

[220] Copying

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**Do not post > 5 lines on
Piazza!**

**Reminder: partners don't
submit project twice!**

**Cheaters caught: 0
(Through P5)**

**14 suspicious works for P6
(email Mike to confess)**

Test yourself!

A what do variables contain?

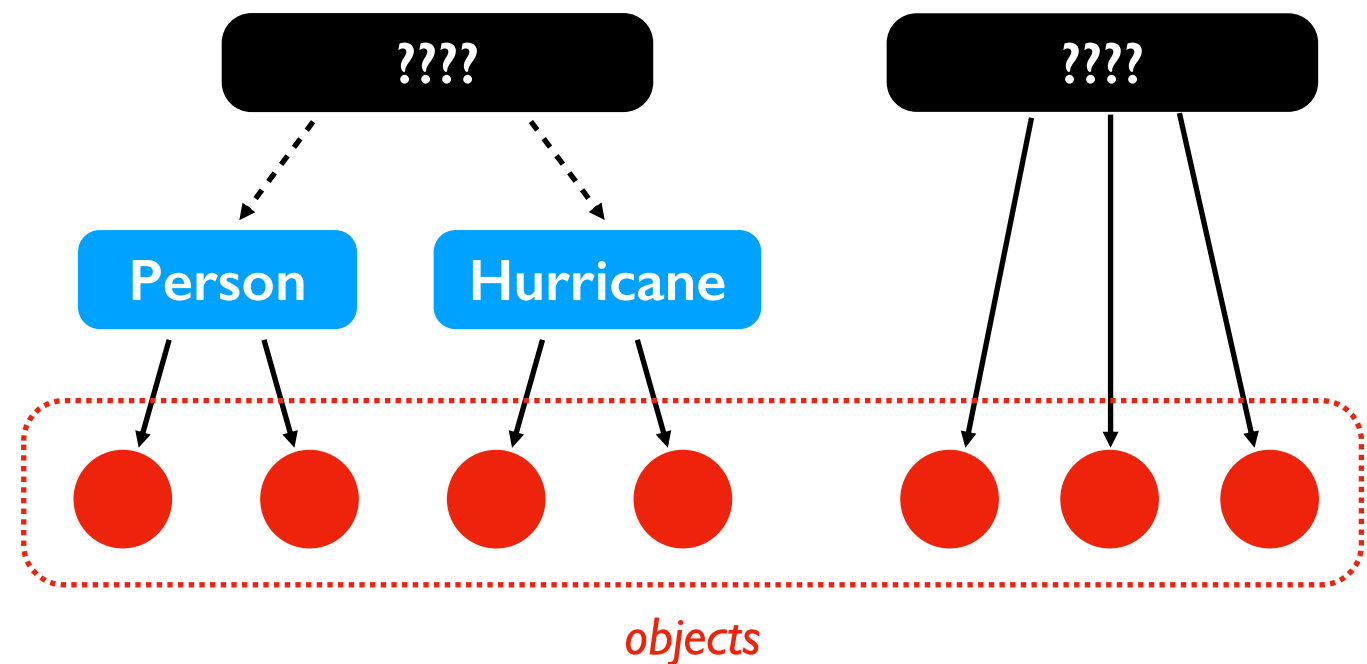
- 1 objects
- 2 references to objects

B how should we label the blanks in the hierarchy?

- 1 namedtuple, tuple
- 2 tuple, namedtuple

C which of the following live inside frames?

- 1 objects
- 2 variables



Learning Objectives Today

Practice objects/references!

Levels of copying

- Making a new reference
- Shallow copy
- Deep copy



<https://www.copymachinesdirect.com/copier-leasing.php>

Read:

- ✦ Sweigart Ch 4 ("References" to the end)
<https://automatetheboringstuff.com/chapter4/>

Today's Outline

Review

More references

Copying

- reference
- shallow
- deep

Worksheet

Worksheet Problem I

What does assignment ACTUALLY do?

```
x = [ "A" , "B" , "C" ]
```

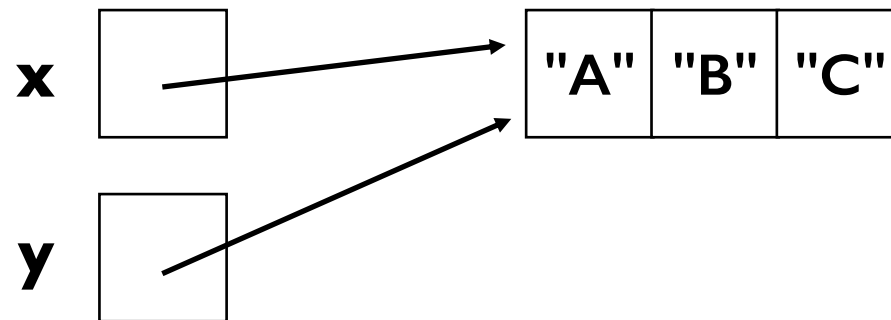
```
y = x
```

What does assignment ACTUALLY do?

```
x = [ "A" , "B" , "C" ]
```

```
y = x
```

YES



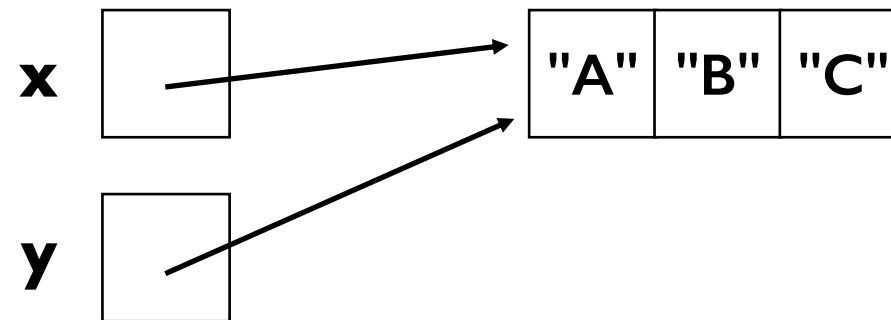
y should reference
whatever x references

What does assignment ACTUALLY do?

```
x = [ "A" , "B" , "C" ]
```

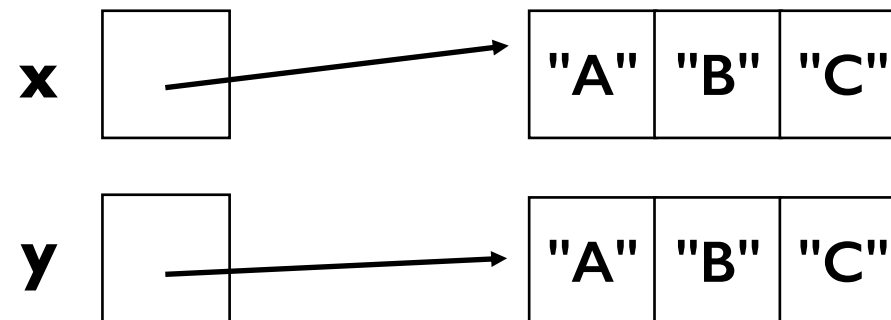
```
y = x
```

YES



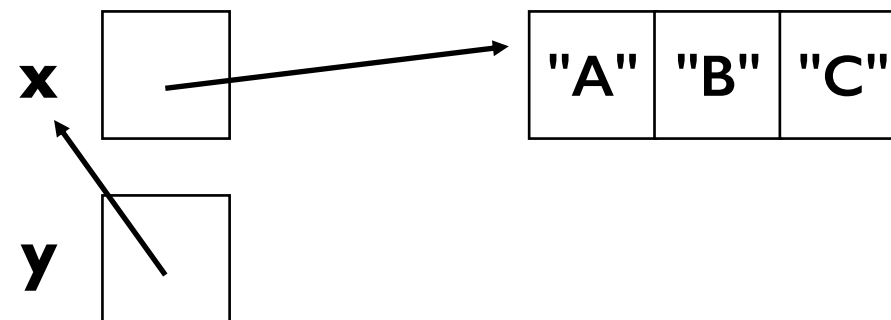
y should reference
whatever x references

NO



different code would
be needed to do this

NO

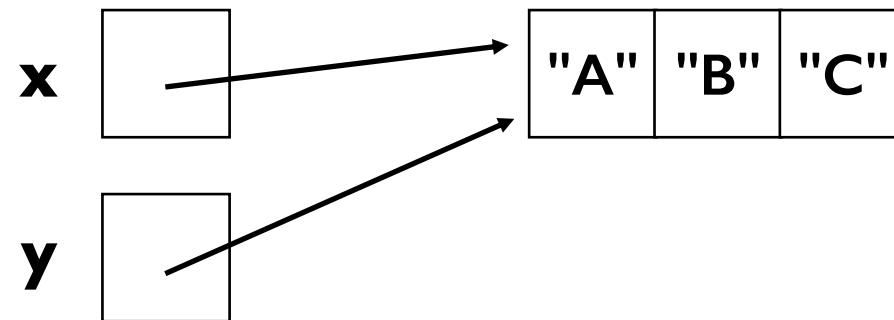


no code could ever
make this happen

What does assignment ACTUALLY do?

```
x = [ "A" , "B" , "C" ]
```

```
y = x
```



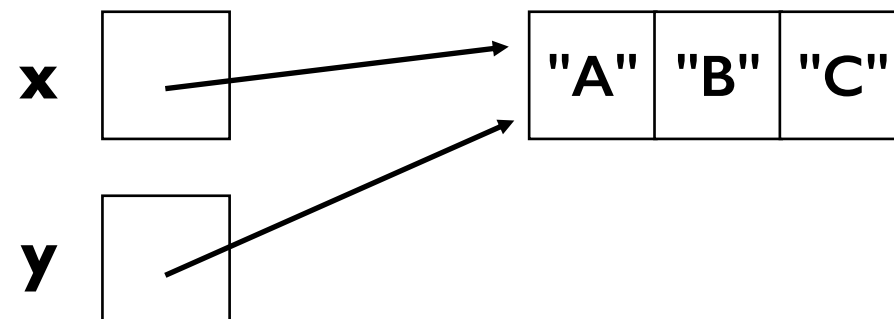
What does assignment ACTUALLY do?

~~x~~ = ["A", "B", "C"]

~~y~~ = ~~x~~

```
def f(y):  
    ➡ pass
```

```
x = [ "A", "B", "C" ]  
f(x)
```



What does assignment ACTUALLY do?

~~x~~ = ["A", "B", "C"]

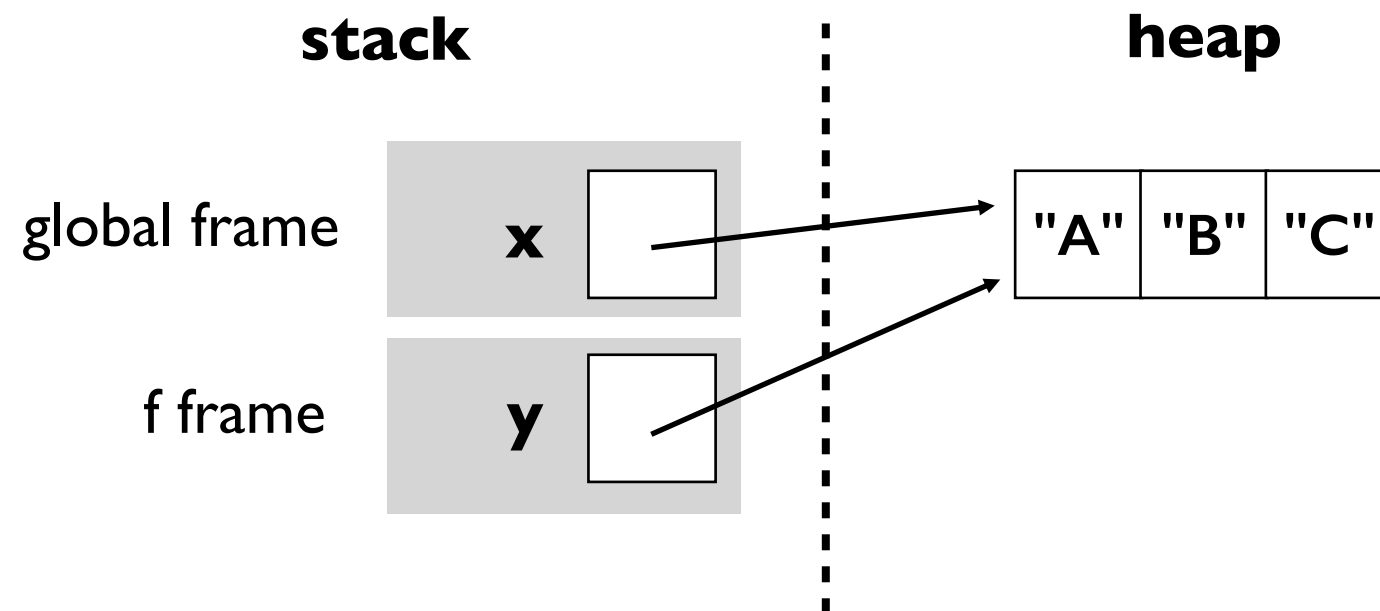
~~y~~ = ~~x~~

```
def f(y):
```

➔ pass

```
x = [ "A", "B", "C" ]
```

```
f(x)
```



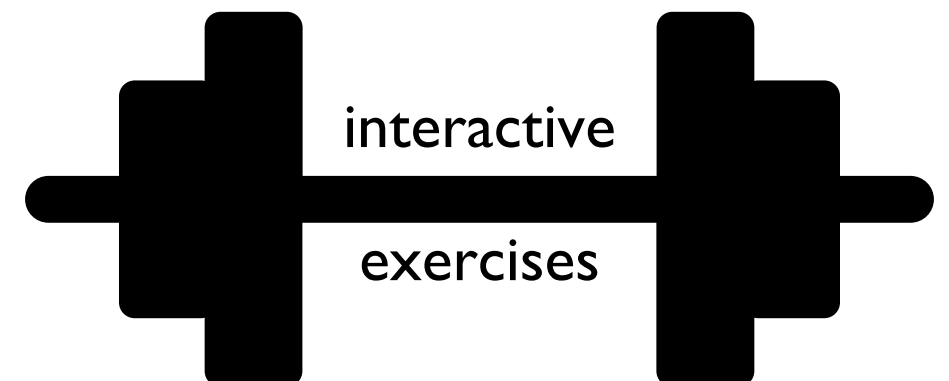
Example I

```
x = {}
```

```
y = x
```

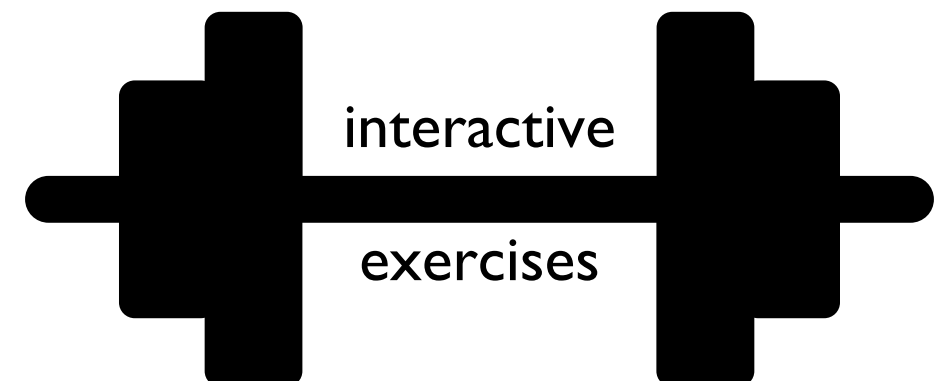
```
y["WI"] = "Madison"
```

```
print(x["WI"])
```



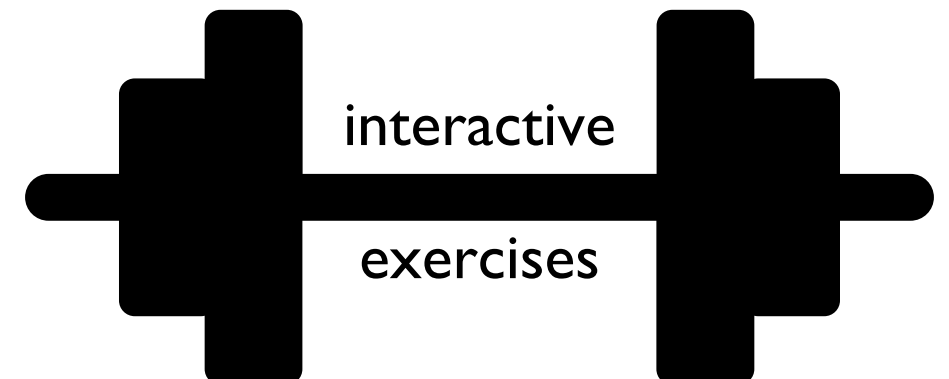
Example 2

```
def foo(nums):  
    nums.append(3)  
    print(nums)  
items = [1,2]  
numbers = items  
foo(numbers)  
print(items)  
print(numbers)
```



Example 3

```
x = [ "aaa", "bbb" ]  
y = x[:]  
x.pop(0)  
print(len(y))
```



Worksheet Problems 2-6

Today's Outline

Review

More references

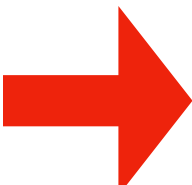
Copying

- reference
- shallow
- deep

Worksheet


```
from recordclass import recordclass
```

```
Person = recordclass("Person", ["name", "score", "age"])
```



```
alice = Person(name="Alice", score=10, age=30)  
bob = Person(name="Bob", score=8, age=25)  
team = [alice, bob]  
players = {"A": alice, "B": bob}
```

State:

references

objects

```
from recordclass import recordclass
```

```
Person = recordclass("Person", ["name", "score", "age"])
```



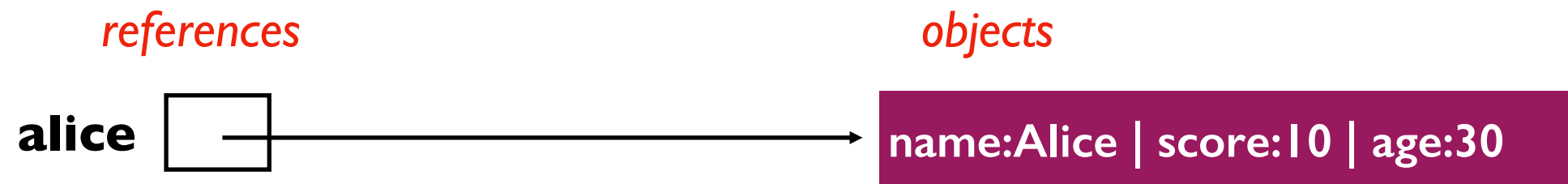
```
alice = Person(name="Alice", score=10, age=30)
```

```
bob = Person(name="Bob", score=8, age=25)
```

```
team = [alice, bob]
```

```
players = {"A": alice, "B": bob}
```

State:



```
from recordclass import recordclass
```

```
Person = recordclass("Person", ["name", "score", "age"])
```

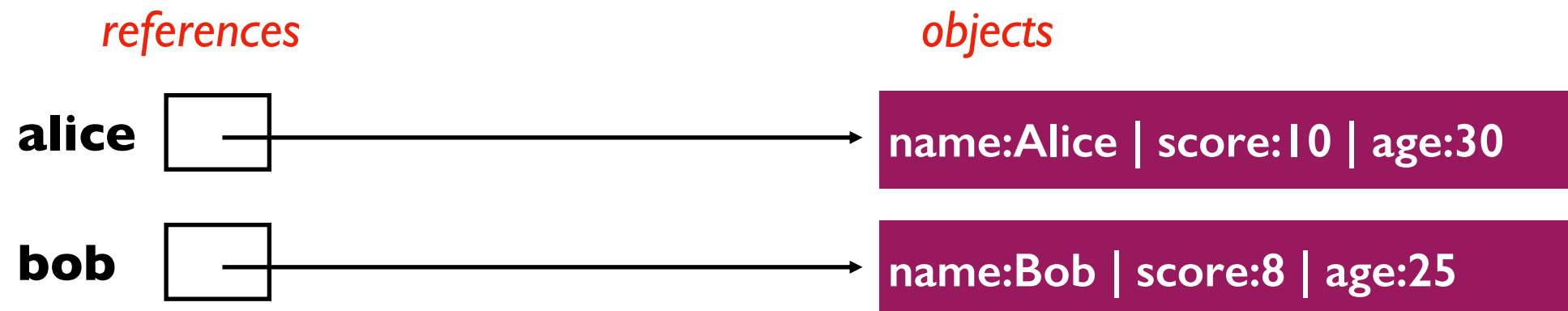
```
alice = Person(name="Alice", score=10, age=30)
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bob = Person(name="Bob", score=8, age=25)
```

```
team = [alice, bob]
```

```
players = {"A": alice, "B": bob}
```

State:



```
from recordclass import recordclass
```

```
Person = recordclass("Person", ["name", "score", "age"])
```

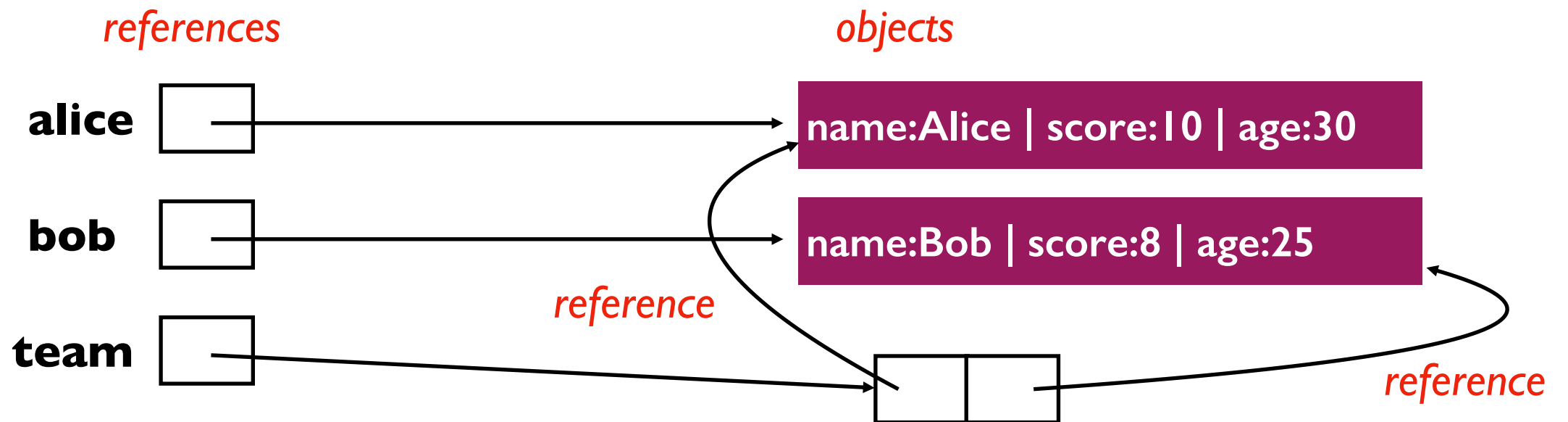
```
alice = Person(name="Alice", score=10, age=30)
```

```
bob = Person(name="Bob", score=8, age=25)
```

```
team = [alice, bob]
```

```
players = {"A": alice, "B": bob}
```

State:



```
from recordclass import recordclass
```

```
Person = recordclass("Person", ["name", "score", "age"])
```

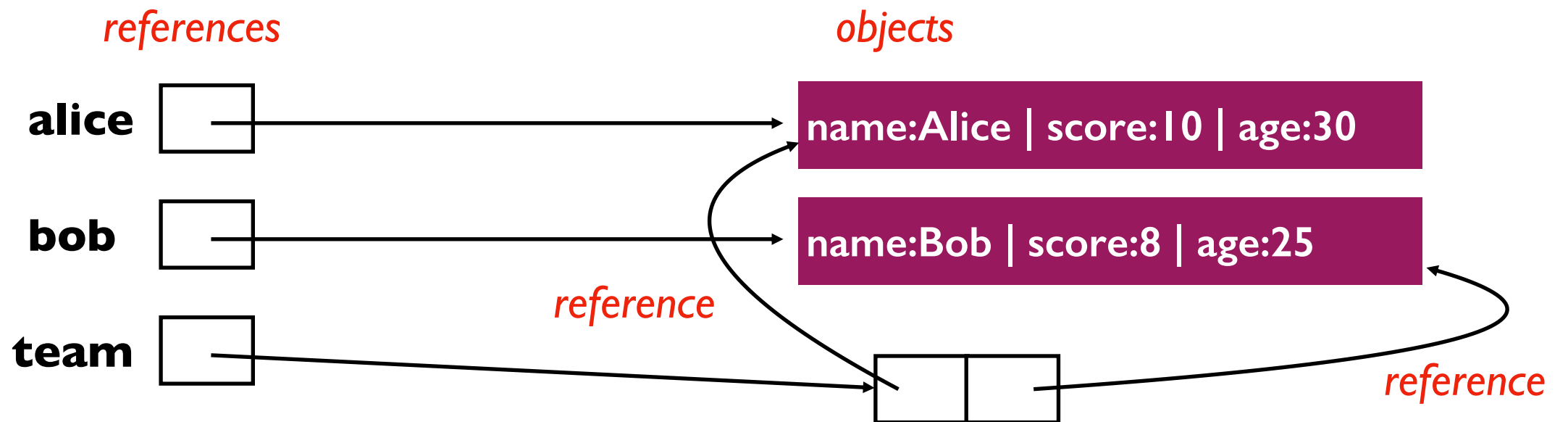
```
alice = Person(name="Alice", score=10, age=30)
```

```
bob = Person(name="Bob", score=8, age=25)
```

```
team = [alice, bob]
```

```
players = {"A": alice, "B": bob}
```

State:



what DID NOT happen: `team` contains the `alice` and `bob` variables

what DID happen: `team` contains references to the objects referenced by `bob` and `alice`

```
from recordclass import recordclass
```

```
Person = recordclass("Person", ["name", "score", "age"])
```

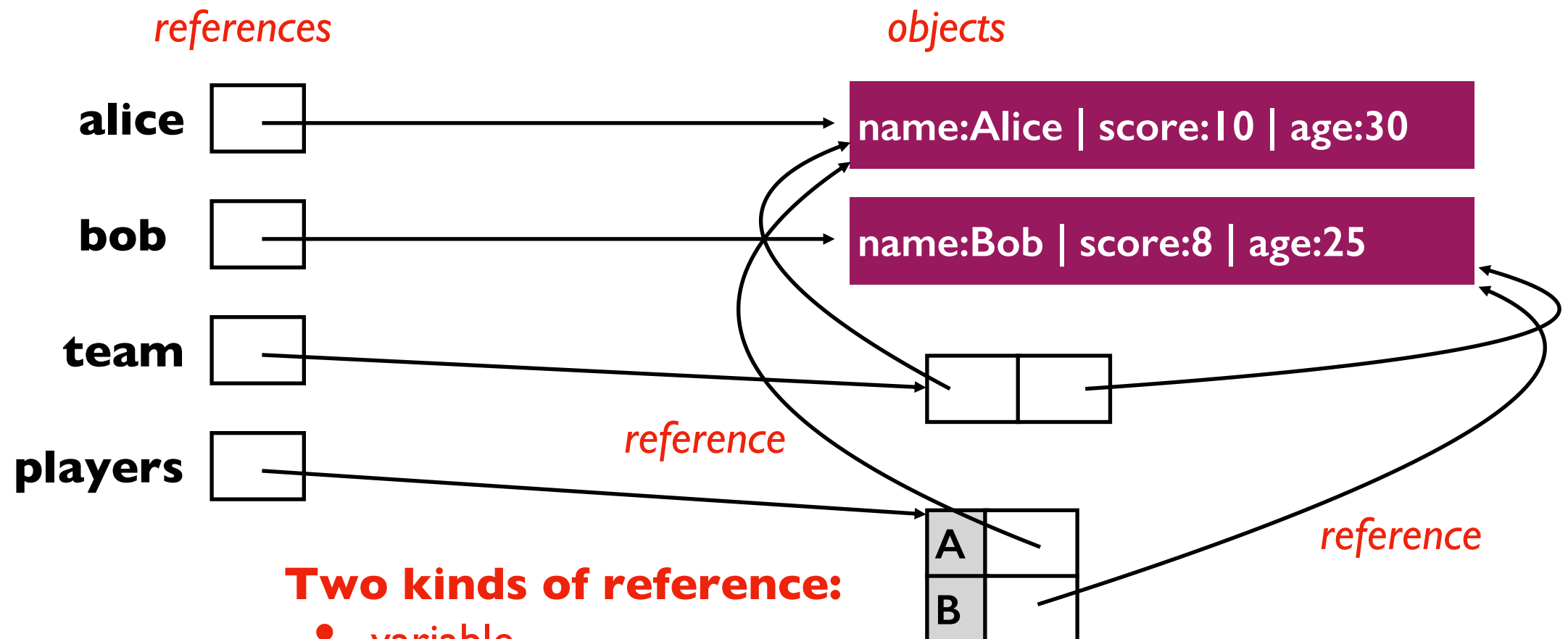
```
alice = Person(name="Alice", score=10, age=30)
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```
bob = Person(name="Bob", score=8, age=25)
```

```
team = [alice, bob]
```

```
players = {"A": alice, "B": bob}
```

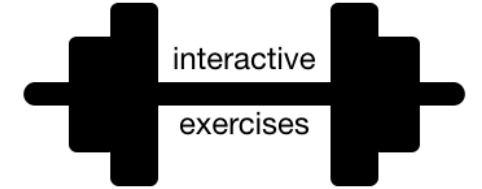
State:



Two kinds of reference:

- variable
- item in list, dict, etc

Deduplication review



```
x = 2**4
y = 2**4
z = y
print(x == z, x is z)
```

```
x = 2**100
y = 2**100
z = y
print(x == z, x is z)
```

Today's Outline

Review

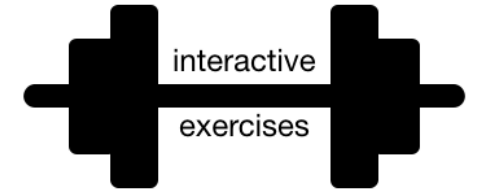
More references

Copying

- reference
- shallow
- deep

Worksheet

Three Levels of Copy



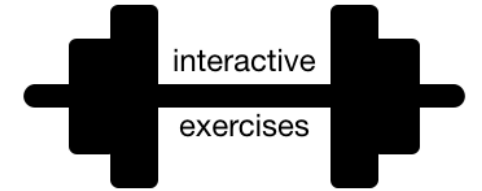
When should we
use which one?

```
import copy
x = [
    {"name": "A", "score": 88},
    {"name": "B", "score": 111},
    {"name": "C", "score": 100}]
```

uncomment one of these

```
#y = x ← reference copy [fastest, most dangerous]
#y = copy.copy(x) ← shallow copy
#y = copy.deepcopy(x) ← deep copy [slowest, safest]
```

Shallow copy of depth level 2



Using shallow copy to
copy other depth levels

```
import copy
x = [
    {"name": "A", "score": 88},
    {"name": "B", "score": 111},
    {"name": "C", "score": 100}]
```

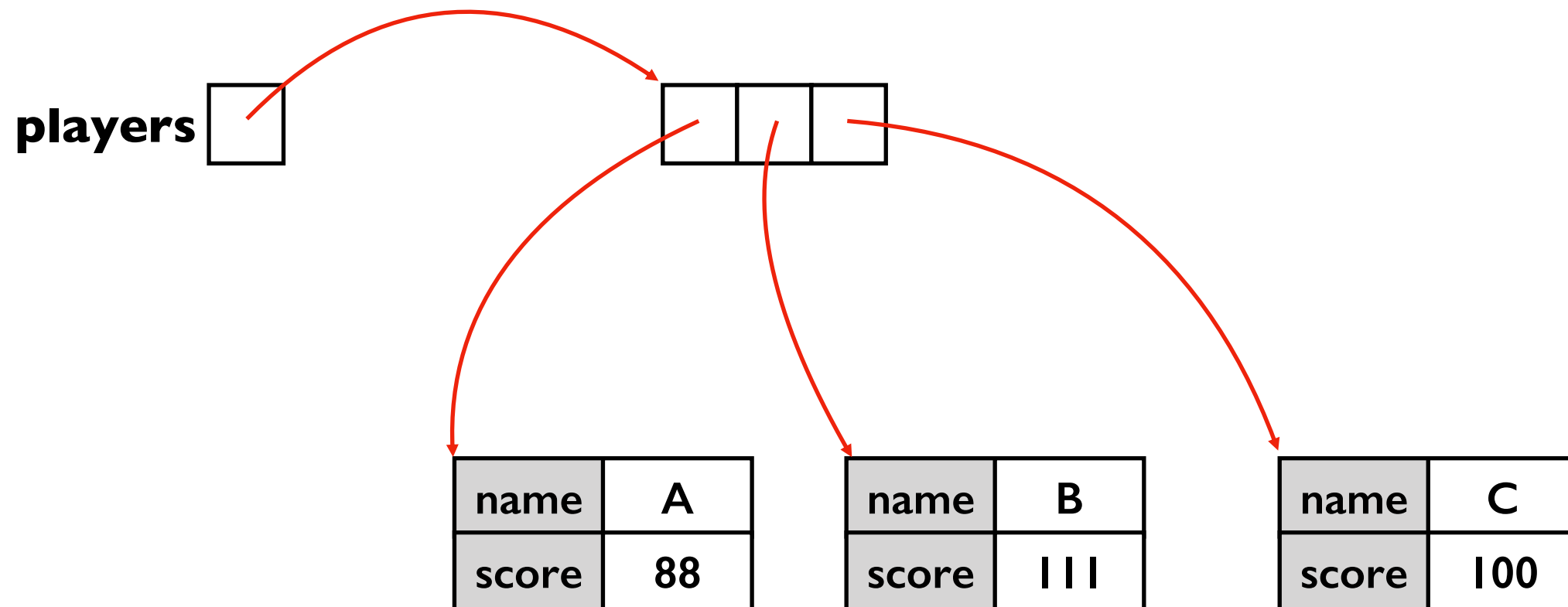
```
y = copy.copy(x) ← shallow copy
```

```
for idx in range(len(x)): ← shallow copy of depth level 2
    y[idx] = copy.copy(x[idx])
```

Example: Player Scores

```
players = [  
    {"name": "A", "score": 88},  
    {"name": "B", "score": 111},  
    {"name": "C", "score": 100}  
]
```

Depending on the use case,
there are **three ways** we might
"copy" the player's data



Example: Player Scores

```
players = [  
    {"name": "A", "score": 88},  
    {"name": "B", "score": 111},  
    {"name": "C", "score": 100}  
]
```

Use Case 1

Get max score
(reference copy)

Use Case 2

Get median score
(shallow copy)

Use Case 3

Record historical scores
(deep copy)

name	A
score	88

score	111
-------	-----

score	100
-------	-----

Example: Player Scores

```
players = [  
    {"name": "A", "score": 88},  
    {"name": "B", "score": 111},  
    {"name": "C", "score": 100}  
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Use Case 1

Get max score
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Get median score
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Record historical scores
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-------	-----


score	100
-------	-----

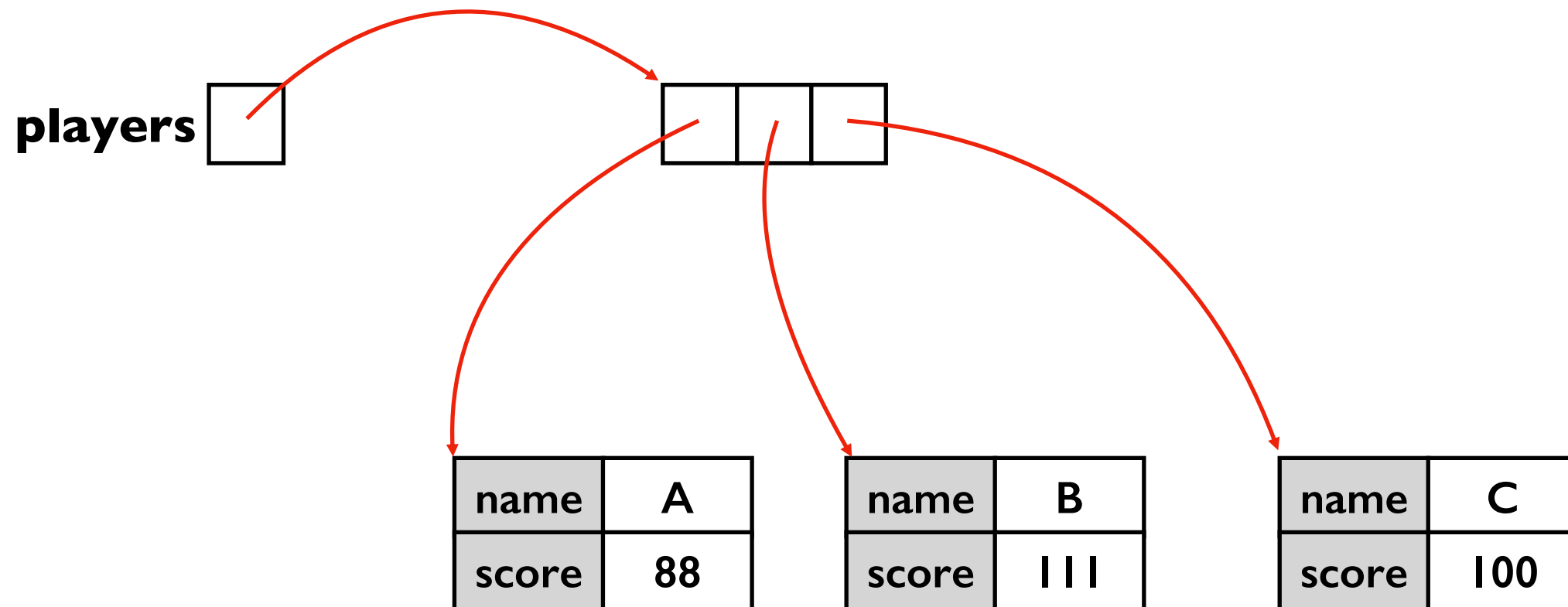
```
def max_score(people):  
    highest = None  
    for p in people:  
        if highest == None or p["score"] > highest:  
            highest = p["score"]  
    return highest
```

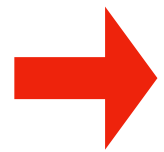


```
players = ...  
m = max_score(players)
```

```
def max_score(people):  
    highest = None  
    for p in people:  
        if highest == None or p["score"] > highest:  
            highest = p["score"]  
    return highest
```

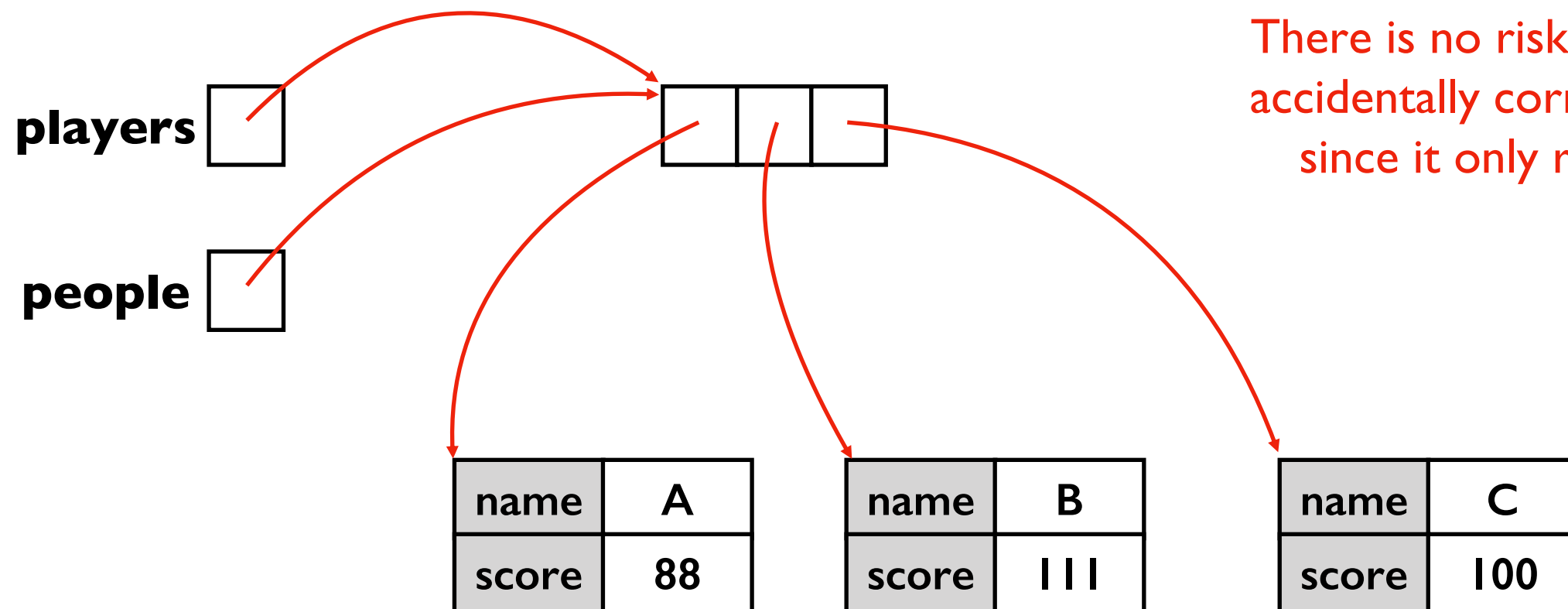
 **players** = ...
m = max_score(**players**)





```
def max_score(people):  
    highest = None  
    for p in people:  
        if highest == None or p["score"] > highest:  
            highest = p["score"]  
    return highest
```

```
players = ...  
m = max_score(players)
```

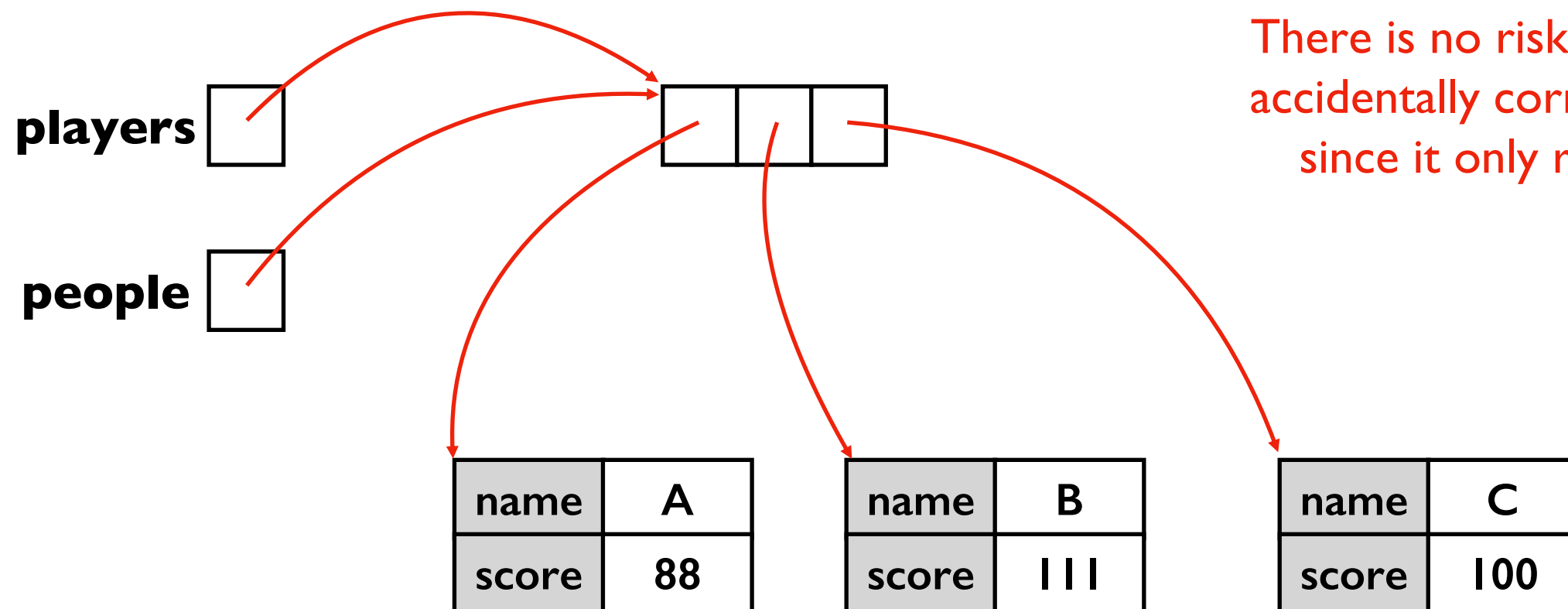


There is no risk of `max_score` accidentally corrupting `players` since it only reads `people`



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def max_score(people):  
    highest = None  
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        if highest == None or p["score"] > highest:  
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    return highest
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```
players = ...  
m = max_score(players)
```

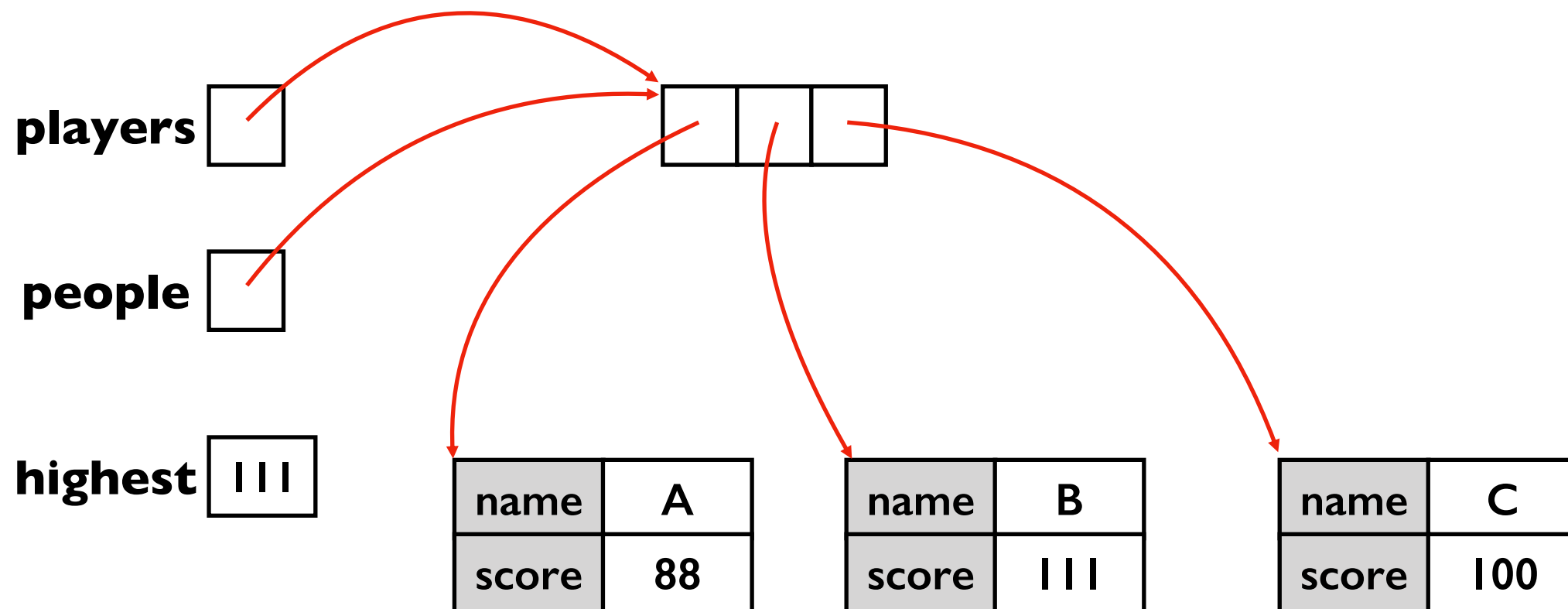


There is no risk of `max_score` accidentally corrupting `players` since it only reads `people`

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def max_score(people):  
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    return highest
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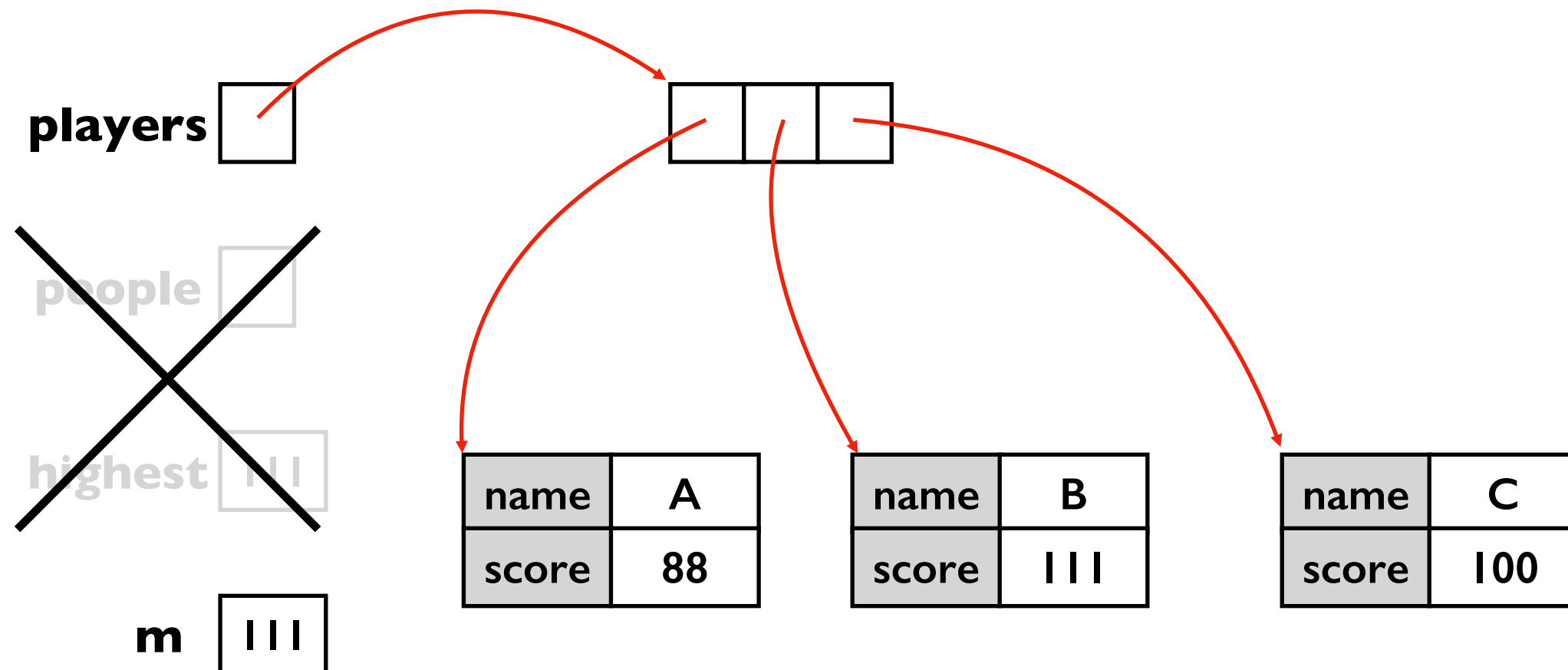
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players = ...  
m = max_score(players)
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```
def max_score(people):  
    highest = None  
    for p in people:  
        if highest == None or p["score"] > highest:  
            highest = p["score"]  
    return highest
```

players = ...

m = max_score(**players**)



Example: Player Scores

```
players = [  
    {"name": "A", "score": 88},  
    {"name": "B", "score": 111},  
    {"name": "C", "score": 100}  
]
```

Use Case 1

Get max score
(reference copy)

Use Case 2

Get median score
(shallow copy)

Use Case 3

Record historical scores
(deep copy)

name	A
score	88

score	111
-------	-----

score	100
-------	-----

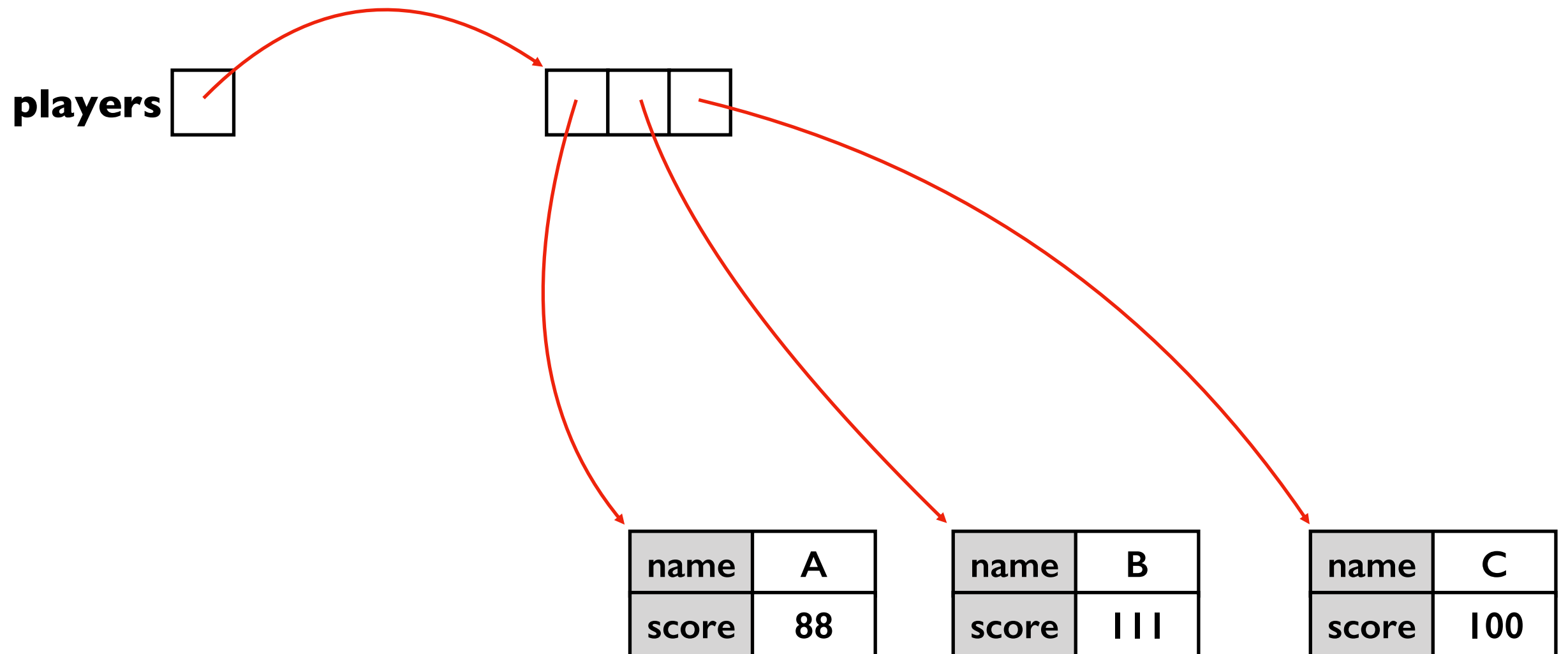
```
def median_score(people):  
    people = copy.copy(people)  
    people.sort(...)  
    # TODO: return score for middle of people
```



```
players = ...  
m = median_score(players)
```

```
def median_score(people):  
    people = copy.copy(people)  
    people.sort(...)  
    # TODO: return score for middle of people
```

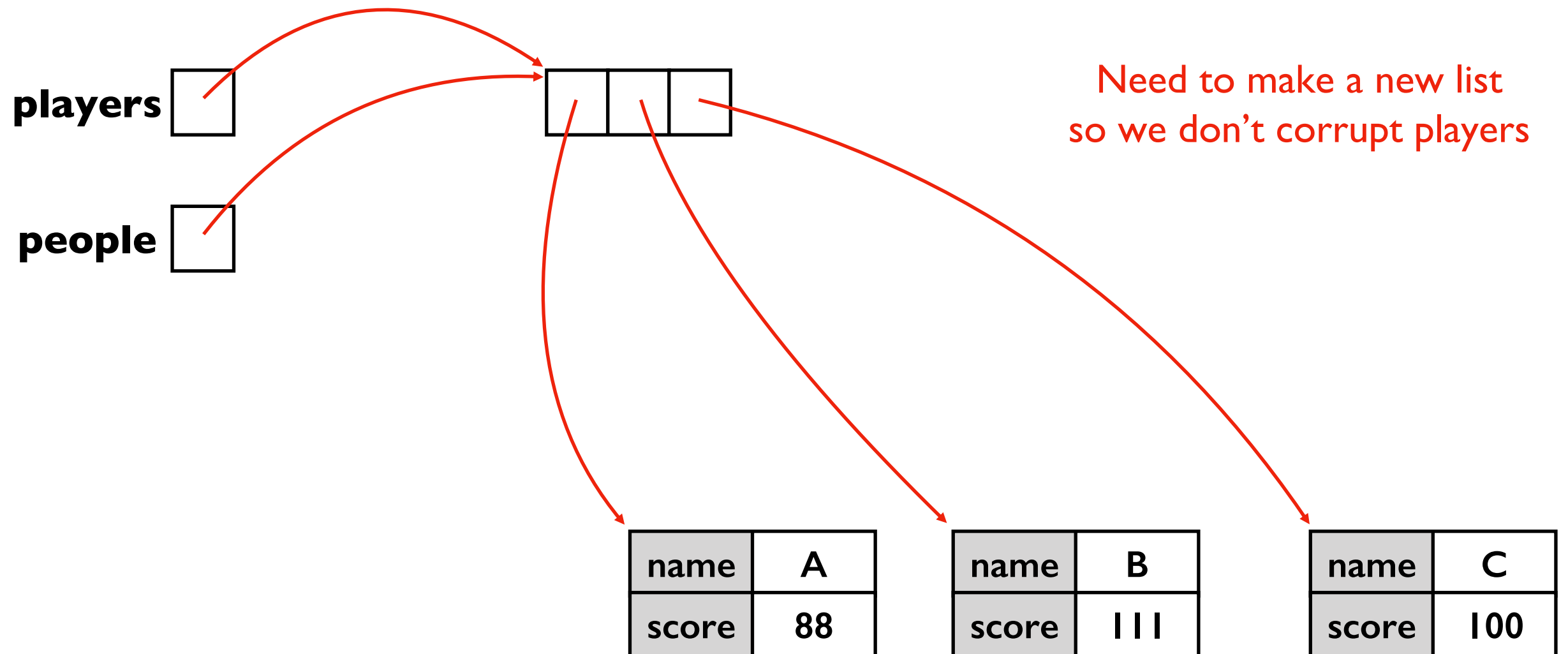
➔ **players** = ...
m = median_score(**players**)





```
def median_score(people):  
    people = copy.copy(people)  
    people.sort(...)  
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```

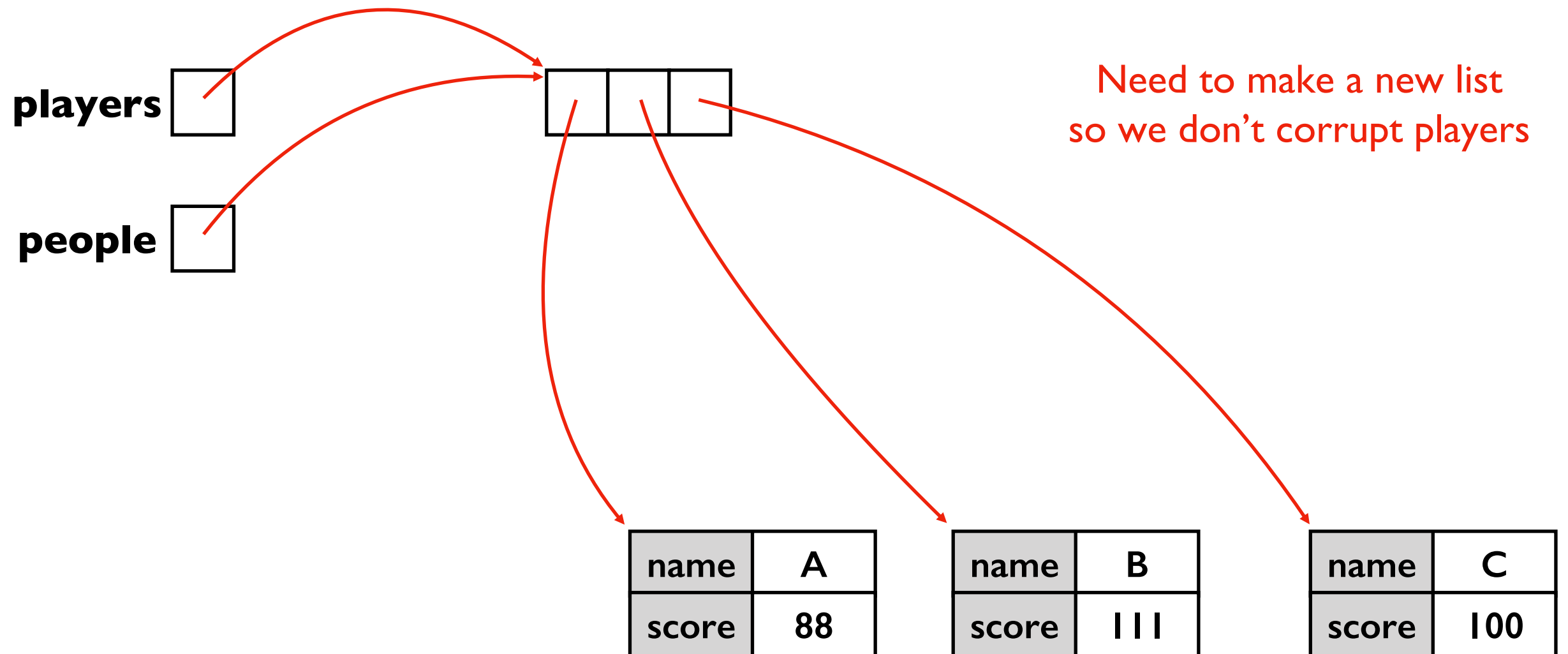
```
players = ...  
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```
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    people = copy.copy(people)  
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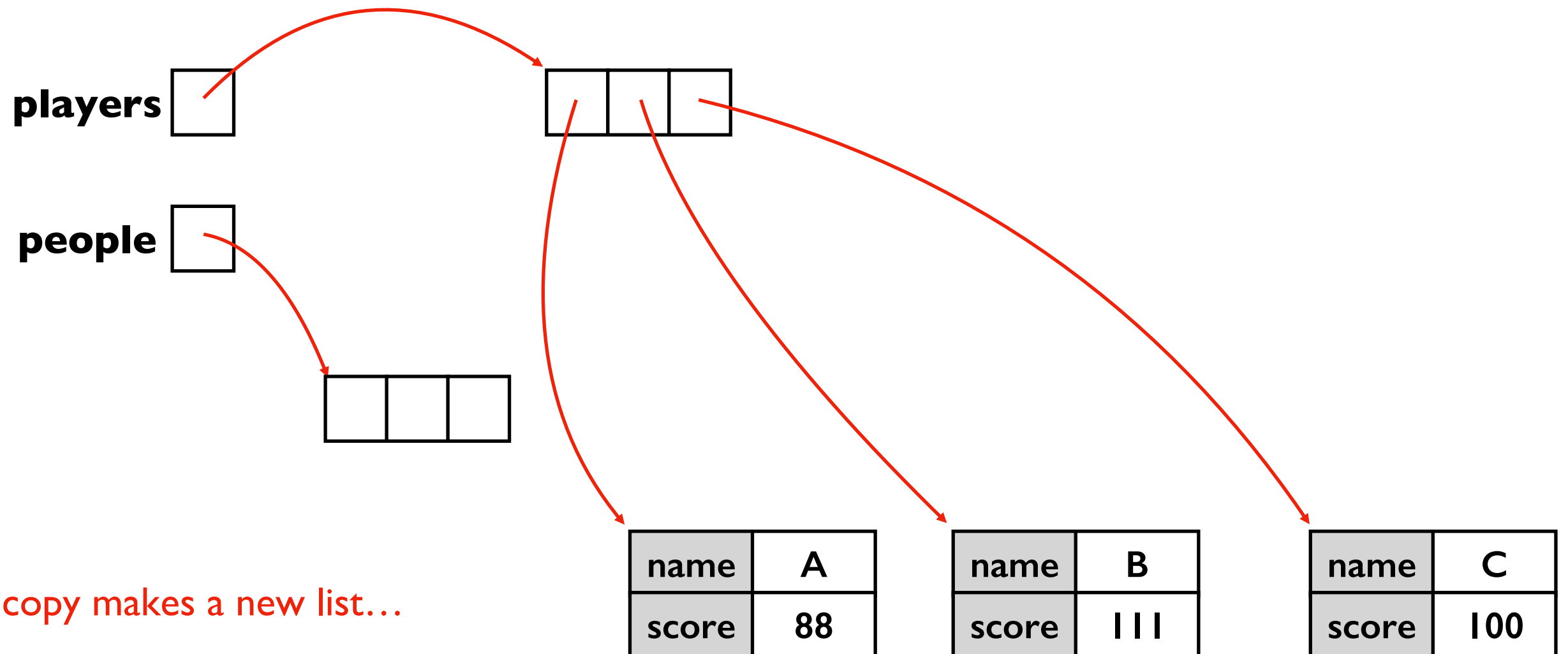
```
players = ...  
m = median_score(players)
```





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    people = copy.copy(people)  
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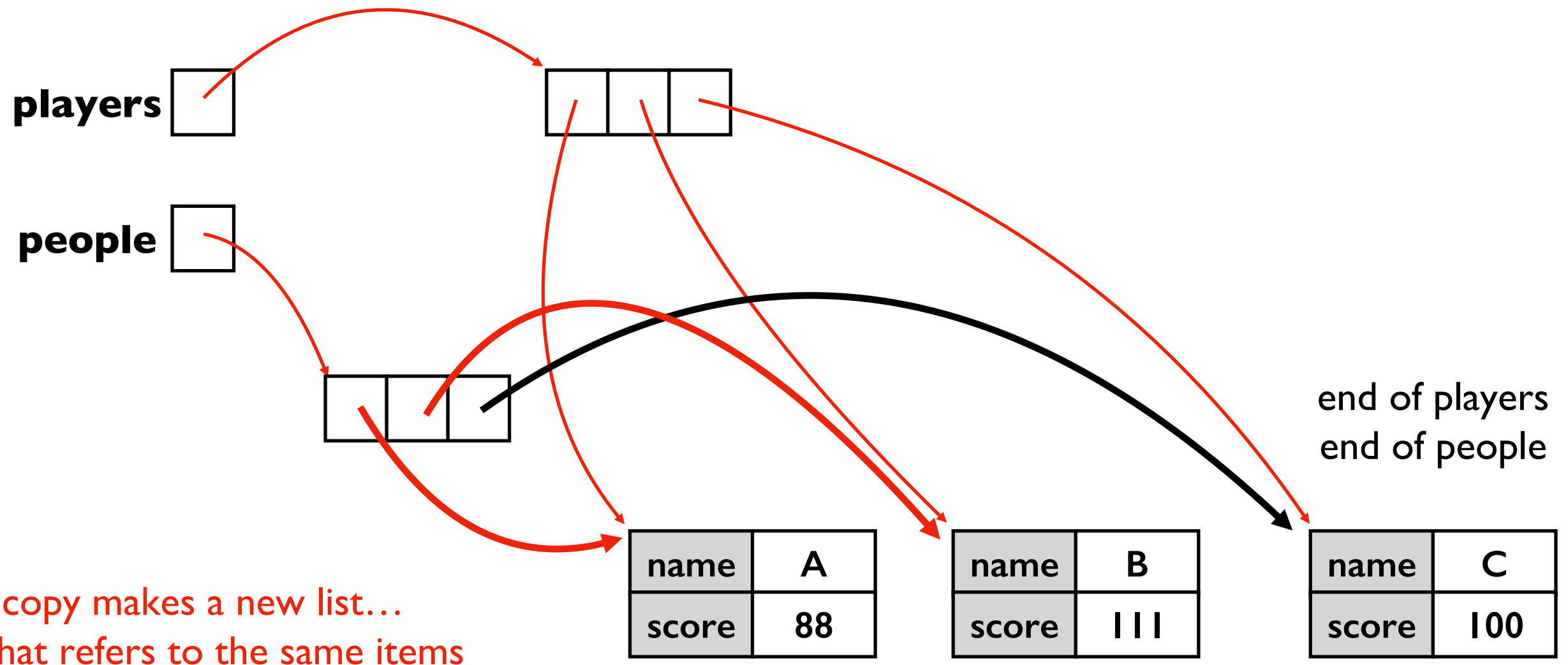
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players = ...  
m = median_score(players)
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    people = copy.copy(people)  
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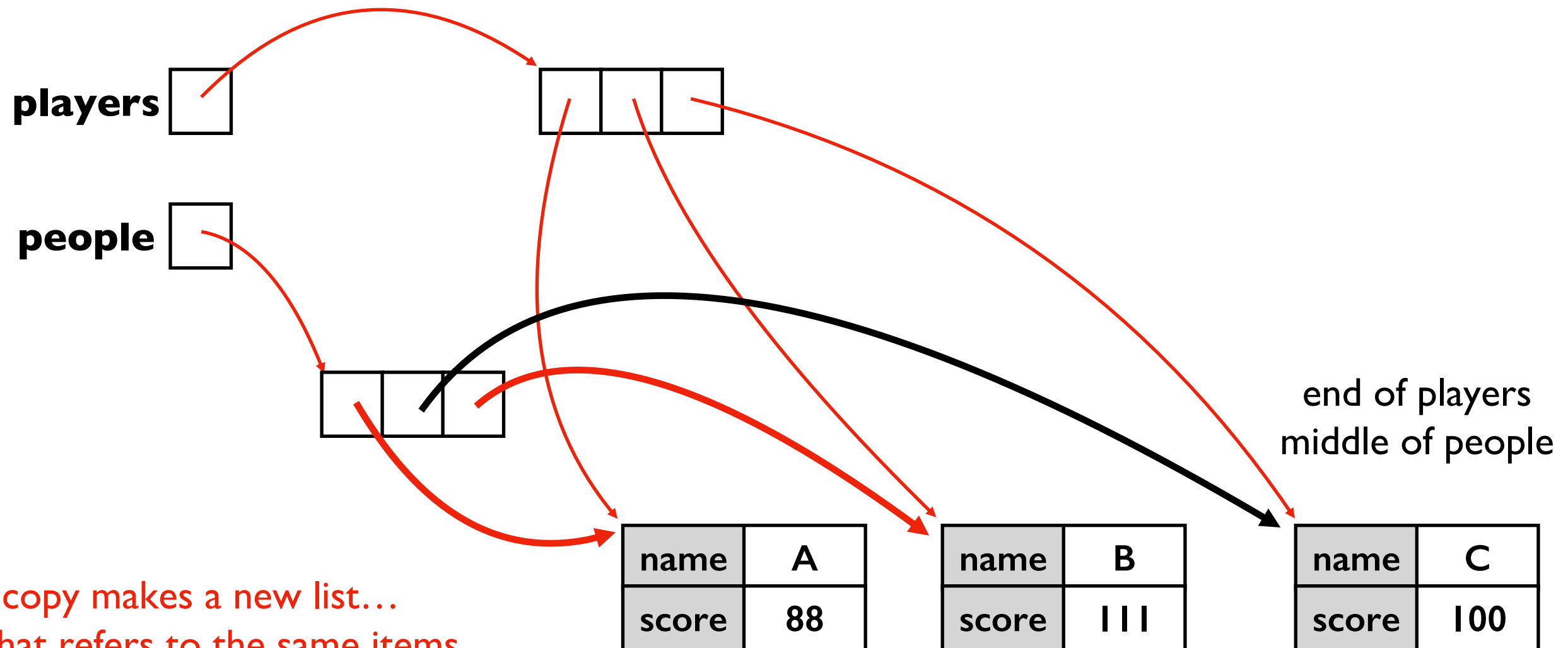
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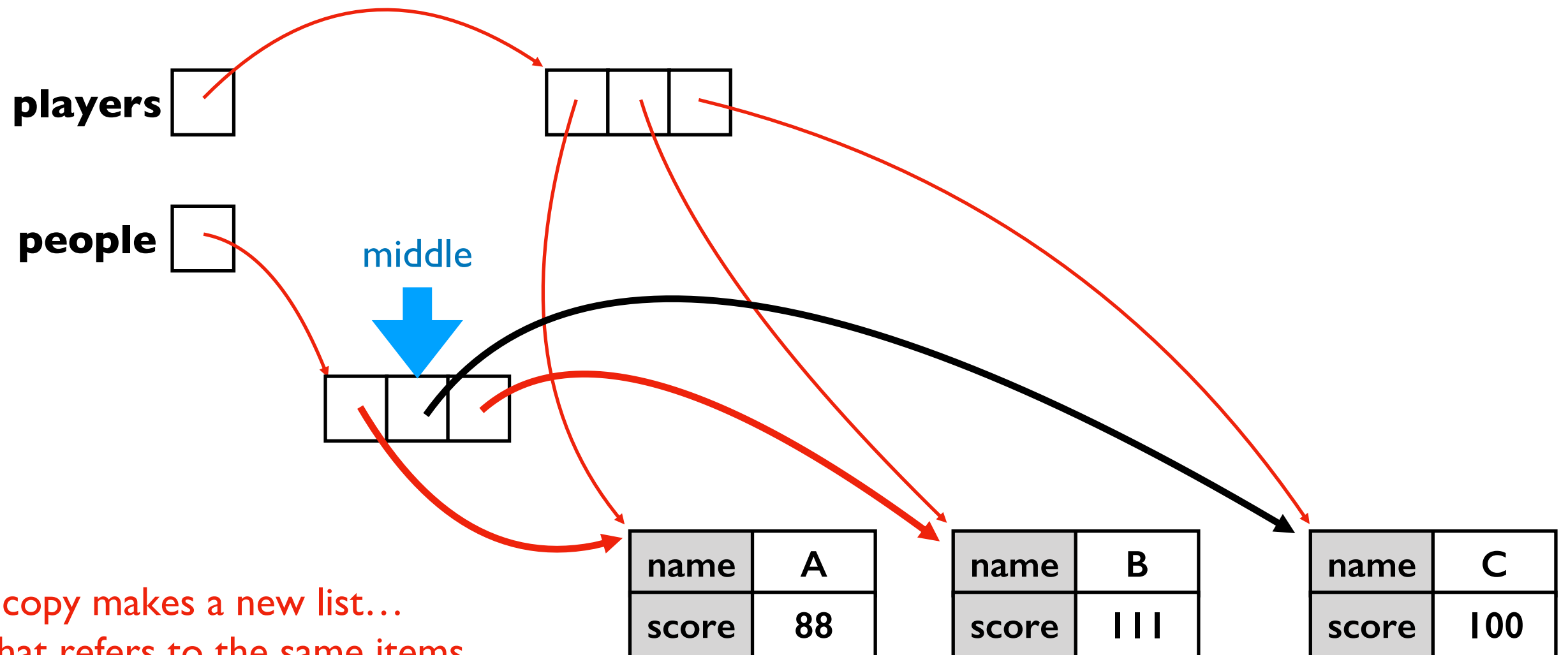
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players = ...  
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def median_score(people):  
    people = copy.copy(people)  
    people.sort(...)  
    # TODO: return score for middle of people
```



```
players = ...  
m = median_score(players)
```



Example: Player Scores

```
players = [  
    {"name": "A", "score": 88},  
    {"name": "B", "score": 111},  
    {"name": "C", "score": 100}  
]
```

Use Case 1

Get max score
(reference copy)

Use Case 2

Get median score
(shallow copy)


Use Case 3

Record historical scores
(deep copy)

name	A
score	88

score	111
-------	-----

score	100
-------	-----



```
players = ...
players_before = copy.deepcopy(players)

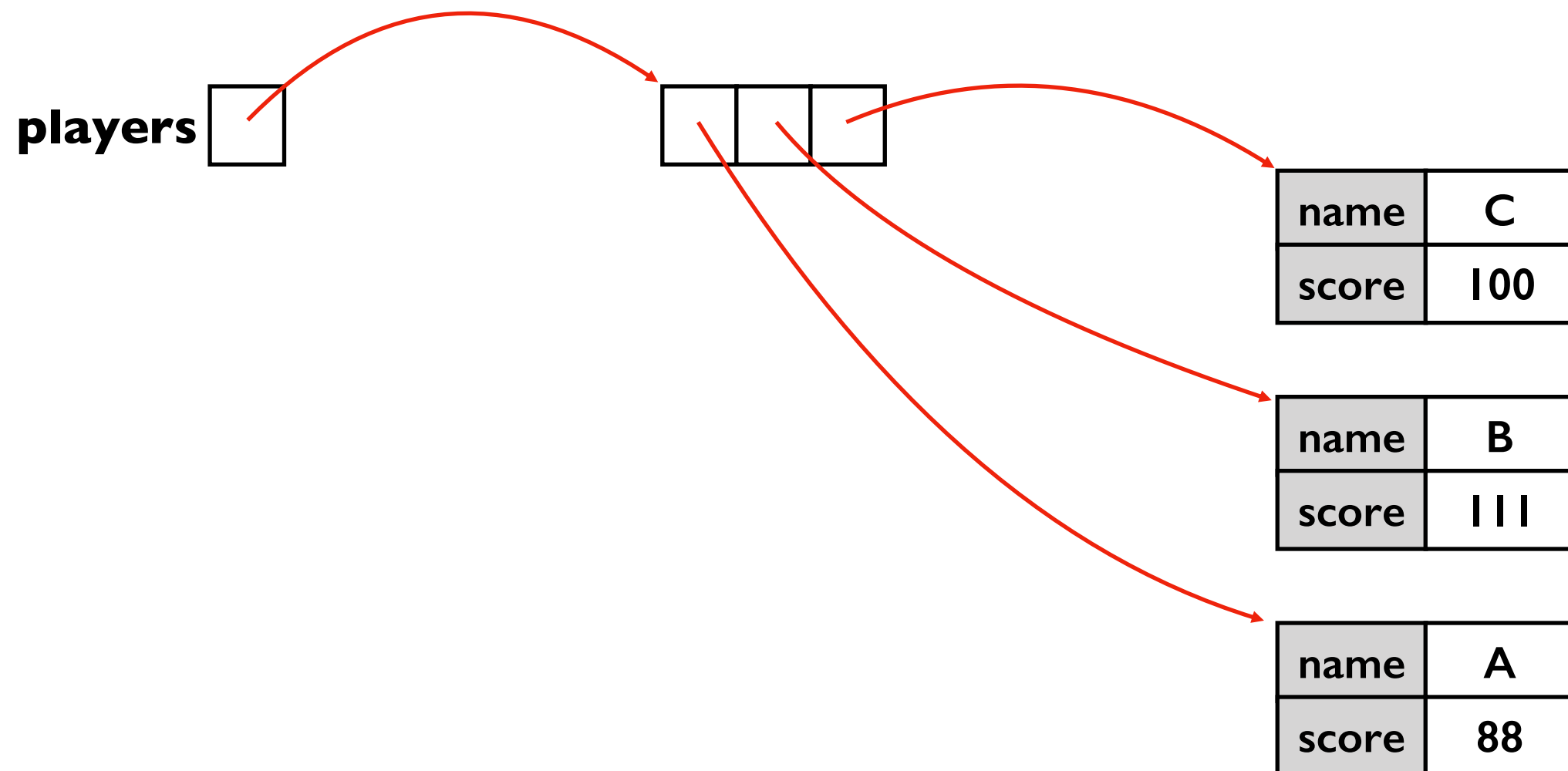
# make changes to players
players[0]["score"] += 10

print("score change:",
      players[0]["score"] - players_before[0]["score"])
```

➔ **players** = ...
players_before = `copy.deepcopy(players)`

make changes to **players**
players[0]["score"] += 10

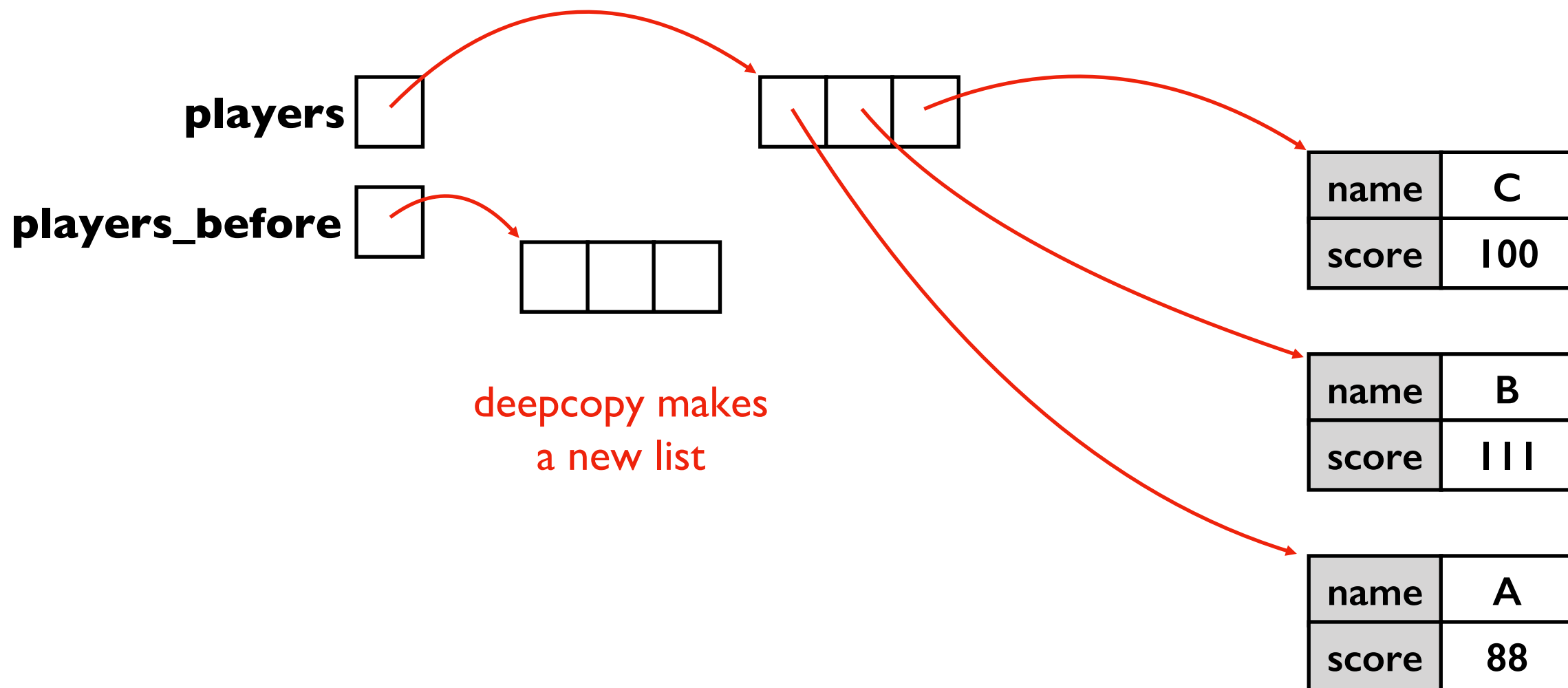
`print("score change:",
 players[0]["score"] - players_before[0]["score"])`



➔ **players** = ...
players_before = `copy.deepcopy(players)`

make changes to **players**
players[0]["score"] += 10

`print("score change:",
 players[0]["score"] - players_before[0]["score"])`




```
players = ...
```

```
players_before = copy.deepcopy(players)
```

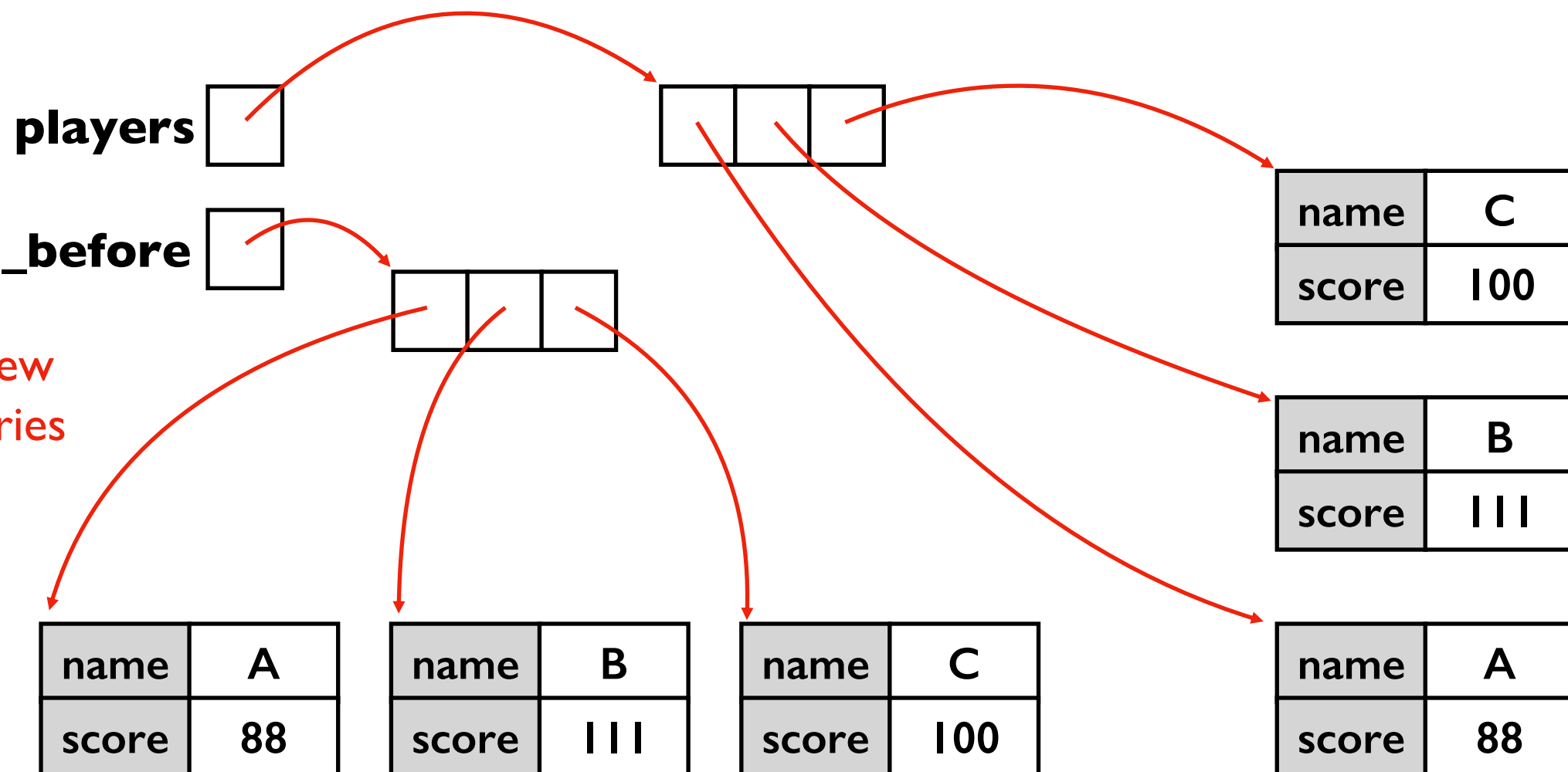


```
# make changes to players
```

```
players[0]["score"] += 10
```

```
print("score change:",
```

```
      players[0]["score"] - players_before[0]["score"])
```

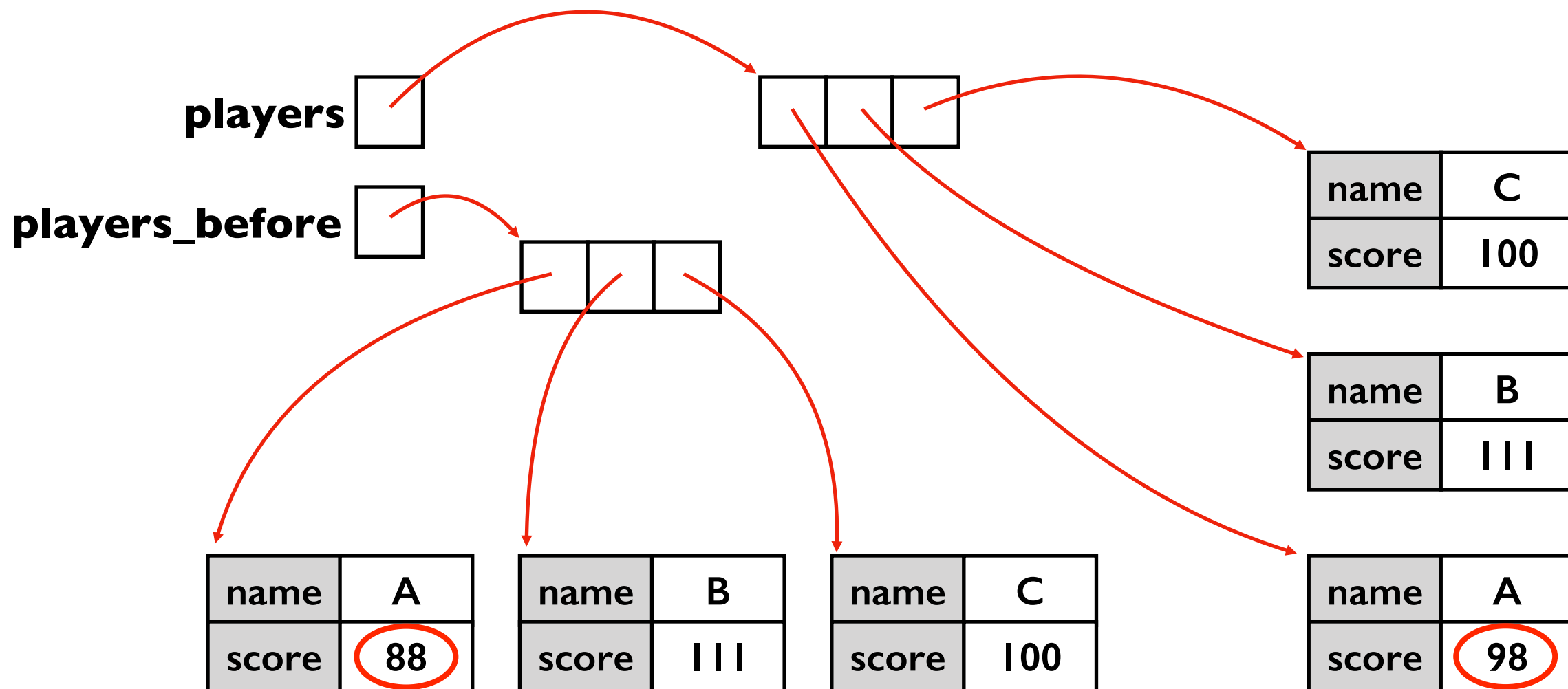


```
players = ...  
players_before = copy.deepcopy(players)
```

```
# make changes to players  
players[0]["score"] += 10
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➔

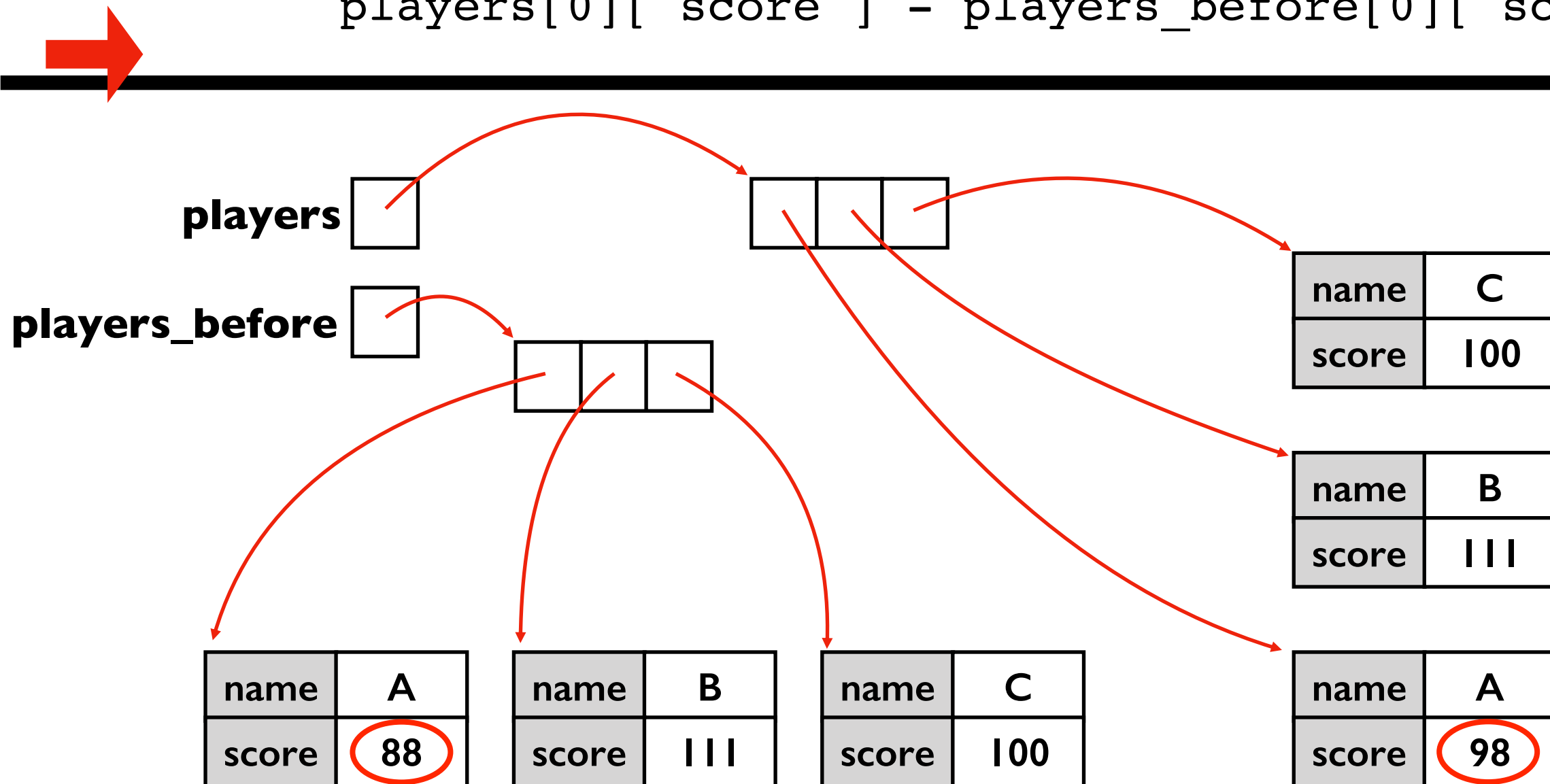
```
print("score change:",  
      players[0]["score"] - players_before[0]["score"])
```



```
players = ...
players_before = copy.deepcopy(players)

# make changes to players
players[0]["score"] += 10

print("score change:",      prints 10
      players[0]["score"] - players_before[0]["score"])
```



Today's Outline

Review

More references

Copying

- reference
- shallow
- deep

Worksheet

Worksheet Problems 7-11