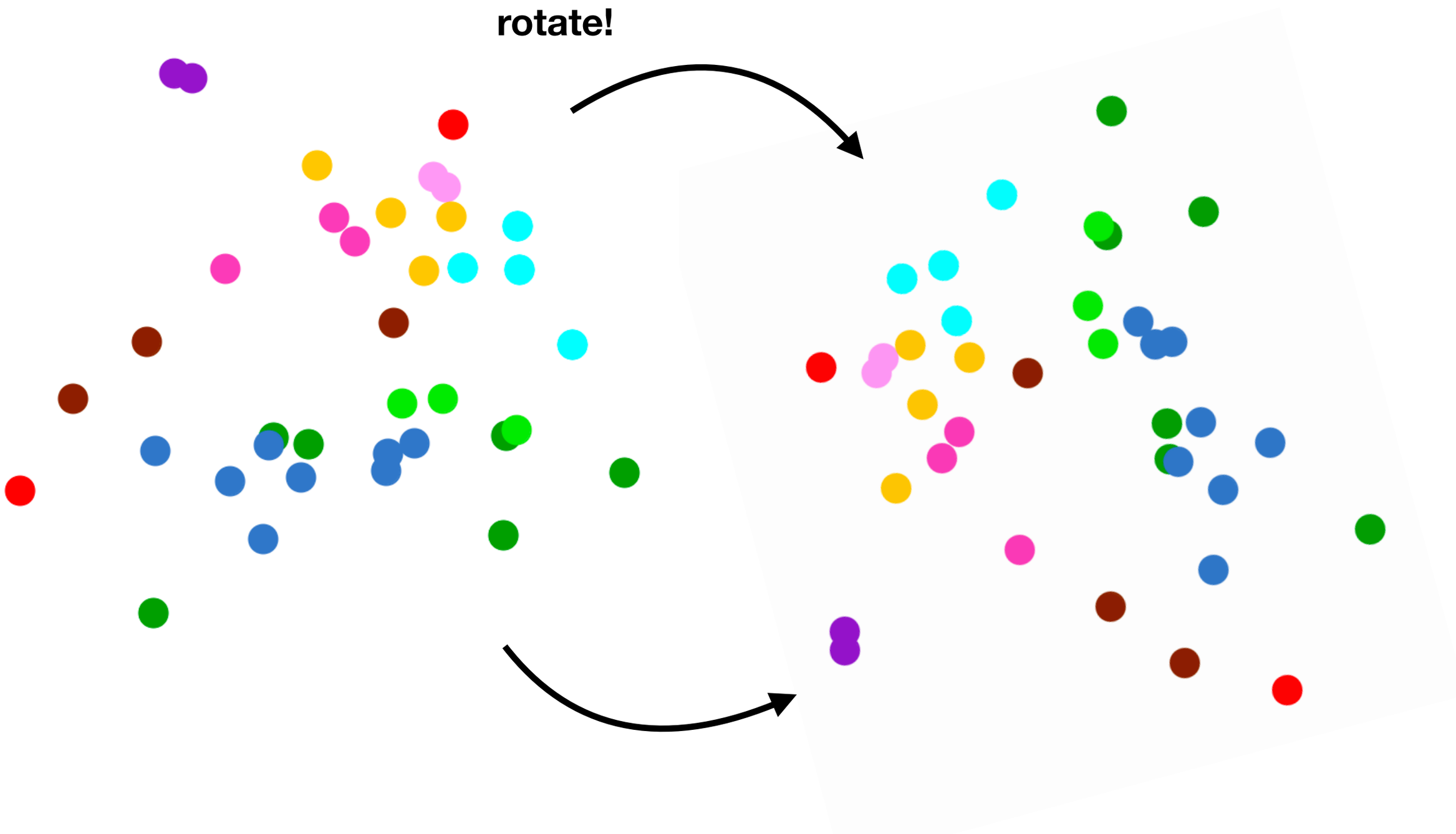


our data visualization output

Mapping Genomes

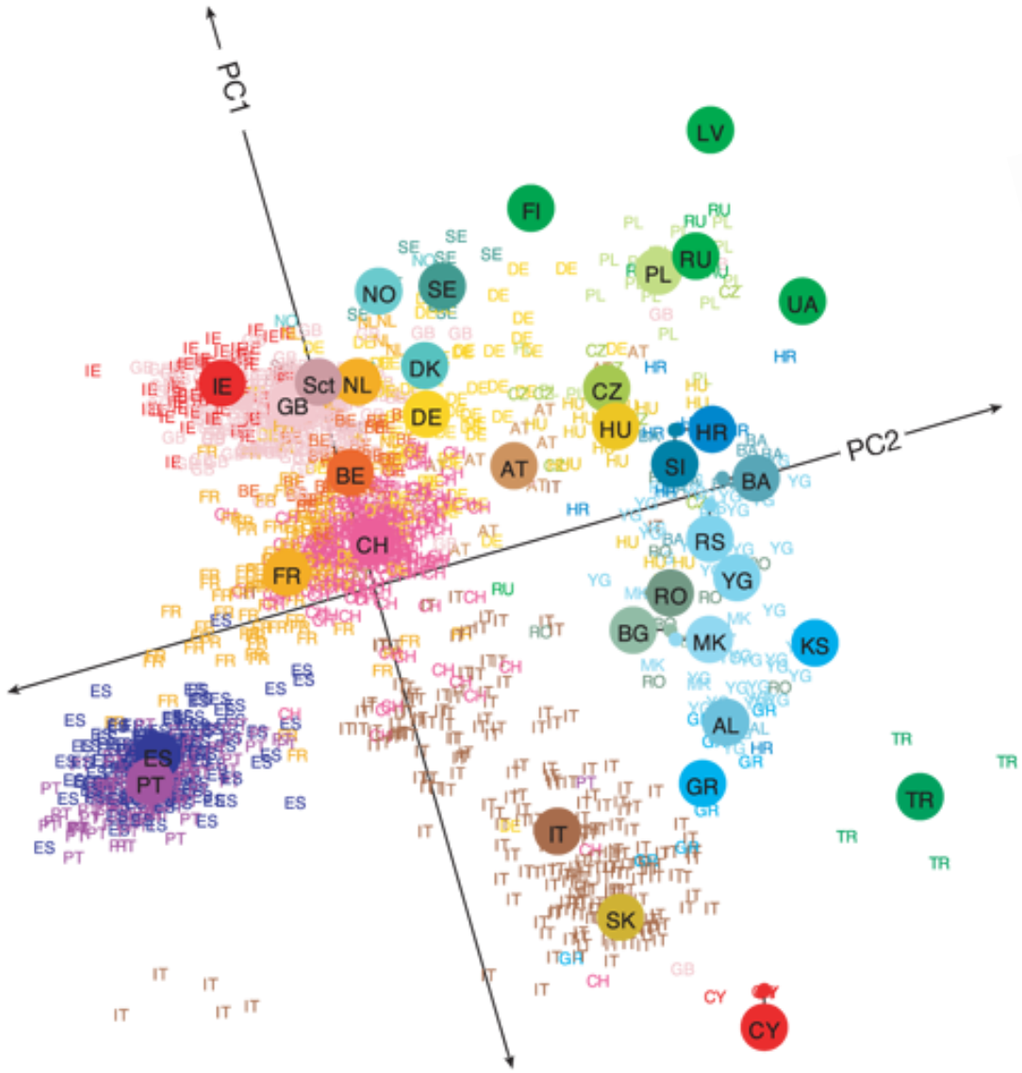


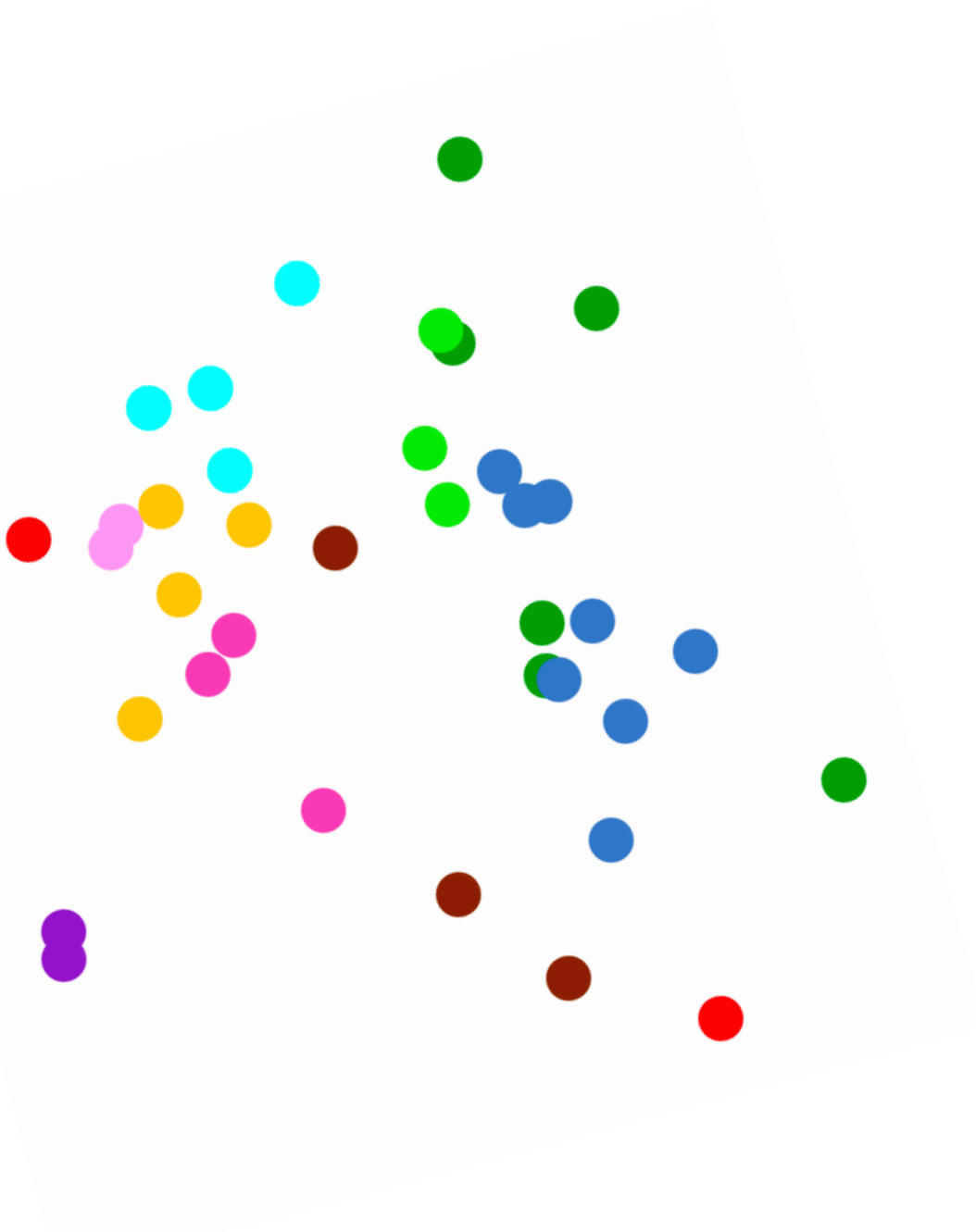
Mapping Genomes

same information, just at a different angle

Mapping Genomes

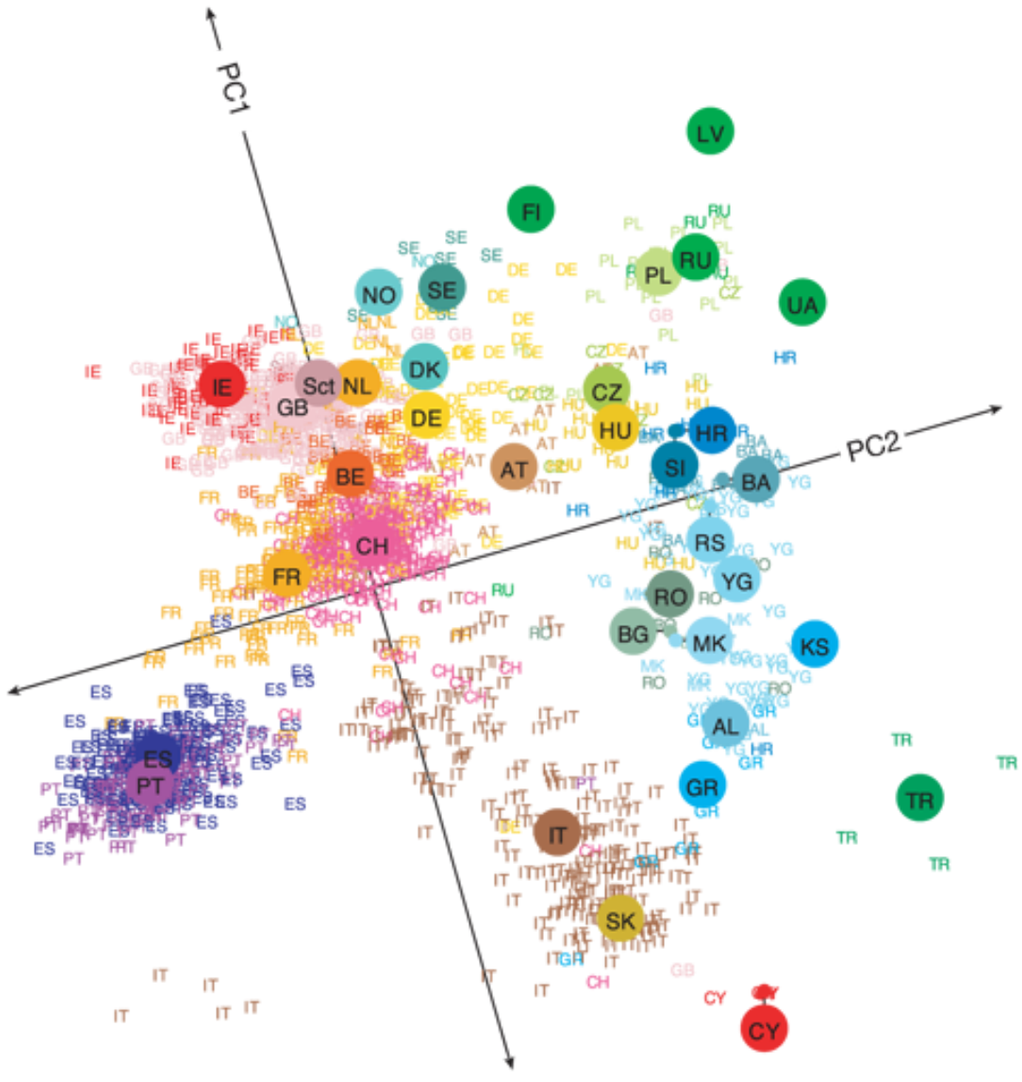
the full dataset, adjusted for sample sizes

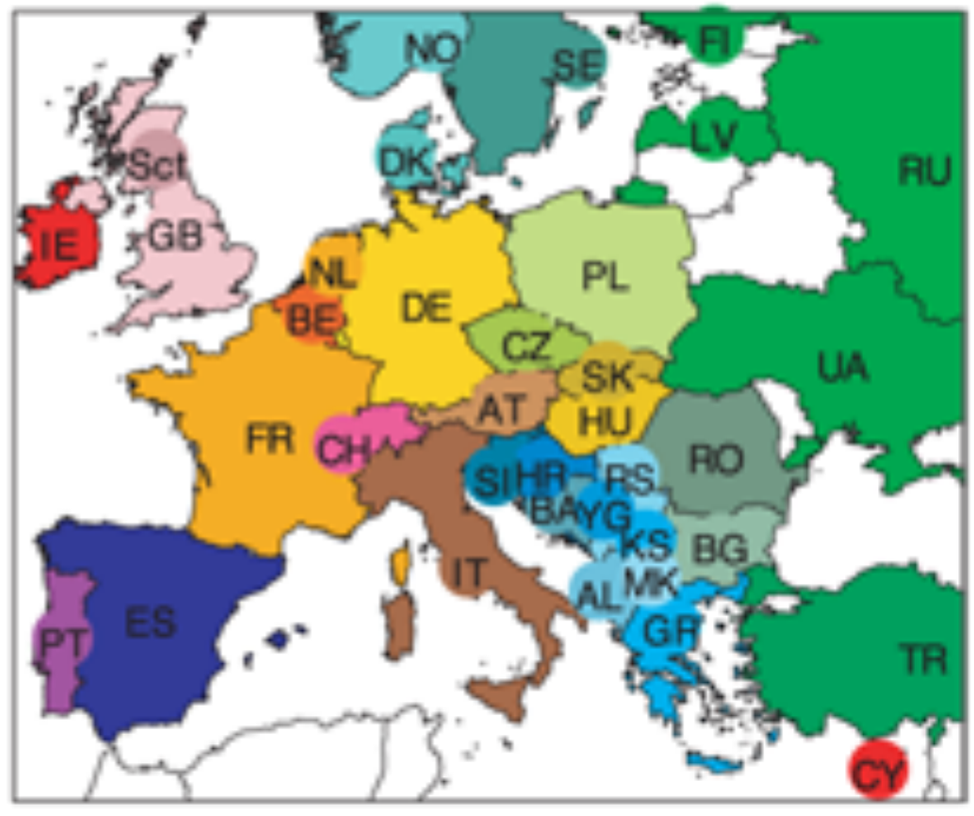




Mapping Genomes

the way genomes differ mathematically
corresponds to their differences in geographical origin!

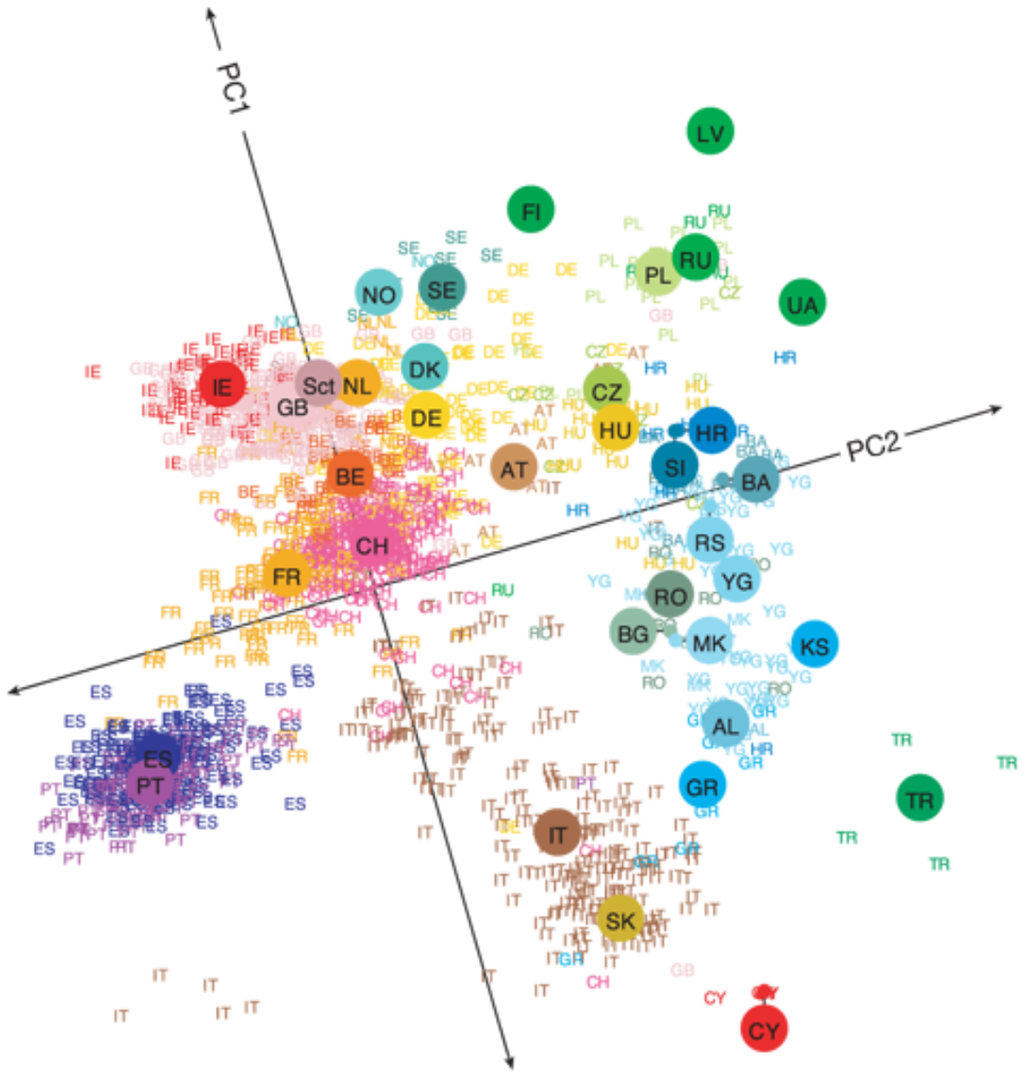


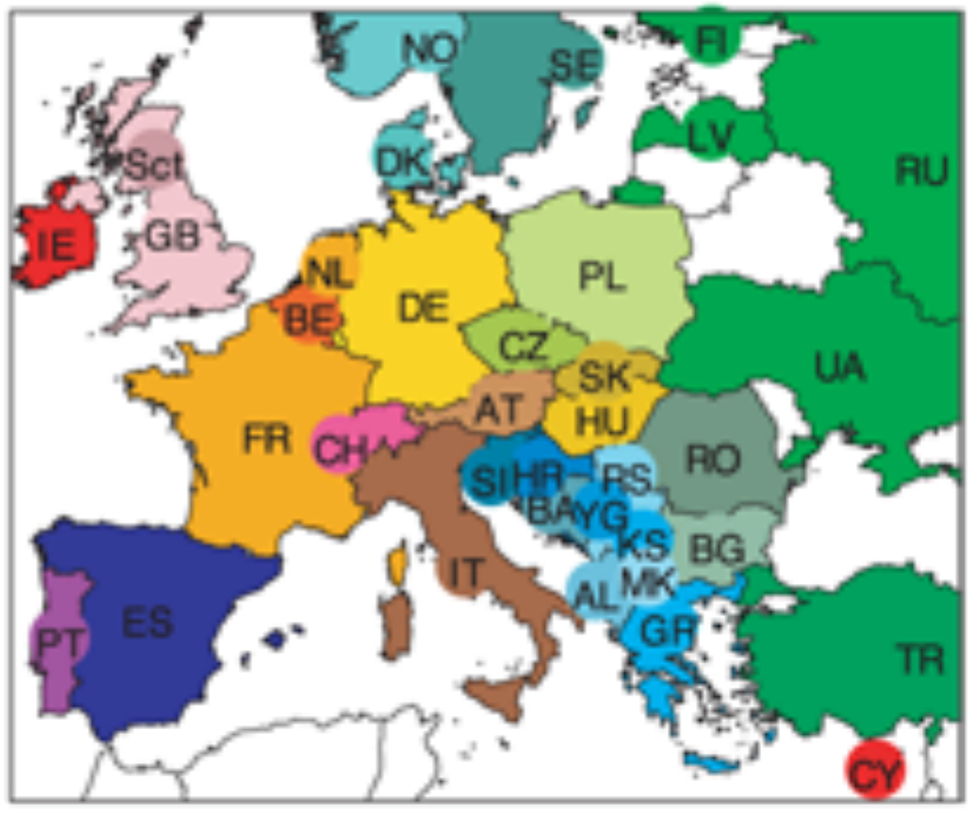


https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2735096/pdf/nihms132060.pdf

Mapping Genomes

all it took was a `HashMap`, and some `ArrayLists`, and some `arrays` of `doubles`...





https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2735096/pdf/nihms132060.pdf