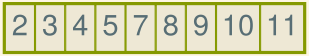
# The linked list

EECS 214, Fall 2017

## A problem with vectors

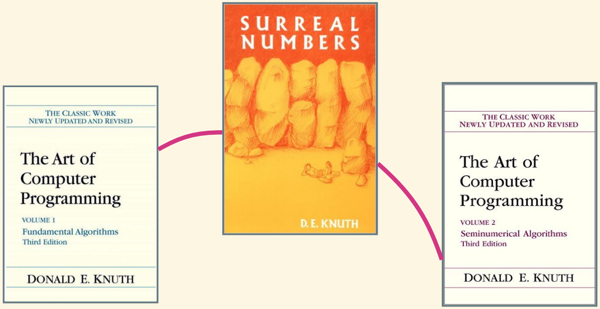


## A problem with vectors

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 4 | 5 | 7 | 8 | 9 | 10 | 11 |

What if we want to add 6 between 5 and 7?

## Books on a string



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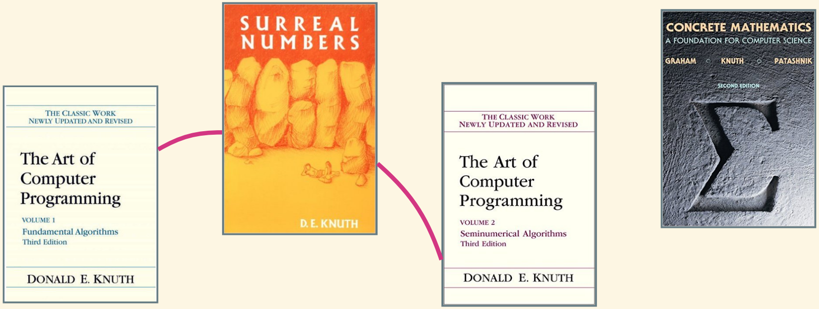
The Classic Work Newly Updated and Revised
The Art of Computer Programming
Volume 1
Fundamental Algorithms
Third Edition
Donald E. Knuth
SURREAL NUMBERS
D. E. KNUTH
The Classic Work Newly Updated and Revised
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Seminumerical Algorithms
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CONCRETE MATHEMATICS
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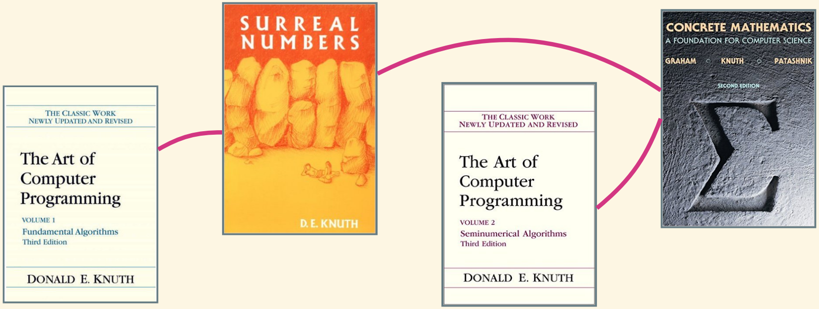
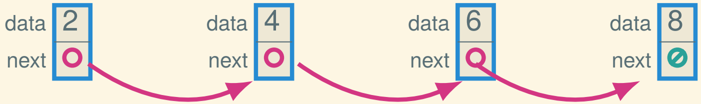


# Nodes and pointers



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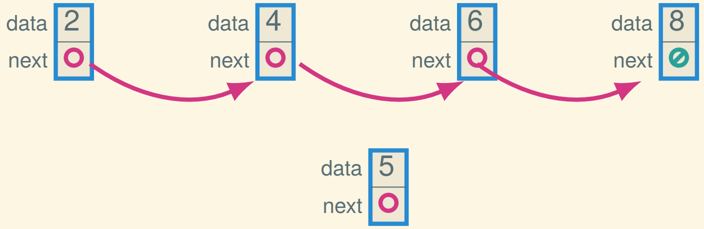

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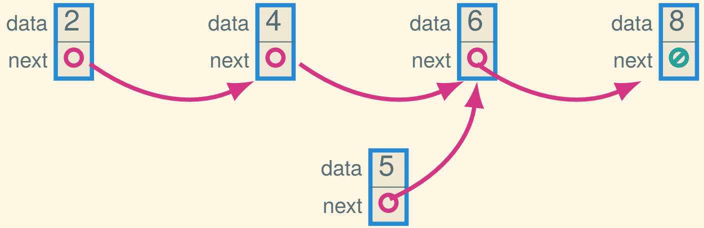

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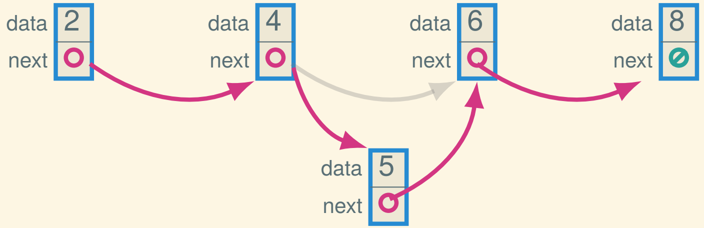

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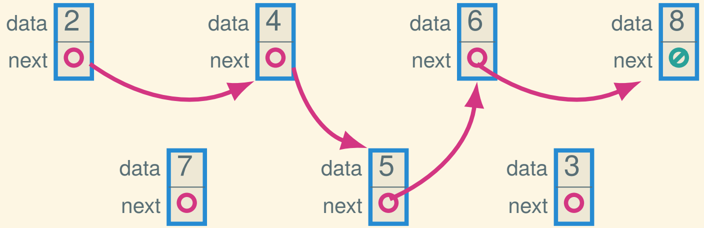

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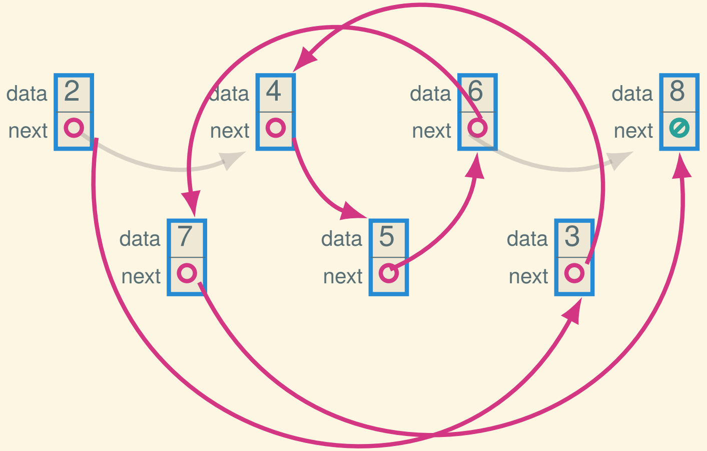
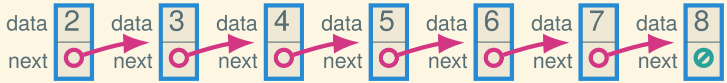


## Inserting at the beginning



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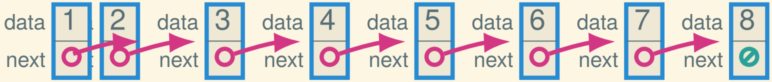

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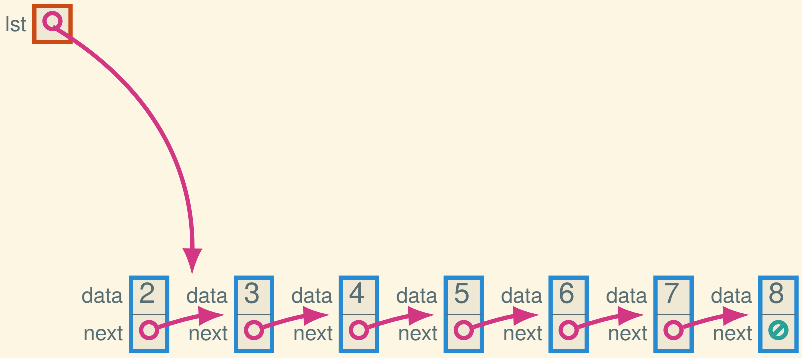

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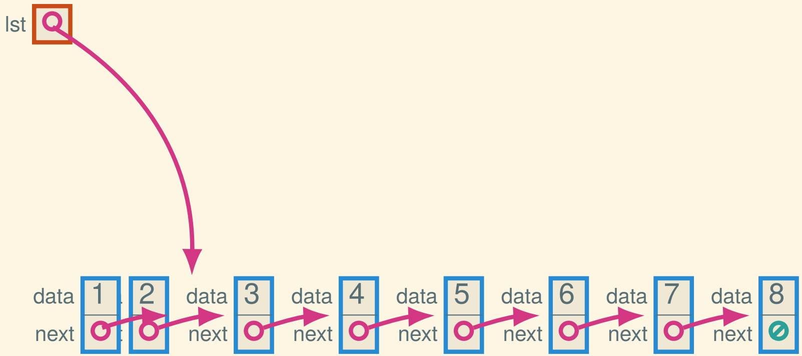

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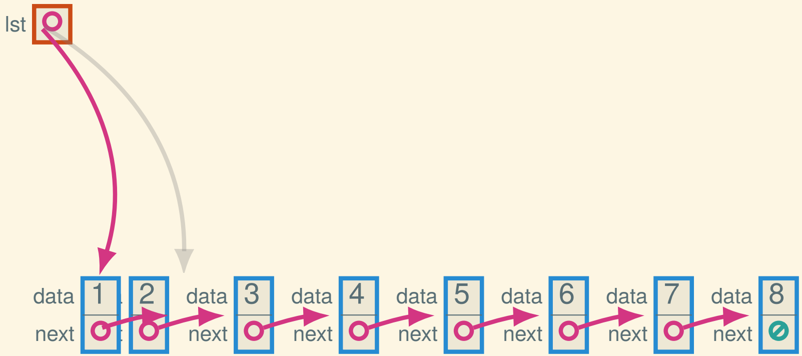
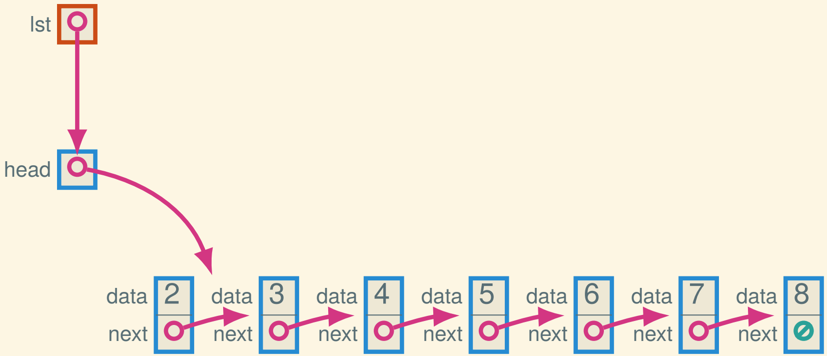


## Indirection



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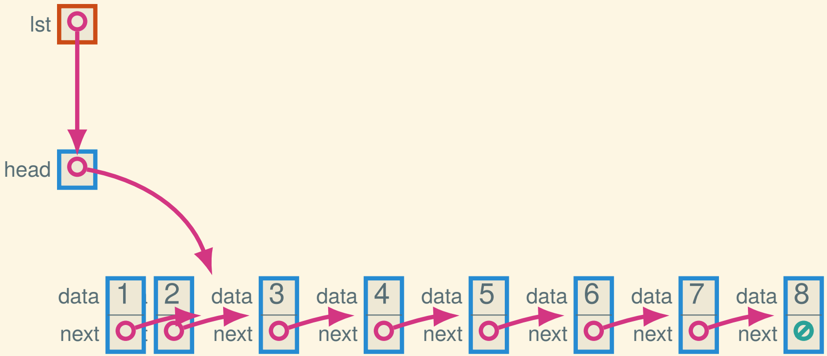

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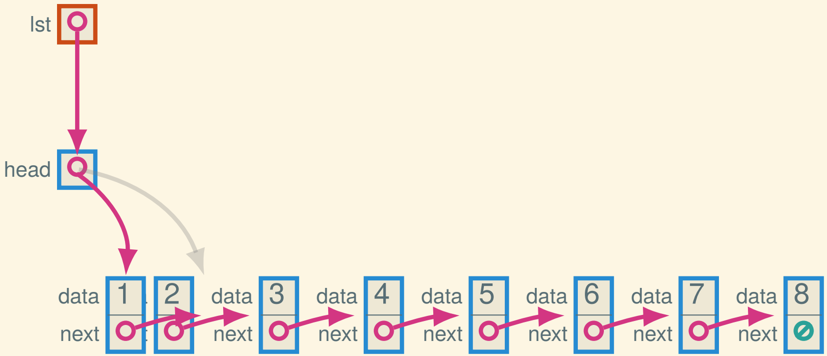

## Now in DSSL2

## Linked lists in DSSL2

```
# List is ll { head: Link }
defstruct ll(head)

# Link is one of:
# – node { data: Number, next: Link }
# – nil()
defstruct node(data, next)
defstruct nil()
```

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# - node { data: Number, next: Link }
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defstruct node(data, next)
defstruct nil()

# new_list : -> List
def new_list():
    ll { head: nil() }

# insert_front : Number List ->
def insert_front(n, lst):
    lst.head = node { data: n, next: lst.head }
```

## List operations in DSSL2

```
# get_front : List -> Number
def get_front(lst):
    if node?(lst.head): lst.head.data
    else: error('get_front: got empty list')
```

## List operations in DSSL2

```
# get_front : List -> Number
def get_front(lst):
    if node?(lst.head): lst.head.data
    else: error('get_front: got empty list')

# get_nth : List Natural -> Number
def get_nth(lst, n0):
    def loop(link, n):
        if nil?(link): error('get_nth: list too short')
        elif n == 0: return link.data
        else: return loop(link.next, n - 1)
    loop(lst.head, n0)
```

## More DSSL2 list operations

```
# find_nth_node : Link Natural -> Link
def find_nth_node(link, n):
    if nil?(link): error('find_nth_node: too short')
    elif n == 0: link
    else: find_nth_node(link.next, n - 1)

# get_nth : List Natural -> Number
def get_nth(lst, i):
    find_nth_node(lst.head, i).data

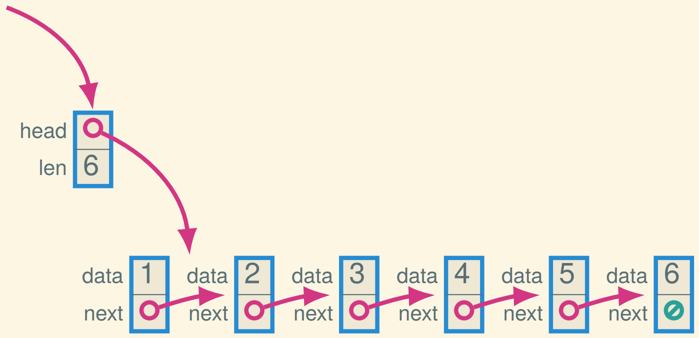
# set_nth! : List Natural Number ->
def set_nth!(lst, i, val):
    find_nth_node(lst.head, i).data = val
```

What else might we want to do?

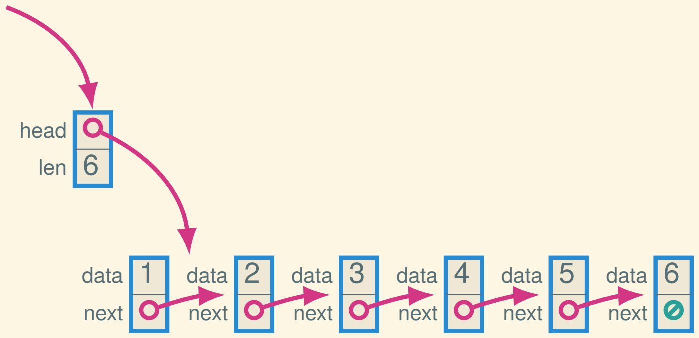
## What else might we want to do?

- Insert or remove at the given position or the end.
- Split a list in two or splice two into one.
- Know how long the list is without counting.

## Keeping the length

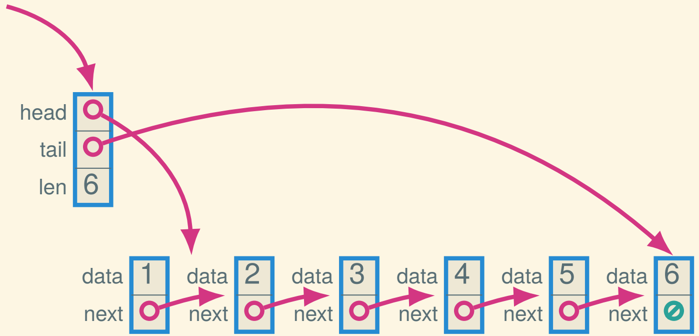


## Keeping the length

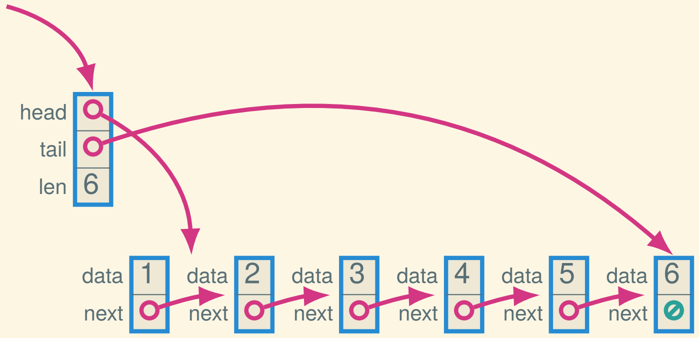


How can we make sure the `len` field is always right?

## Quick access to the tail

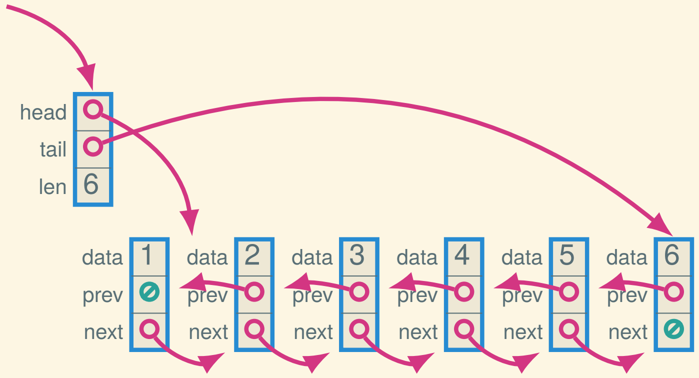


## Quick access to the tail

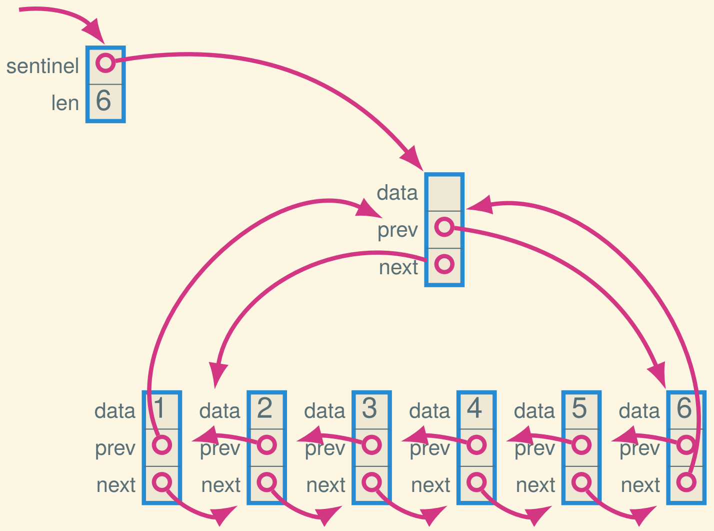


Which operations are simple now? Which are still more work?

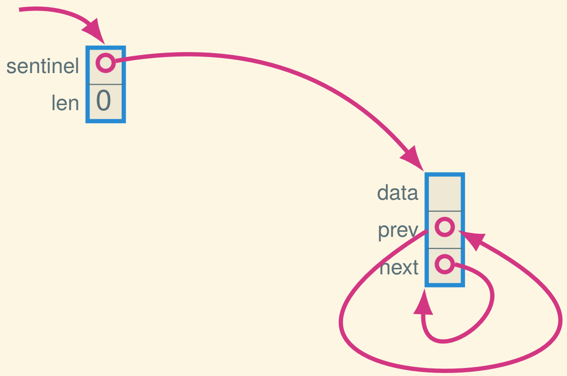
## Doubly-linked



# Circular, doubly-linked with sentinel



## Empty (circular, doubly-linked w/sentinel)



Next time: asymptotic complexity