USABLE PROGRAMMING TOOLS FOR EXPERIMENTAL BIOLOGISTS

Justin Lubin

Advisor: Sarah E. Chasins

EPIC Retreat, Spring 2022

Vaccines

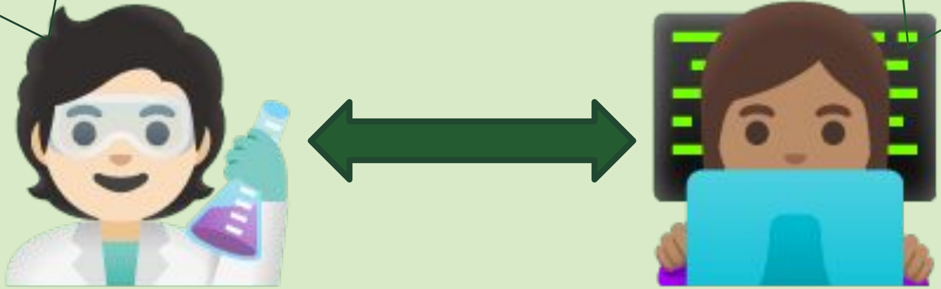
Precision health

Genomic editing

Wet lab ↔ Dry lab

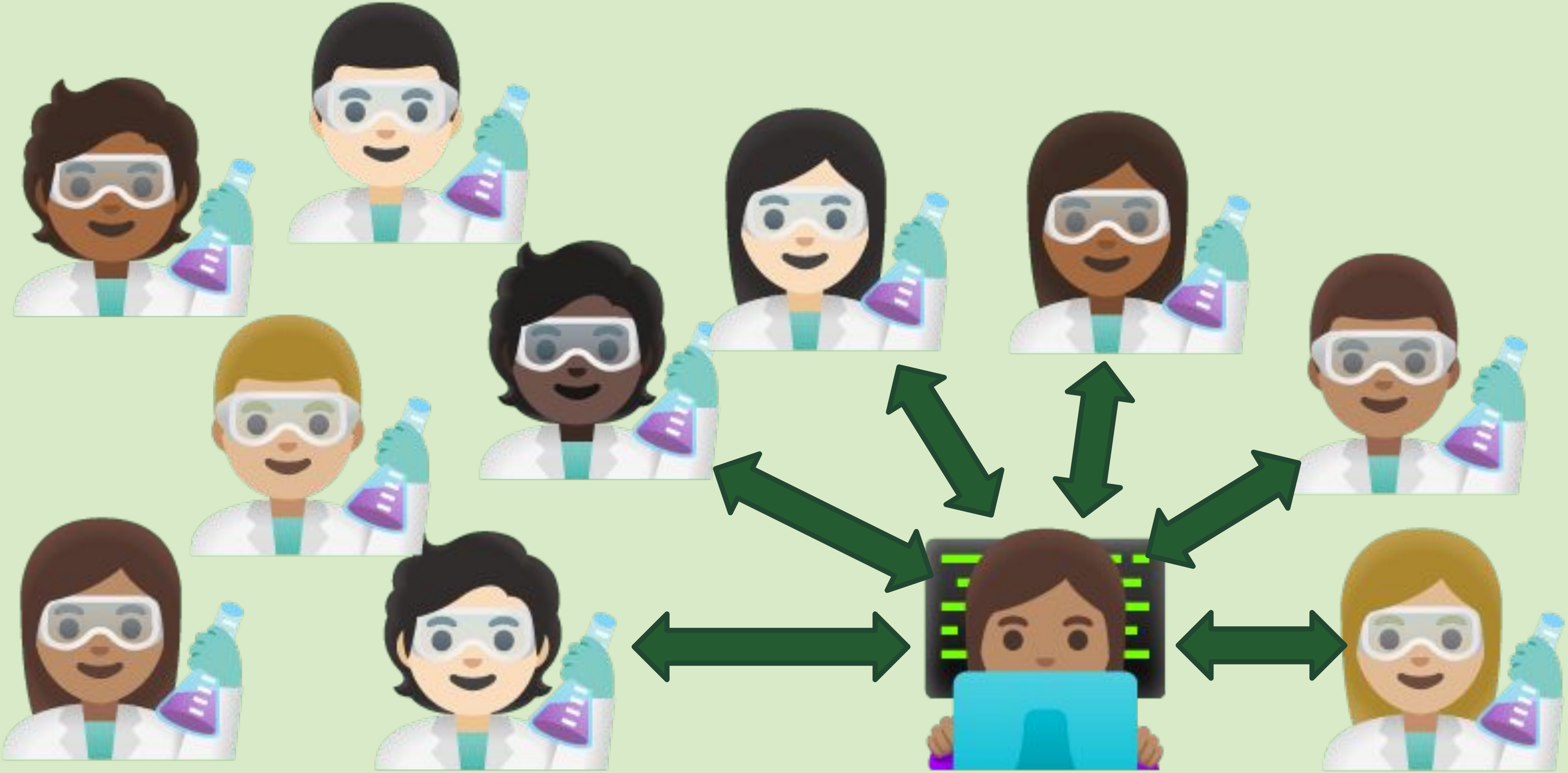
HANDS-ON PROTOCOLS

CODE, MATH

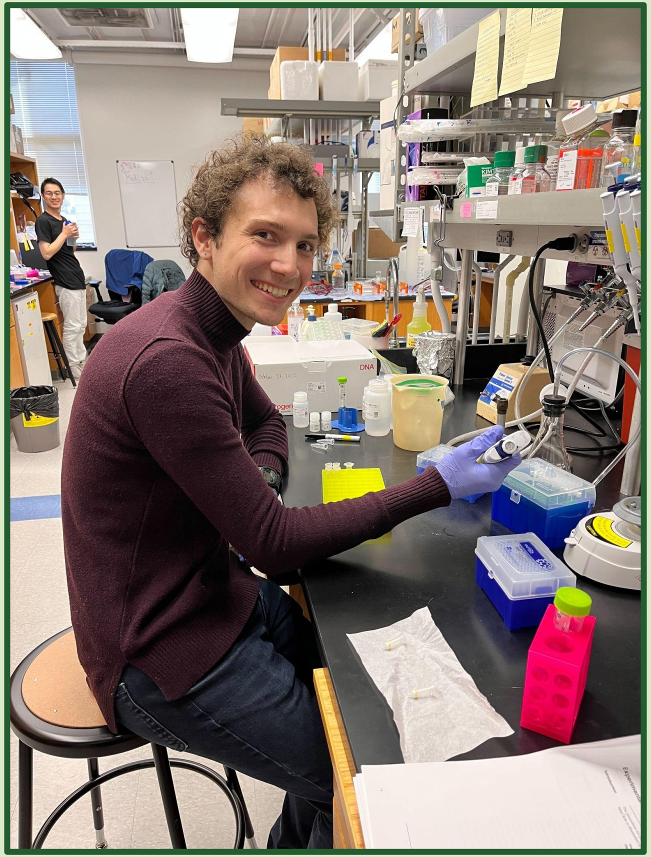


Wet lab

Dry lab



NUÑEZ lab
EXIT


DNA

USABLE PROGRAMMING TOOLS FOR EXPERIMENTAL BIOLOGISTS

Vaccines

💉

Precision health

🎯

Genomic editing

🧬

COMPONENT-BASED REFACTORING

WET LAB LANGUAGE

COMPONENT-BASED REFACTORING

WET LAB
LANGUAGE

COMPONENT-BASED REFACTORING

1. Motivating example
2. Naïve approach
3. Our approach

COMPONENT-BASED REFACTORING

1. **Motivating example**
2. Naïve approach
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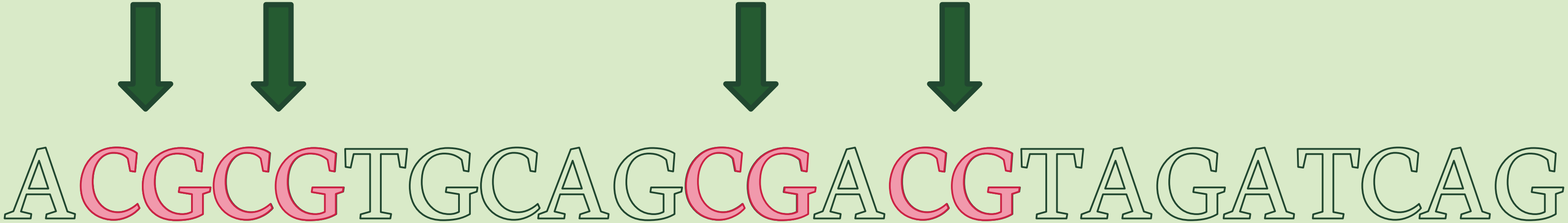
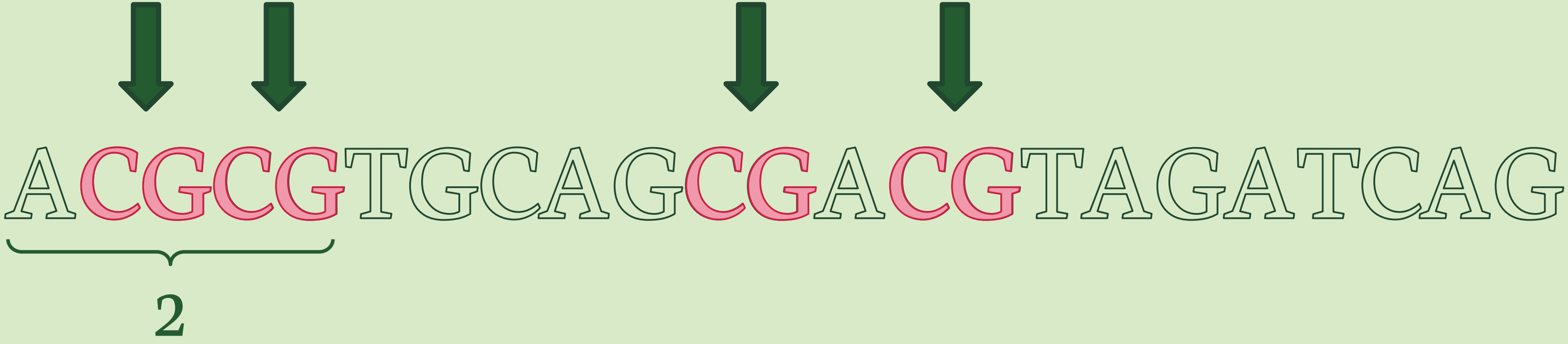
ACGCGTGCAGCGACGTAGATCAG

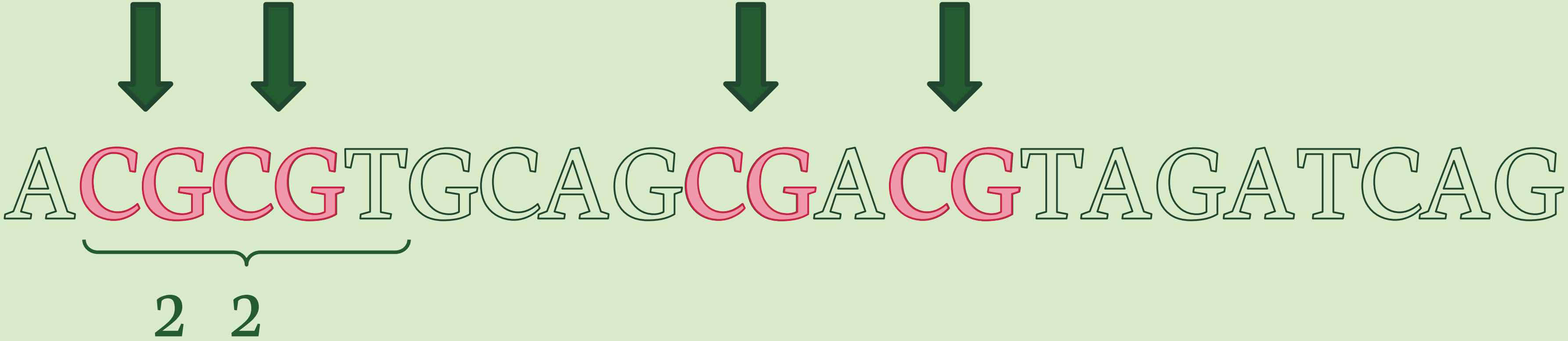


A**CGCG**TGCAG**CG**A**CG**TAGATCAG



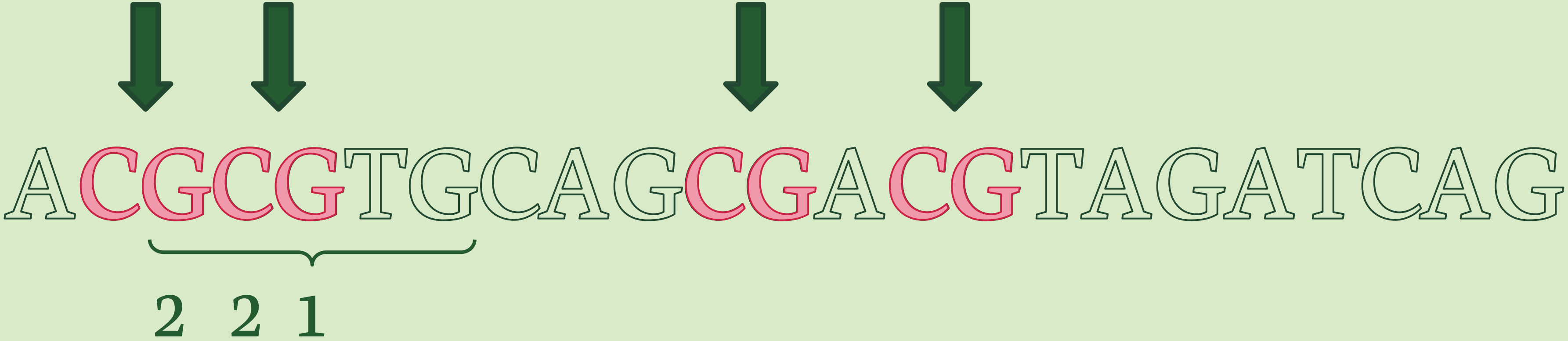
ACGCGTGCAGCGACGTAGATCAG

2



ACGCGTGCAGCGACGTAGATCAG

2 2



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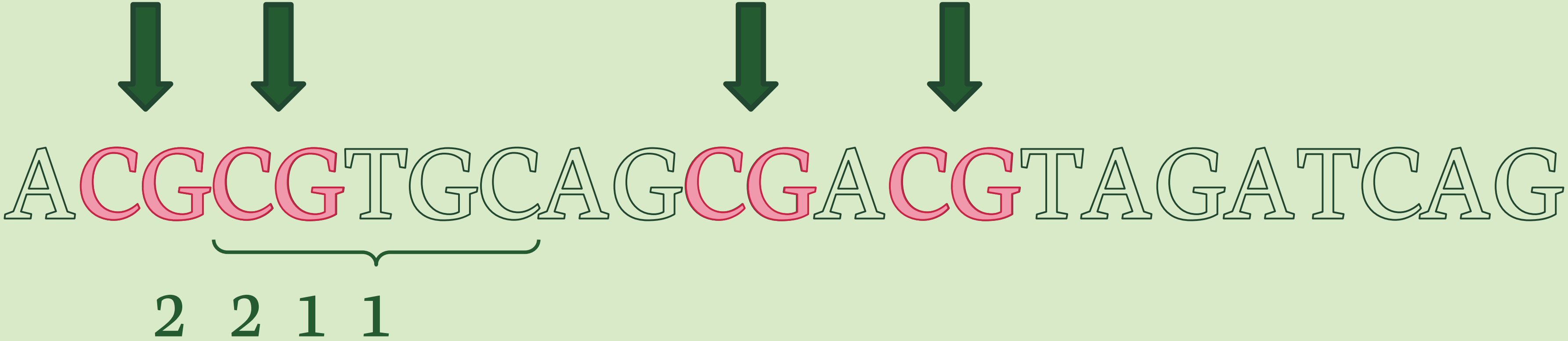
2 2 1



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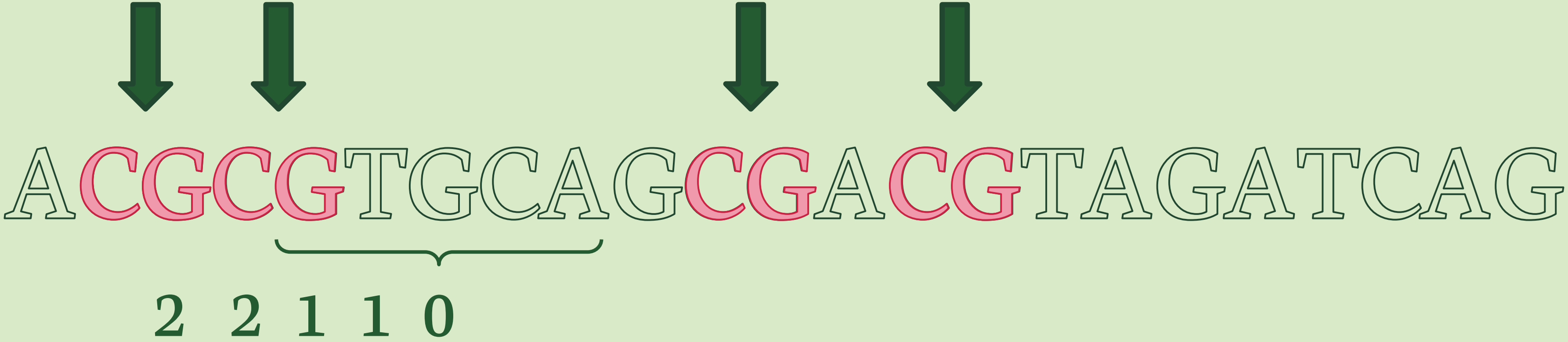
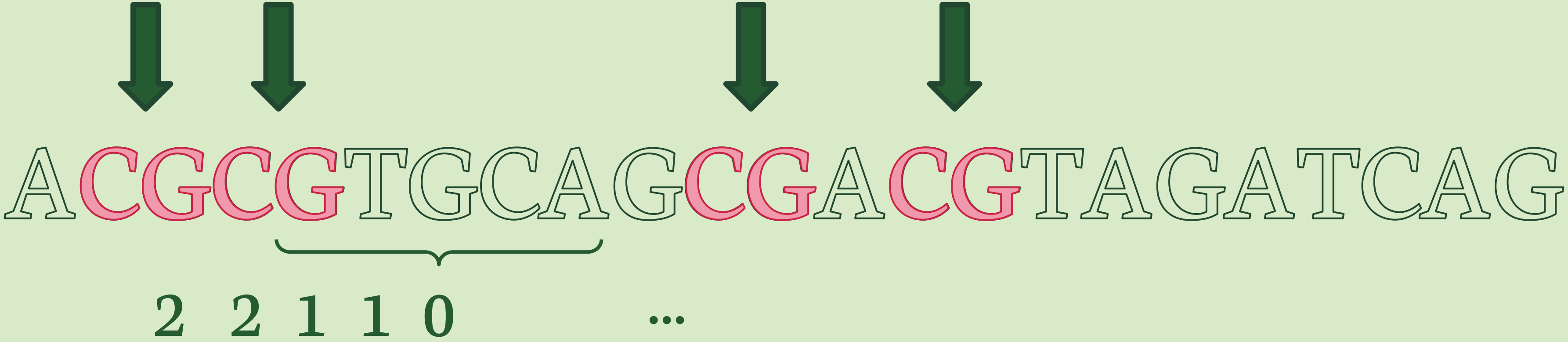
2 2 1 1



ACGCGTGCAGCGACGTAGATCAG

2 2 1 1 0



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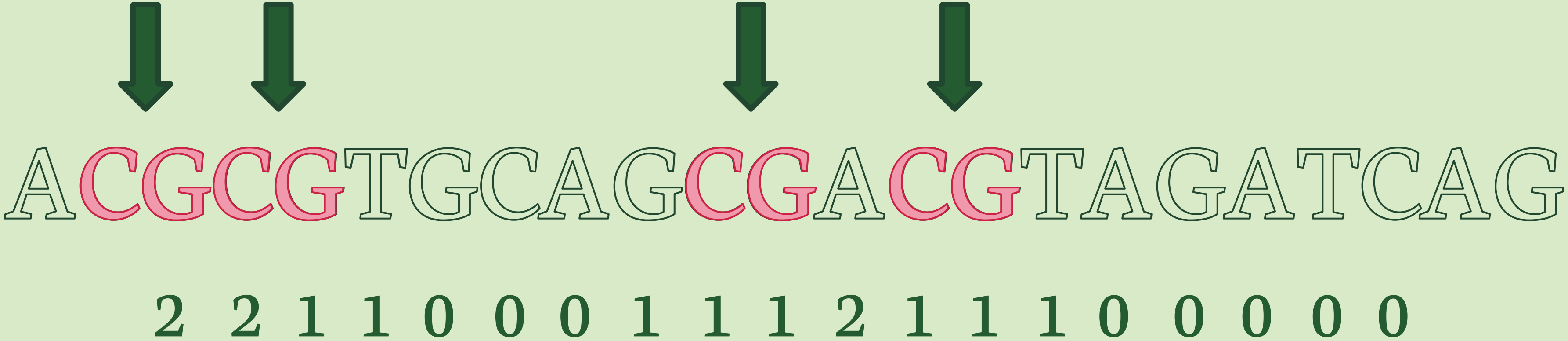
2 2 1 1 0 …



ACGCGTGCAGCGACGTAGATCAG

2 2 1 1 0 0 0 1 1 1 2 1 1 1 0 0 0 0 0

Straightforward solution:

Two nested `for` loops

*...but takes **>1 day** to run...*

Faster solution:

```
np.concatenate([
  np.convolve(
    (seq == "C")[:-1] & (seq == "G")[1:],
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*…but takes **<15 min** to run!*

COMPONENT-BASED REFACTORING

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COMPONENT-BASED REFACTORING

1. Motivating example
2. **<u>Naïve approach</u>**
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```
sum(mul(x, y))
```

```
def dot(x, y):
  total = 0
  for i in range(len(x)):
    total += x[i] * y[i]
  return total
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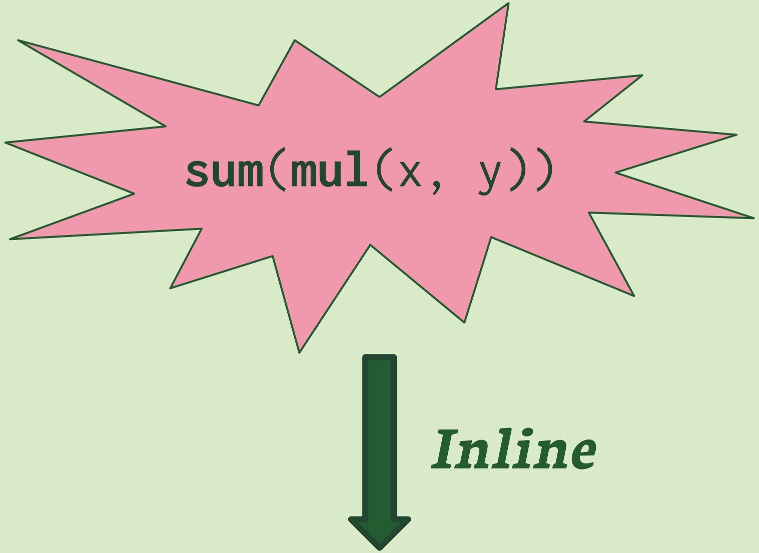

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Inline

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total = 0
for i in range(len(mul(x, y))):
  total += mul(x, y)[i]
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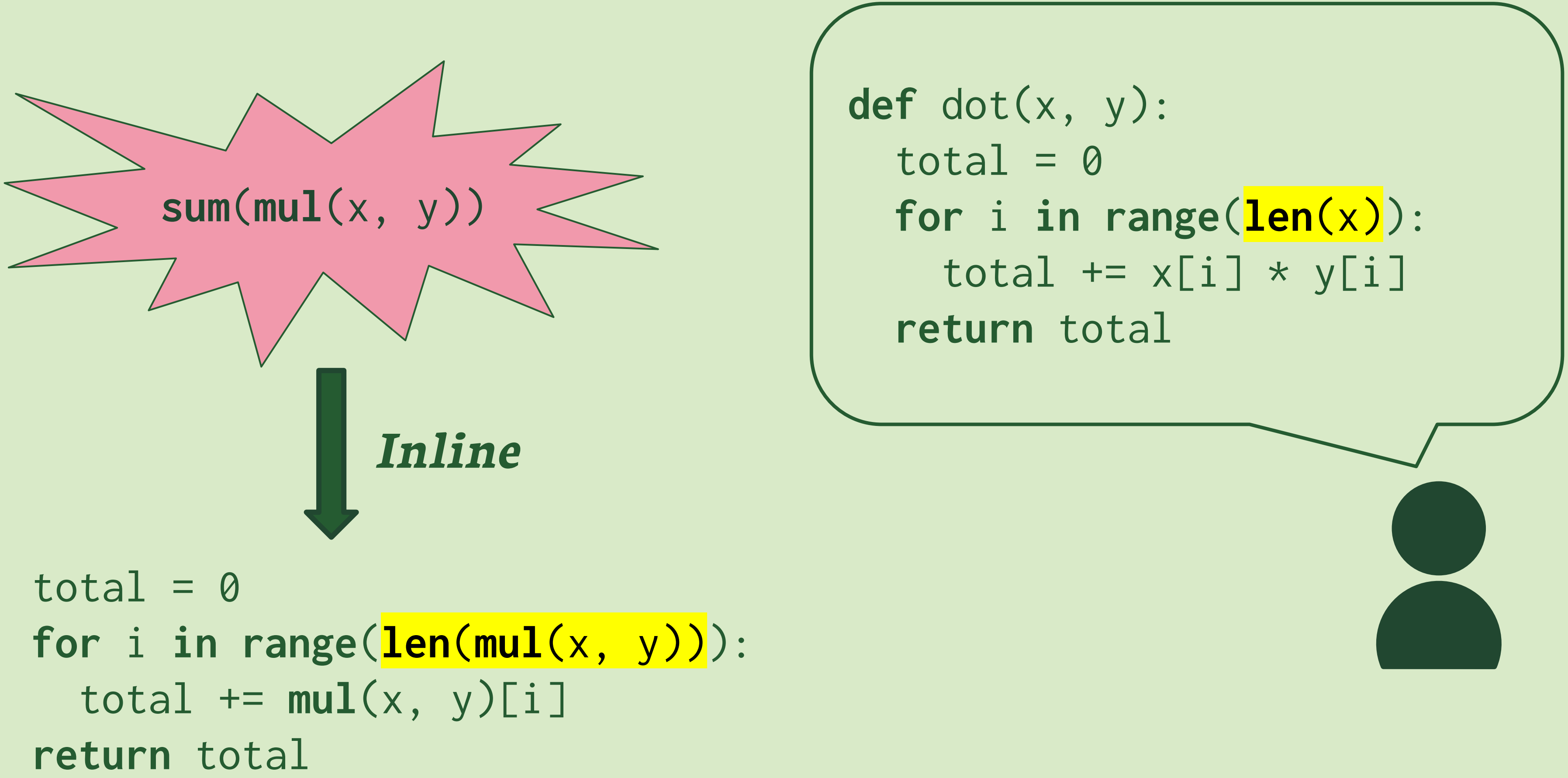

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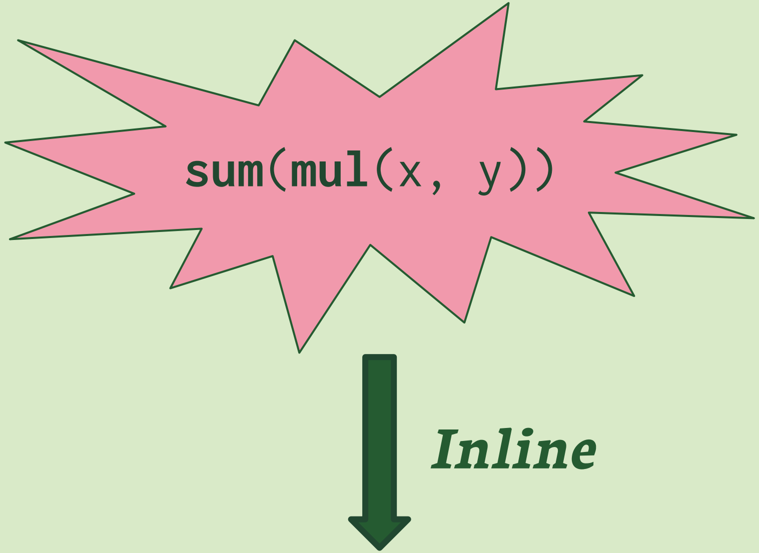

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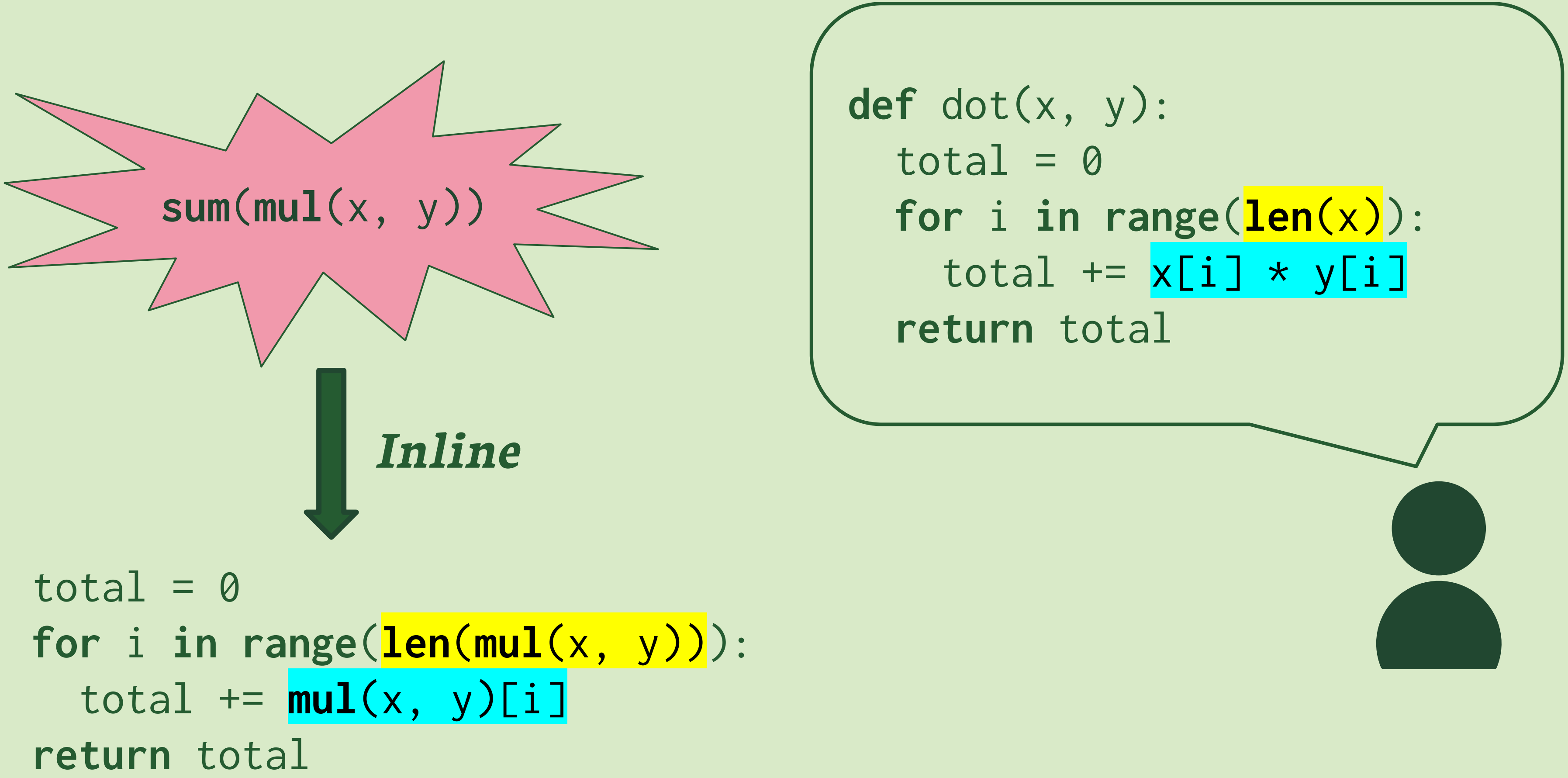

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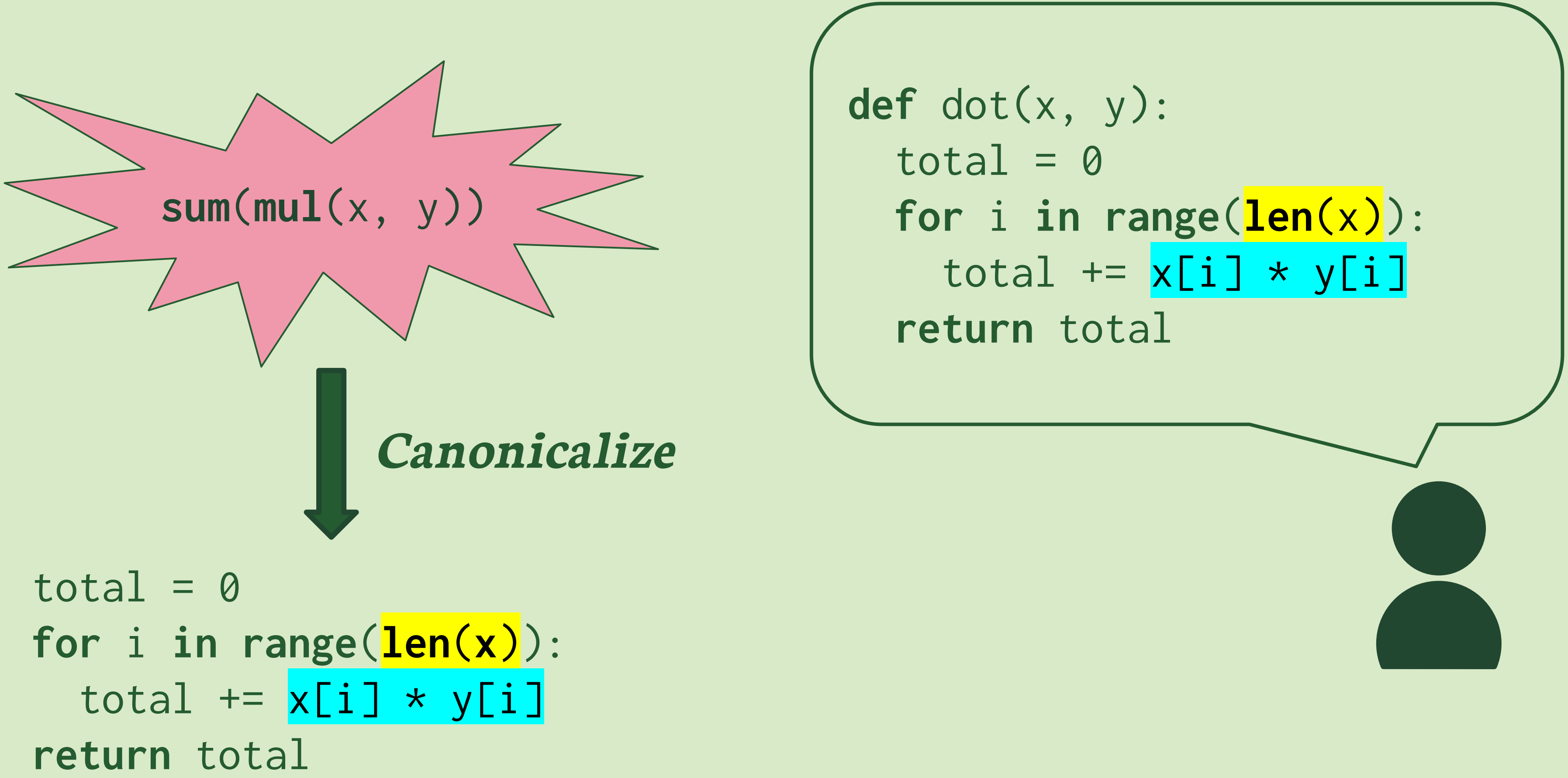
```
    len(x)
x[i] * y[i]
```

```
    len(mul(x, y))
mul(x, y)[i]
```

CANONICALIZATION

`len(mul(x, y))` → `len(x)`

`mul(x, y)[i]` → `x[i] * y[i]`



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↓ ***Canonicalize***

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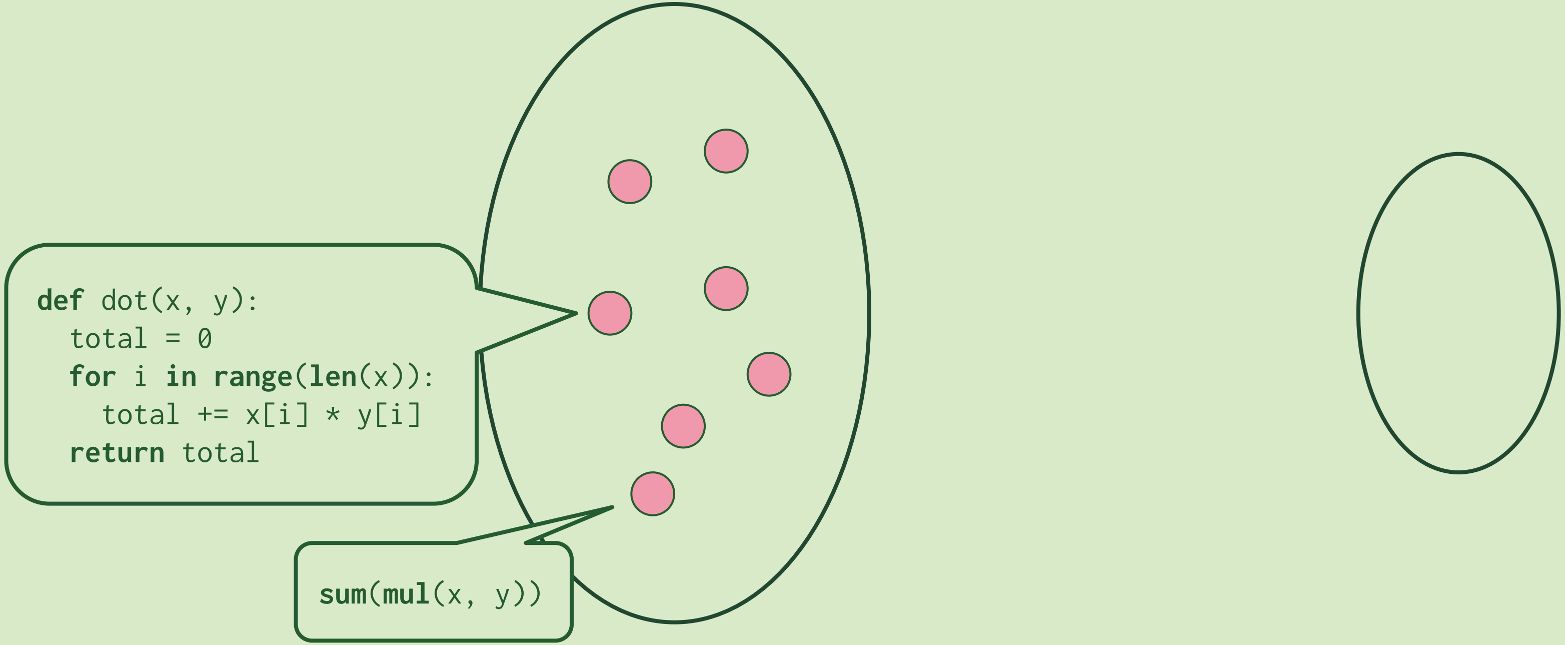

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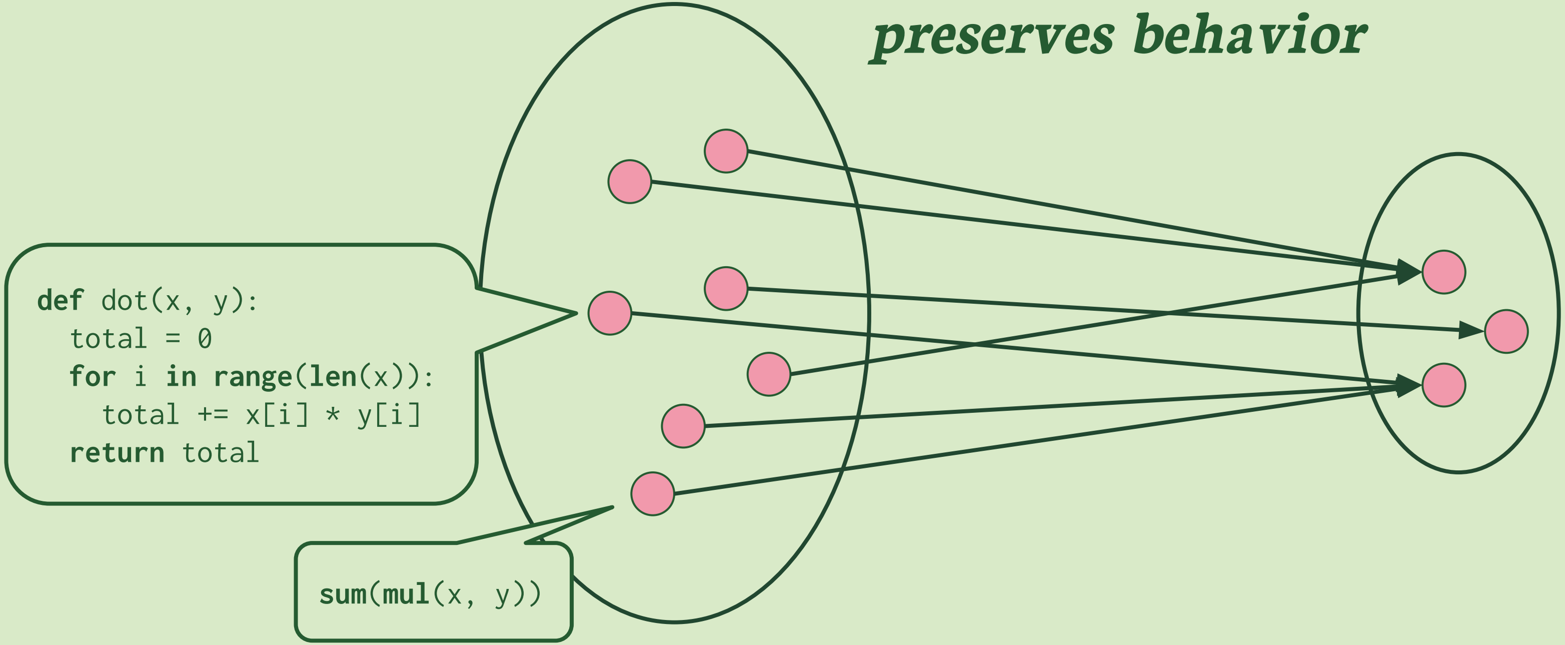

preserves behavior

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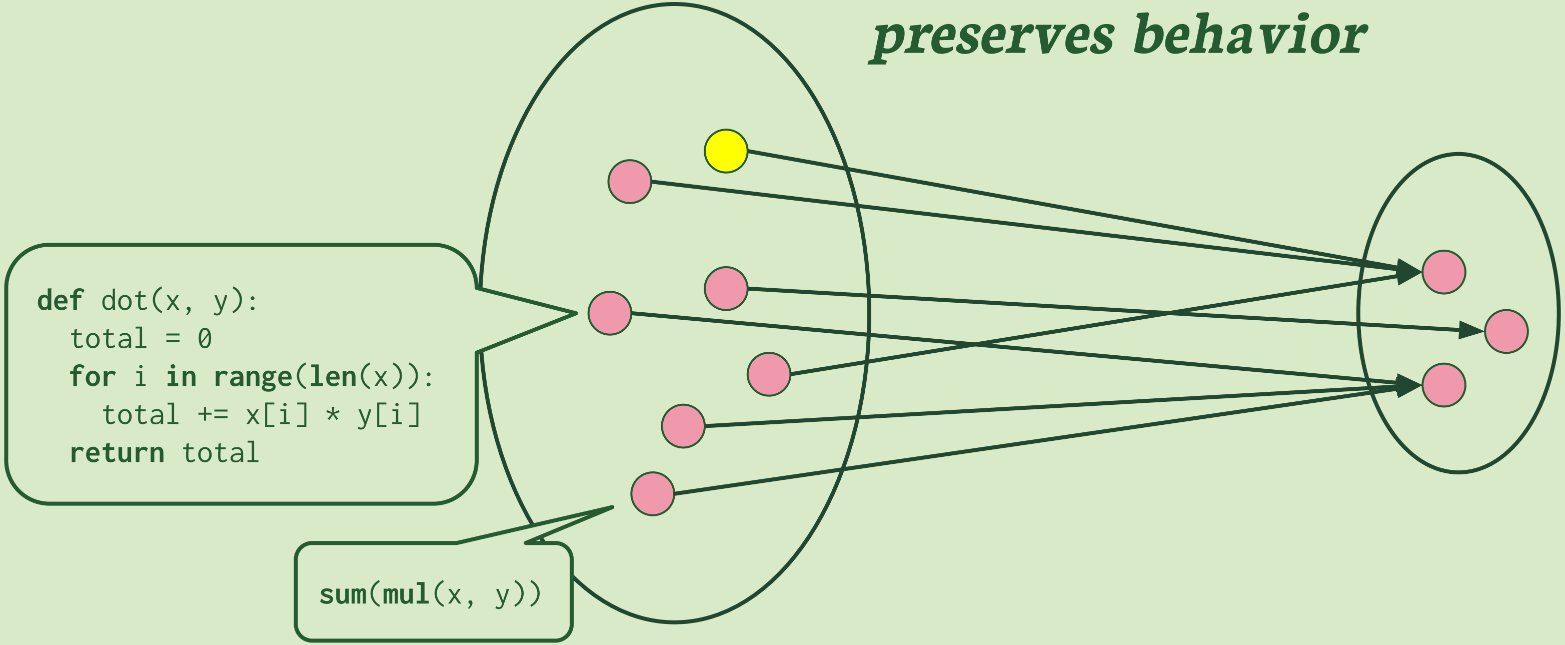

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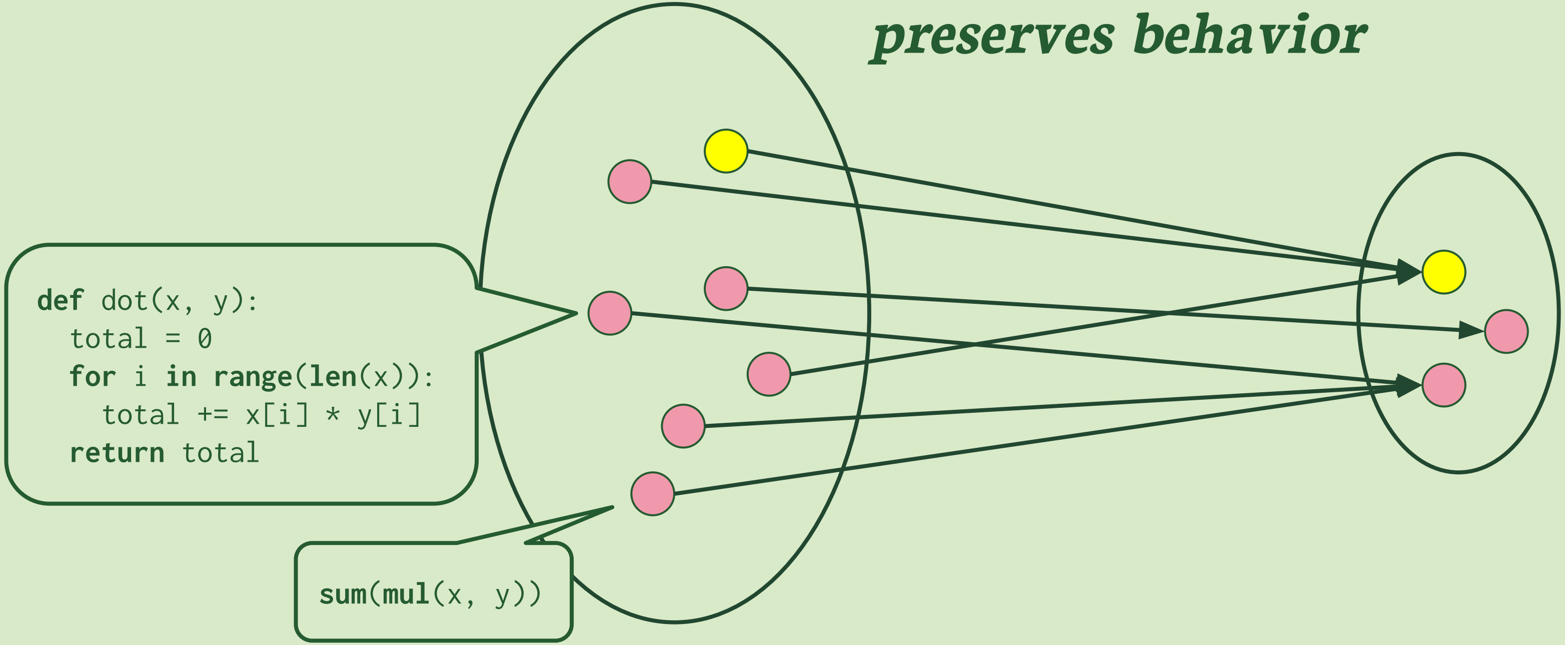

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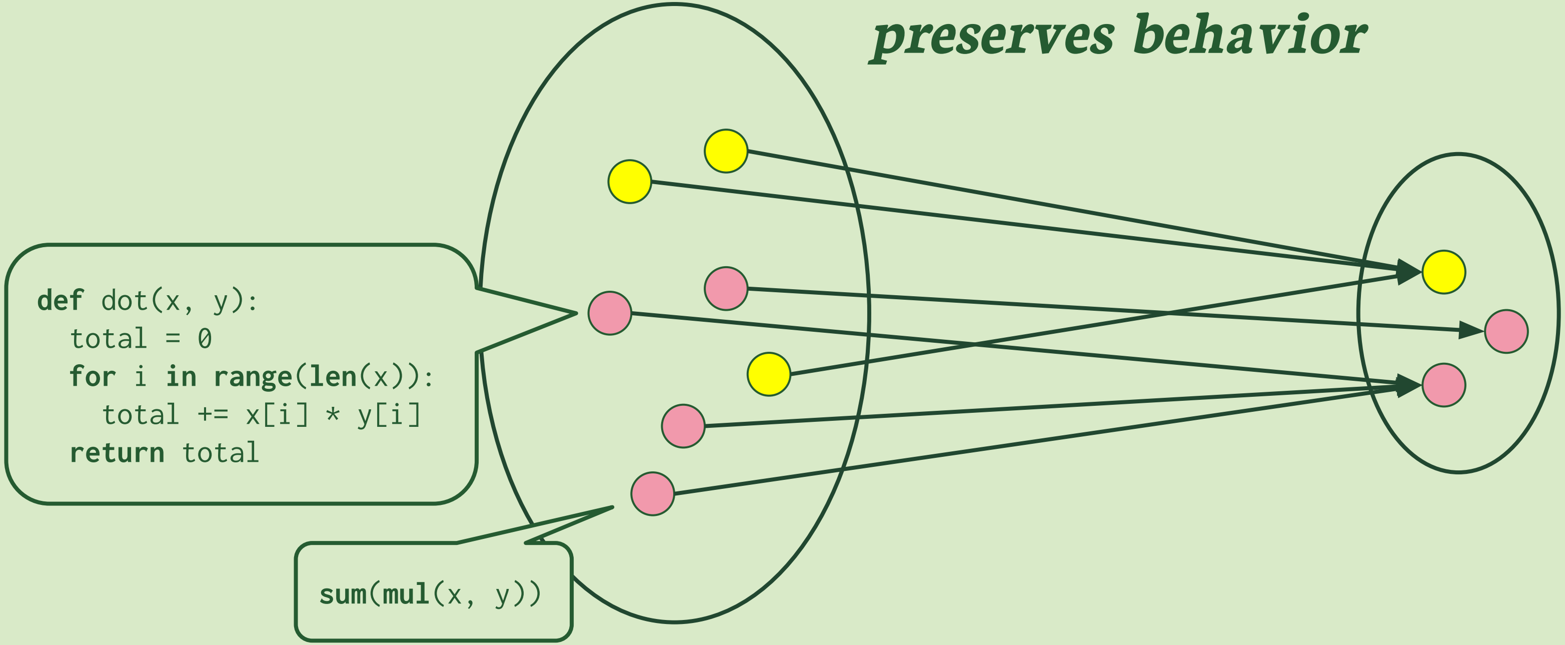

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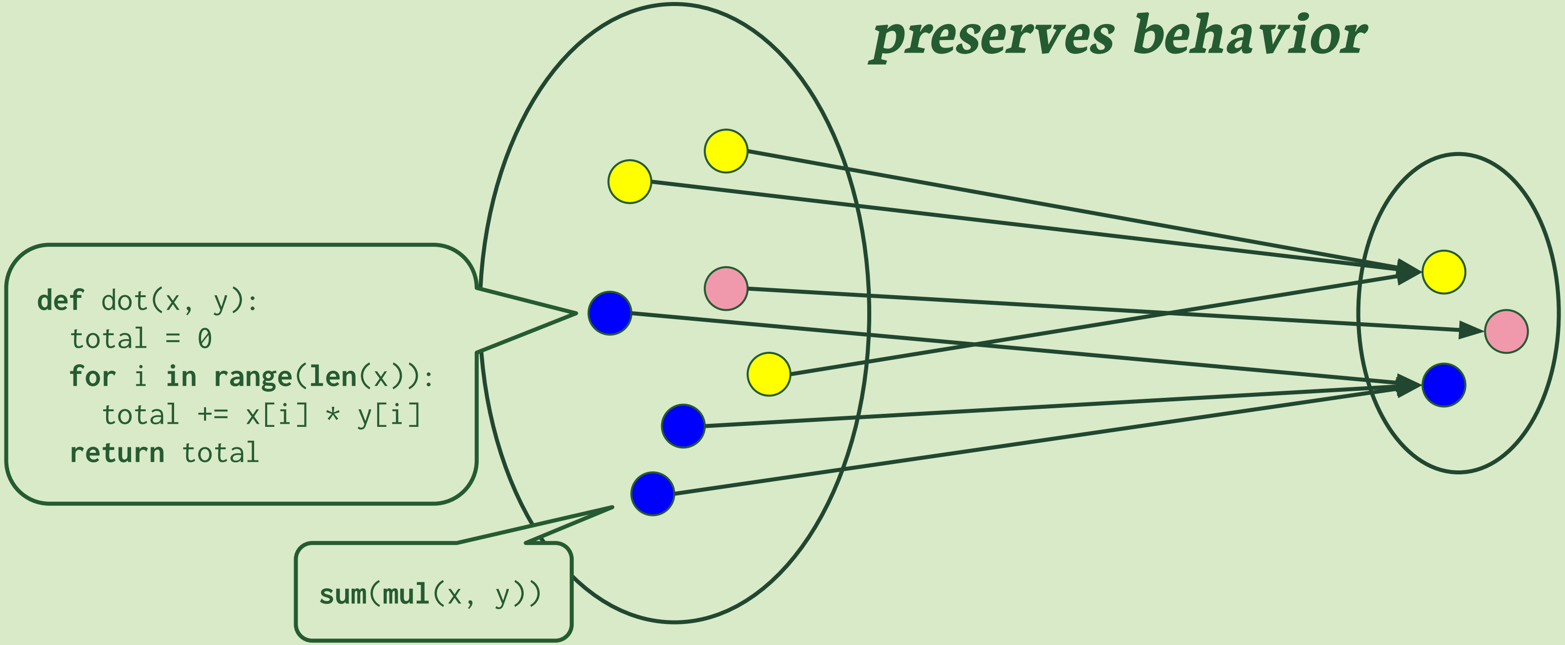

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KEY IDEA

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we can check ***extensional equality***

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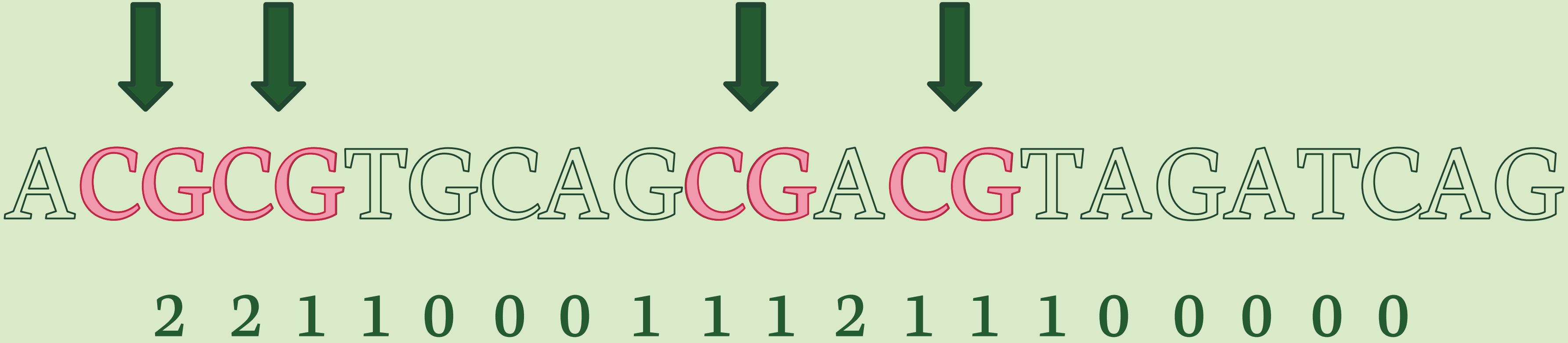
For many programs,

we can check
extensional equality

– by –

syntactic equality
modulo
canonicalization



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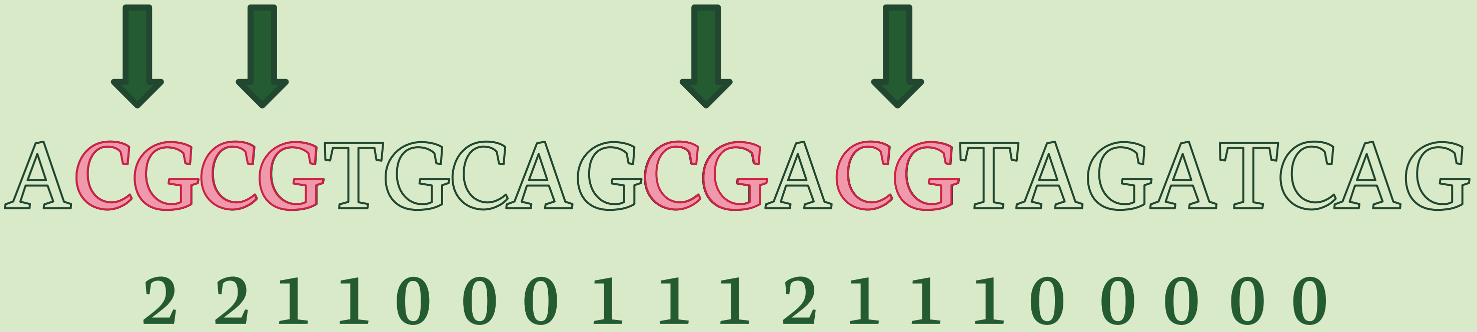
Jeremy Ferguson

Kevin Ye

Jacob Yim



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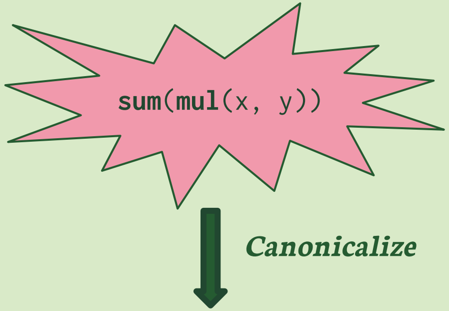

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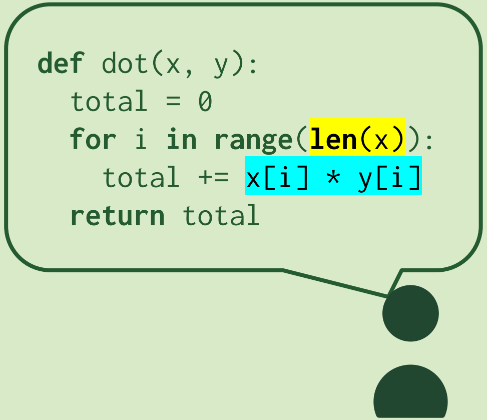

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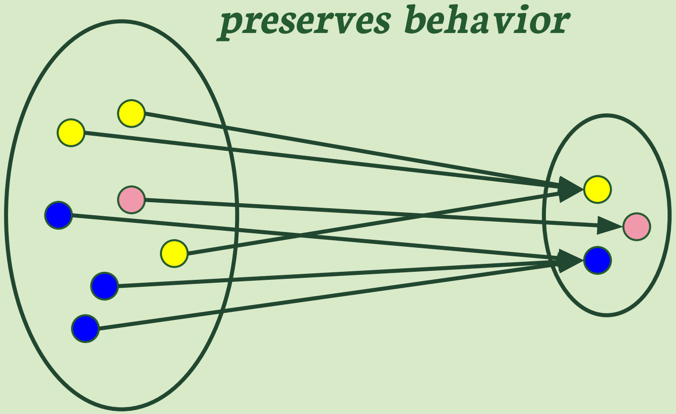
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