

Tail Recursion

We have seen examples of linear recursion but there is another type of recursion that feels more like iteration (loops). Consider an alternate version of the factorial function:

```
factTail :: Int -> Int
factTail n = fTail n 1 where
  fTail n result =
    if n == 0
    then result
    else fTail (n-1) (result * n)
```

This type of recursion is called *tail recursion* and we had to define a helper function `fTail` with two arguments within our function `factTail`. Let's look at the computation of `factTail 4` with the substitution model

Expression	Substitution explanation
<code>factTail 4</code>	substitute into the body of <code>factTail</code>
<code>fTail 4 1</code>	substitute for <code>fTail</code> (computes $4! * 1$)
<code>fTail 3 4</code>	substitute for <code>fTail</code> (computes $3! * 4$)
<code>fTail 2 12</code>	substitute for <code>fTail</code> (computes $2! * 12$)
<code>fTail 1 24</code>	substitute for <code>fTail</code> (computes $1! * 24$)
<code>fTail 0 24</code>	substitute for <code>fTail</code> (computes $0! * 24$)
<code>24</code>	

In tail recursion there is no winding and unwinding. Instead you see that this feels like we are looping and remembering and changing values each time through the loop.

Let's do a tail recursive version of `revWord`:

```
revWordTail :: Language -> Language
revWordTail w = revTail w (word "") where
  revTail w result = if (empty w)
    then result
    else revTail (butFirst w) ((firstItem w) +++ result)
```

Use the substitution model to look at the computation `revWordTail (word "cat")`.

Try writing tail recursive functions for the following:

```
-- compute the base value raised to the power of the exponent
powerTail :: Int -> Int -> Int
powerTail base exp = ...

-- compute the number of letters in a word
lengthTail :: Language -> Int
lengthTail w = ...
```