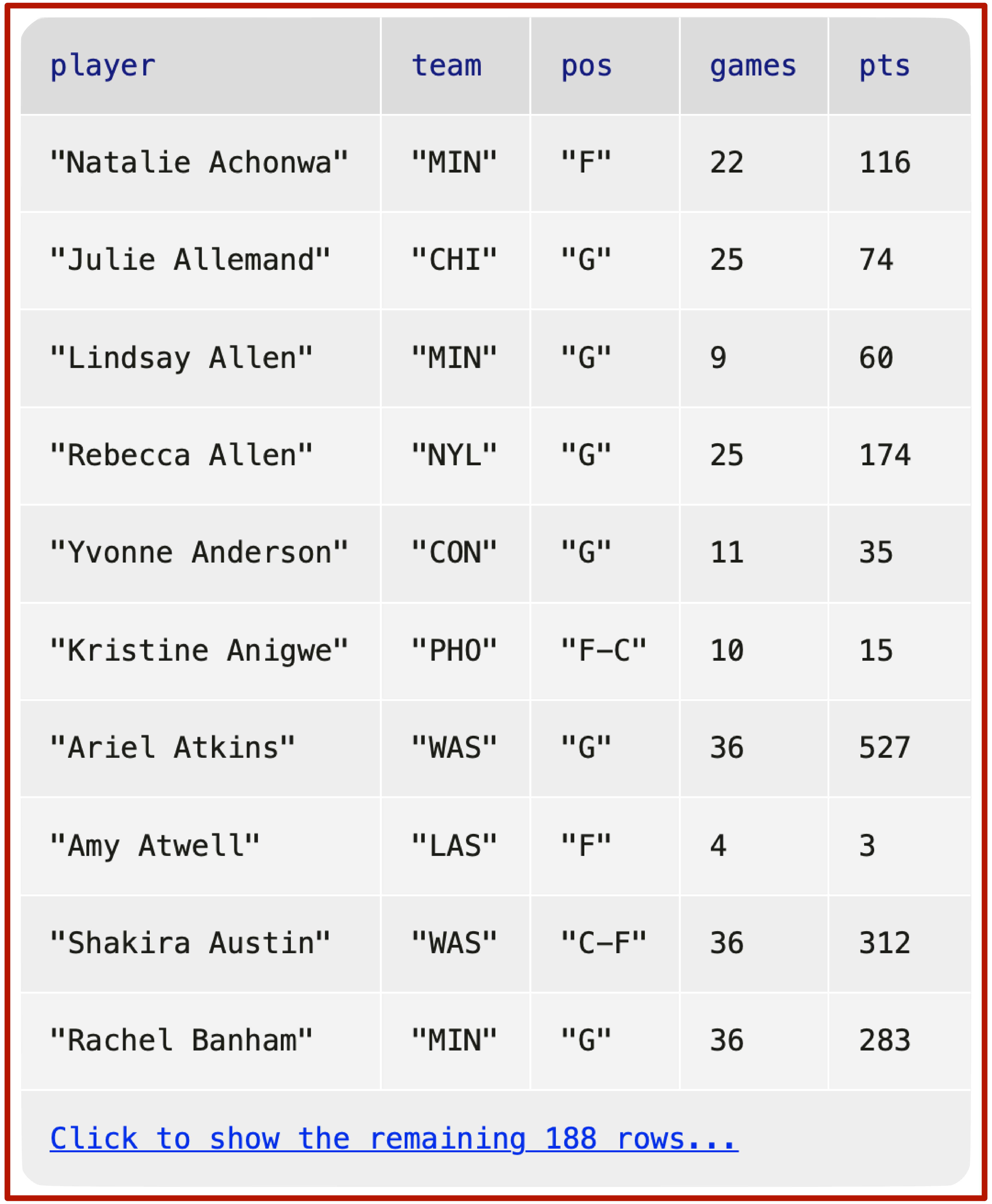
CMPU 101 § 54 · Computer Science I

Tables and Lists

8 February 2023

Where are we?

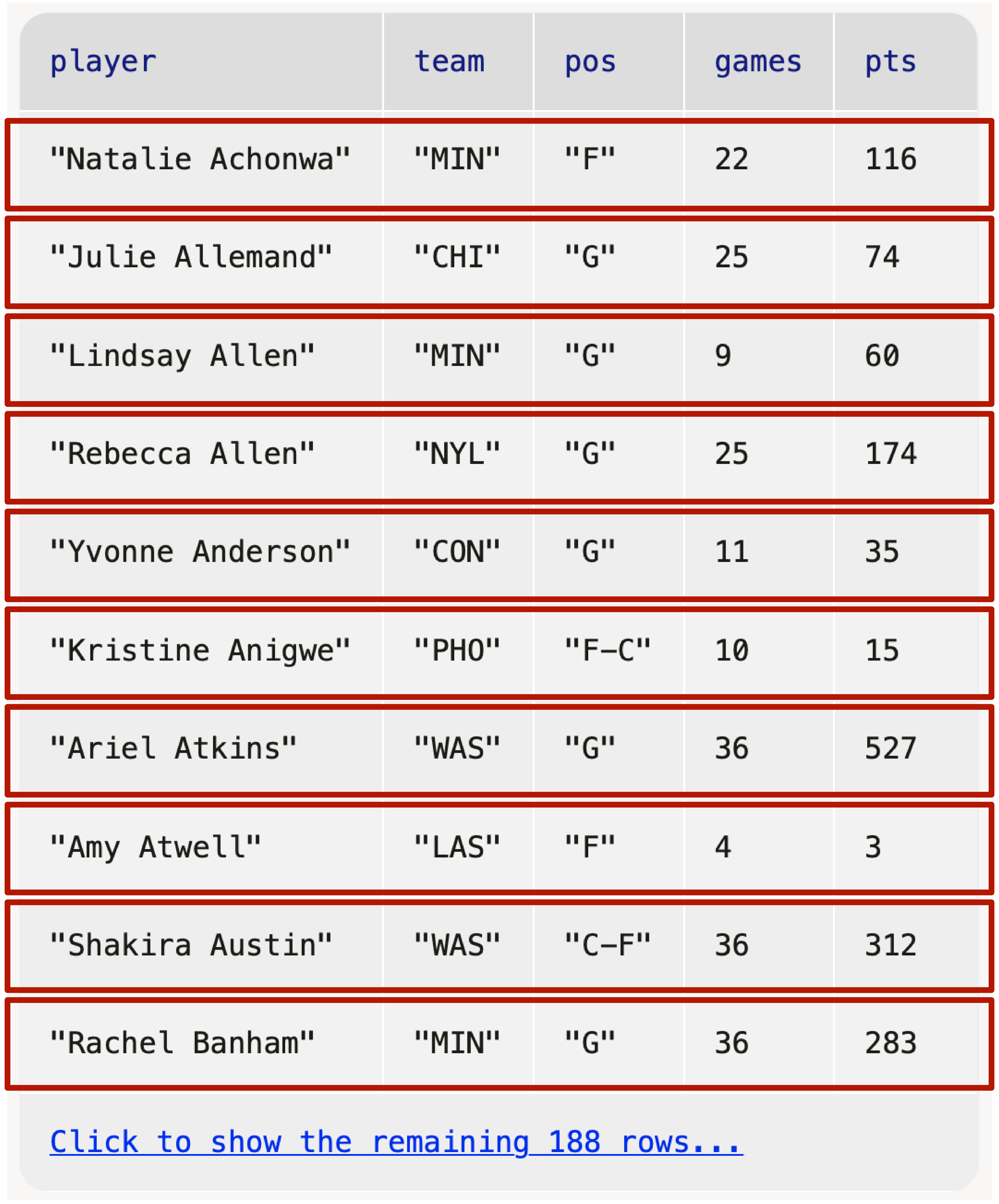
(SEA, then NY, I believe)



player	team	pos	games	pts
"Natalie Achonwa"	"MIN"	"F"	22	116
"Julie Allemand"	"CHI"	"G"	25	74
"Lindsay Allen"	"MIN"	"G"	9	60
"Rebecca Allen"	"NYL"	"G"	25	174
"Yvonne Anderson"	"CON"	"G"	11	35
"Kristine Anigwe"	"PHO"	"F-C"	10	15
"Ariel Atkins"	"WAS"	"G"	36	527
"Amy Atwell"	"LAS"	"F"	4	3
"Shakira Austin"	"WAS"	"C-F"	36	312
"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

Tables!



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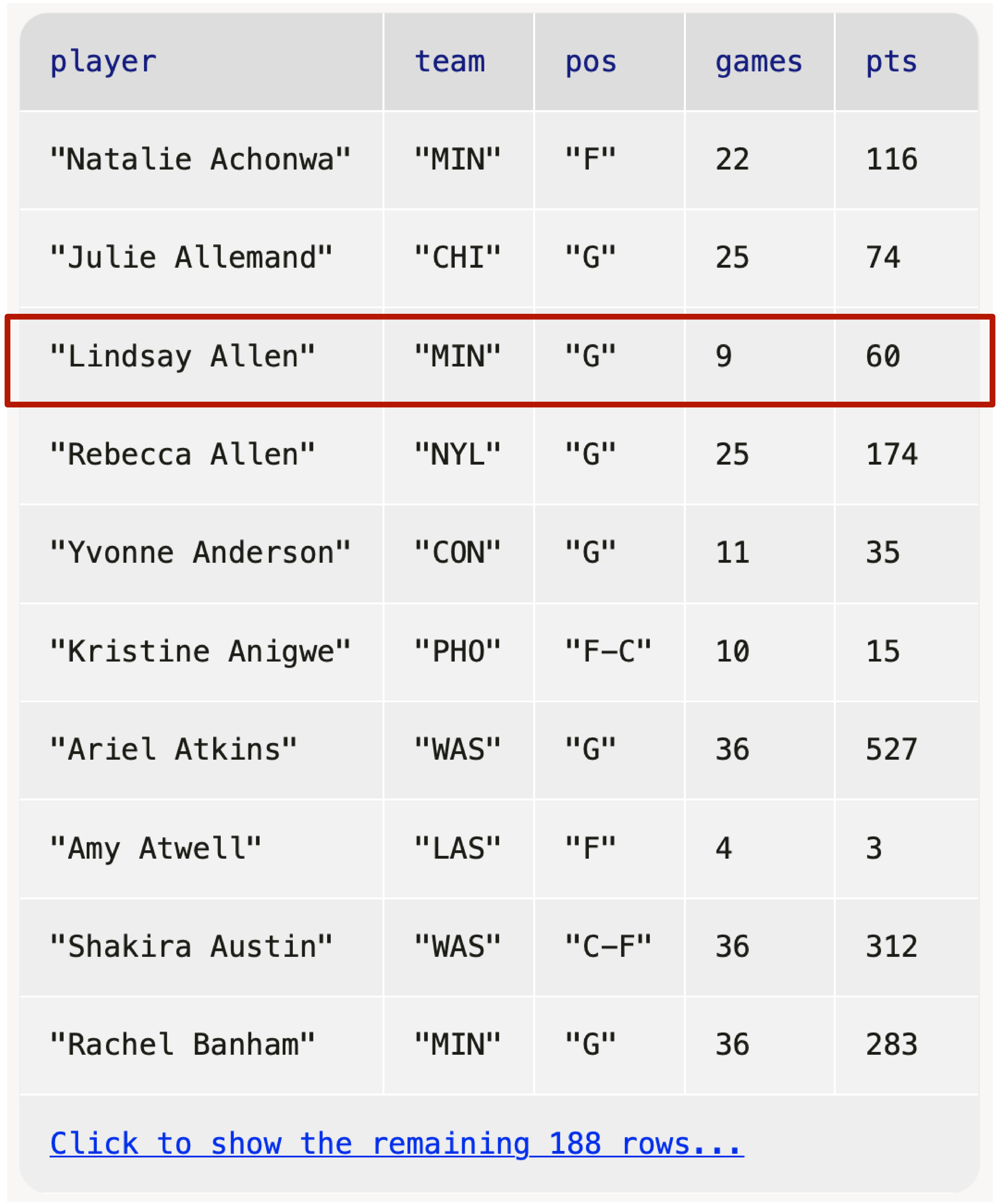
"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

Rows!

stats =



player	team	pos	games	pts
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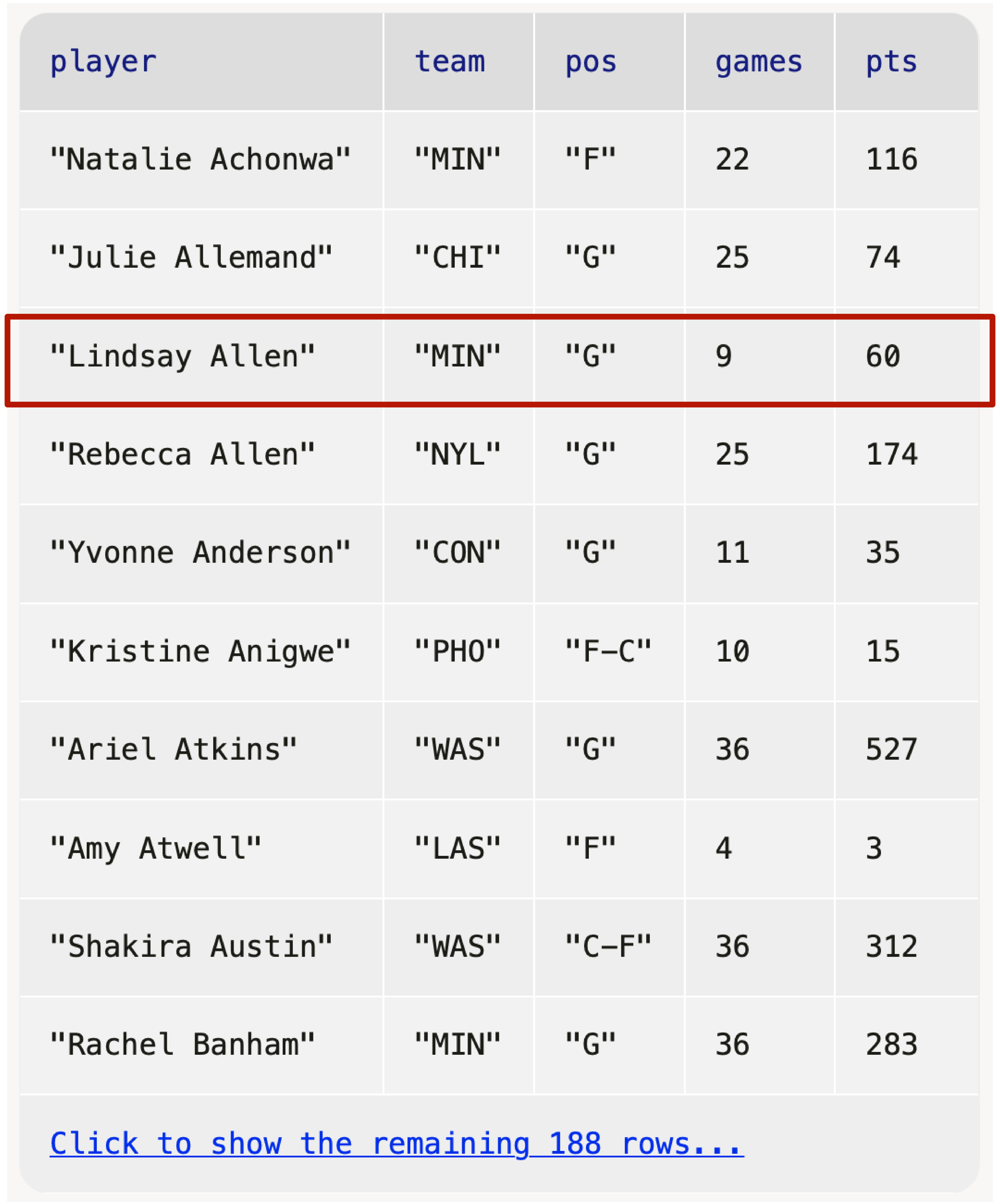
"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

How do I get just this row from ***stats****?*

stats =

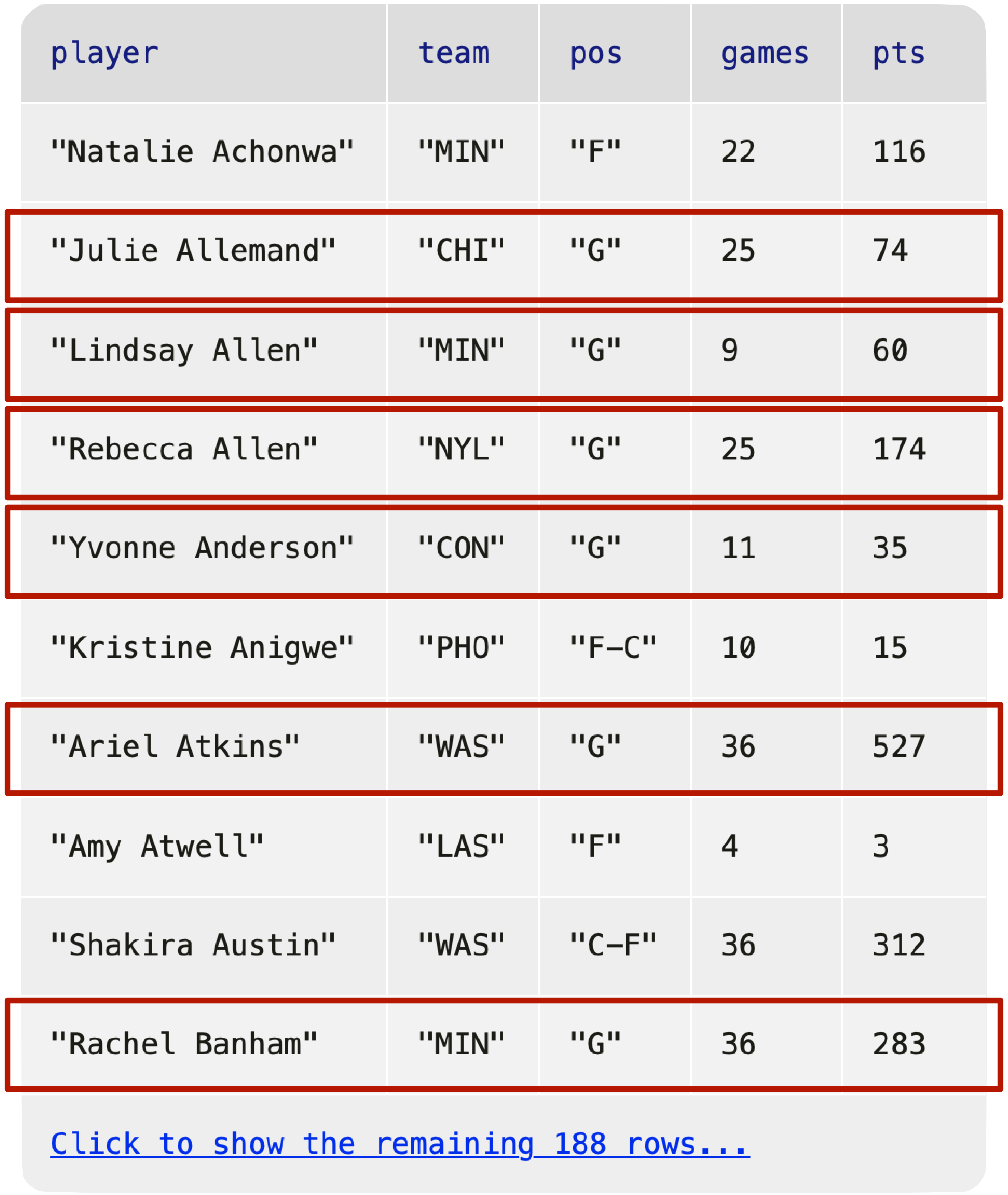


n	player	team	pos	games	pts
0	"Natalie Achonwa"	"MIN"	"F"	22	116
1	"Julie Allemand"	"CHI"	"G"	25	74
2	"Lindsay Allen"	"MIN"	"G"	9	60
3	"Rebecca Allen"	"NYL"	"G"	25	174
4	"Yvonne Anderson"	"CON"	"G"	11	35
5	"Kristine Anigwe"	"PHO"	"F-C"	10	15
6	"Ariel Atkins"	"WAS"	"G"	36	527
7	"Amy Atwell"	"LAS"	"F"	4	3
8	"Shakira Austin"	"WAS"	"C-F"	36	312
9	"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

*How do I get just this row from **stats**?*

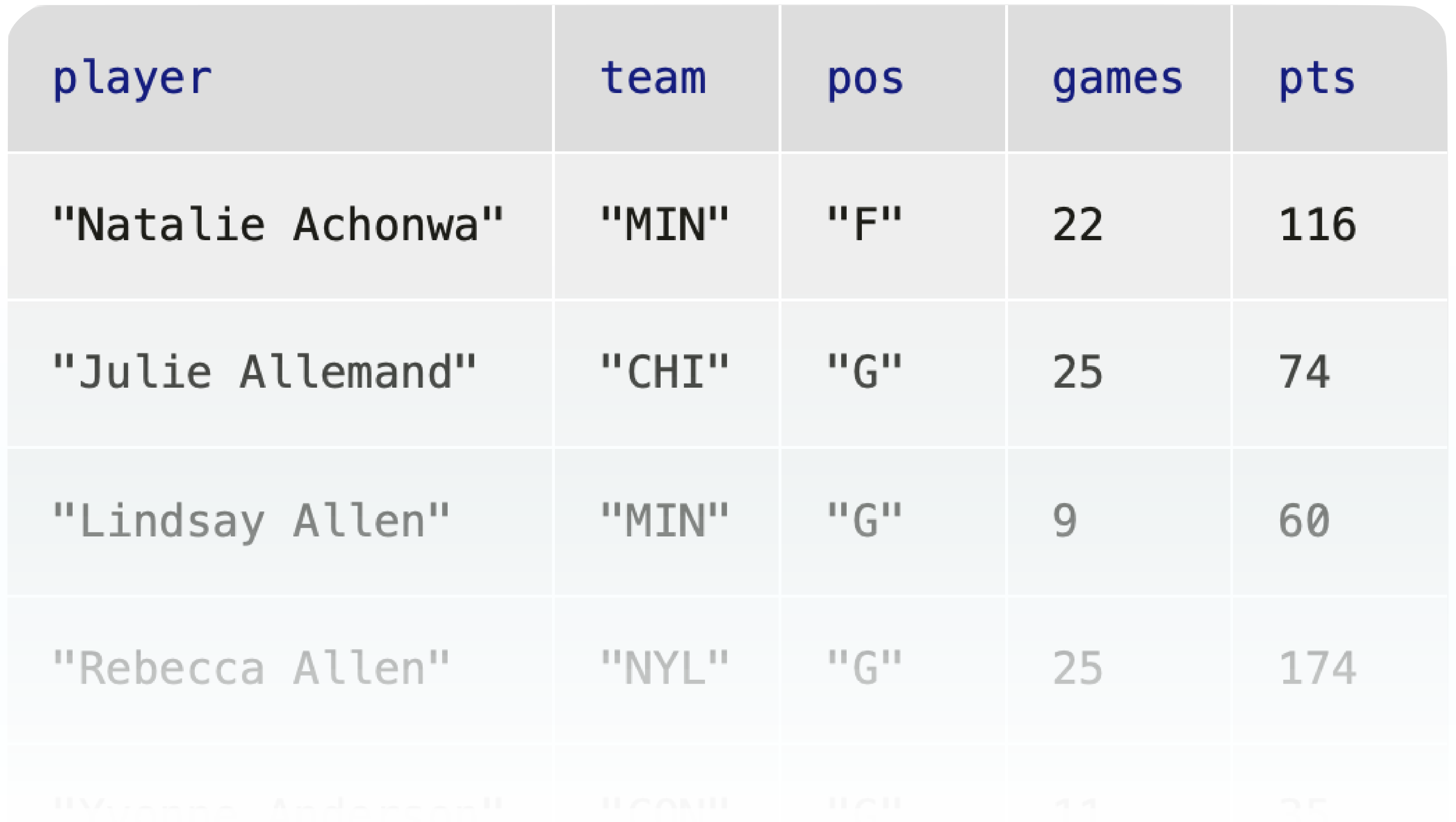
stats.row-n(2)



player	team	pos	games	pts
"Natalie Achonwa"	"MIN"	"F"	22	116
"Julie Allemand"	"CHI"	"G"	25	74
"Lindsay Allen"	"MIN"	"G"	9	60
"Rebecca Allen"	"NYL"	"G"	25	174
"Yvonne Anderson"	"CON"	"G"	11	35
"Kristine Anigwe"	"PHO"	"F-C"	10	15
"Ariel Atkins"	"WAS"	"G"	36	527
"Amy Atwell"	"LAS"	"F"	4	3
"Shakira Austin"	"WAS"	"C-F"	36	312
"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

How do I get just the rows for players who are guards?

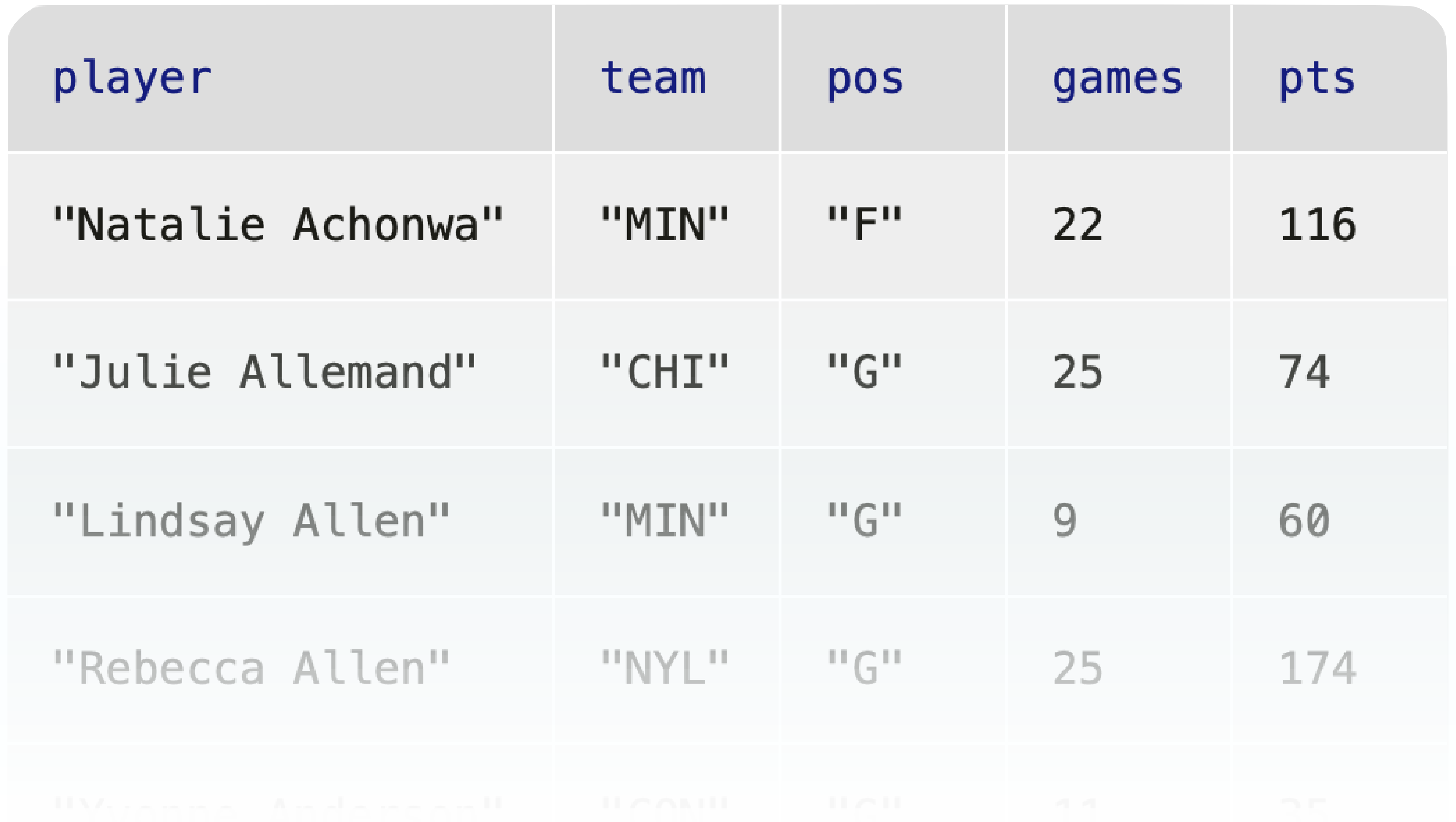


player	team	pos	games	pts
"Natalie Achonwa"	"MIN"	"F"	22	116
"Julie Allemand"	"CHI"	"G"	25	74
"Lindsay Allen"	"MIN"	"G"	9	60
"Rebecca Allen"	"NYL"	"G"	25	174

How do I get just the rows for players who are guards?

```
fun is-guard(player :: Row)
  -> Boolean:
  doc: "Return true if the player's primary position is guard"
  player["pos"] == "G"
where:
  is-guard(t.row-n(0)) is false
  is-guard(t.row-n(1)) is true
end
```

```
filter-with(stats,
  is-guard)
```



player	team	pos	games	pts
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"Yvonne Anderson"	"CON"	"G"	11	25

How do I get just the rows for players who are guards?

```
fun is-guard(player :: Row)
  -> Boolean:
  doc: "Return true if the player's primary position is
guard"
  player["pos"] == "G"
where:
  is-guard(t.row-n(0)) is false
  is-guard(t.row-n(1)) is true
end
```

```
filter-with(stats,
  lam(player):
    player["pos"] == "G"
  end)
```

PL’s rule of Lazy Programming: *programmers will invent ways to avoid writing verbose code.*
Corollary: *A coding solution that allows us to write less code and is functionally equivalent to a solution that requires us to write more code is the preferred solution*

This is the only place we want to use this helper function, so there’s no need to name it, document it, etc.

We can write less code (!) with a lambda expression.

```
filter-with(stats, lam(player): player["pos"] == "G" end)
```

player	team	pos	games	pts
"Natalie Achonwa"	"MIN"	"F"	22	116
"Julie Allemand"	"CHI"	"G"	25	74
"Lindsay Allen"	"MIN"	"G"	9	60
"Rebecca Allen"	"NYL"	"G"	25	174
"Yvonne Anderson"	"CON"	"G"	11	35
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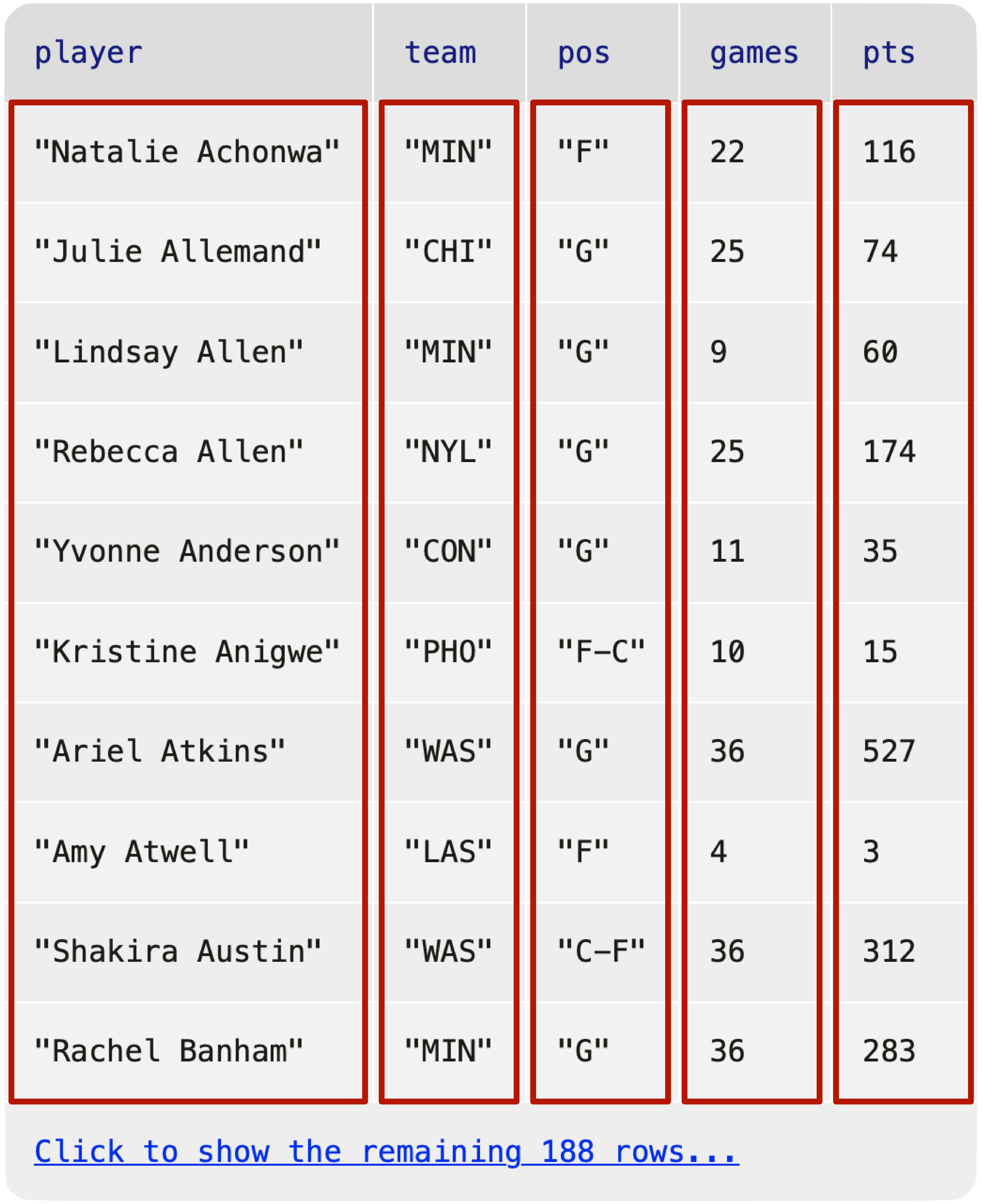
"Amy Atwell"	"LAS"	"F"	4	3
"Shakira Austin"	"WAS"	"C-F"	36	312
"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...



player	team	pos	games	pts
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"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

What about columns?

player	team	pos	games	pts	*frequent-player*
"Natalie Achonwa"	"MIN"	"F"	22	116	"very"
"Julie Allemand"	"CHI"	"G"	25	74	"very"
"Lindsay Allen"	"MIN"	"G"	9	60	"no"
"Rebecca Allen"	"NYL"	"G"	25	174	"very"
"Yvonne Anderson"	"CON"	"G"	11	35	"somewhat"
"Kristine Anigwe"	"PHO"	"F-C"	10	15	"somewhat"
"Ariel Atkins"	"WAS"	"G"	36	527	"very"
"Amy Atwell"	"LAS"	"F"	4	3	"no"
"Shakira Austin"	"WAS"	"C-F"	36	312	"very"
"Rachel Banham"	"MIN"	"G"	36	283	"very"

Click to show the remaining 188 rows...

How can I add a new column like this?

player	team	pos	games	pts	*frequent-player*
"Natalie Achonwa"	"MIN"	"F"	22	116	"very"
"Julie Allemand"	"CHI"	"G"	25	74	"very"
"Lindsay Allen"	"MIN"	"G"	9	60	"no"
"Rebecca Allen"	"NYL"	"G"	25	174	"very"
"Yvonne Anderson"	"CON"	"G"	11	35	"somewhat"
"Kristine Anigwe"	"PHO"	"F-C"	10	15	"somewhat"
"Ariel Atkins"	"WAS"	"G"	36	527	"very"

How can I add a new column like this?

Although we'll only use this function here, it'll be too long to conveniently write as a lambda expression.

```
build-column(stats, "frequent-player", how-frequent)
```

player	team	pos	games	pts	*frequent-player*
"Natalie Achonwa"	"MIN"	"F"	22	116	"very"
"Julie Allemand"	"CHI"	"G"	25	74	"very"
"Lindsay Allen"	"MIN"	"G"	9	60	"no"
			25	174	"very"
			11	35	"somewhat"
			10		
			36		

```
fun how-frequent(player :: Row)
  -> String:
 if player["games"] >= 20:
   "very"
  else if player["games"] >= 10:
   "somewhat"
  else:
   "no"
  end
end
```

*Be sure to add a docstring and **where** block to make this definition complete!*

```
build-column(stats, "frequent-player", how-frequent)
```

Changing a column

So, we’ve seen that we can build a new column based on the values in each row, but what if we just want to change an existing column?

player	team	pos	games	pts
"Natalie Achonwa"	"MIN"	"F"	22	116
"Julie Allemand"	"CHI"	"G"	25	74
"Lindsay Allen"	"MIN"	"G"	9	60
"Rebecca Allen"	"NYL"	"G"	25	174
"Yvonne Anderson"	"CON"	"G"	11	35
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"Amy Atwell"	"LAS"	"F"	4	3
"Shakira Austin"	"WAS"	"C-F"	36	312
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Click to show the remaining 188 rows...

A fake WNBA fan like me can't remember what these team abbreviations stand for.

Let's fill in the actual team names.

What *are* the team names?

	WESTERN		EASTERN
DAL	Dallas Wings	ATL	Atlanta Dream
LVA	Las Vegas Aces	CHI	Chicago Sky
LAS	Los Angeles Sparks	CON	Connecticut Sun
MIN	Minnesota Lynx	IND	Indiana Fever
PHO	Phoenix Mercury	NYL	New York Liberty
SEA	Seattle Storm	WAS	Washington Mystics

```
fun team-name(abbr :: String) -> String:
  doc: "Return the name of the team with the given abbreviation"
  ...
where:
  team-name("NYL") is "New York Liberty"
  team-name("CHI") is "Chicago Sky"
  ...
end
```

Use this as a template:

- Start with (grey) keywords
- Fill in fun: I/O (input/output), etc.
- Fill in doc: with something descriptive
- Use ellipses for code (TBD)
- Think of tests to write in where: clause

(to help us write the actual function code)

- Don’t forget to end the function

```
fun team-name(abbr :: String) -> String:
  doc: "Return the name of the team with the given abbreviation"
  ...
where:
  team-name("NYL") is "New York Liberty"
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  ...
end
```

Use this as a template:

- Start with (grey) keywords
- Fill in fun: I/O (input/output), etc.
- Fill in doc: with something descriptive
- Use ellipses for code (TBD)
- Think of tests to write in where: clause

(to help us write the actual function code)

- Don’t forget to end the function

(I don’t have to write “`return type`”, just “`->`”)

```
fun team-name(abbr :: String) -> String:
 doc: "Return the name of the team with the given abbreviation"
 if abbr == "DAL": "Dallas Wings"
 else if abbr == "LVA": "Las Vegas Aces"
 ...
 end
where:
 team-name("NYL") is "New York Liberty"
 team-name("CHI") is "Chicago Sky"
 ...
end
```

This will work, but remember what we said when we introduced tables for looking up population: We want to ***separate data from computation****.*

```
teams =
table: abbr, name
  row: "DAL", "Dallas Wings"
  row: "LVA", "Las Vegas Aces"
  row: "LAS", "Los Angeles Sparks"
  row: "MIN", "Minnesota Lynx"
  row: "PHO", "Phoenix Mercury"
  row: "SEA", "Seattle Storm"
  row: "ATL", "Atlanta Dream"
  row: "CHI", "Chicago Sky"
  row: "CON", "Connecticut Sun"
  row: "IND", "Indiana Fever"
  row: "NYL", "New York Liberty"
  row: "WAS", "Washington Mystics"
end
```

Let’s use this new table we are calling teams!

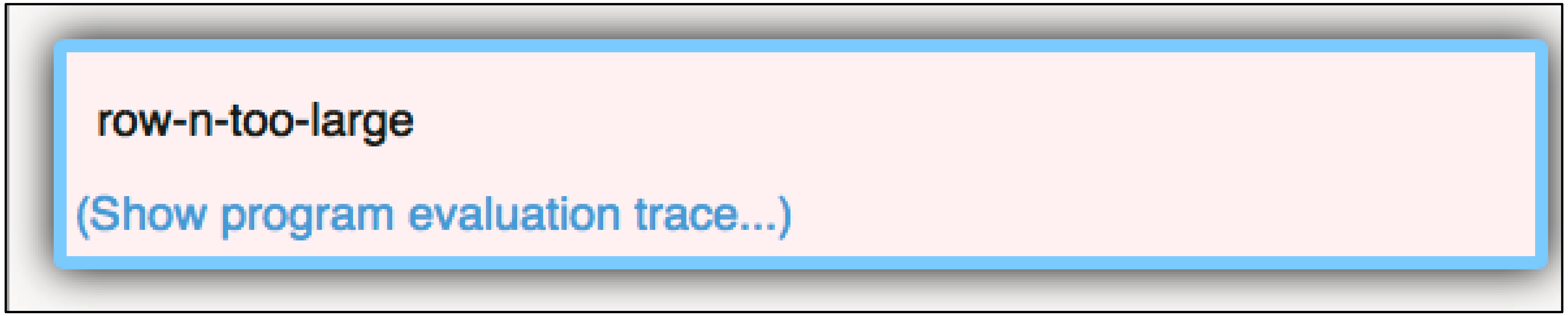
Advantage: This makes it easy to add new teams or more information about these teams, in a central place.

```
teams = ...

fun team-name(abbr :: String) -> String:
  doc: "Return the name of the team with the given abbreviation"
  # Get the row with abbreviation `abbr`
  # Return the value in the `name` column
where:
  team-name("NYL") is "New York Liberty"
  team-name("CHI") is "Chicago Sky"
  ...
end
```

```
teams = ...

fun team-name(abbr :: String) -> String:
 doc: "Return the name of the team with the given abbreviation"
 matches =
   filter-with(teams, lam(r): r["abbr"] == abbr end)
 team = matches.row-n(0)
 # Return the value in the `name` column
where:
 team-name("NYL") is "New York Liberty"
 team-name("CHI") is "Chicago Sky"
 ...
end
```

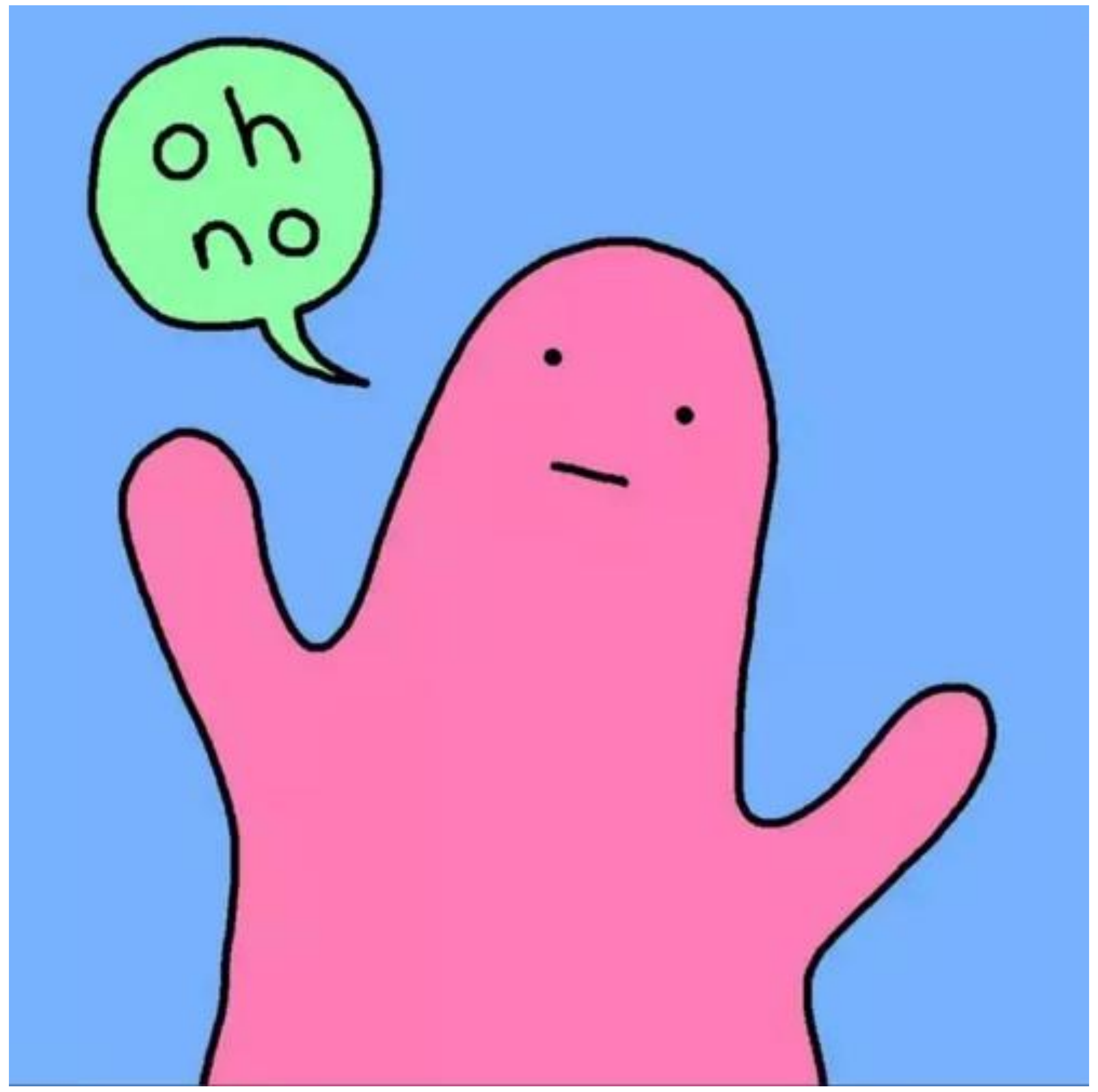
```
teams = ...

fun team-name(abbr :: String) -> String:
 doc: "Return the name of the team with the given abbreviation"
 matches =
  filter-with(teams, lam(r): r["abbr"] == abbr end)
 team = matches.row-n(0)
 team["name"]
where:
 team-name("NYL") is "New York Liberty"
 team-name("CHI") is "Chicago Sky"
 ...
end
```

```
teams = ...

fun team-name(abbr :: String) -> String:
  doc: "Return the name of the team with the given abbreviation"
  matches =
    filter-with(teams, lam(r): r["abbr"] == abbr end)
  team = matches.row-n(0)
  team["name"]
where:
  team-name("NYL") is "New York Liberty"
  team-name("CHI") is "Chicago Sky"
  ...
end

transform-column(stats, "team", team-name)
```



```
row-n-too-large
```

(Show program evaluation trace...)



```
teams = ...

fun team-name(abbr :: String) -> String:
  doc: "Return the name of the team with the given abbreviation"
  matches =
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  team = matches.row-n(0)
  team["name"]
where:
  team-name("NYL") is "New York Liberty"
  team-name("CHI") is "Chicago Sky"
  ...
end

transform-column(stats, "team", team-name)
```

0 is too big? That means there were no matching rows! An abbreviation not in our table. What is it?

```
teams = ...

fun team-name(abbr :: String) -> String:
 doc: "Return the name of the team with the given abbreviation"
 matches =
  filter-with(teams, lam(r): r["abbr"] == abbr end)
 if matches.length() == 0:
  abbr
 else:
  team = matches.row-n(0)
  team["name"]
 end
where:
 ...
end

transform-column(stats, "team", team-name)
```

"A'ja Wilson"	"Las Vegas Aces"	"F"	36	703
"Han Xu"	"New York Liberty"	"C"	32	273
"Jackie Young"	"Las Vegas Aces"	"G"	34	542
"Li Yueru"	"Chicago Sky"	"C"	16	28
"Emma Cannon"	"TOT"	"F"	24	164
"Tina Charles"	"TOT"	"C"	34	502
"Crystal Dangerfield"	"TOT"	"G"	33	180
"Kaela Davis"	"TOT"	[illegible]	[illegible]	34
"Rennia Davis"	"TOT"	"F"	8	10
"AD Durr"	"TOT"	"G"	25	174
"Reshanda Gray"	"TOT"	"F"	27	59

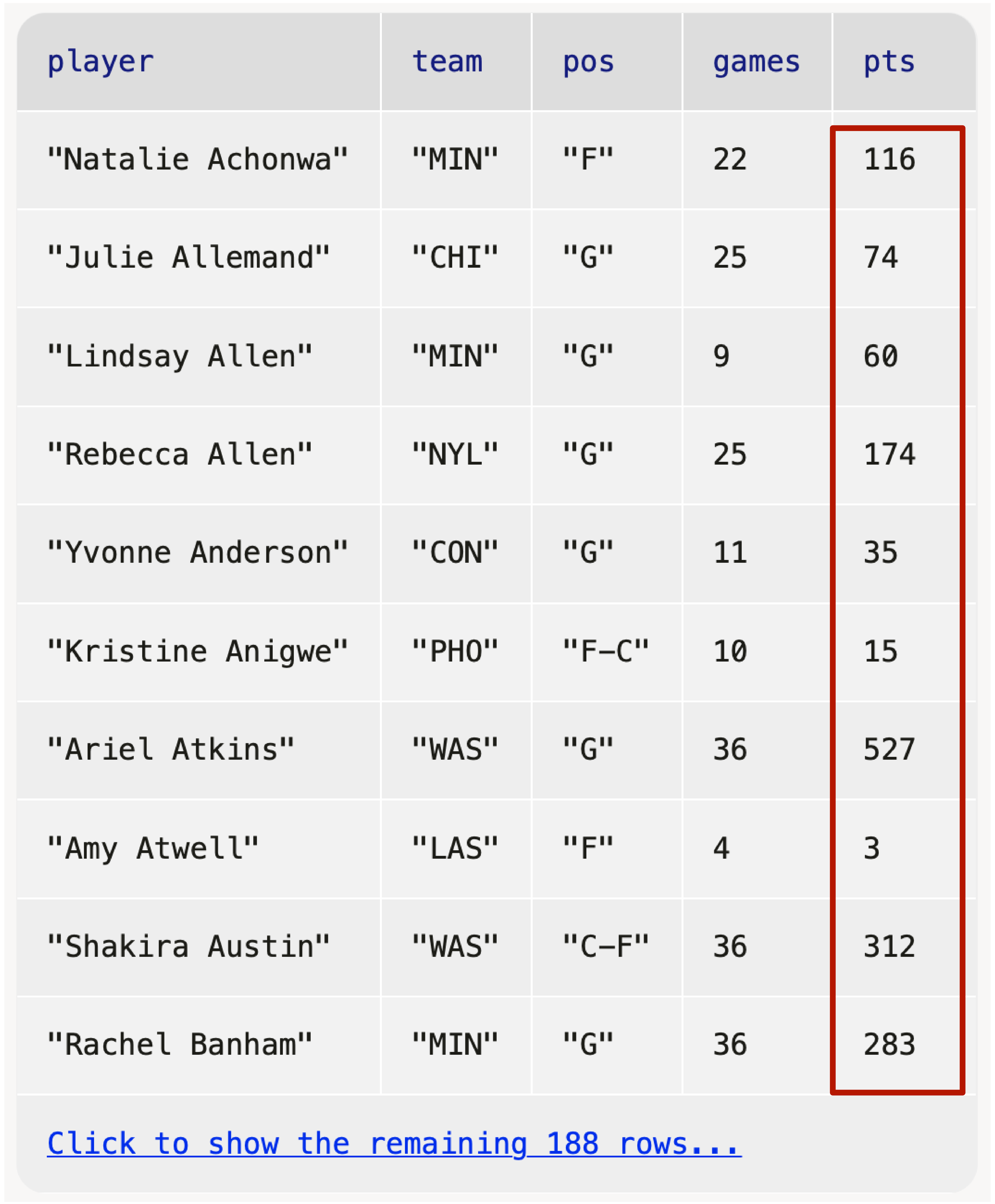
Total? Players who played for more than one team?

What’s a column anyway?

We’ve seen that when you want a row of a table, you use **.row-n** and get a Row.

What about getting a column?

stats =



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"Amy Atwell"	"LAS"	"F"	4	3
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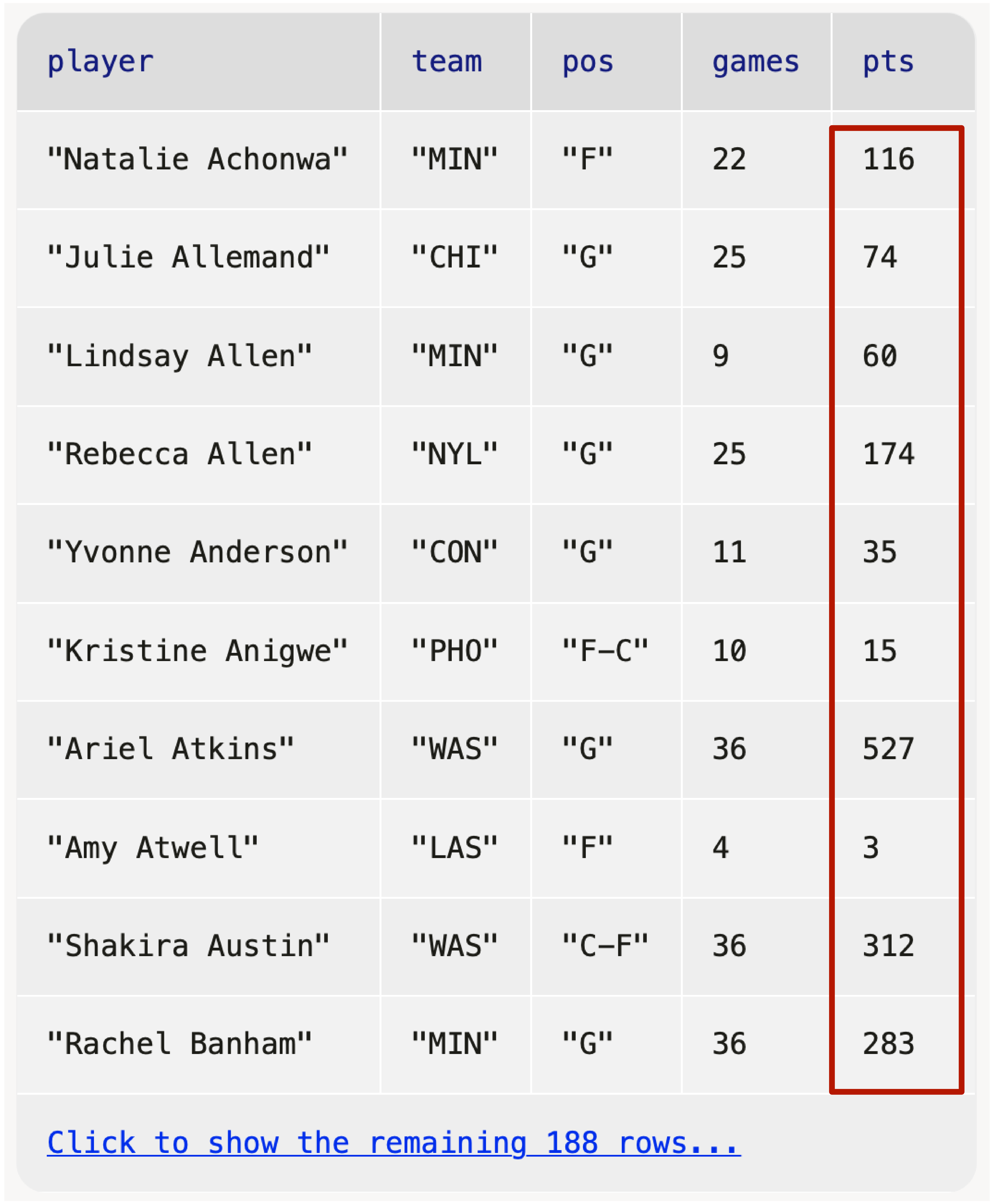
"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

How do I get just the points column?

stats =



player	team	pos	games	pts
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"Rachel Banham"	"MIN"	"G"	36	283

Click to show the remaining 188 rows...

How do I get just the points column?

```
stats.column("pts")
```

```
››› stats.get-column("pts")
[list: 116, 74, 60, 174, 35, ...]
```

The data type isn’t Column; it’s List!

A *List* is an ordered sequence of data.

For example,

```
grades = [list: 0.96, 0.73, 1.0, 0.5]

fellowship = [list:
  "Frodo", "Sam", "Merry", "Pippin", "Gandalf",
  "Legolas", "Gimli", "Aragorn", "Boromir"
]
```

So, what good is a List?

Mad Libs!

Plural-Noun
Plural-Noun
Plural-Noun *Number*
Plural-Noun
Noun

Noun
Noun *Noun* *Body-Part*

Alphabet-Letter
Plural-Noun
Plural-Noun *Plural-Noun*
Body-
Part *Body-Part*

Adjective *Noun*

Thousands of ago, there were calendars that enabled the ancient to divide a year into twelve , each month into weeks, and each week into seven . At first, people told time by a sun clock, sometimes known as the dial. Ultimately, they invented the great timekeeping devices of today, such as the grandfather , the pocket , the alarm , and, of course, the watch. Children learn about clocks and time almost before they learn their A-B- s. They are taught that a day consists of 24 , an hour has 60 , and a minute has 60 . By the time they are in Kindergarten, they know if the big is at twelve and the little is at three, that it is Number o'clock. I wish we could continue this lesson, but we've run out of .

How can we represent a text?

template = "Thousands of Plural-Noun ago, there were calendars that enabled the ancient Plural-Noun to divide a year into twelve Plural-Noun , each month into Number weeks, and each week into seven Plural-Noun . At first, people told time by a sun clock, sometimes known as the Noun dial. Ultimately, they invented the great timekeeping devices of today, such as the grandfather Noun , the pocket Noun , the alarm Noun , and, of course, the Body-Part watch. Children learn about clocks and time almost before they learn their A-B- Alphabet-Letter s. They are taught that a day consists of 24 Plural-Noun , an hour has 60 Plural-Noun , and a minute has 60 Plural-Noun . By the time they are in Kindergarten, they know if the big Body-Part is at twelve and the little Body-Part is at three, that it is Number o'clock. I wish we could continue this Adjective lesson, but we’ve run out of Noun ."

```
template = "Thousands of Plural-Noun ago, ..."

template-words = string-split-all(template, " ")
```

```
››› template-words
[list: "Thousands", "of", "Plural-Noun", "ago", ...]
```

```
template = "Thousands of Plural-Noun ago, ..."

template-words = string-split-all(template, " ")
```

```
››› template-words
[list: "Thousands", "of", "Plural-Noun", "ago", ...]
```

We need to substitute a random plural noun here!

"Thousands of Plural-Noun ago, ..."

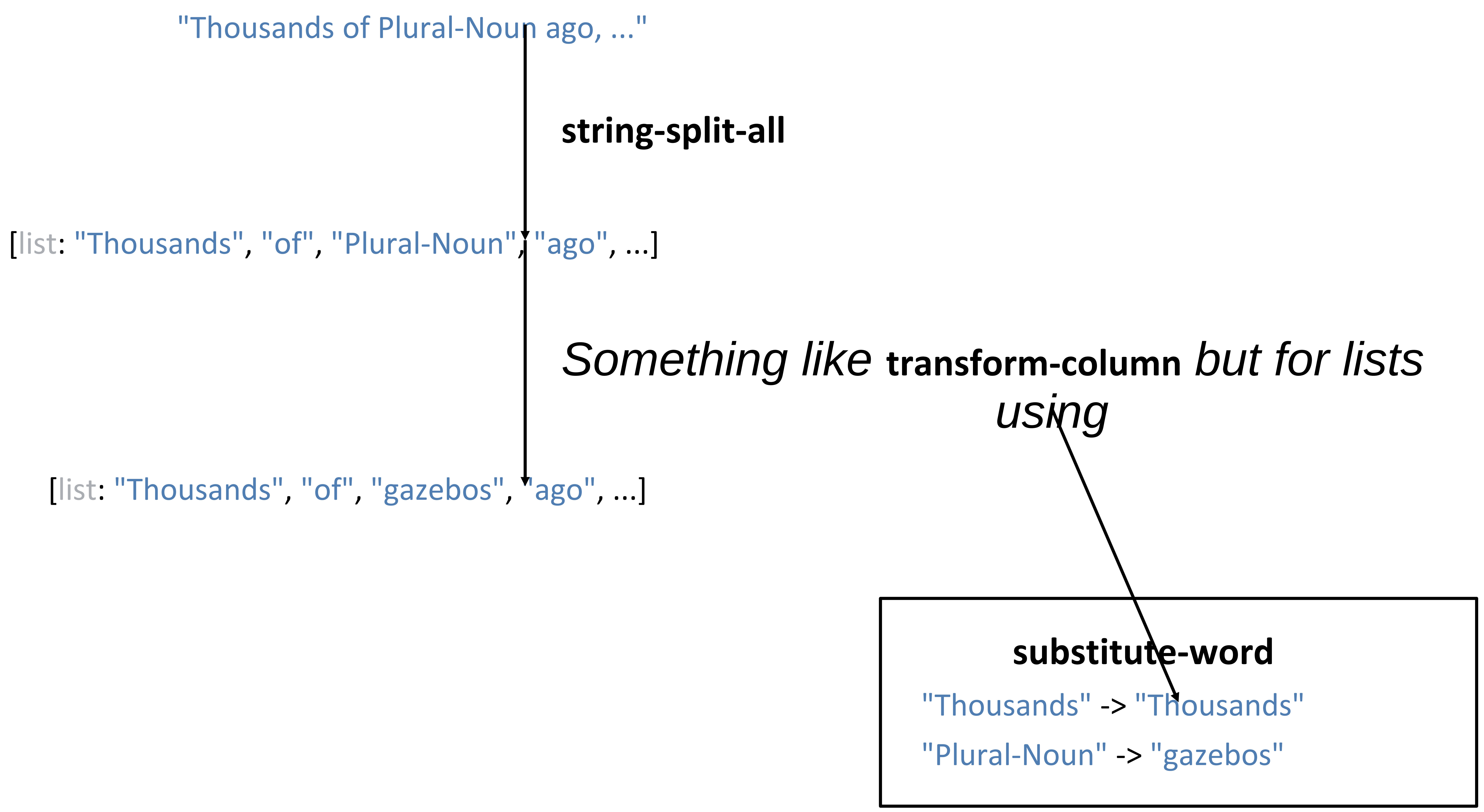
string-split-all

[list: "Thousands", "of", "Plural-Noun", "ago", ...]

Something like **transform-column** *but for lists*

[list: "Thousands", "of", "gazebos", "ago", ...]

Needs a helper function!



"Thousands of Plural-Noun ago, ..."

string-split-all

[list: "Thousands", "of", "Plural-Noun", "ago", ...]

Something like **transform-column** *but for lists using*

[list: "Thousands", "of", "gazebos", "ago", ...]

substitute-word

"Thousands" -> "Thousands"

"Plural-Noun" -> "gazebos"

I’d write the helper function first!

```
fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  ...
where:
  substitute-word("Thousands") is "Thousands"
  substitute-word("Plural-Noun") is ...
end
```

Uh oh! We don’t know what particular word it will be!

```
fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  ...
where:
  substitute-word("Thousands") is "Thousands"
  substitute-word("Plural-Noun") is-not "Plural-Noun"
end
```

We know what it isn’t!

```
plural-nouns = [list: "gazebos", "avocados", "pandas"]

fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  ...
where:
  substitute-word("Thousands") is "Thousands"
  substitute-word("Plural-Noun") is-not "Plural-Noun"
  plural-nouns.member(
    substitute-word("Plural-Noun"))
    is true
end
```

And we know it’s one of the right choic

```
plural-nouns = [list: "gazebos", "avocados", "pandas"]

fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  ...
where:
  substitute-word("Thousands") is "Thousands"
  substitute-word("Plural-Noun") is-not "Plural-Noun"
  plural-nouns.member(
    substitute-word("Plural-Noun"))
    is true
end
```

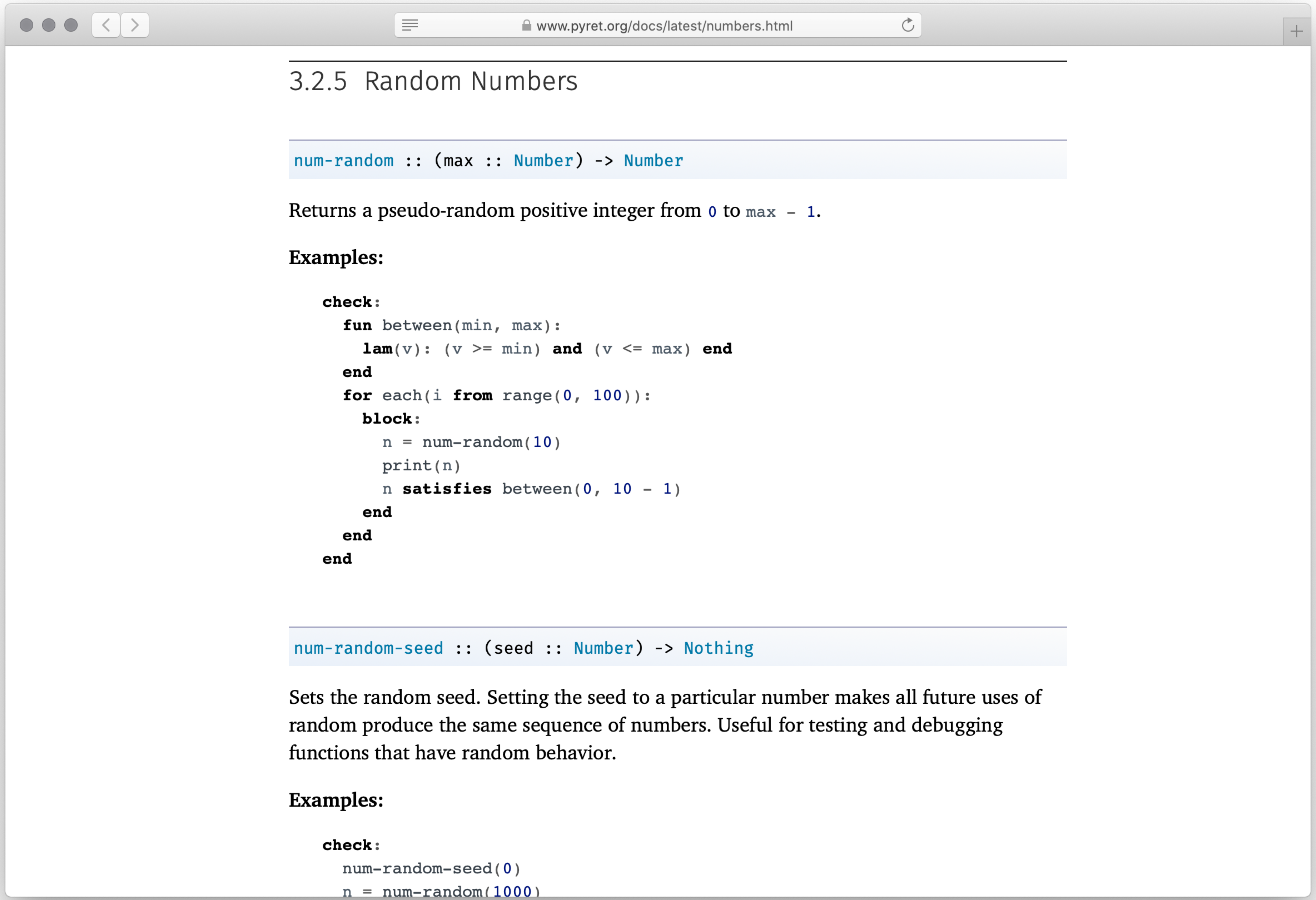
The left part of an example can be any expression!

```
plural-nouns = [list: "gazebos", "avocados", "pandas"]

fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  if w == "Plural-Noun":
    ...
  else:
    w
  end
where:
  ...
end
```

We need a random element of a list.

Time to check the Pyret documentation!



3.2.5 Random Numbers

```
num-random :: (max :: Number) -> Number
```

Returns a pseudo-random positive integer from `0` to `max - 1`.

Examples:

```
check:
  fun between(min, max):
    lam(v): (v >= min) and (v <= max) end
  end
  for each(i from range(0, 100)):
    block:
      n = num-random(10)
      print(n)
      n satisfies between(0, 10 - 1)
    end
  end
end
```

```
num-random-seed :: (seed :: Number) -> Nothing
```

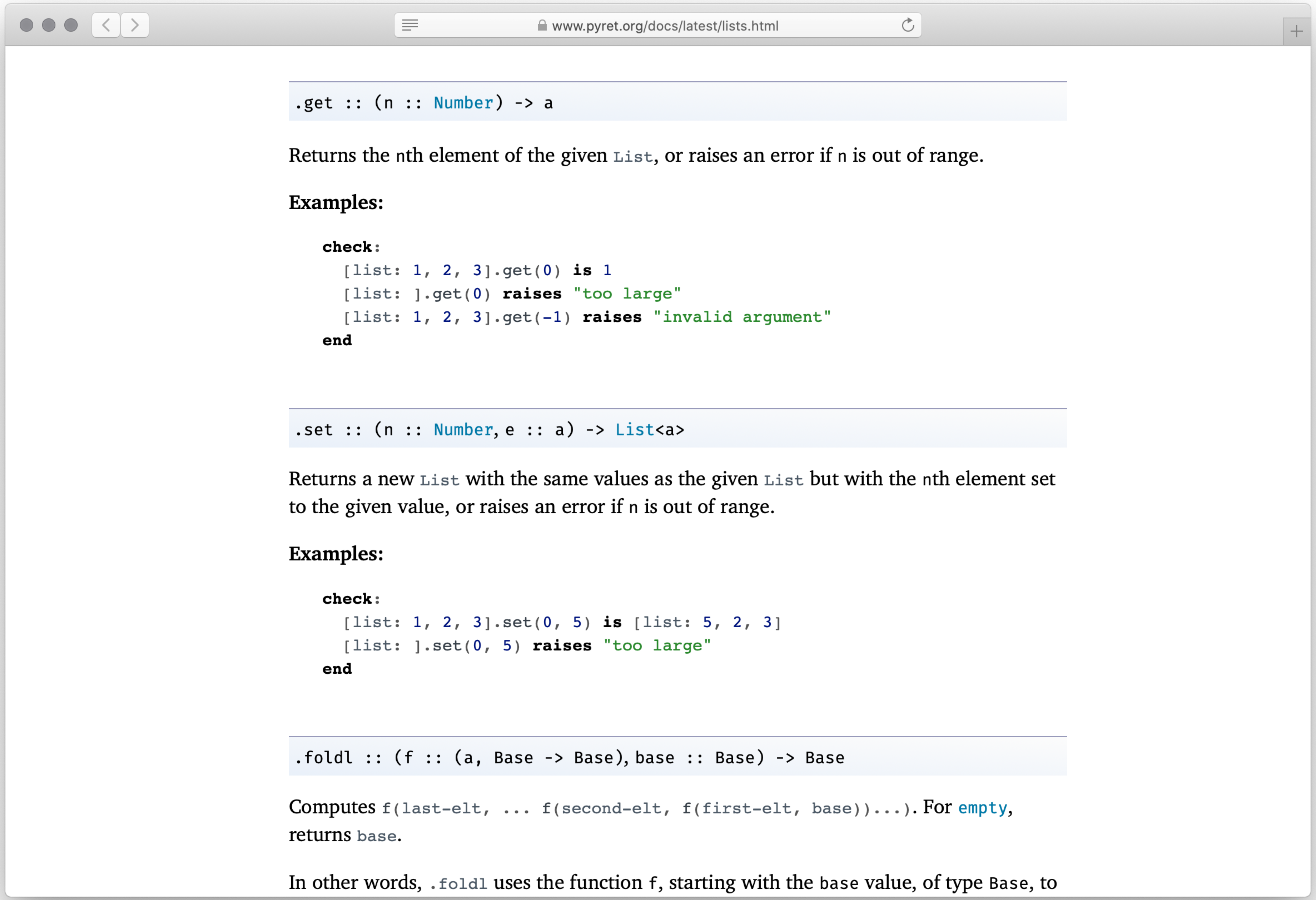
Sets the random seed. Setting the seed to a particular number makes all future uses of random produce the same sequence of numbers. Useful for testing and debugging functions that have random behavior.

Examples:

```
check:
  num-random-seed(0)
  n = num-random(1000)
```

We didn’t find a built-in way to get a random element of a list, but we found a way to get a random number.

How could we use this?



```
.get :: (n :: Number) -> a
```

Returns the nth element of the given `List`, or raises an error if `n` is out of range.

Examples:

```
check:
  [list: 1, 2, 3].get(0) is 1
  [list: ].get(0) raises "too large"
  [list: 1, 2, 3].get(-1) raises "invalid argument"
end
```

```
.set :: (n :: Number, e :: a) -> List<a>
```

Returns a new `List` with the same values as the given `List` but with the nth element set to the given value, or raises an error if `n` is out of range.

Examples:

```
check:
  [list: 1, 2, 3].set(0, 5) is [list: 5, 2, 3]
  [list: ].set(0, 5) raises "too large"
end
```

```
.foldl :: (f :: (a, Base -> Base), base :: Base) -> Base
```

Computes `f(last-elt, ... f(second-elt, f(first-elt, base))...)`. For `empty`, returns `base`.

In other words, `.foldl` uses the function `f`, starting with the `base` value, of type `Base`, to

With a table, we could use **.row-n** to get a specific row by its index number.

With a list, we can use **.get** to get an item.

Get a random number

Get then list element positioned at that number

```
plural-nouns = [list: "gazebos", "avocados", "pandas"]


fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  if w == "Plural-Noun":
    rand = num-random(3)
    plural-nouns.get(rand)
  else:
    w
  end
where:
  ...
end
```

```
plural-nouns = [list: "gazebos", "avocados", "pandas"]


fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  if w == "Plural-Noun":
    rand = num-random(3)
    plural-nouns.get(rand)
  else:
    w
  end
where:
  ...
end
```

```
plural-nouns = [list: "gazebos", "avocados", "pandas",
  "quokkas"]

fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  if w == "Plural-Noun":
    rand = num-random(3)
    plural-nouns.get(rand)
  else:
    w
  end
where:
  ...
end
```

```
plural-nouns = [list: "gazebos", "avocados", "pandas",
  "quokkas"]

fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  if w == "Plural-Noun":
    rand = num-random(length(plural-nouns))
    plural-nouns.get(rand)
  else:
    w
  end
where:
  ...
end
```

template = "Thousands of Plural-Noun ago, there were calendars that enabled the ancient Plural-Noun to divide a year into twelve Plural-Noun , each month into Number weeks, and each week into seven Plural-Noun . At first, people told time by a sun clock, sometimes known as the Noun dial. Ultimately, they invented the great timekeeping devices of today, such as the grandfather Noun, the pocket Noun , the alarm Noun , and, of course, the Body-Part watch. Children learn about clocks and time almost before they learn their A-B- Alphabet-Letter s. They are taught that a day consists of 24 Plural-Noun , an hour has 60 Plural-Noun , and a minute has 60 Plural-Noun . By the time they are in Kindergarten, they know if the big Body-Part is at twelve and the little Body-Part is at three, that it is Number o'clock. I wish we could continue this Adjective lesson, but we've run out of Noun ."

```
plural-nouns =
  [list: "gazebos", "avocados", "pandas", "quokkas"]

numbers =
  [list: "-1", "42", "a billion"]

nouns =
  [list: "apple", "computer", "borscht"]

body-parts =
  [list: "elbow", "head", "spleen"]

alphabet-letters =
  [list: "A", "C", "Z"]

adjectives =
  [list: "funky", "boring"]
```

```
fun substitute-word(w :: String) -> String:
  doc: "Substitute a random word if w is a category"
  if w == "Plural-Noun":
    rand = num-random(length(plural-nouns))
    plural-nouns.get(rand)
  else if w == "Number":
    rand = ...
  else:
    w
  end
where:
  ...
end
```

Don't repeat yourself!

```
fun rand-word(l :: List<String>) -> String:
  doc: "Return a random word in the given list"
  rand = num-random(length(l))
  l.get(rand)
where:
  plural-nouns.member(rand-word(plural-nouns)) is true
  numbers.member(rand-word(numbers)) is true
end
```

```
fun substitute-word(w :: String) -> String:
 doc: "Substitute a random word if w is a category"
 if w == "Plural-Noun":
  rand-word(plural-nouns)
 else if w == "Number":
  rand-word(numbers)
 else if w == "Noun":
  rand-word(nouns)
 else if w == "Body-Part":
  rand-word(body-parts)
 else if w == "Alphabet-Letter":
  rand-word(alphabet-letters)
 else if w == "Adjective":
  rand-word(adjectives)
 else:
  w
 end
end
```

This is still a bit repetitious – but it's good enough for today!

Go back to the task plan.

We’ve completed our helper, and now we need to

split the input into words

run the helper on every word in the list

Similar to how **transform-column** runs a function on every row of a table.

```
fun mad-libs(t :: String) -> String:
  doc: "Randomly fill in the blanks in the mad libs template"
  words = string-split-all(t, " ")
  ...
end
```

Go back to the task plan.

We’ve completed our helper, and now we need to

✓ split the input into words

run the helper on every word in the list

Similar to how **transform-column** runs a function on every row of a table.

This is called **map!**

```
fun mad-libs(t :: String) -> String:
  doc: "Randomly fill in the blanks in the mad libs template"
  words = string-split-all(t, " ")
  map(substitute-word, t)
  ...
end
```

Go back to the task plan.

We’ve completed our helper, and now we need to

- ✓ split the input into words
- ✓ run the helper on every word in the list

Similar to how **transform-column** runs a function on every row of a table.

Ok – are we done?

```
fun mad-libs(t :: String) -> String:
  doc: "Randomly fill in the blanks in the mad libs template"
  words = string-split-all(t, " ")
  map(substitute-word, t)
  ...
end
```

This gives us a list of strings. How can we join it back into a single string?

```
fun mad-libs(t :: String) -> String:
 doc: "Randomly fill in the blanks in the mad libs template"
 words = string-split-all(t, " ")
 words-sub = map(substitute-word, words)
 join-str(with-sub, " ")
end
```

```
fun mad-libs(t :: String) -> String:
  doc: "Randomly fill in the blanks in the mad libs template"
  words = string-split-all(t, " ")
  words-sub = map(substitute-word, t)
  join-str(words-sub, " ")
where:
  ...


end
```

What do we know is true about the output?

```
fun mad-libs(t :: String) -> String:
  doc: "Randomly fill in the blanks in the mad libs template"
  words = string-split-all(t, " ")
  words-sub = map(substitute-word, t)
  join-str(words-sub, " ")
where:
  mad-libs(template) is-not template


end
```

```
fun mad-libs(t :: String) -> String:
  doc: "Randomly fill in the blanks in the mad libs template"
  words = string-split-all(t, " ")
  words-sub = map(substitute-word, t)
  join-str(words-sub, " ")
where:
  mad-libs(template) is-not template
  string-contains(mad-libs(template), "Plural-Noun")
    is false
end
```

Preview: Lists and recursion

What if **join-str** didn’t already exist for our convenience?

To write a function that processes a list element by element, we need to understand the real nature of lists.

A list consists of two parts: a **first** element and the **rest** of the list.

```
››› l = [list: 1, 2, 3]
››› l.first
1
››› l.rest
[list: 2, 3]
```

The first element is linked to the rest and so on until we reach the empty list:

```
››› link(1, empty)
[list: 1]
››› link(1, link(2, link(3, empty)))
[list: 1, 2, 3]
```

When we write a function that recursively processes a list, we deal with these two cases – linking an element or being empty:

```
fun add-nums(l :: List<Number>) -> Number:
  cases (List) l:
    | empty => 0
    | link(f, r) => f + add-nums(r)
  end
where:
  add-nums([list:     ]) is 0
  add-nums([list:    1]) is 1 + 0
  add-nums([list: 2, 1]) is 2 + 1 + 0
end
```

In the case of joining strings, we need to know not just if the current list is empty but is the rest of the rest empty. This is how we know whether to add a space or not.

```
fun join-with-spaces(l :: List<String>) -> String:
  doc: "Join the strings in l with a space between each one"
  cases (List) l:
    | empty => ""
    | link(f, r) =>
      cases (List) r:
        | empty => f
        | link(fr, rr) =>
         f + " " + join-with-spaces(r)
      end
  end
where:
  join-with-spaces([list:         ]) is                  ""
  join-with-spaces([list:      "y"]) is            "y" + ""
  join-with-spaces([list: "x", "y"]) is "x" + " " + "y" + ""
end
```

Class code:

https://code.pyret.org/editor#share=1pl3aebeS704fGGlxGhSc-NNFaQCBE9On&v=4f2ac8e