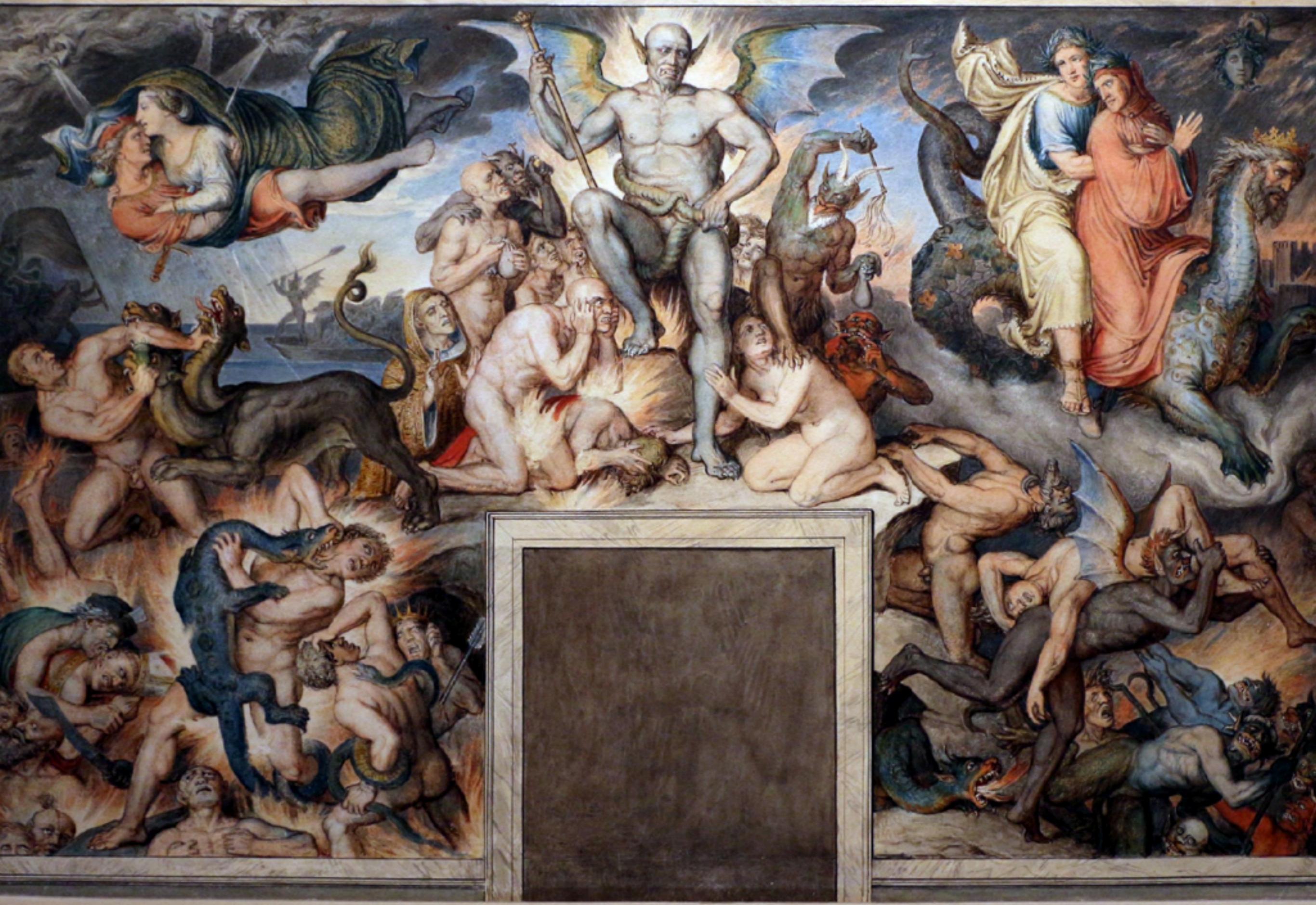




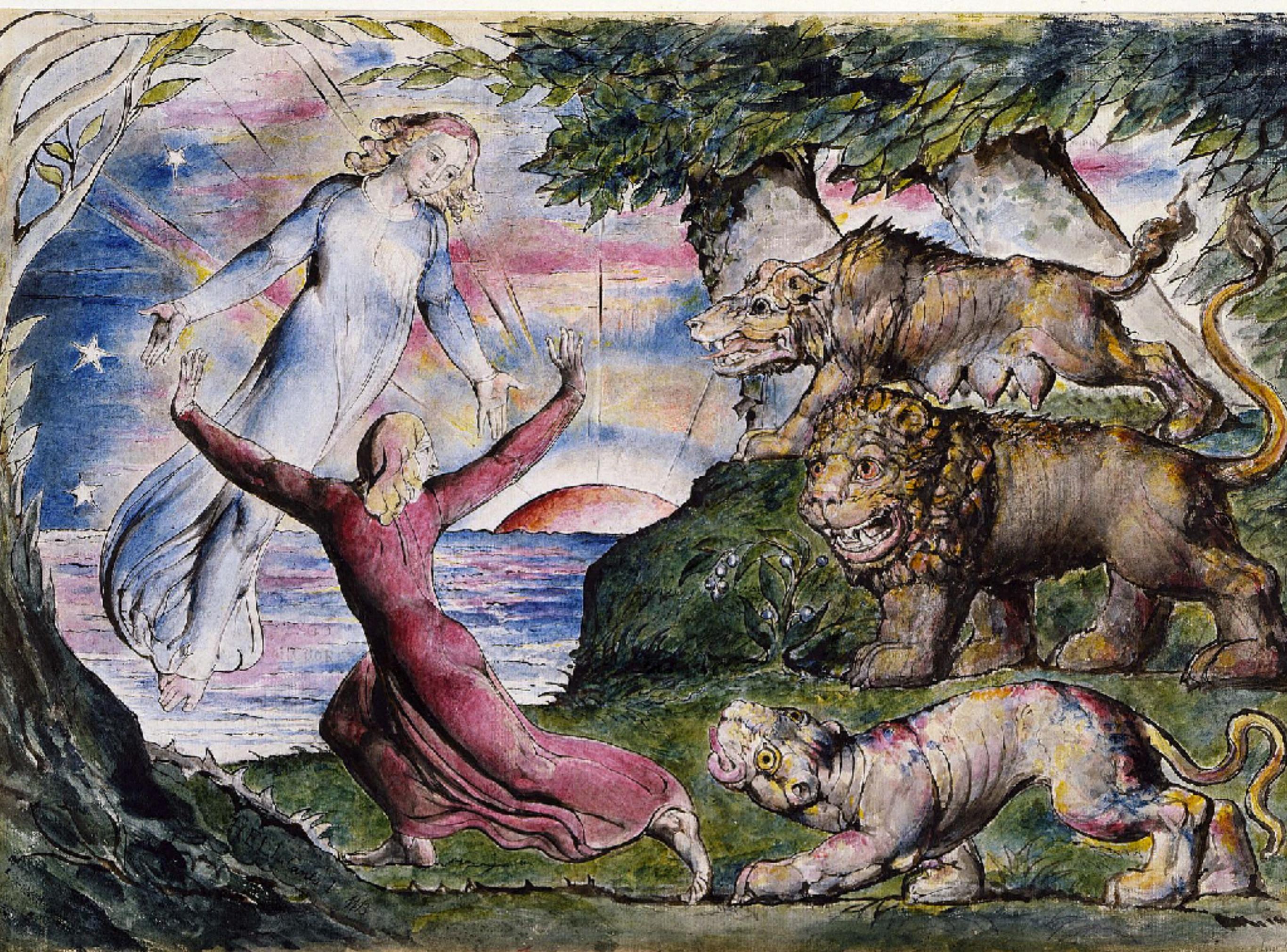
A Divine Data Comedy in JavaScript

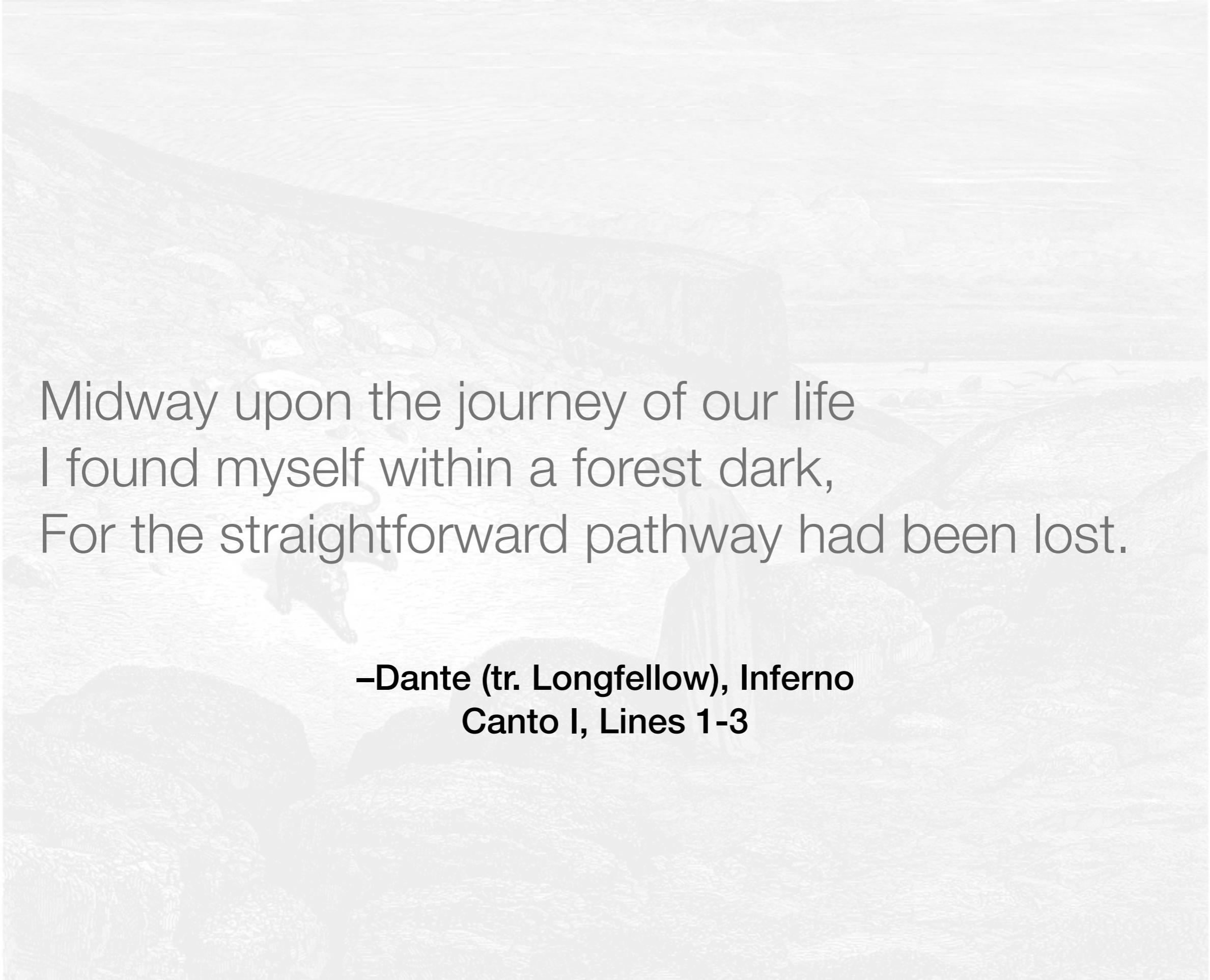
Mike Harris











Midway upon the journey of our life
I found myself within a forest dark,
For the straightforward pathway had been lost.

**—Dante (tr. Longfellow), Inferno
Canto I, Lines 1-3**

Canto

- Data Flow in a System
- The Language of Data Flow Manipulations
- Data Flow in Context

Canto

- **Data Flow in a System**
- The Language of Data Flow Manipulations
- Data Flow in Context

Example Data Set

```
create table stock_price (
    symbol varchar(5) not null
    , price_date date not null
    , price money not null
) ;

insert into stock_price
(symbol, price_date, price)
values
    ('ZVZZT', '2017-01-03', 10.02)
    , ('CBO' , '2017-01-03', 18.99)
    , ('ZVZZT', '2017-01-04', 9.99)
    , ('CBO' , '2017-01-04', 19.01)
;
```

Example Data Set

Symbol	Price Date	Price
ZVZZT	2017-01-03	10.02
CBO	2017-01-03	18.99
ZVZZT	2017-01-04	9.99
CBO	2017-01-04	19.01

SQL Statement

```
select symbol, price  
from stock_price  
where symbol = 'ZVZZT'  
order by price_date  
;
```

Symbol	Price Date	Price
ZVZZT	2017-01-03	10.02
ZVZZT	2017-01-04	9.99

Logical Order of a T-SQL Statement

1. FROM
2. ON
3. JOIN
4. WHERE
5. GROUP BY
6. WITH ROLLUP
7. HAVING
8. SELECT
9. DISTINCT
10. ORDER BY
11. TOP

Logical Order of a T-SQL Statement

1. FROM
2. ON
3. JOIN
4. WHERE
5. GROUP BY
6. WITH ROLLUP
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8. SELECT
9. DISTINCT
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11. TOP

Extract

Aggregate

Map

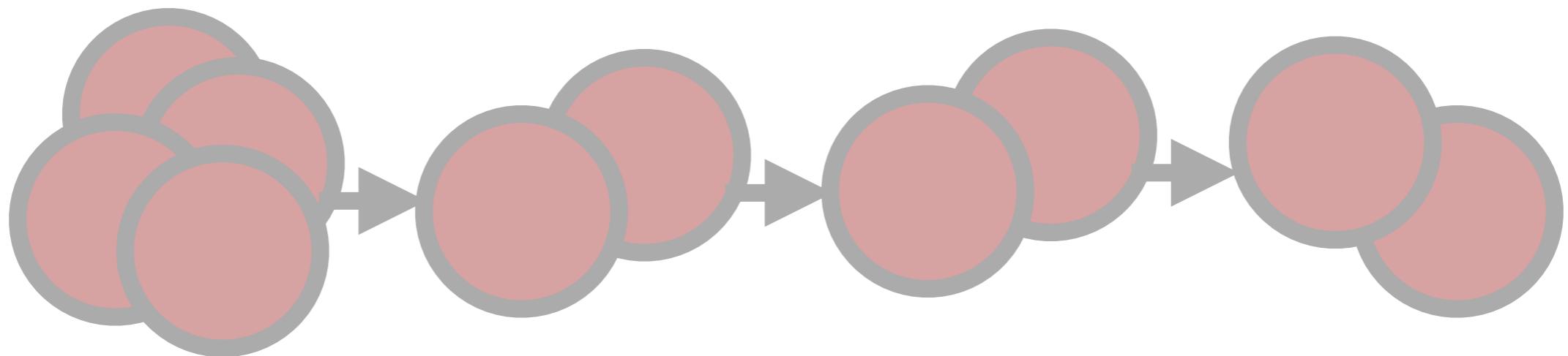
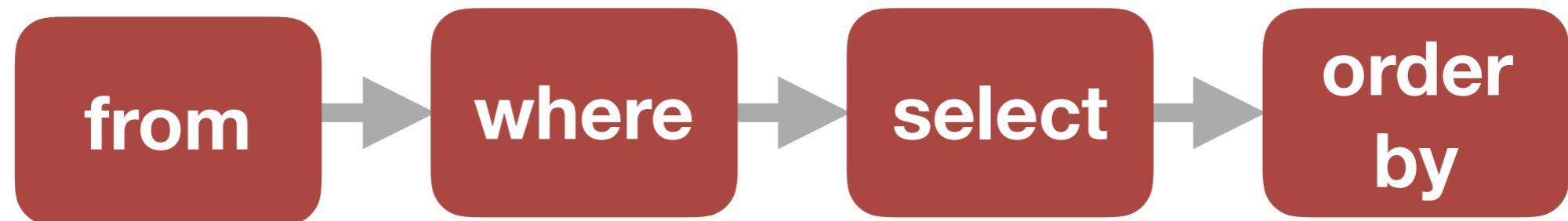
Order

Filter

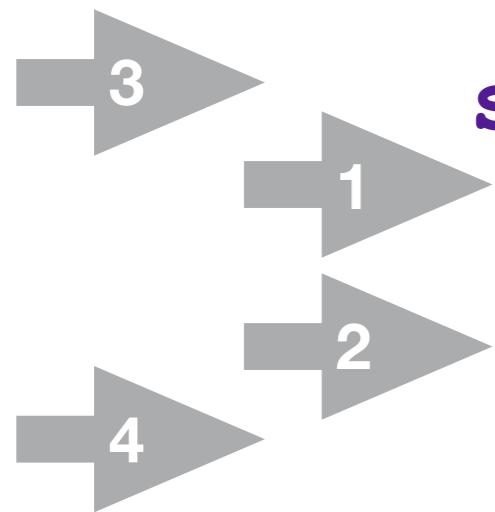
Logical Order of a T-SQL Statement

- 1. FROM**
2. ON
3. JOIN
- 4. WHERE**
5. GROUP BY
6. WITH ROLLUP
7. HAVING
- 8. SELECT**
9. DISTINCT
- 10. ORDER BY**
11. TOP

SQL Statement Data Flow



SQL Statement



```
3 select symbol, price  
1 from stock_price  
2 where symbol = 'ZVZZT'  
4 order by price_date  
;
```

Symbol	Price Date	Price
ZVZZT	2017-01-03	10.02
ZVZZT	2017-01-04	9.99

A faint, watermark-like illustration occupies the background. It depicts a woman on the left, wearing a light-colored, flowing dress and a crown, looking down at something in her hands. On the right, a man in a blue robe and a white turban stands, holding a long staff or object. They are positioned in a field of tall, golden-brown grass under a clear sky.

Folded SQL

Folded SQL Statement

```
select max(price_date) as price_date  
from stock_price  
;
```

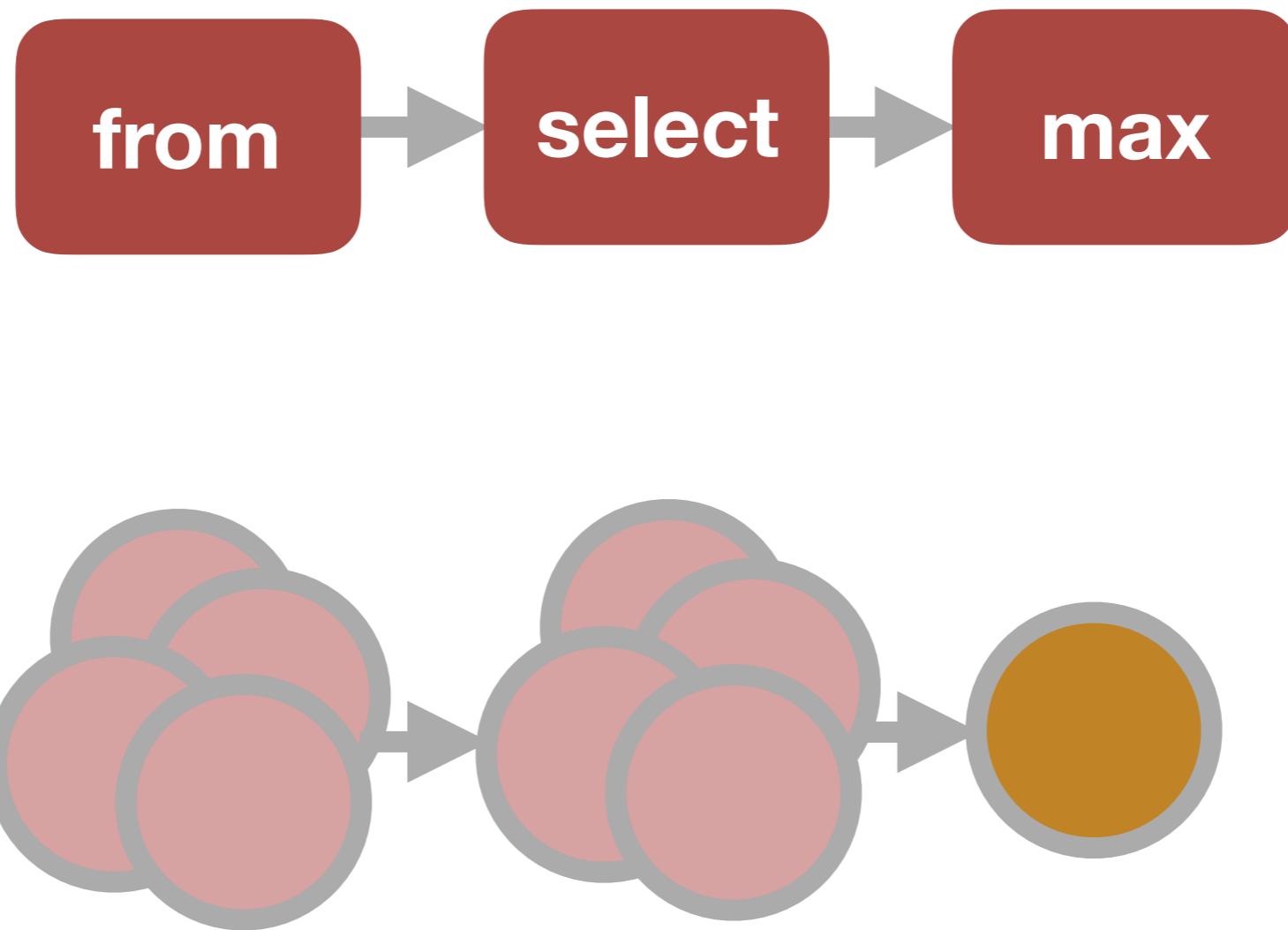
Price Date
2017-01-04

Logical Order of a T-SQL Statement

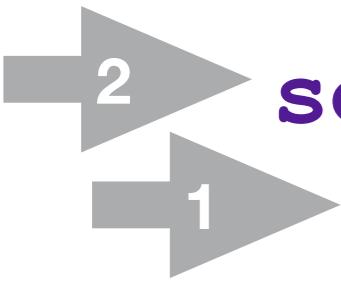
- 1. FROM**
2. ON
3. JOIN
4. WHERE
5. GROUP BY
6. WITH ROLLUP
7. HAVING

- 8. SELECT**
9. DISTINCT
10. ORDER BY
11. TOP

Folded SQL Statement Data Flow

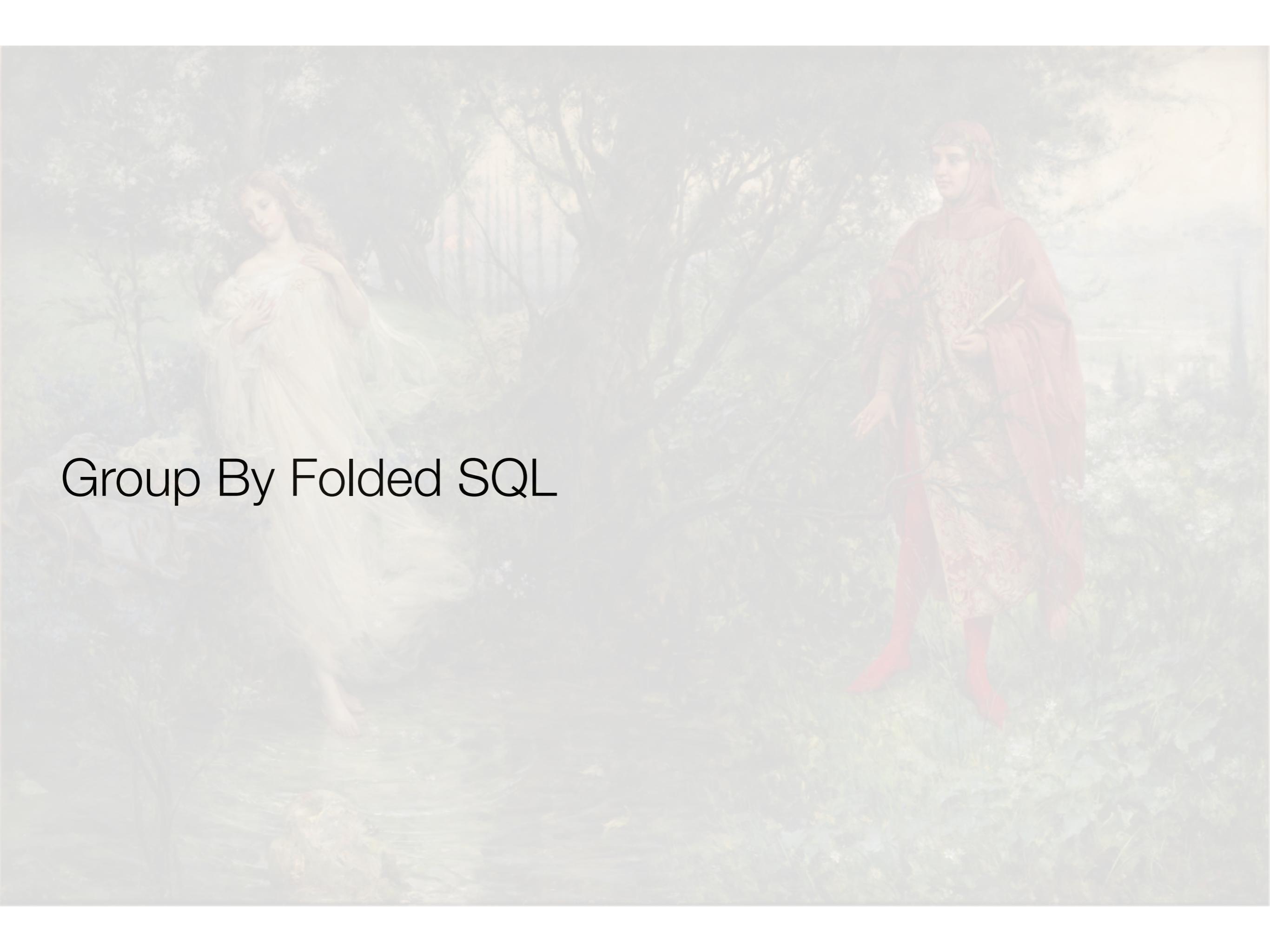


Folded SQL Statement



```
2 select max(price_date) as price_date  
1 from stock_price  
;
```

Price Date
2017-01-04

A faint, semi-transparent background image of a classical painting. It depicts two figures in a lush, green garden. On the left, a woman with long, light-colored hair is seated or reclining, looking towards the right. On the right, a man in a red robe and a white turban stands, holding a long staff or object. The scene is filled with dense foliage and flowers.

Group By Folded SQL

Group By Folded SQL Statement

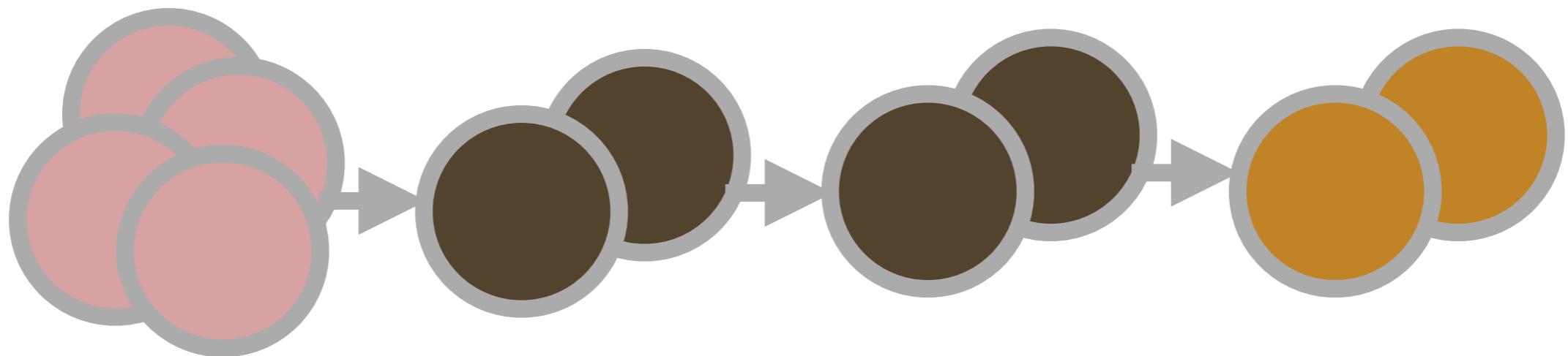
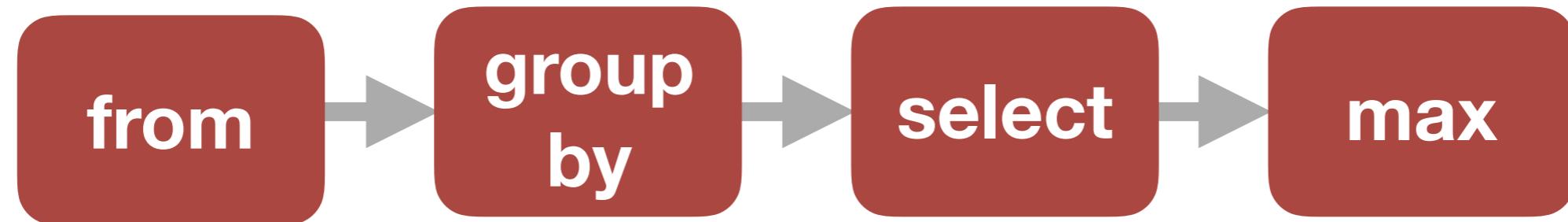
```
select
    symbol
    ,max(price_date) as price_date
from stock_price
group by symbol
;
```

Symbol	Price Date
CBO	2017-01-04
ZVZZT	2017-01-04

Logical Order of a T-SQL Statement

- 1. FROM**
2. ON
3. JOIN
4. WHERE
- 5. GROUP BY**
6. WITH ROLLUP
7. HAVING
- 8. SELECT**
9. DISTINCT
10. ORDER BY
11. TOP

Group By Folded SQL Statement Data Flow



Group By Folded SQL Statement

```
3  select
     symbol
     , max(price_date) as price_date
1  from stock_price
2  group by symbol
;

```

Symbol	Price Date
CBO	2017-01-04
ZVZZT	2017-01-04

Window Folded SQL



Window Folded SQL Statement

```
select distinct
    symbol
    , max(price_date) over(
        partition by symbol) as price_date
from stock_price
;
```

Symbol	Price Date
CBO	2017-01-04
ZVZZT	2017-01-04

Logical Order of a T-SQL Statement

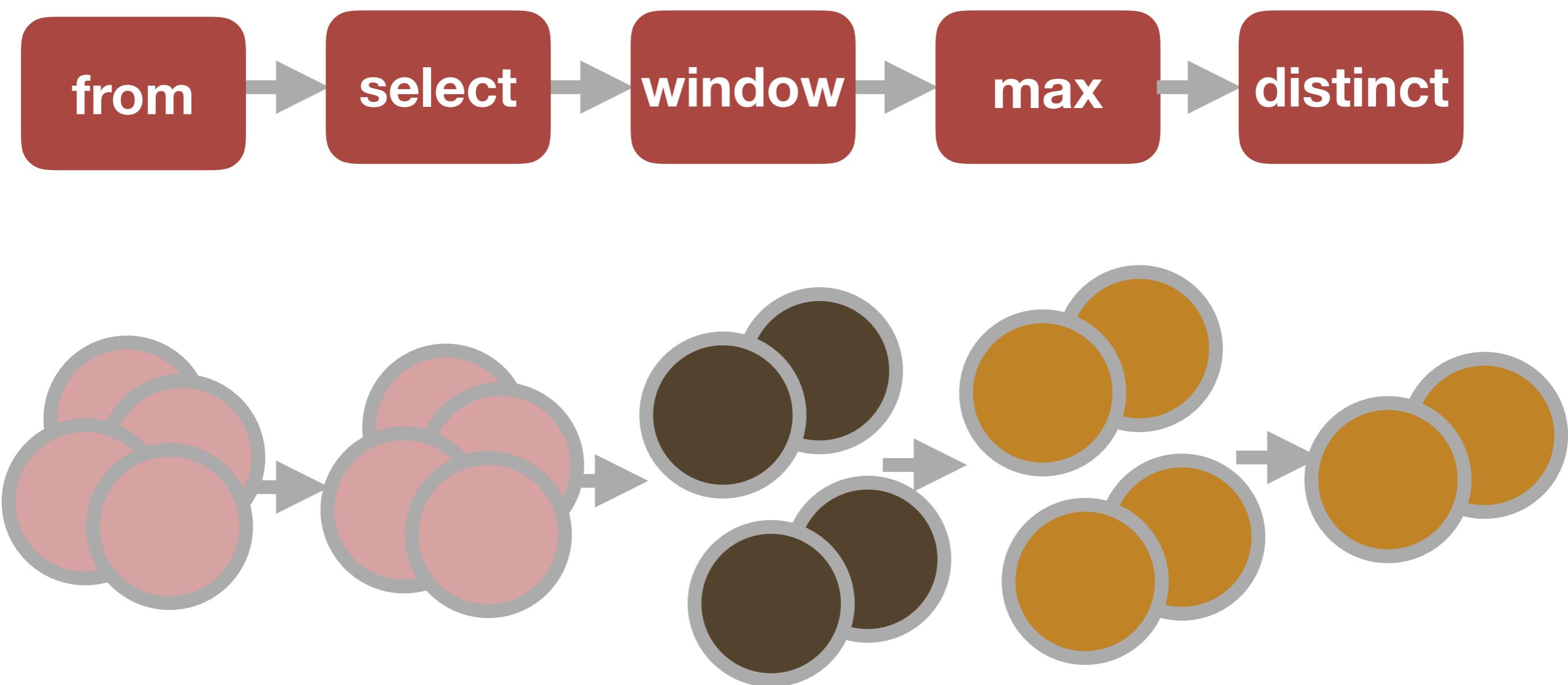
- 1. FROM**
2. ON
3. JOIN
4. WHERE
5. GROUP BY
6. WITH ROLLUP
7. HAVING
- 8. SELECT**
- 9. DISTINCT**
10. ORDER BY
11. TOP

Window SQL Statement Data View

```
max(price_date) over(  
partition by symbol) as price_date
```



Window SQL Statement Data Flow



Window Folded SQL Statement

```
select distinct  
    symbol  
    , max(price_date) over(  
        partition by symbol) as price_date  
from stock_price  
;  
2
```

Symbol	Price Date
CBO	2017-01-04
ZVZZT	2017-01-04

A faint, watermark-like illustration occupies the background. It depicts a woman with long, wavy hair, wearing a light-colored, flowing dress. To her right, another figure is partially visible, wearing a red cloak and holding a small object, possibly a book or a scroll. They are standing in a field of tall grass and small white flowers.

Window SQL

Window SQL Statement

```
select
    symbol
    ,price
    ,lag(price, 1) over (
        partition by symbol
        order by price_date) as prev_price
    ,price - lag(price, 1) over (
        partition by symbol
        order by price_date) as price_change
    ,lead(price, 1) over (
        partition by symbol
        order by price_date) as next_price
from stock_price
; 
```

Window SQL Statement

Symbol	Price	prev_price	price_change	next_price
CBO	18.99	(null)	(null)	19.01
CBO	19.01	18.99	0.02	(null)
ZVZZT	10.02	(null)	(null)	9.99
ZVZZT	9.99	10.02	-0.03	(null)

Window SQL Statement Data View

```
lag(price, 1) over (
    partition by symbol
    order by price_date) as prev_price
```

The diagram illustrates the transformation of a data table into a windowed view using the `lag` function. On the left, a table with columns `Symbol`, `Price_Date`, and `Price` contains two rows for symbol 'CBO'. An arrow points from this table to a vertical column on the right labeled `prev_price`, which shows the previous price for each row.

Symbol	Price_Date	Price	prev_price
CBO	2017-01-03	18.99	(null)
CBO	2017-01-04	19.01	18.99

Window SQL Statement Data View

```
lead(price, 1) over (
    partition by symbol
    order by price_date) as next_price
```

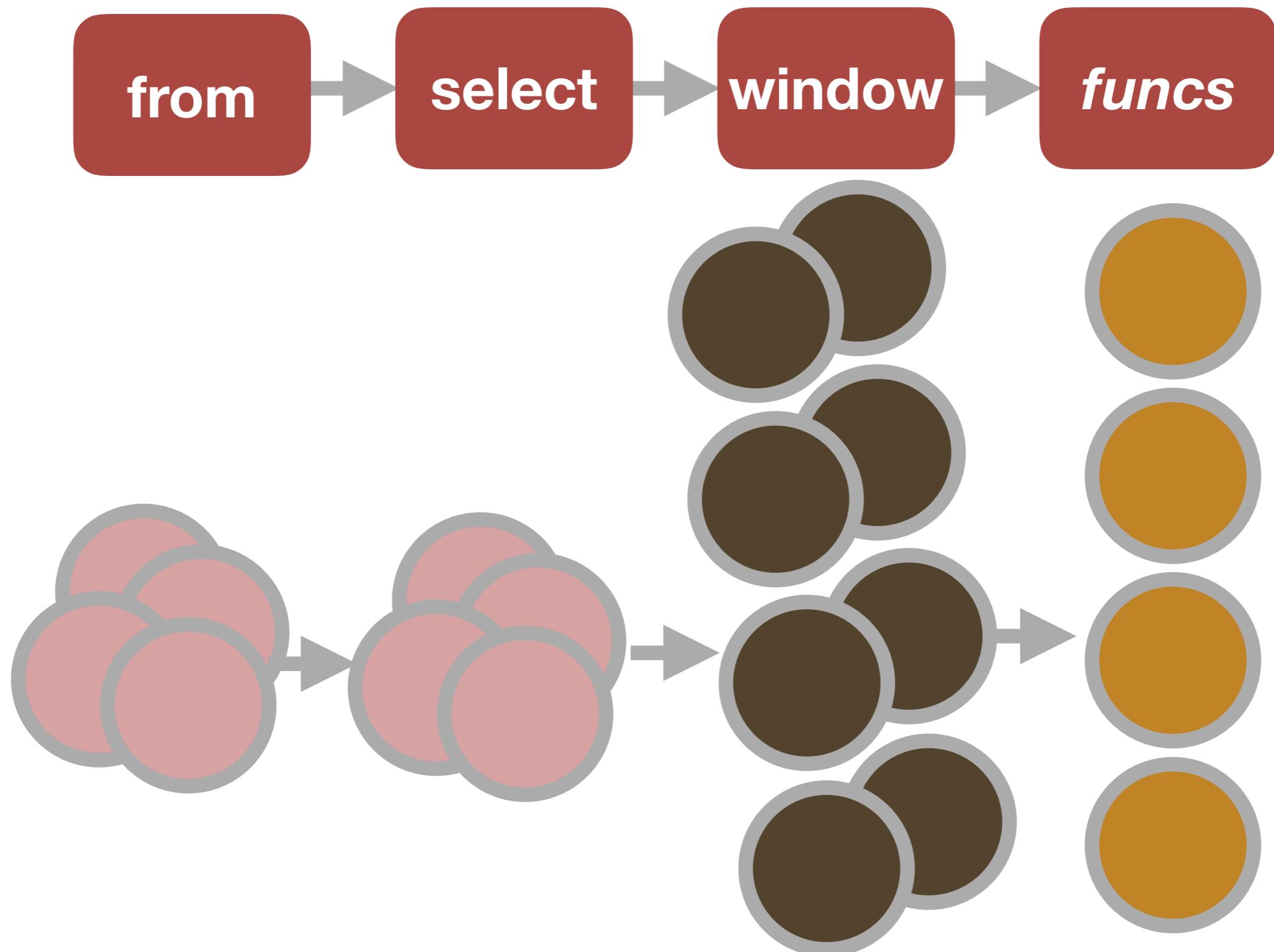
Symbol	Price_Date	Price	next_price
CBO	2017-01-03	18.99	19.01
CBO	2017-01-04	19.01	(null)

Logical Order of a T-SQL Statement

- 1. FROM**
2. ON
3. JOIN
4. WHERE
5. GROUP BY
6. WITH ROLLUP
7. HAVING

- 8. SELECT**
9. DISTINCT
10. ORDER BY
11. TOP

Window SQL Statement Data Flow



Window SQL Statement

```
select
→ 2 symbol
, price
, lag(price, 1) over (
    partition by symbol
    order by price_date) as prev_price
, price - lag(price, 1) over (
    partition by symbol
    order by price_date) as price_change
, lead(price, 1) over (
    partition by symbol
    order by price_date) as next_price
→ 1 from stock_price
;
```

Canto

- Data Flow in a System
- **The Language of Data Flow Manipulations**
- Data Flow in Context

Imperative Example

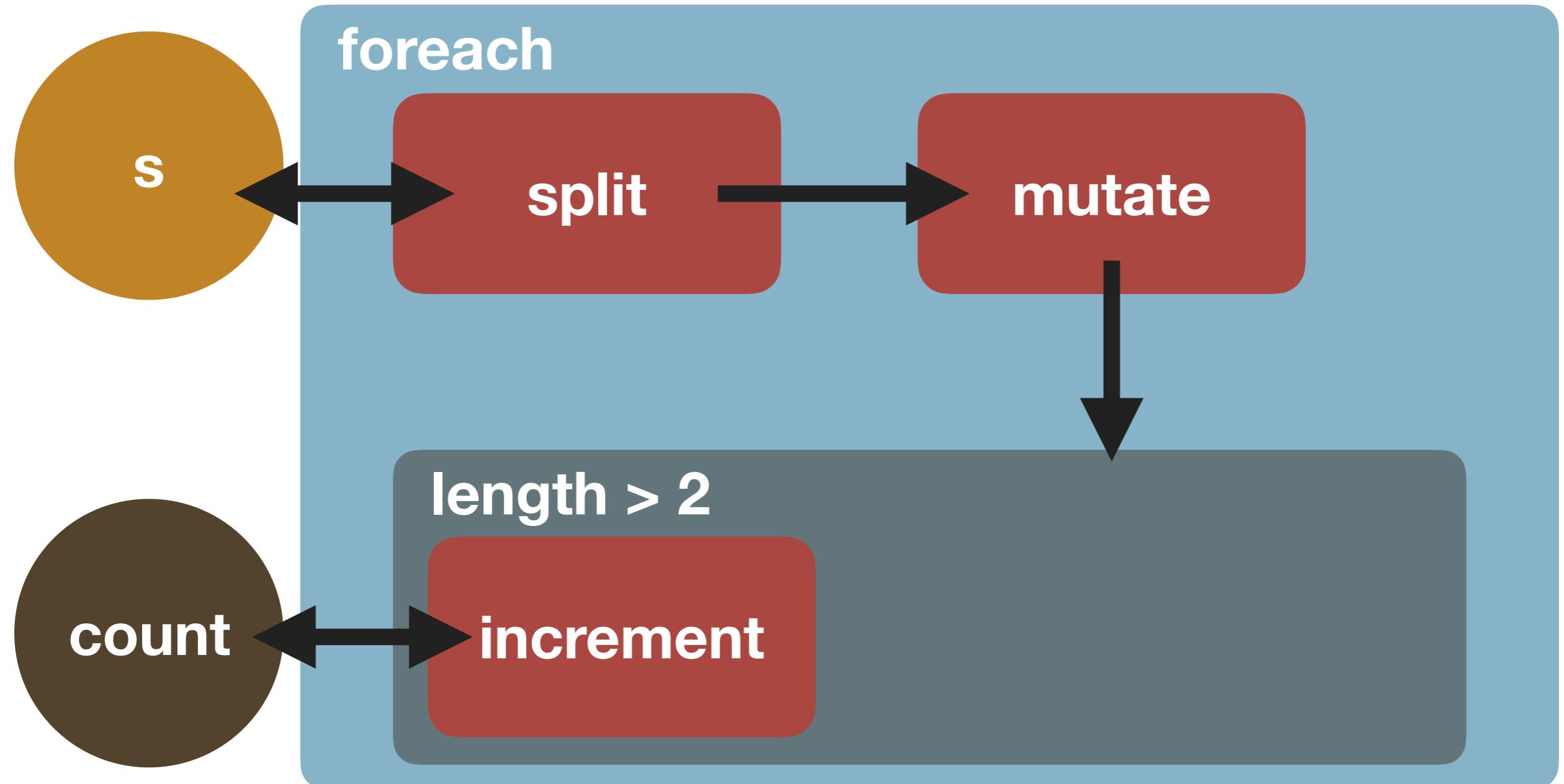


```
var _ = require('lodash');
```

Imperative Example

```
const s =
  'Midway in our life\'s journey, I went astray';
var count = 0;
for(var word of _.split(s, ' ')) {
  var stripped = _.replace(word, '(\\'s)|\w+', '');
  if (stripped.length > 2)
    count++;
}
```

Imperative Data Flow



Nested Example

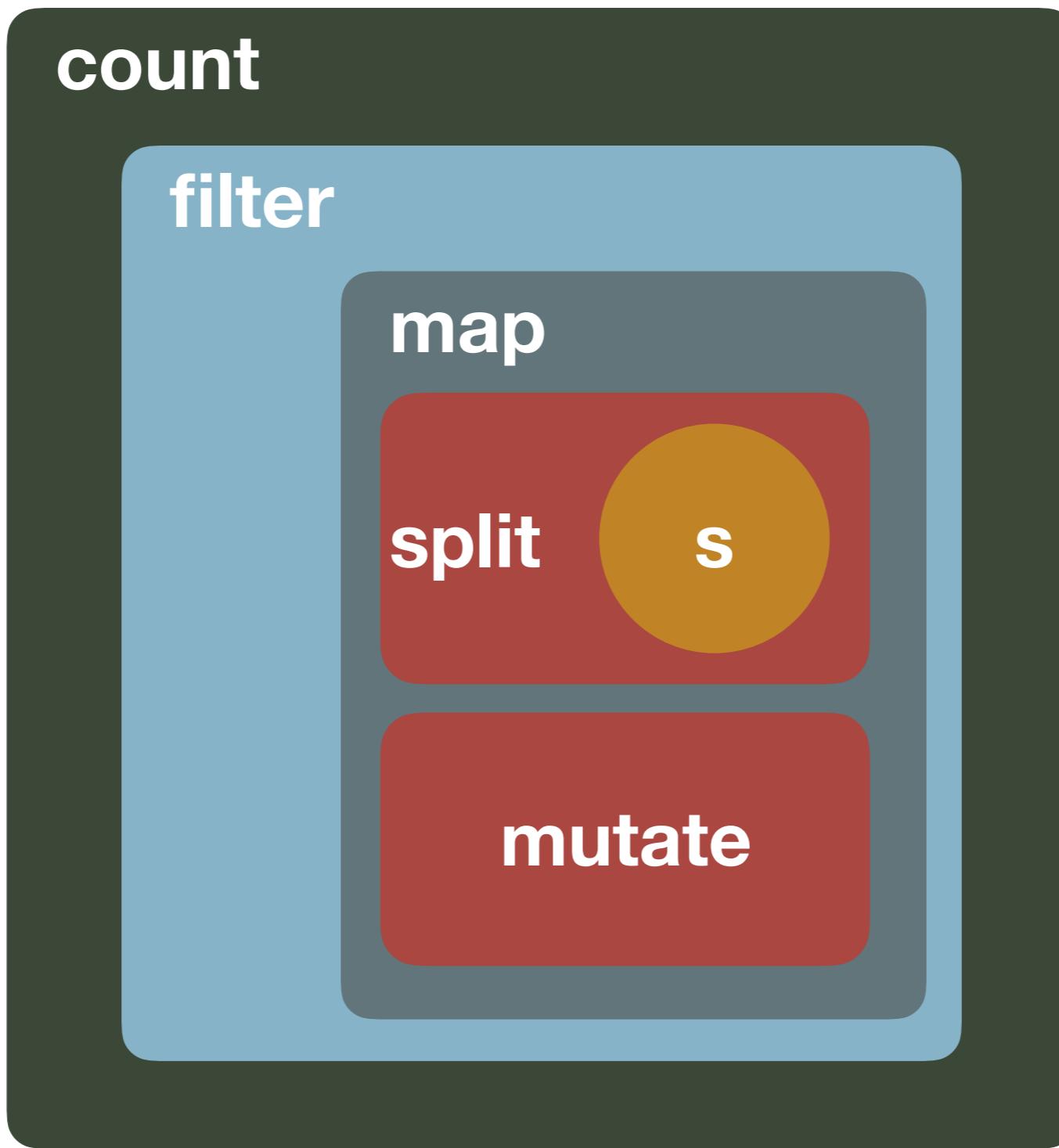


```
var _ = require('lodash');
```

Nested Example

```
const s =
  'Midway in our life\'s journey, I went astray';
const count = _.size(
  _.filter(
    _.map(
      _.split(s, ' '),
      word => _.replace(word, '(\\'s)|\w+', '')
    ),
    stripped => _.gt(stripped.length, 2)
  )
);
```

Nested Data Flow



Piped Example

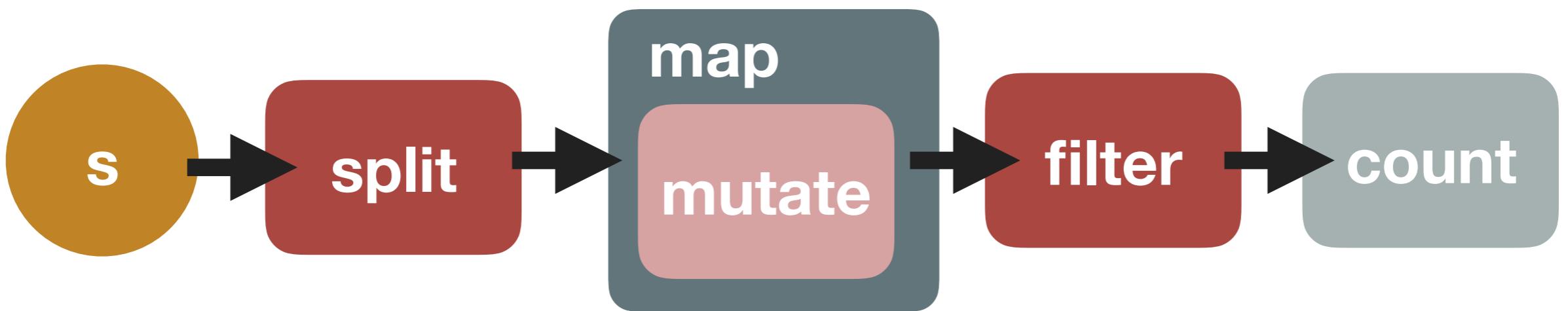


```
var { flow, map, filter, split, size, replace } = require('lodash/fp');
```

Piped Example

```
const count = flow([
  split(' '),
  map(
    replace('(\\'s)|\w+')( ''),
    filter(
      stripped => _.gt(stripped.length, 2)),
    size
  )('Midway in our life\'s journey, I went astray');
```

Piped Data Flow



The Language of Data Flow Manipulations

- map
- flat map
- filter
- fold
- mutate
- group by
- order by

The Language of Data Flow Manipulations

- map: **map**
- flat map: **flatMap**
- filter: **filter**
- fold: **reduce**
- mutate: **each**
- group by: **groupBy**
- order by: **orderBy**

The Language of Data Flow Manipulations

- **map**
- flat map
- filter
- fold
- mutate
- group by
- order by

Map

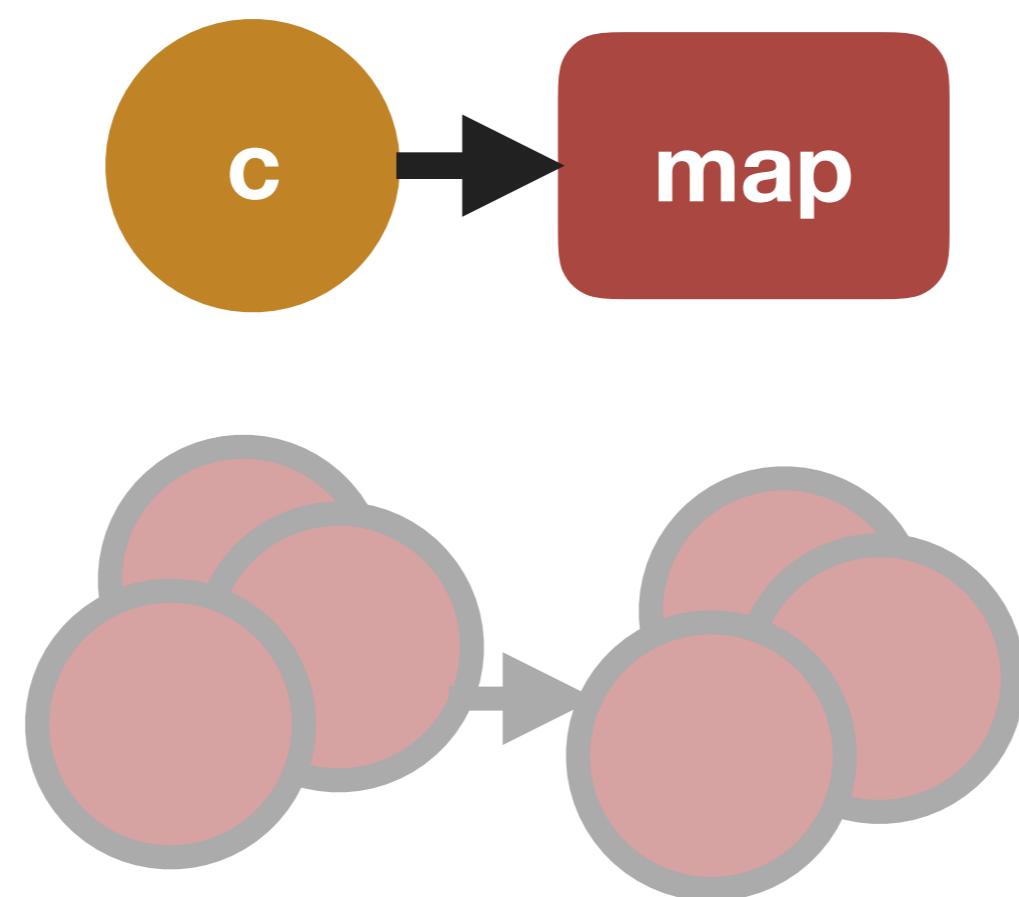


Map Example

```
const numbers =  
  _.map([3, 9, 10], x => x * 10);
```

output>
[30, 90, 100]

Map Data Flow



map Source Code

```
function map(array, iteratee) {
  let index = -1
  const length = array == null ? 0 : array.length
  const result = new Array(length)

  while (++index < length) {
    result[index] = iteratee(array[index], index, array)
  }
  return result
}
```

Map Example

```
const numbers =  
  _.map([3, 9, 10], x => x * 10);
```

output>
[30, 90, 100]

The Language of Data Flow Manipulations

- map
- **flat map**
- filter
- fold
- mutate
- group by
- order by

Flat Map



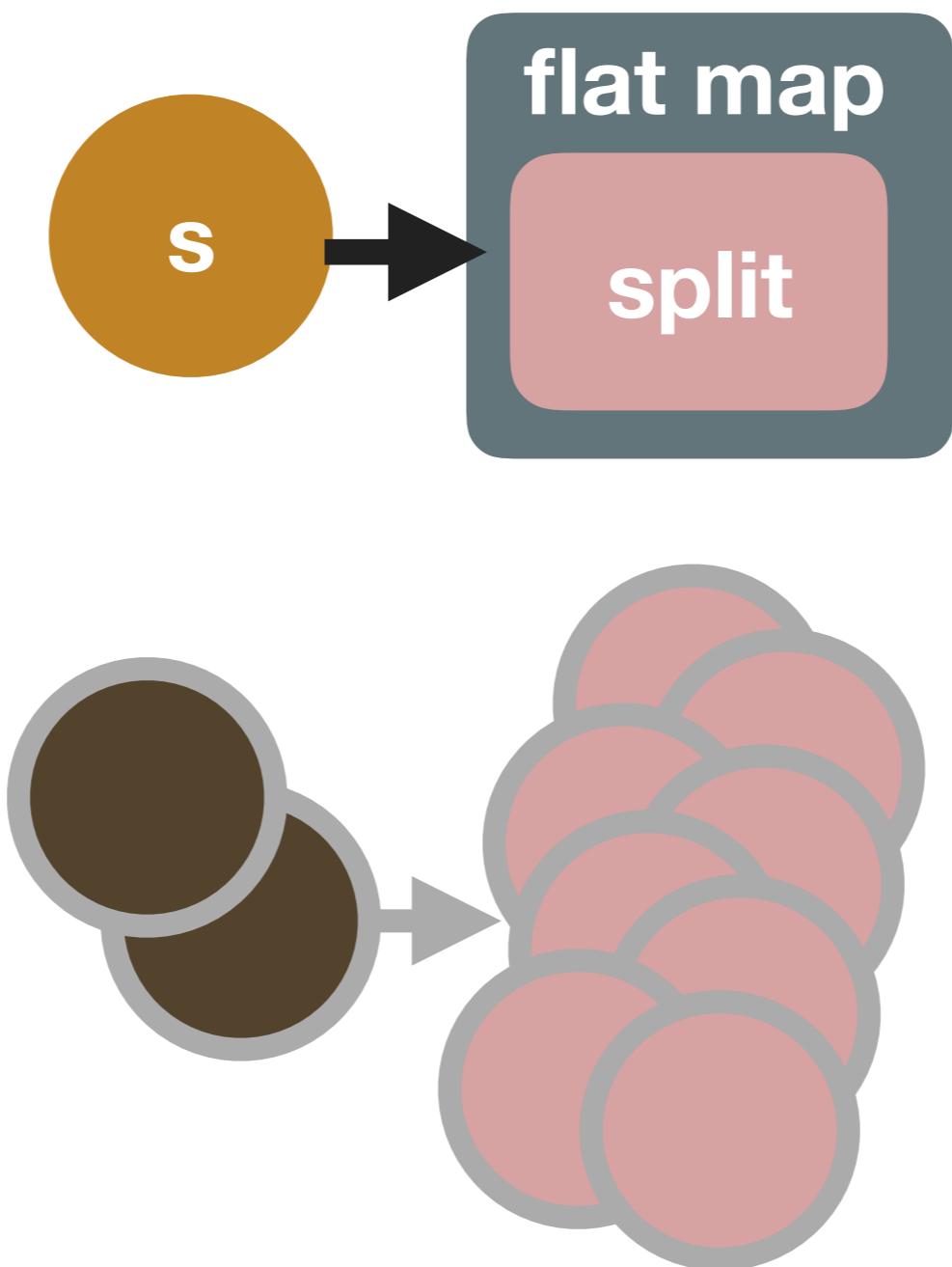
Flat Map Example

```
const list = _.flatMap([
  'Midway in our life\'s journey',
  'I went astray'
],  
  s => _.split(s, ' ')
);
```

output>

```
[ 'Midway', 'in', 'our',
  'life\'s', 'journey',
  'I', 'went', 'astray' ]
```

Flat Map Query Syntax Data Flow



flatMap Source Code

```
function flatMap(collection, iteratee) {  
  return baseFlatten(map(collection, iteratee), 1)  
}
```

baseFlatten Source Code

```
function baseFlatten(array, depth, predicate, isStrict, result) {
  predicate || (predicate = isFlattenable)
  result || (result = [])

  if (array == null) {
    return result
  }

  for (const value of array) {
    if (depth > 0 && predicate(value)) {
      if (depth > 1) {
        // Recursively flatten arrays (susceptible to call stack limits).
        baseFlatten(value, depth - 1, predicate, isStrict, result)
      } else {
        result.push(...value)
      }
    } else if (!isStrict) {
      result[result.length] = value
    }
  }
  return result
}
```

baseFlatten Source Code

```
function baseFlatten(array, depth, predicate, isStrict, result) {
  predicate || (predicate = isFlattenable)
  result || (result = [])
  // check for null ..

  for (const value of array) {
    if (depth > 0 && predicate(value)) {
      if (depth > 1) {
        baseFlatten(value, depth - 1, predicate, isStrict, result)
      } else {
        result.push(...value)
      }
    }
  } // else ..
}

return result
```

Flat Map Example

```
const list = _.flatMap([
  'Midway in our life\'s journey',
  'I went astray'
],  
  s => _.split(s, ' ')
);
```

output>

```
[ 'Midway', 'in', 'our',
  'life\'s', 'journey',
  'I', 'went', 'astray' ]
```

The Language of Data Flow Manipulations

- map
- flat map
- **filter**
- fold
- mutate
- group by
- order by

Filter

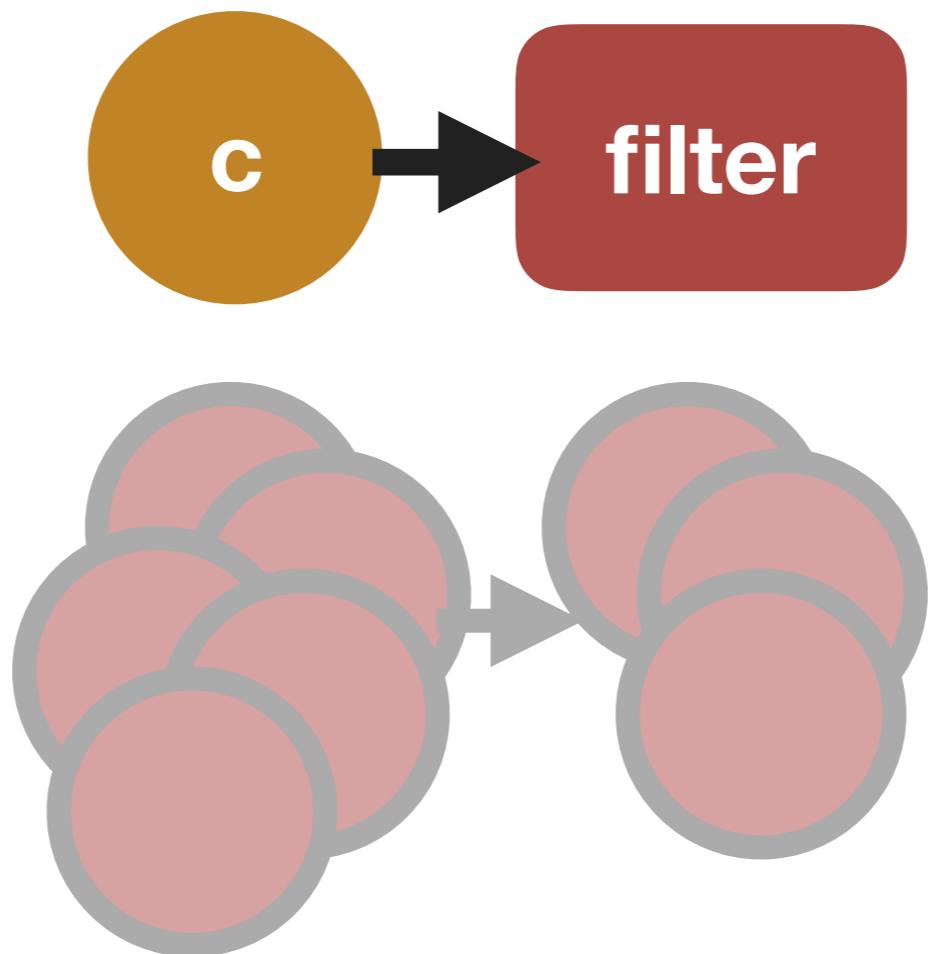


Filter Example

```
const numbers =  
  _.filter(  
    [3, 9, 10, 33, 100],  
    n => n % 2 != 0  
  );
```

output>
[3, 9, 33]

Filter Data Flow



filter Source Code

```
function filter(array, predicate) {
  let index = -1
  let resIndex = 0
  const length = array == null ? 0 : array.length
  const result = []

  while (++index < length) {
    const value = array[index]
    if (predicate(value, index, array)) {
      result[resIndex++] = value
    }
  }
  return result
}
```

Filter Example

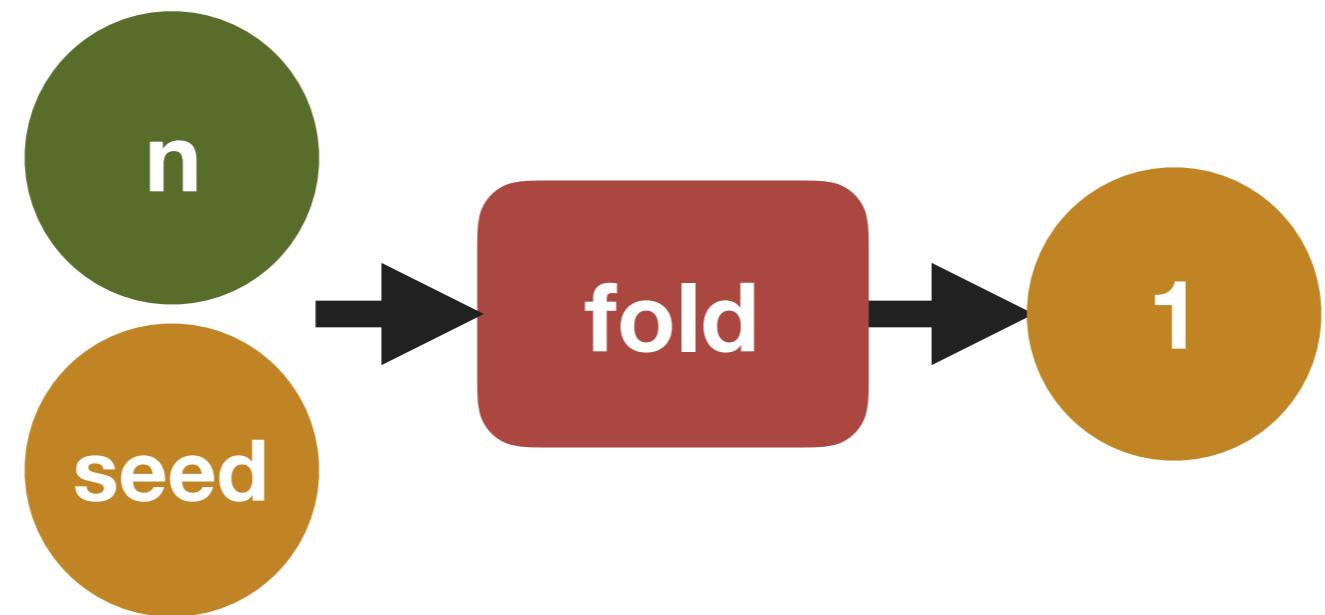
```
const numbers =  
  _.filter(  
    [3, 9, 10, 33, 100],  
    n => n % 2 != 0  
  );
```

output>
[3, 9, 33]

The Language of Data Flow Manipulations

- map
- flat map
- filter
- **fold**
- mutate
- group by
- order by

Fold

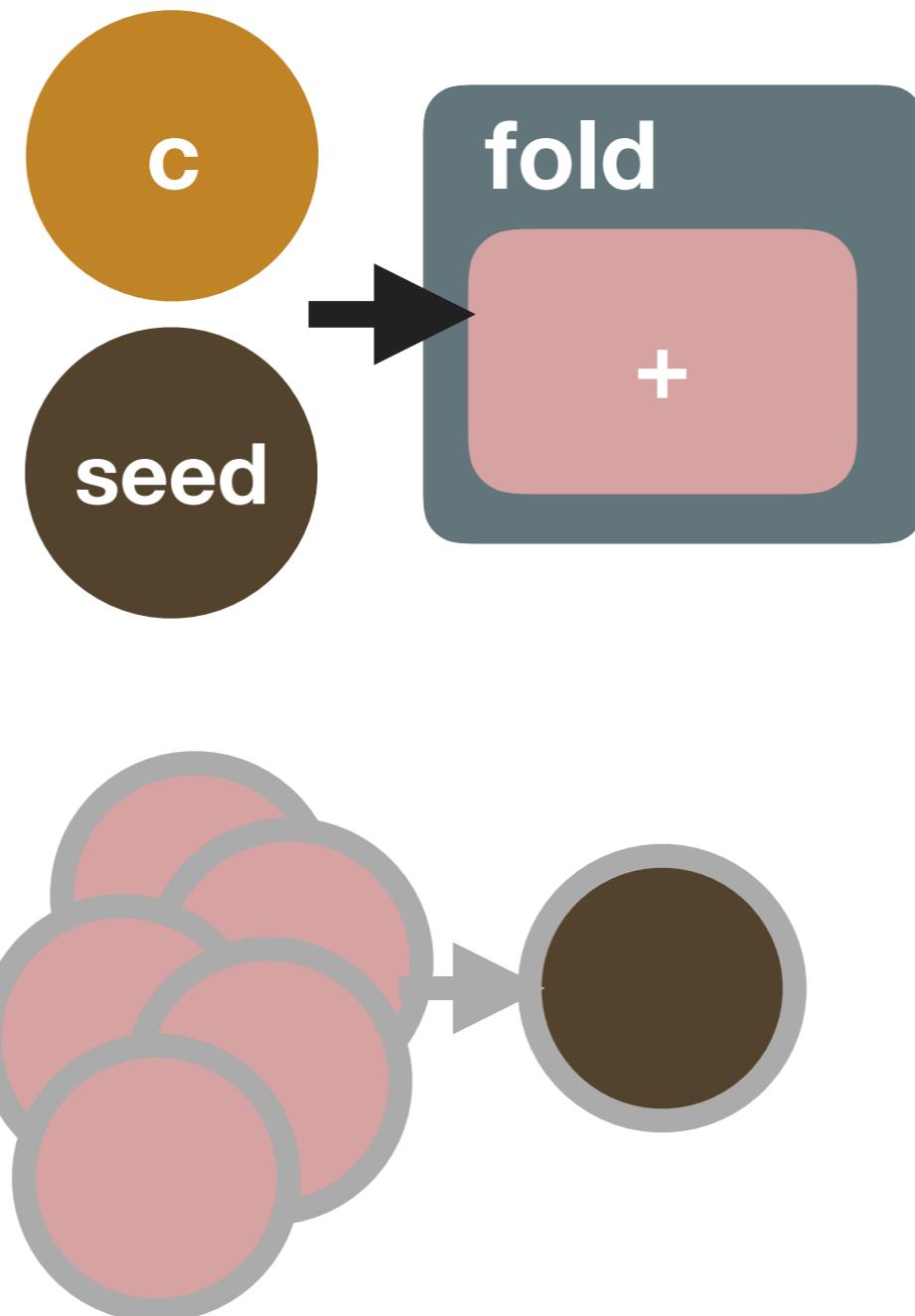


Fold Example

```
const sum =  
  _.reduce(  
    [3, 9, 10, 33, 100],  
    (m, x) => m + x,  
    0  
  );
```

output>
155

Fold Data Flow



reduce Source Code

```
function reduce(collection, iteratee, accumulator) {  
  const func = Array.isArray(collection)  
    ? arrayReduce : baseReduce  
  const initAccum = arguments.length < 3  
  return func(collection, iteratee, accumulator,  
              initAccum, baseEach)  
}
```

arrayReduce Source Code

```
function arrayReduce(array, iteratee, accumulator, initAccum) {  
  let index = -1  
  const length = array == null ? 0 : array.length  
  
  if (initAccum && length) {  
    accumulator = array[++index]  
  }  
  while (++index < length) {  
    accumulator = iteratee(  
      accumulator, array[index], index, array)  
  }  
  return accumulator  
}
```

Fold Example

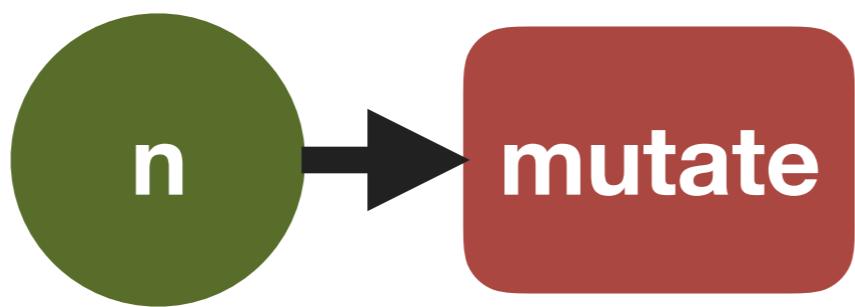
```
const sum =  
  _.reduce(  
    [3, 9, 10, 33, 100],  
    (m, x) => m + x,  
    0  
  );
```

output>
155

The Language of Data Flow Manipulations

- map
- flat map
- filter
- fold
- **mutate**
- group by
- order by

Mutate



Mutate Example

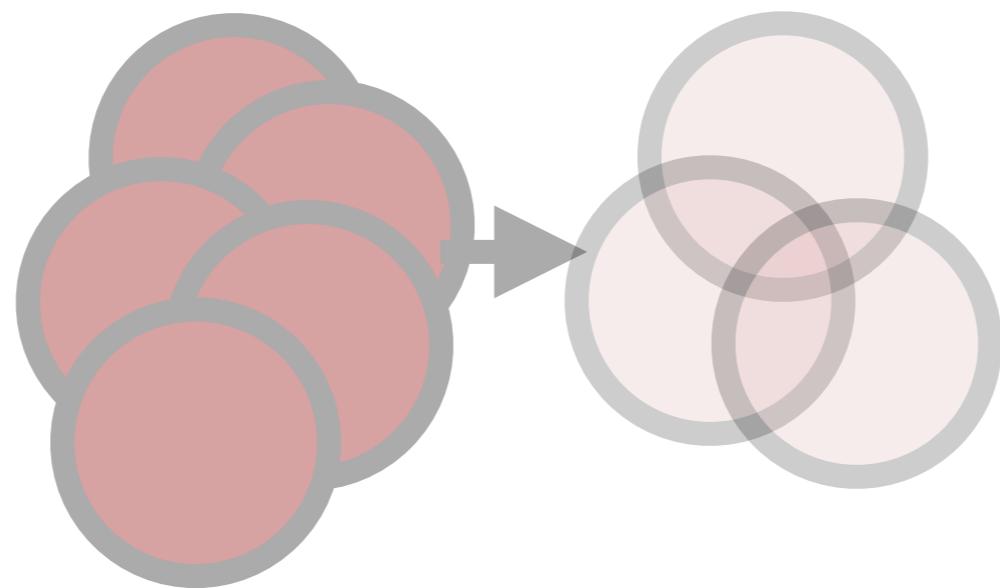
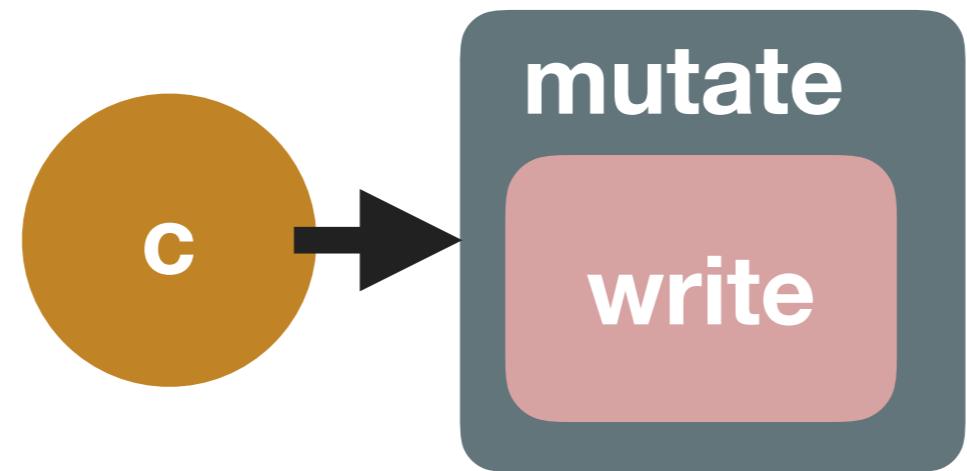
```
let r = [];
_.each(
  [3, 9, 10, 33, 100],
  n => { if (n % 3 === 0) { r.push(n); } }
);
```

output>

// void

r = [3, 9, 33]

Mutate Data Flow



The Language of Data Flow Manipulations

- map
- flat map
- filter
- fold
- mutate
- **group by**
- order by

Group By



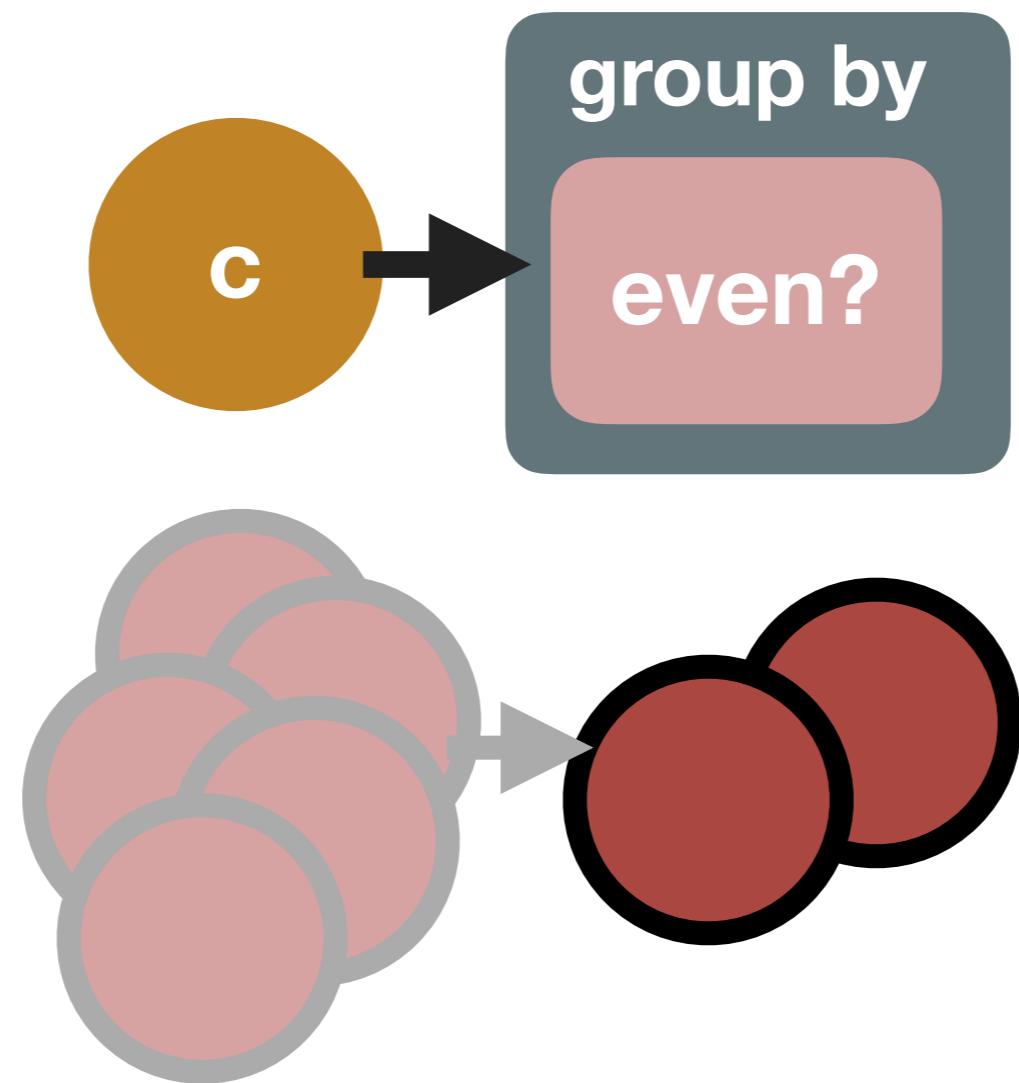
Group By Example

```
const groups =  
  _.groupBy(  
    [3, 9, 10, 33, 100],  
    n => n % 2 === 0  
  );
```

output>

```
{'true': [10, 100],  
 'false': [3, 9, 33]}
```

Group By Data Flow



The Language of Data Flow Manipulations

- map
- flat map
- filter
- fold
- mutate
- group by
- **order by**

Order By

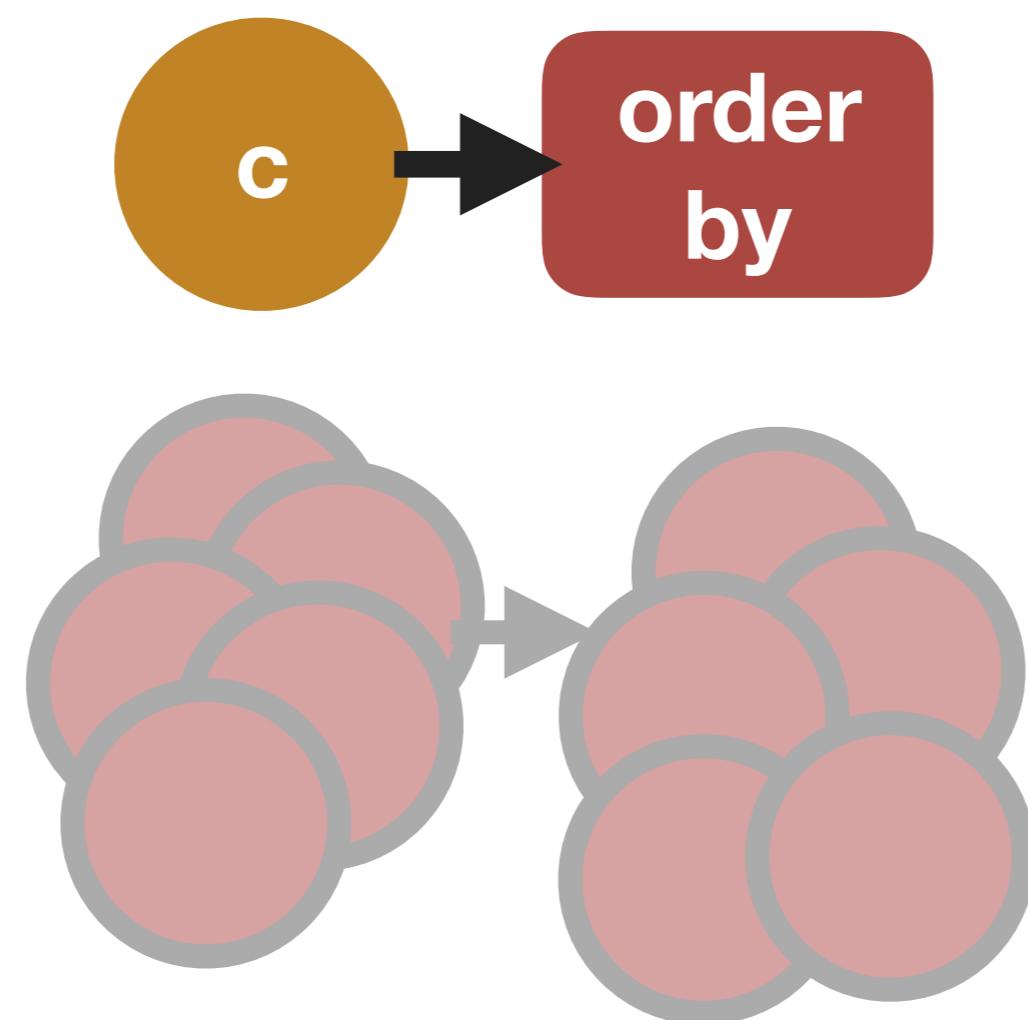


Order By Example

```
const ordered =  
  _.orderBy( [33, 9, 100, 3, 10]);
```

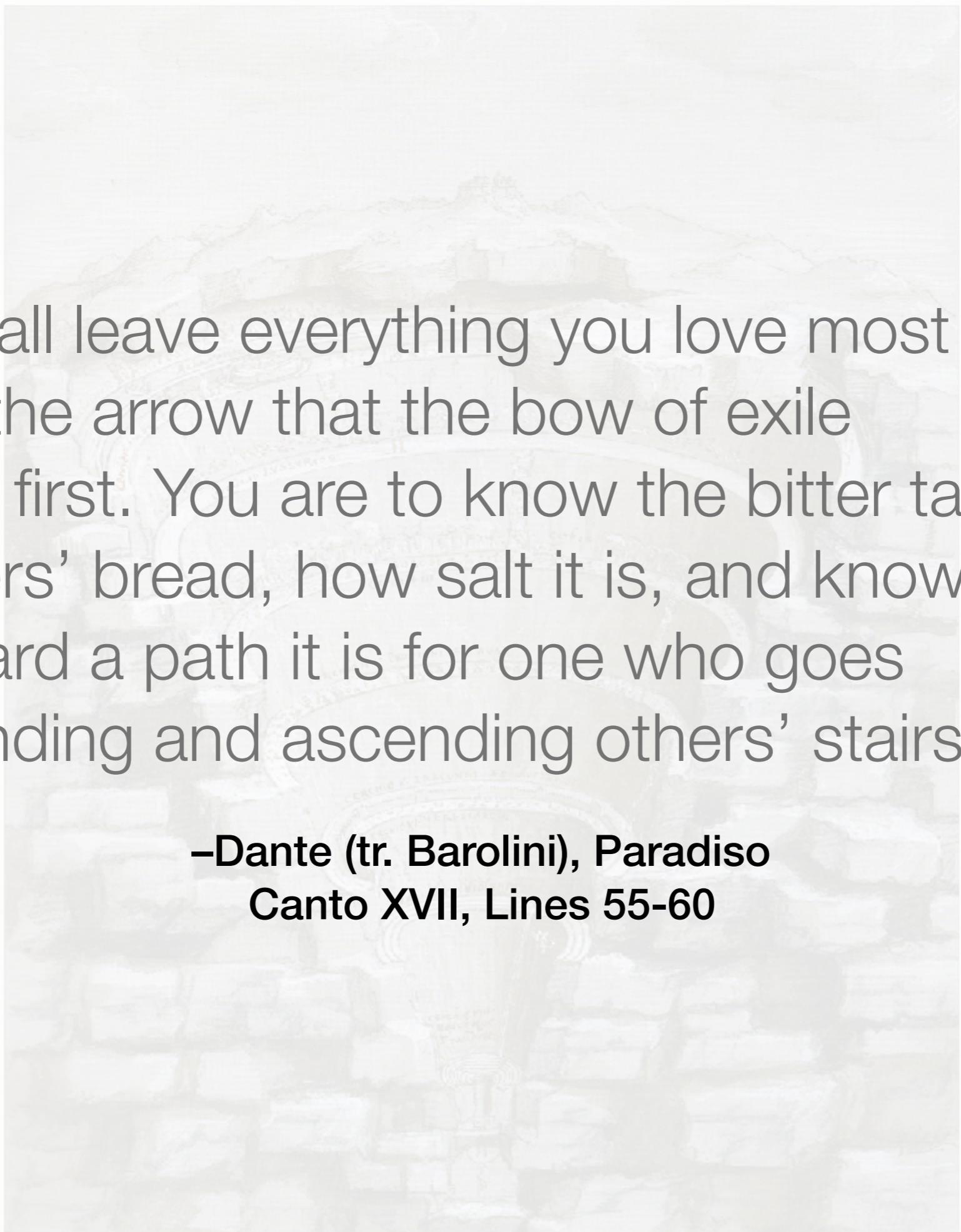
output>
[3, 9, 10, 33, 100]

Order By Data Flow



Canto

- Data Flow in a System
- The Language of Data Flow Manipulations
- **Data Flow in Context**



You shall leave everything you love most dearly:
this is the arrow that the bow of exile
shoots first. You are to know the bitter taste
of others' bread, how salt it is, and know
how hard a path it is for one who goes
descending and ascending others' stairs.

**—Dante (tr. Barolini), Paradiso
Canto XVII, Lines 55-60**

Functions in Context



Identity Context



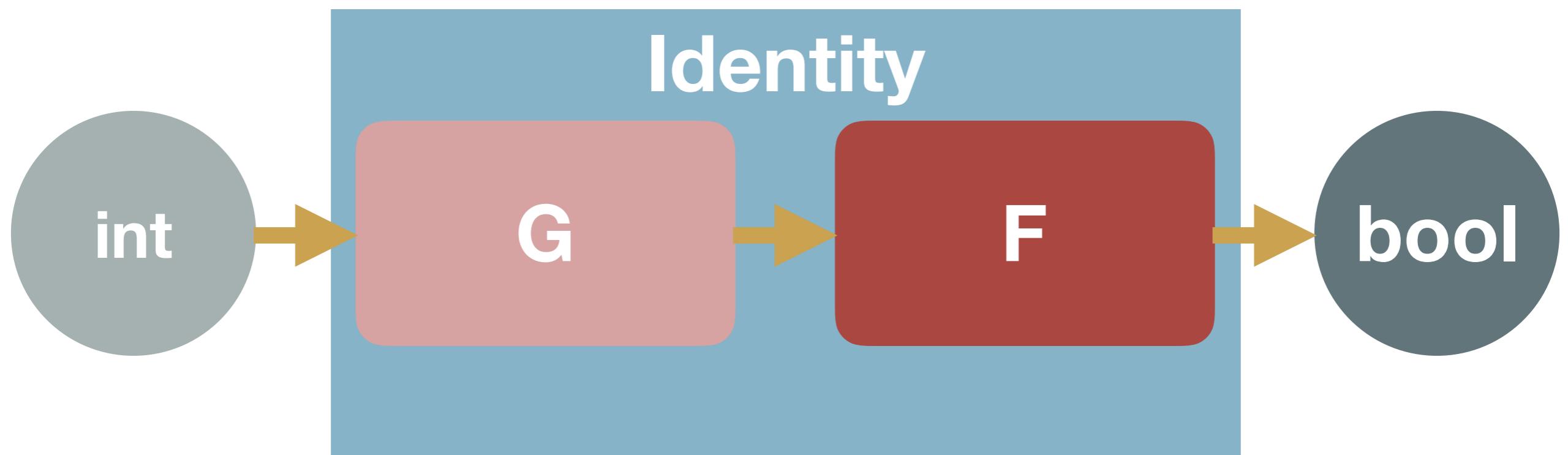
Example of Composed Functions

```
class Identity {  
    static of(value) { return [value]; }  
}
```

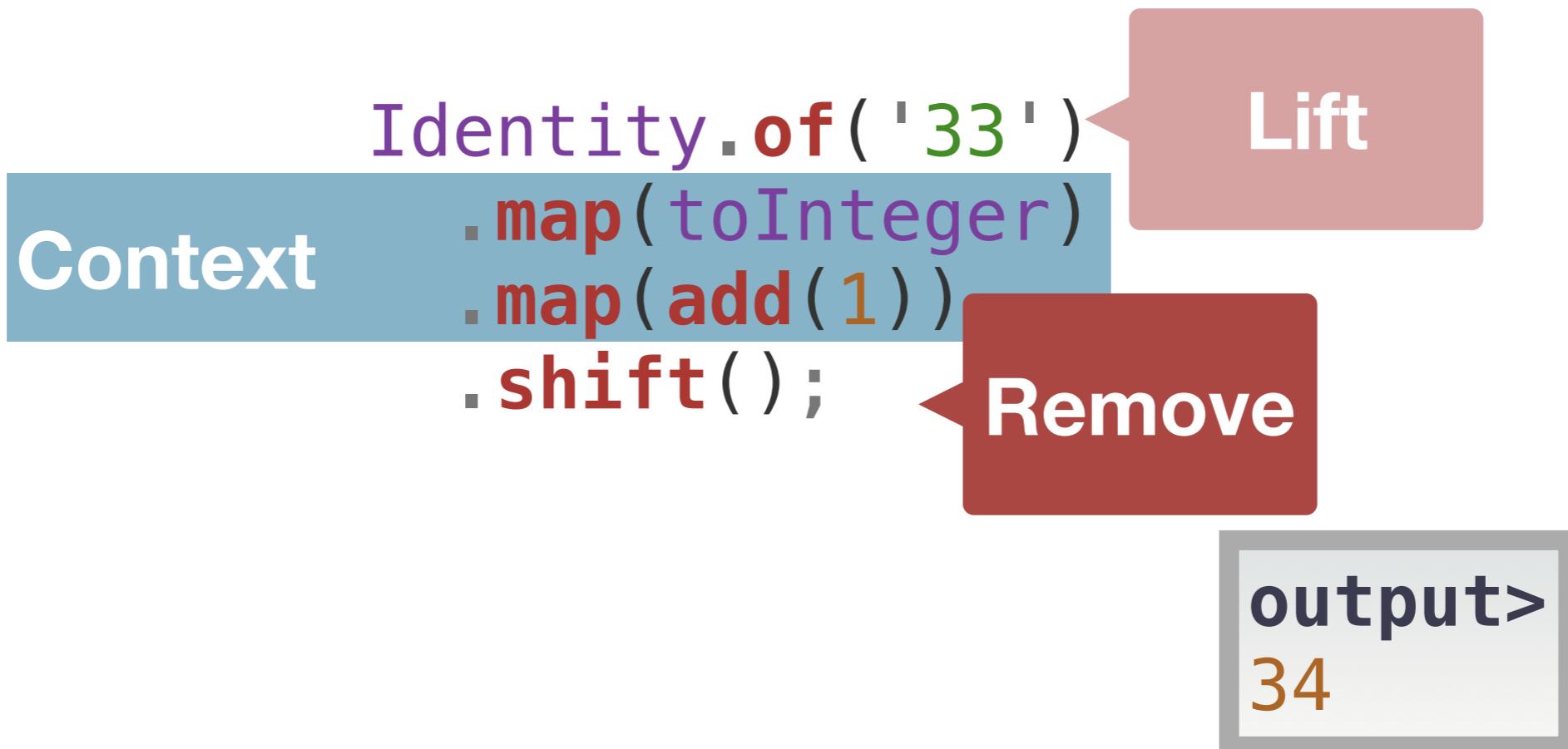
```
Identity.of('33')  
    .map(toInteger)  
    .map(add(1))  
    .shift();
```

output>
34

Example of Composed Functions



Example of Composed Functions

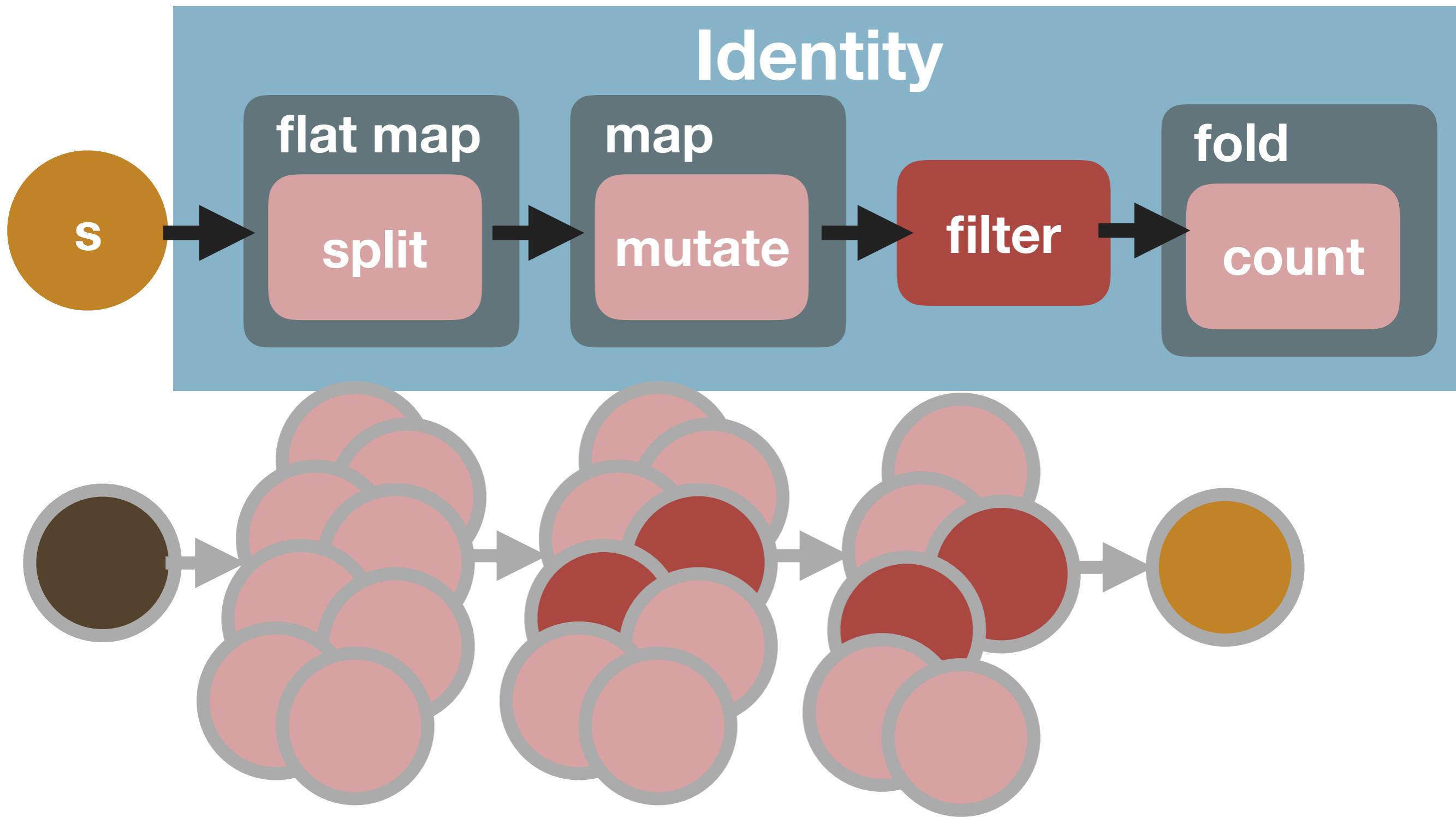


Identity in Context Example

```
const count = Identity.of(  
  'Midway in our life\'s journey, I went astray'  
  .map(split(' '))  
  .reduce(concat)  
  .map(replace('(\\'s)|\\w+')(''))  
  .filter(word => _.gt(word.length, 2))  
  .reduce(number => ++number, 0);
```

output>
6

Identity in Context Data Flow



Identity in Context Example

```
const count = Identity.of(  
  'Midway in our life\'s journey, I went astray'  
  .map(split(' '))  
  .reduce(concat)  
  .map(replace('(\\'s)|\w+')(''))  
  .filter(word => _.gt(word.length, 2))  
  .reduce(number => ++number, 0);
```

Lift

Context

Remove

output>
6

String Context



String in Context Example

```
const count =  
  'Midway in our life\'s journey, I went astray'  
    .split(' ')  
    .map(replace('(\\'s)|\W+')(''))  
    .filter(word => _.gt(word.length, 2))  
    .reduce(number => ++number, 0);
```

output>
6

String in Context Example

Lift

```
const count =  
  'Midway in our life\'s journey, I went astray'  
  .split(' ')  
  .map(replace('(\\'s)|\W+')(''))  
  .filter(word => _gt(word.length, 2))  
  .reduce(number => ++number, 0);
```

Context

Remove

output>
6

A faint, semi-transparent background illustration depicting a scene from a classic story. On the right, a man in a blue robe and a red hooded cloak stands with his back slightly turned, looking over his shoulder towards the left. He holds a long staff or a thin sword. To his left, a woman in a green dress and a blue shawl is seated on a large tree root, looking down at something in her hands. The setting is a dense forest with tall trees and foliage.

Maybe Context

If Context Example

Lift

```
const size = s => {
  if (s) {
    return s.trim().length;
  } else {
    return 0;
  }
};
```

Context

```
const Maybe = require('data.maybe');
```

Maybe Context Example

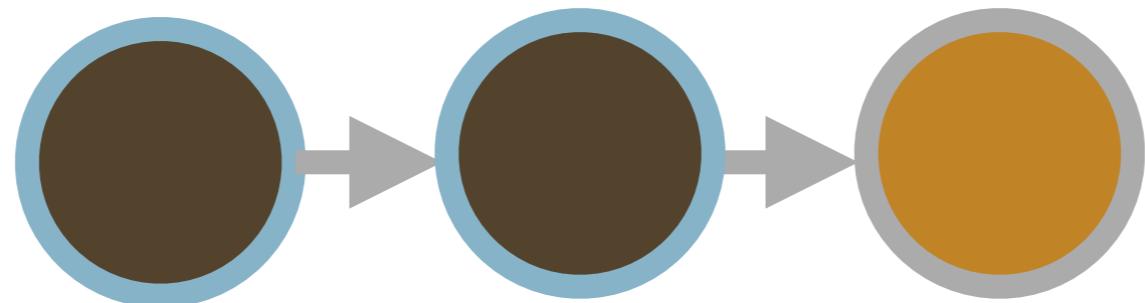
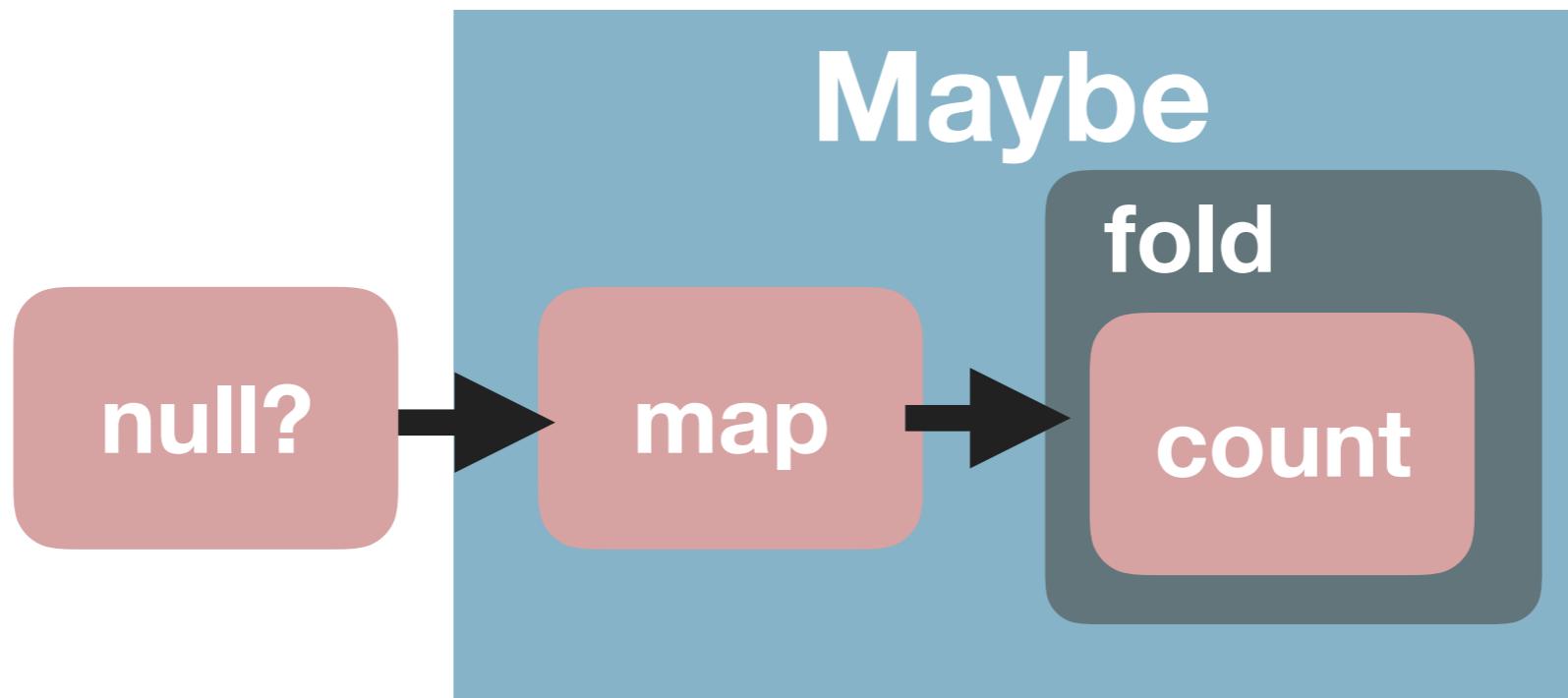
```
const size = s =>  
  Maybe.fromNullable(s)  
    .map(s => s.trim())  
    .cata({  
      Nothing: _ => 0,  
      Just: t => t.length});
```

Lift

Context

Remove

Maybe in Context Data Flow



```
const Maybe = require('data.maybe');
```

Maybe Context Example

```
const size = s =>  
  Maybe.fromNullable(s)  
    .map(s => s.trim())  
    .cata({  
      Nothing: _ => 0,  
      Just: t => t.length});
```

Lift

Context

Remove

Maybe in Context Examples

```
counter(  
    'Midway in our life\'s journey, I went astray');
```

output>
6

```
counter(null);
```

output>
0

```
const Maybe = require('data.maybe');
```

Maybe in Context Example

```
const counter = s =>
  Maybe.fromNullable(s)
    .map(s => s.split(' '))
      .map(replace(`(\\s)|\\w+`)( ))
      .filter(w => _.gt(w.length, 2)))
    .cata({
      Nothing: _ => 0,
      Just: words => words.length
    });

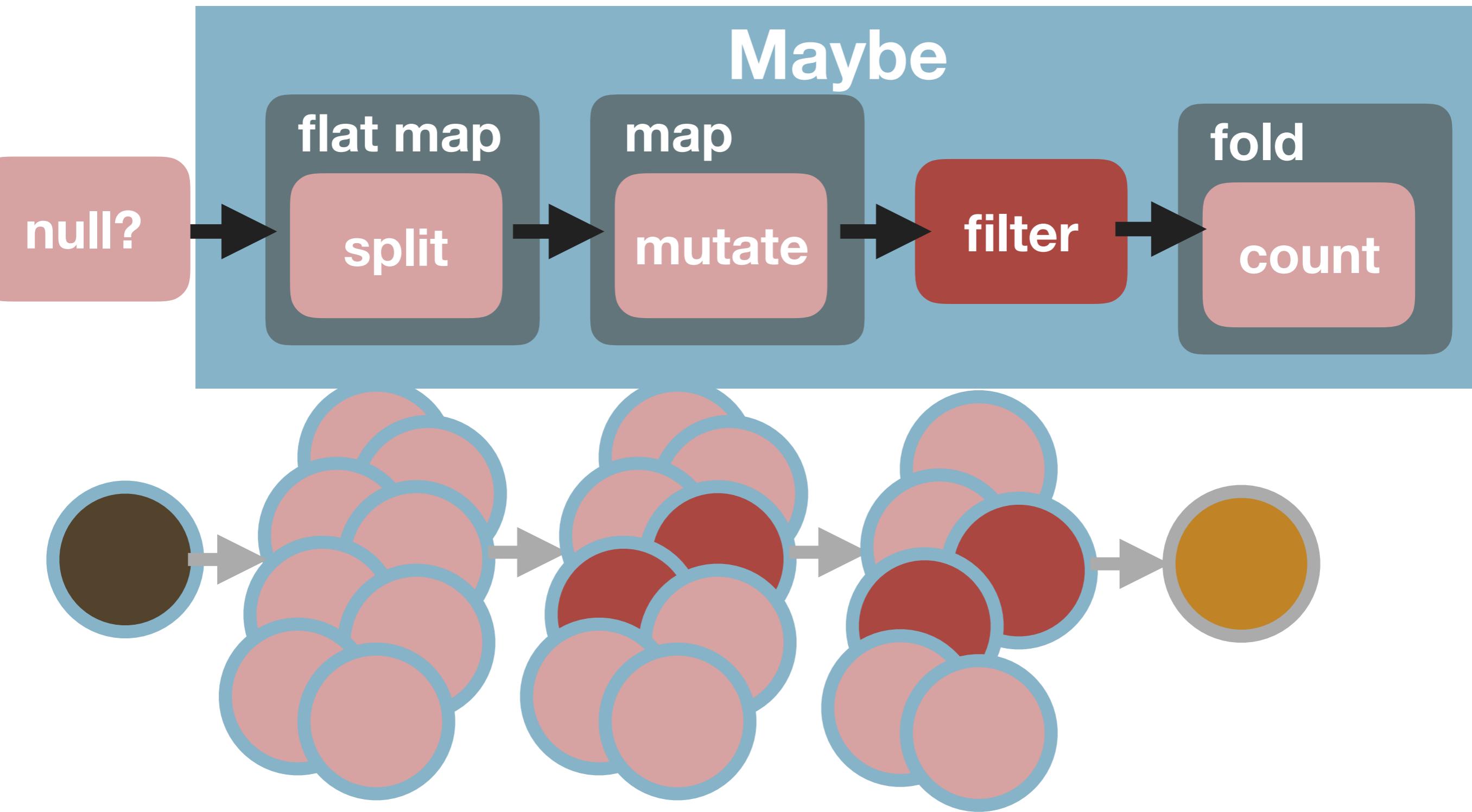
```

```
const Maybe = require('data.maybe');
```

Maybe in Context Example

```
const counter = s =>
  Maybe.fromNullable(s) Lift
    .map(s => s.split(' '))
      .map(replace(/\s|w+/g))
      .filter(w => _gt_(w.length, 2)) Context
    .cata({
      Nothing: _ => 0,
      Just: words => words.length
    });
Remove
```

Maybe in Context Data Flow



```
const Maybe = require('data.maybe');
```

Maybe in Context Example

```
const counter = s =>
  Maybe.fromNullable(s) Lift
    .map(s => s.split(' '))
    .map(replace(/\s|w+/g))
    .filter(w => _gt_(w.length, 2)) Context
    .cata({
      Nothing: _ => 0,
      Just: words => words.length
    });
Remove
```

List Context

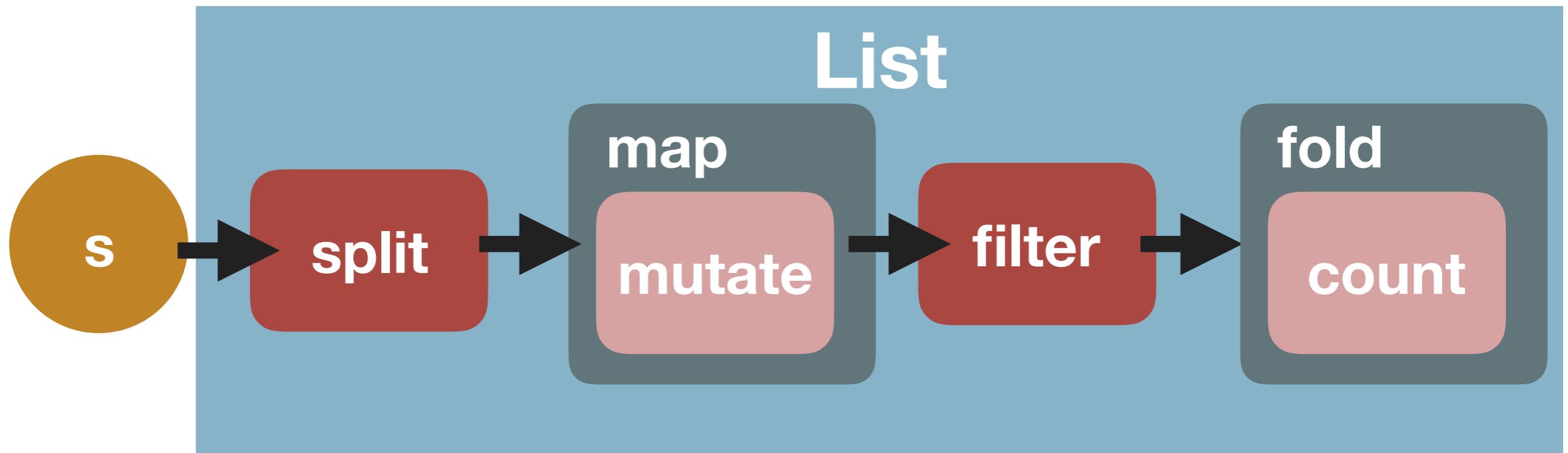


List Context Example

Lift

```
const count = flow( [  
  split(' ') ,  
  map(  
    replace('(\\'s) | \w+')(' ') ) ,  
  filter(  
    stripped => _.gt(stripped.length, 2)) ,  
  size ← Remove  
] )  
( 'Midway in our life\'s journey, I went astray' );
```

List in Context Data Flow



List Context Example

Lift

```
const count = flow( [  
  split(' ') ,  
  map(  
    replace('(\\'s) | \w+')(' ') ) ,  
  filter(  
    stripped => _.gt(stripped.length, 2)) ,  
  size ← Remove  
] )  
( 'Midway in our life\'s journey, I went astray' );
```



OVI COELVM DEONIT MEDIVMOVE IMMVOQUE TRIBUNALE
SENSIT CONSILIS AC PLEIADE PATRIGM
LVSTRAVIT QVE ANIMO CVNCTA POETA SVO¹⁴ DOCTVS AEST DANTES SVA QVEM FLORENTIA SAEPE
NIL POTVIT TANTO MORS SAEVA NOCERE POETAE
QVEM VIVVM VIRTUS GARMEN IMAGO FACIE



Thank you!

Mike Harris

@MikeMKH

<http://comp-phil.blogspot.com/>

<https://github.com/MikeMKH/talks/tree/master/a-divine-data-comedy-in-javascript>



Next Steps

- StrangeLoop (conference)
<https://www.thestrangeloop.com/>
- Brian Lonsdorf - Professor Frisby Introduces Composable Functional JavaScript (video series)
<https://egghead.io/courses/professor-frisby-introduces-composable-functional-javascript>
- Aditya Bhargava - Functors, Applicatives, And Monads In Pictures (blog post)
http://adit.io/posts/2013-04-17-functors,_applicatives,_and_monads_in_pictures.html
- Luis Atencio - Functional Programming in JavaScript (book)
<https://www.manning.com/books/functional-programming-in-javascript>
- Reginald Braithwaite - JavaScript Allongé, The “Six” Edition (book)
<https://leanpub.com/javascriptallongesix/read>

Code from Lodash Source Code

- map
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/map.js#L19-L28>
- flatMap
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/flatMap.js#L24-L26>
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/.internal/baseFlatten.js#L14-L35>
- filter
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/filter.js#L24-L37>
- reduce
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/reduce.js#L38-L42>
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/.internal/arrayReduce.js#L12-L23>

Code from Lodash Source Code

- foreach
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/forEach.js#L28-L31>
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/.internal/arrayEach.js#L9-L19>
- groupBy
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/groupBy.js#L24-L34>
- orderBy
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/orderBy.js#L30-L41>
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/.internal/baseOrderBy.js#L14-L24>
 - <https://github.com/lodash/lodash/blob/6ad829fa90af199150b11ba1d3c944b648a39ce5/.internal/baseSortBy.js#L11-L19>

Code

- SQL Code, <https://github.com/MikeMKH/talks/blob/master/a-divine-data-comedy-in-javascript/example.sql>
- JavaScript Code, <https://github.com/MikeMKH/talks/blob/master/a-divine-data-comedy-in-javascript/test.js>

Yes, Lodash's source code does not have ;

- [https://github.com/lodash/lodash/commit/
6cb3460fcefe66cb96e55b82c6feb2153c992cc](https://github.com/lodash/lodash/commit/6cb3460fcefe66cb96e55b82c6feb2153c992cc)

Biography

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