Data Structures
Chapter 4

1. Singly Linked List
   - Pointer Reviewed & Linked
   - Linked List (1)
   - Linked List (2)
   - **Reverse Singly Linked List**
     - in-place O(n)
     - using stack O(n)
     - sub-list reverse O(n^2),
     - sub-list reverse O(n)

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하나님이 우리를 구원하사 거룩하신 소명으로 부르심은 우리의 행위대로 하심이 아니요 오직
자기의 뜻과 영원 전부터 그리스도 예수 안에서 우리에게 주신 은혜대로 하심이라 (딤후1:9)

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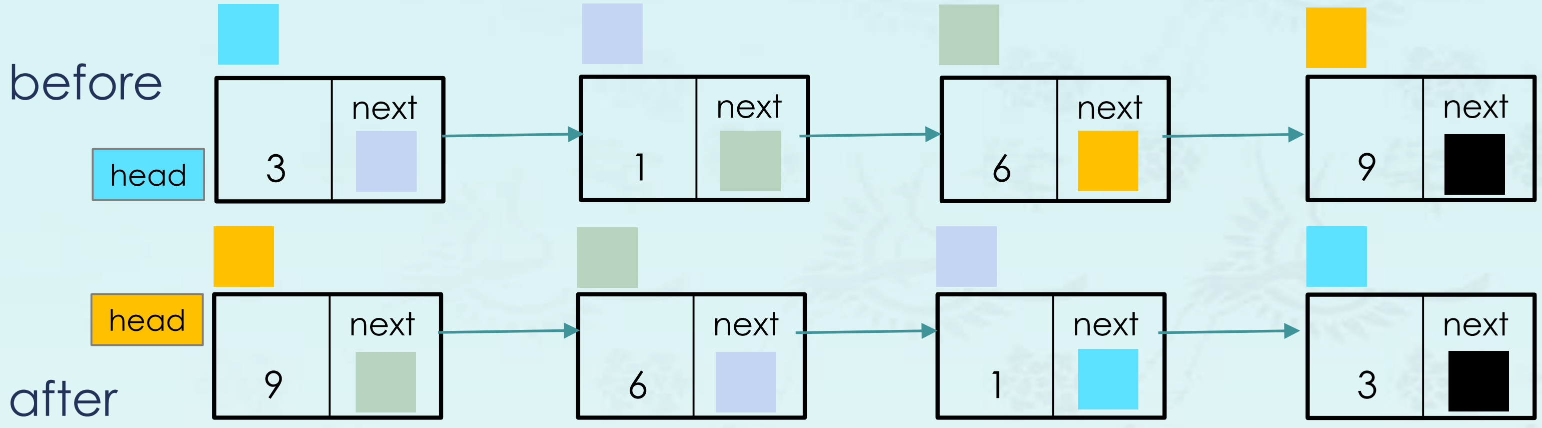
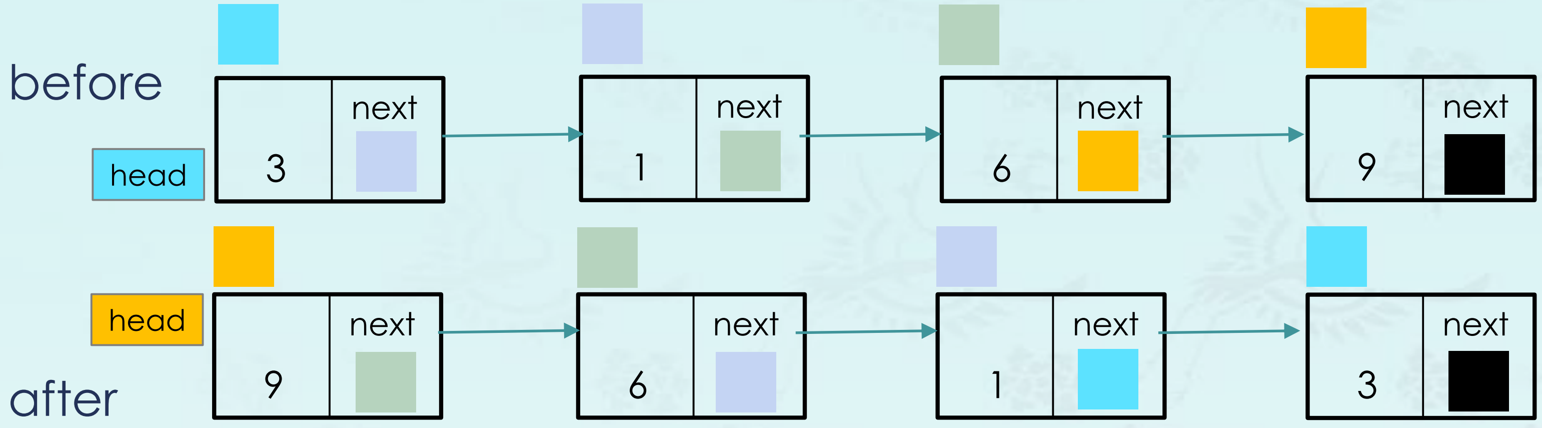
God has saved us and called us to a holy life – not because of anything we have done but because of his own purpose and grace. This grace was given us in Christ Jesus before the beginning of time. 2 Tim1:9

Linked List – reverse using stack

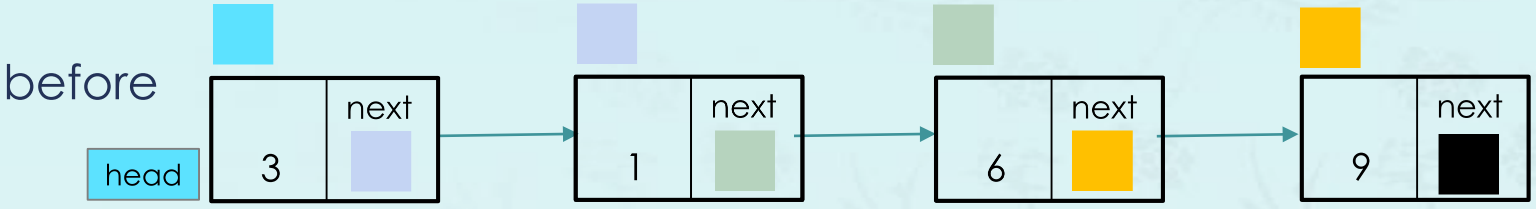


Linked List – reverse using stack



Algorithm:
Step 1. Push all nodes onto the stack.
Step 2. Top/pop all nodes and relink.

Linked List – reverse using stack



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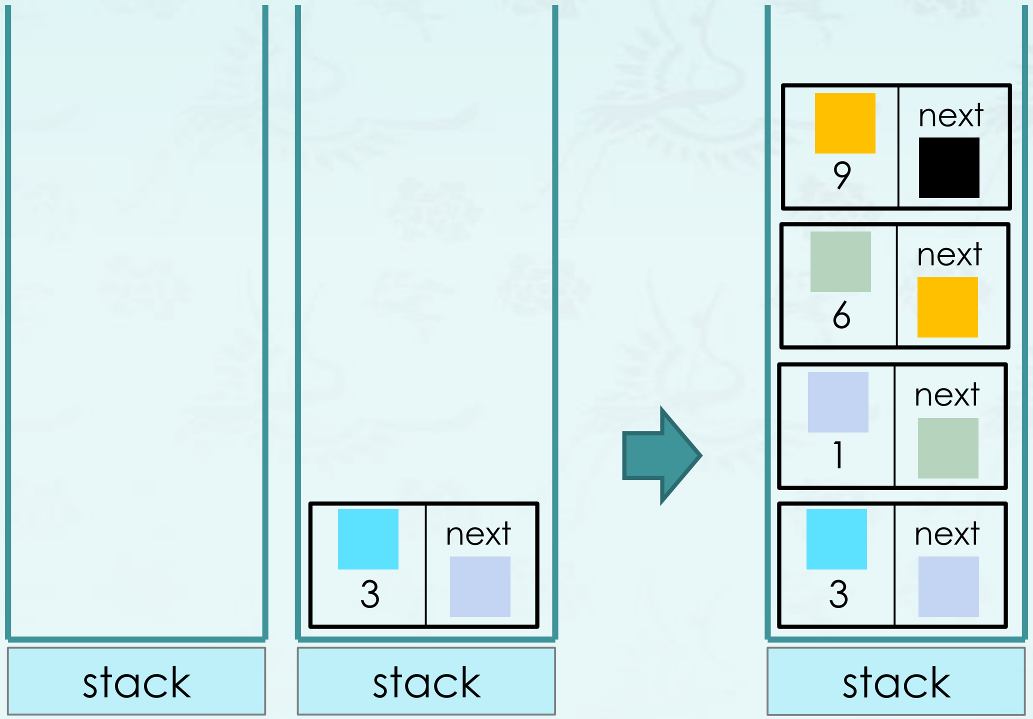

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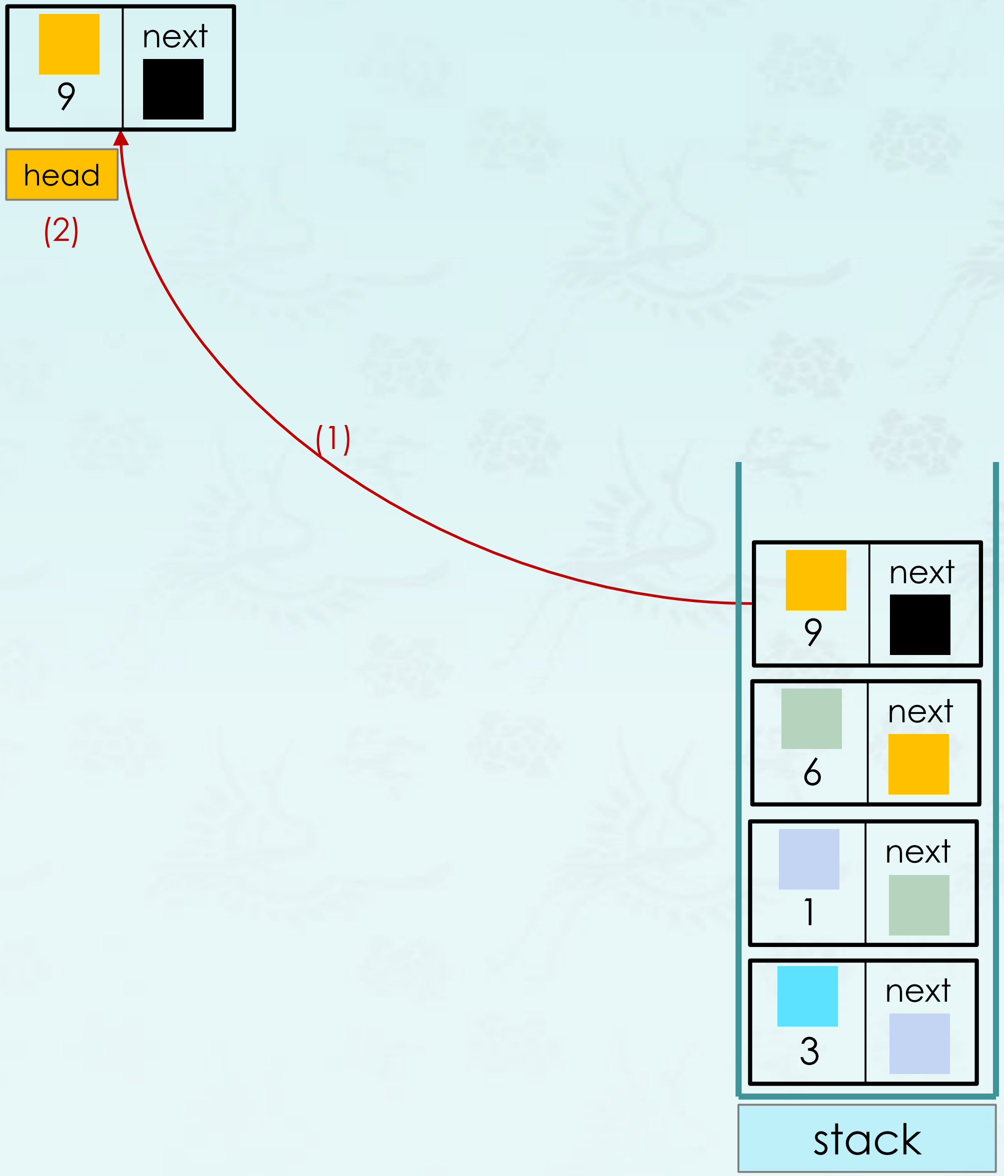

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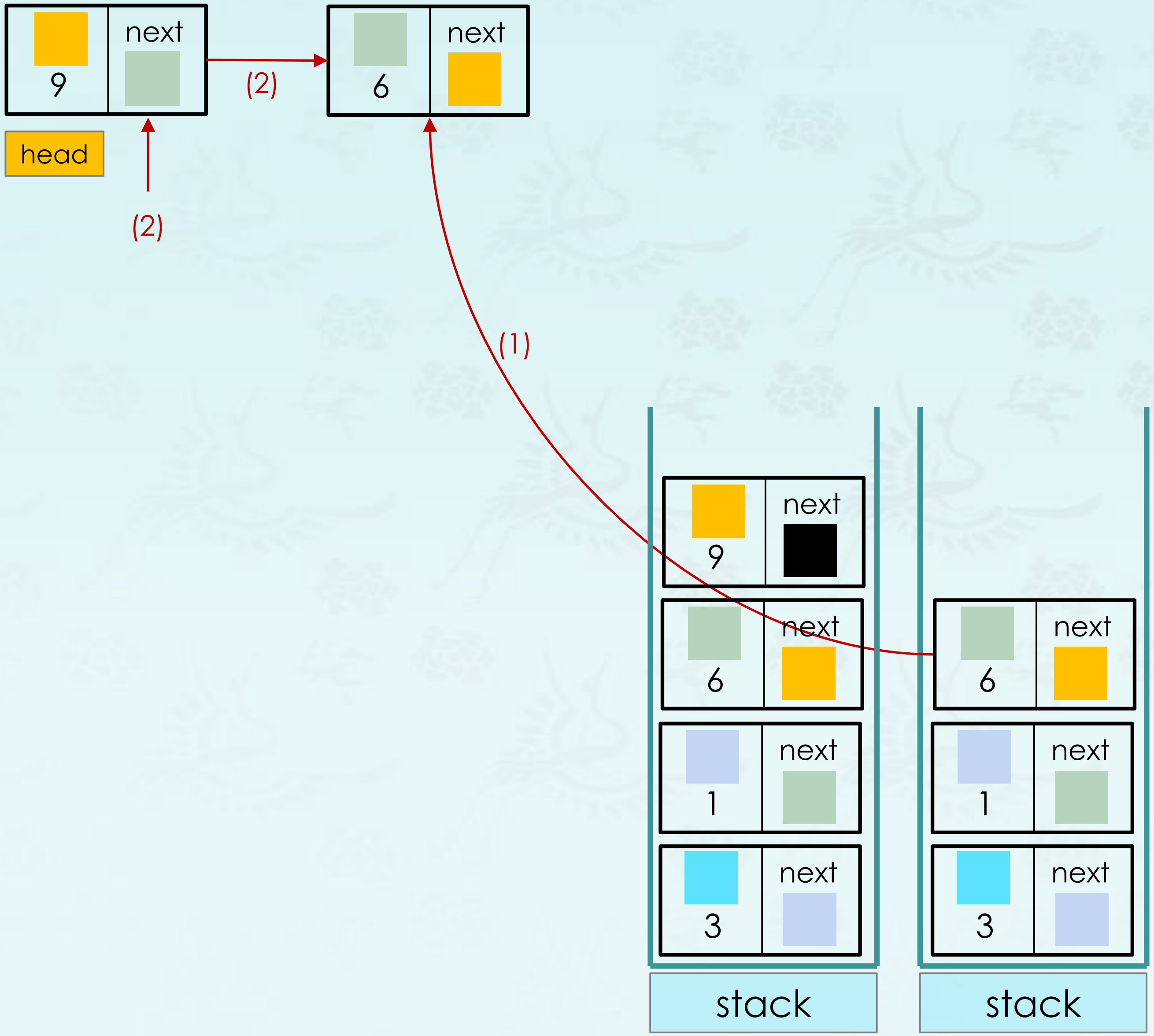

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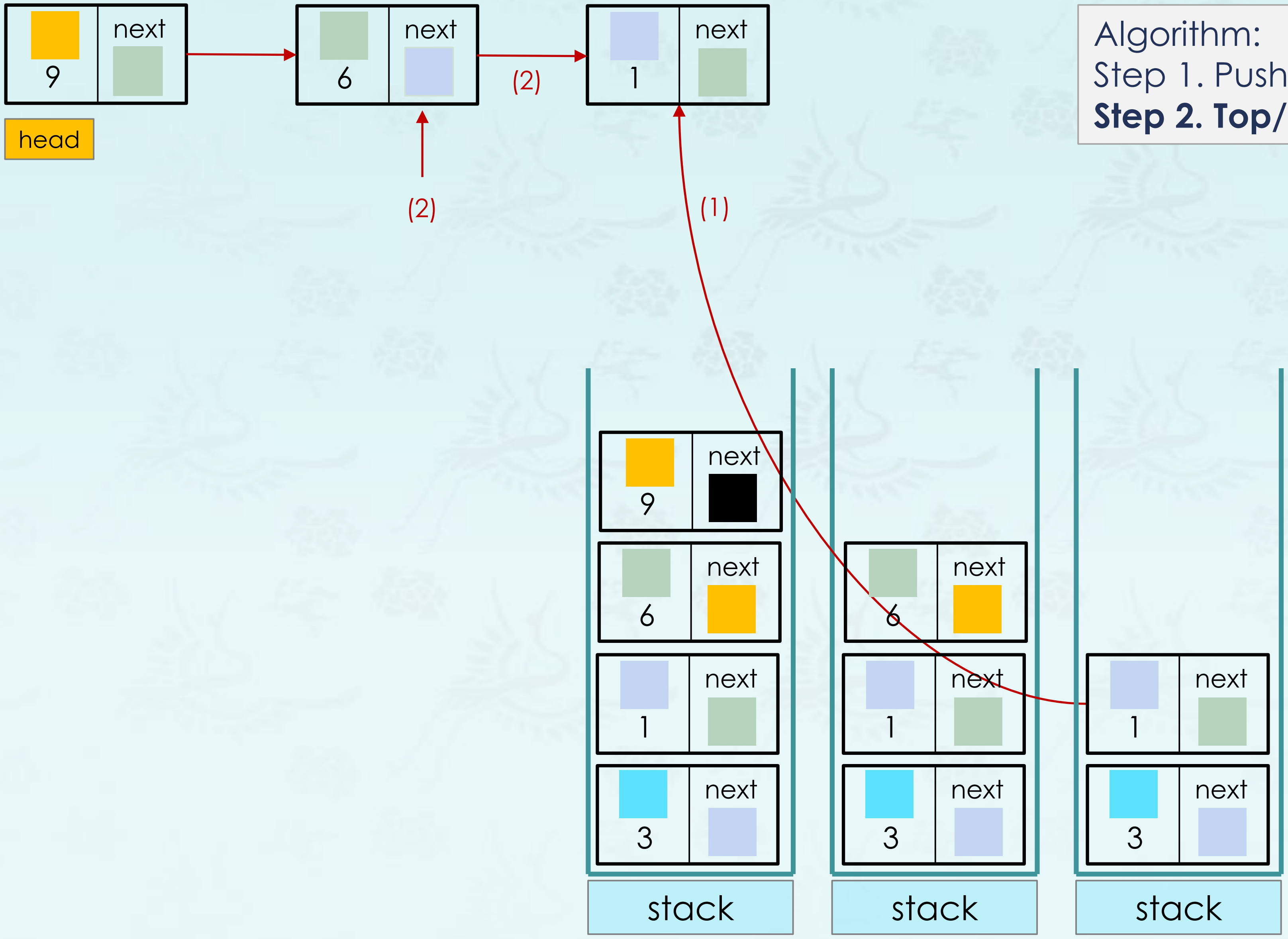

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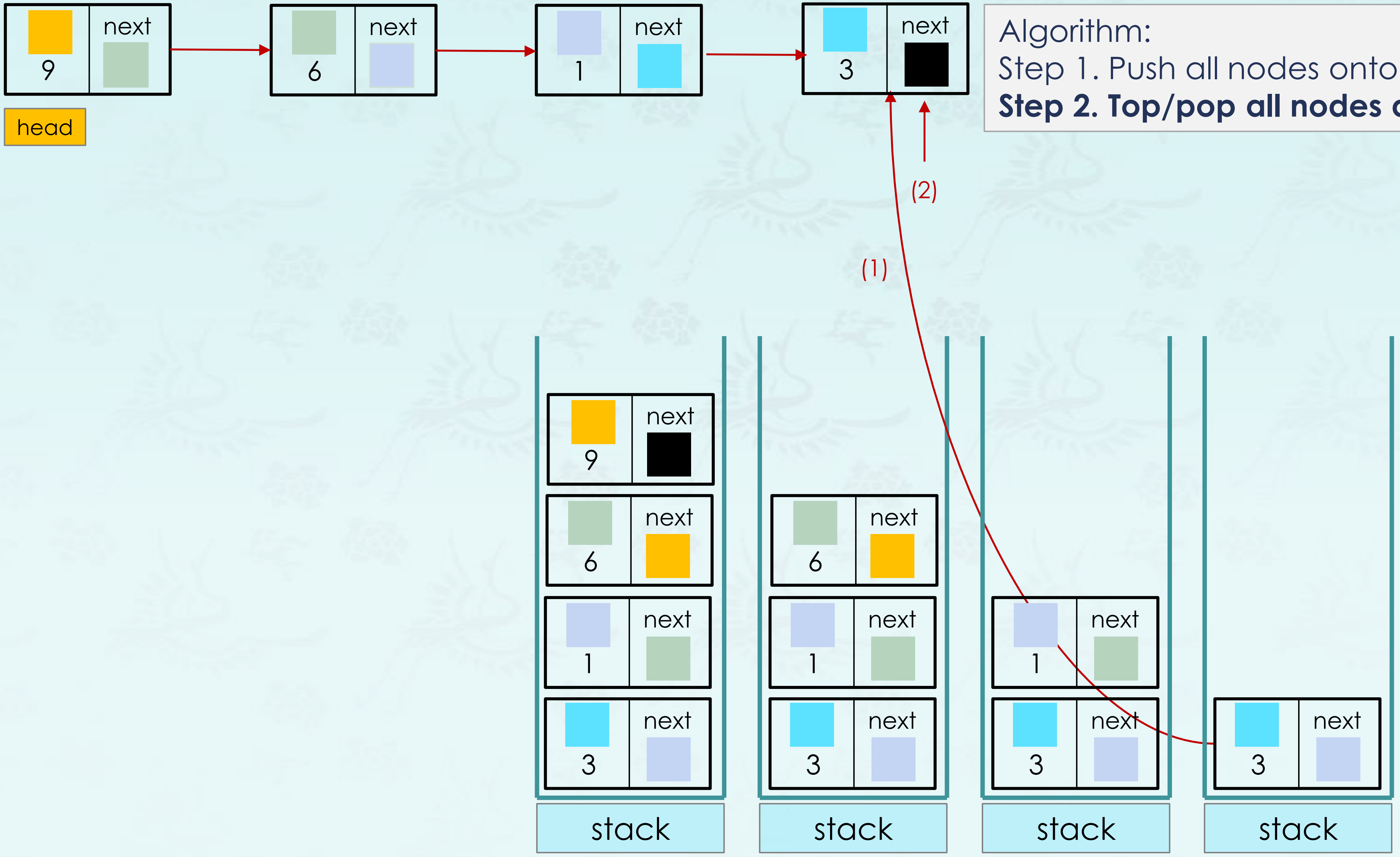

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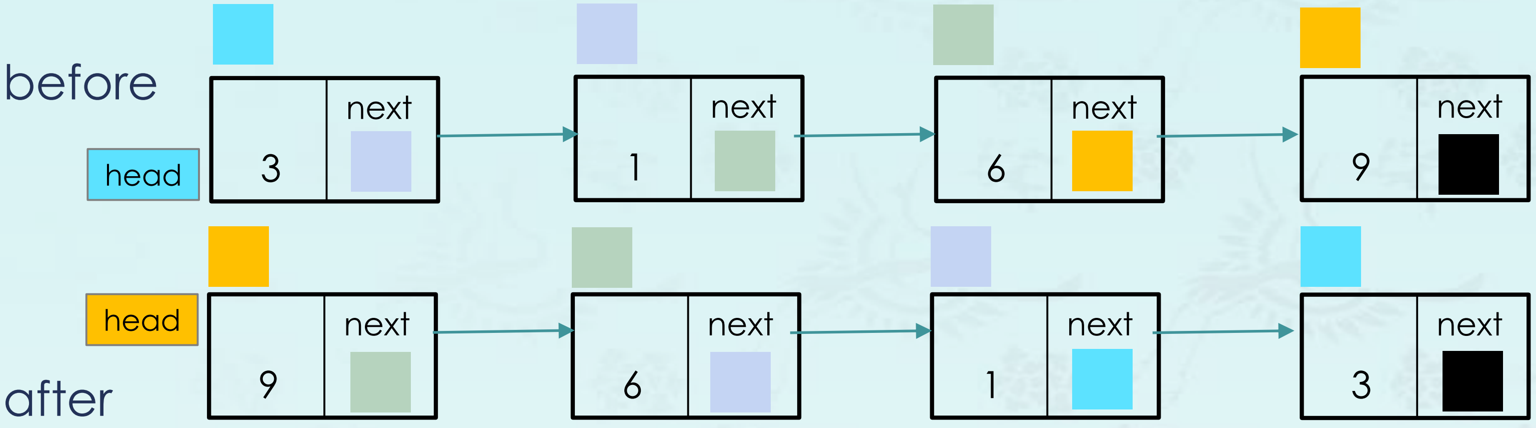
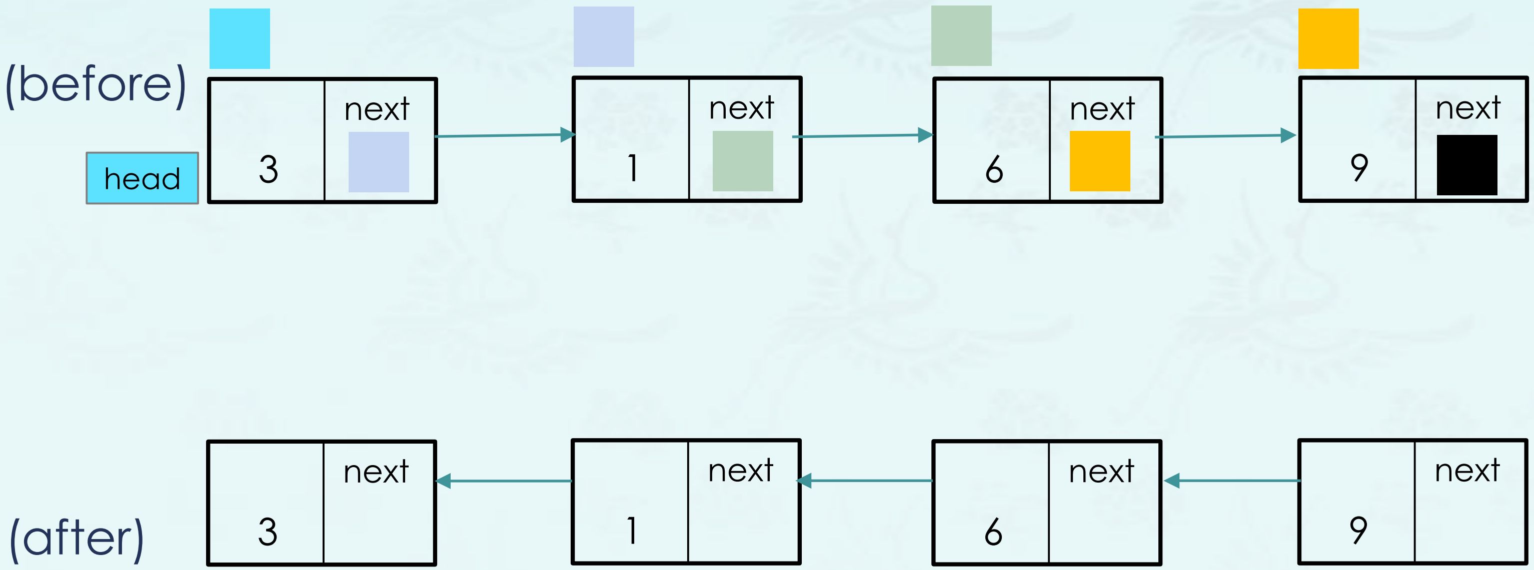
Linked List – reverse using stack




```
pNode reverse(pNode head)
```

```
if (empty(head)) return nullptr;
while( list is not empty )
  get a node from list
  push it onto the stack
}
while( stack is not empty )
  get a node from the stack
  relink it back the new list
}
return head;  // new head
```

Linked List – reverse in-place



Recall that this is the only one we know inside the function

```
pNode reverse(pNode head)
if (empty(head)) return nullptr;



return ________;
```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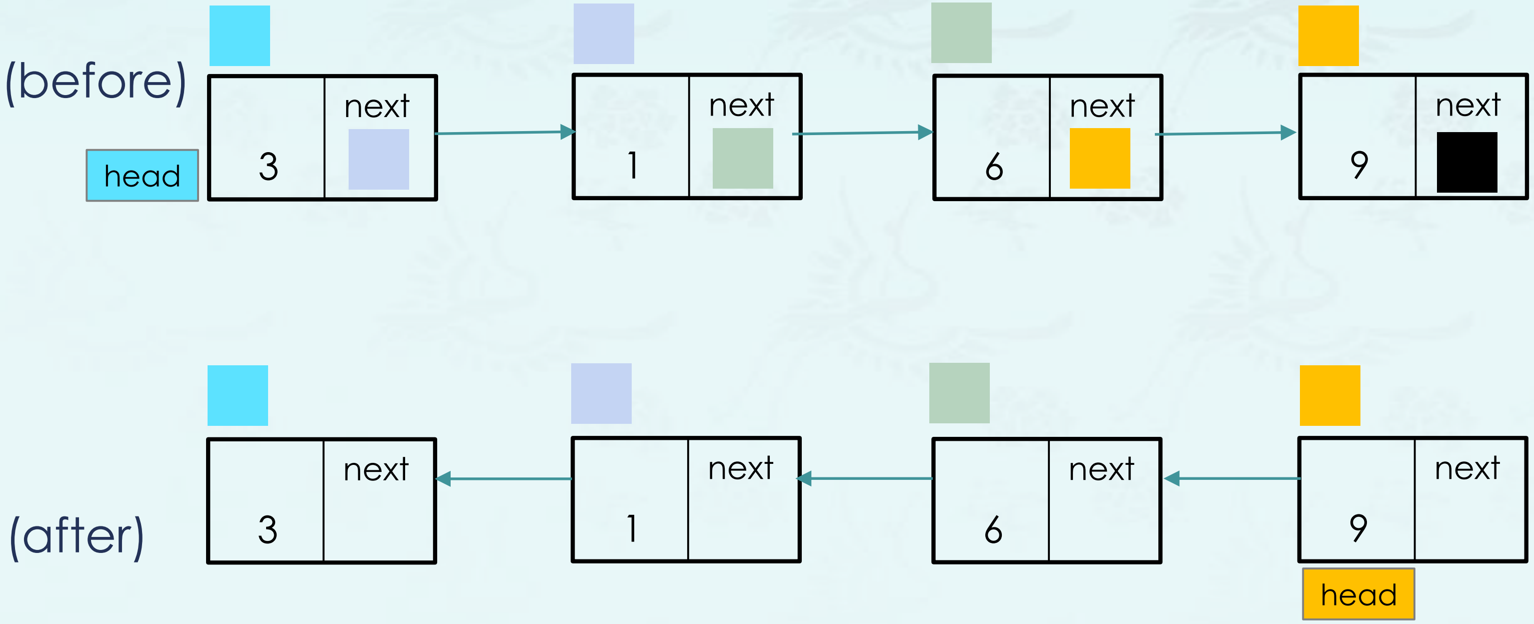
Linked List – reverse in-place



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return ________;
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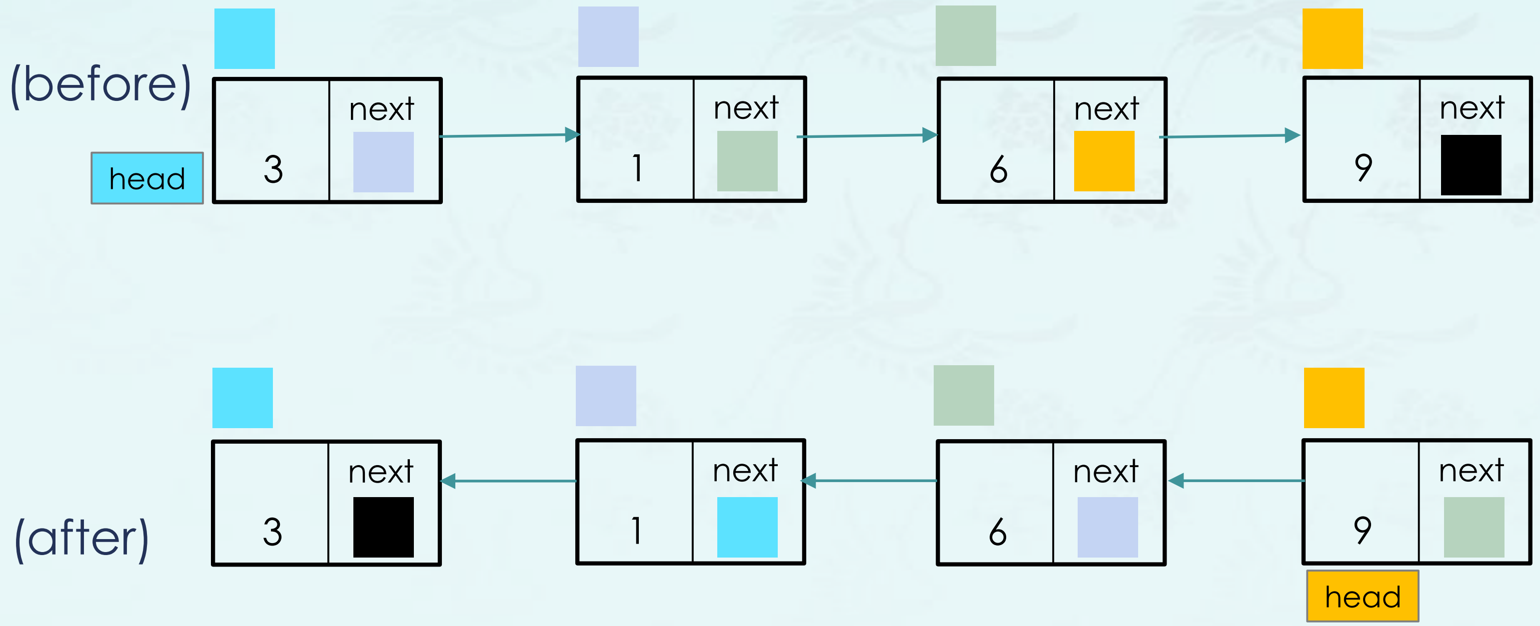

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return ________;
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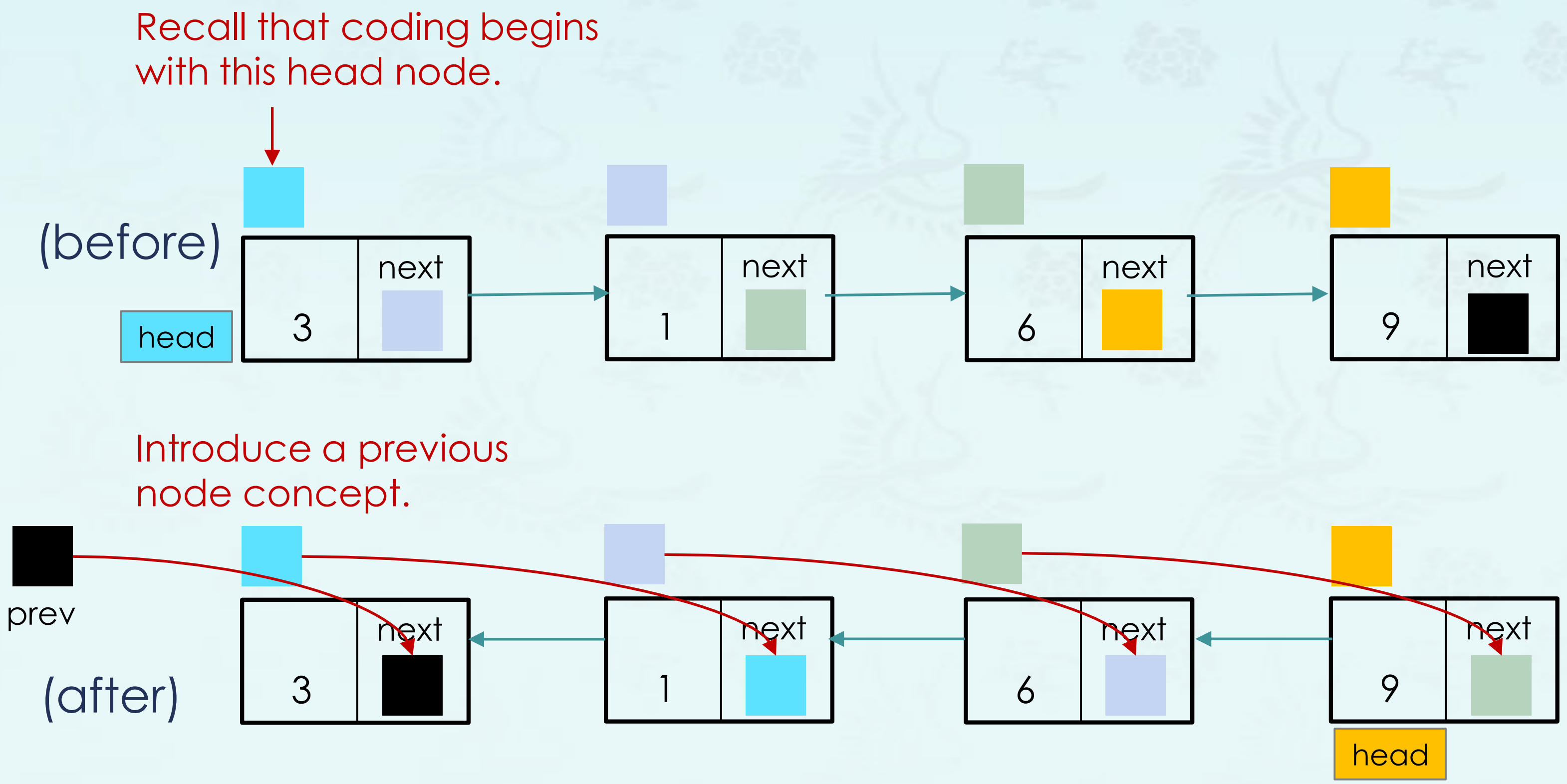

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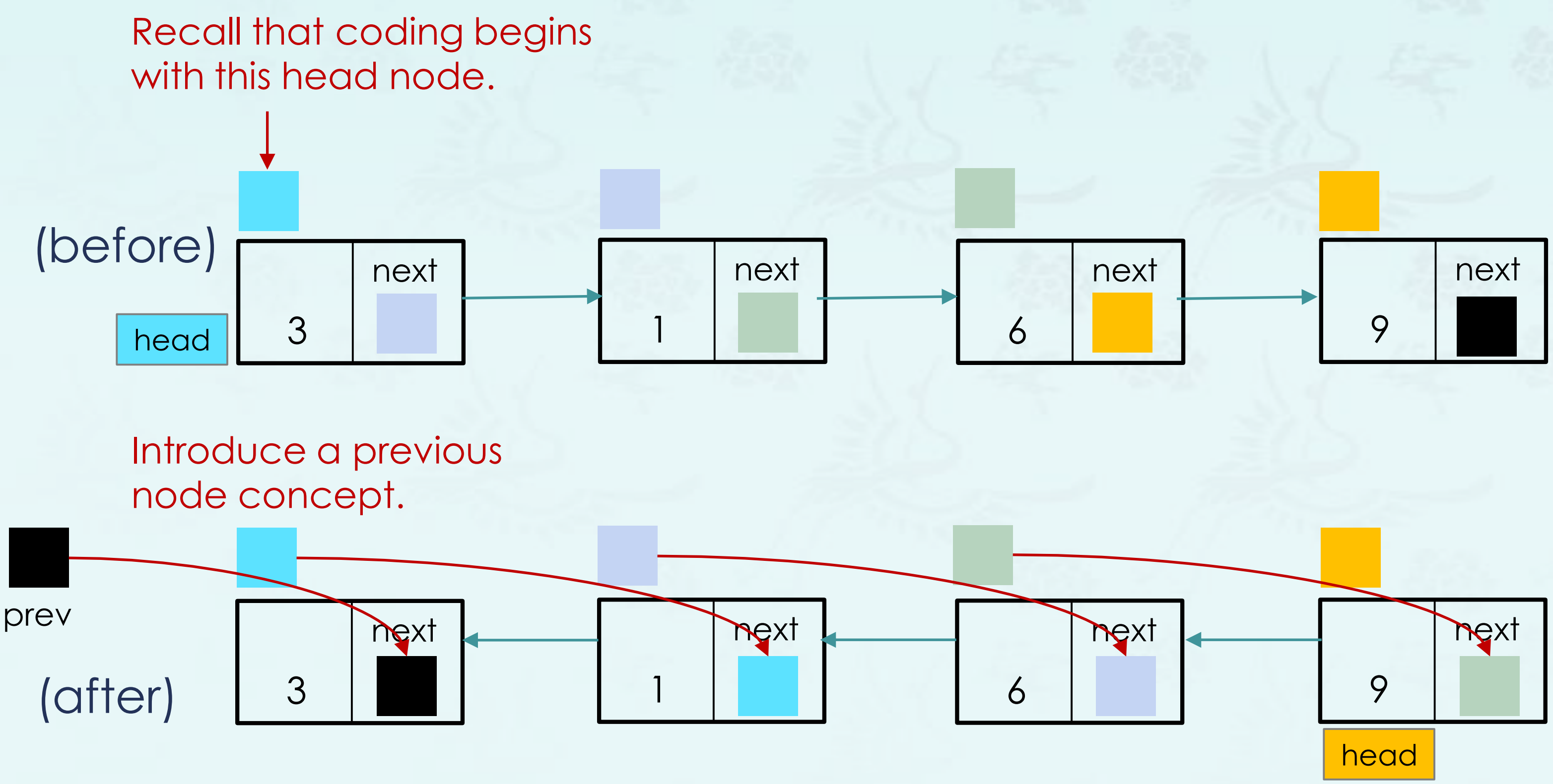
pNode reverse(pNode head)
if (empty(head)) return nullptr;

}
return ________;
```

Linked List – reverse in-place



Recall that this is the only one
we know inside the function

```
pNode reverse(pNode head)
if (empty(head)) return nullptr;

pNode prev = nullptr;
while (head != nullptr) {

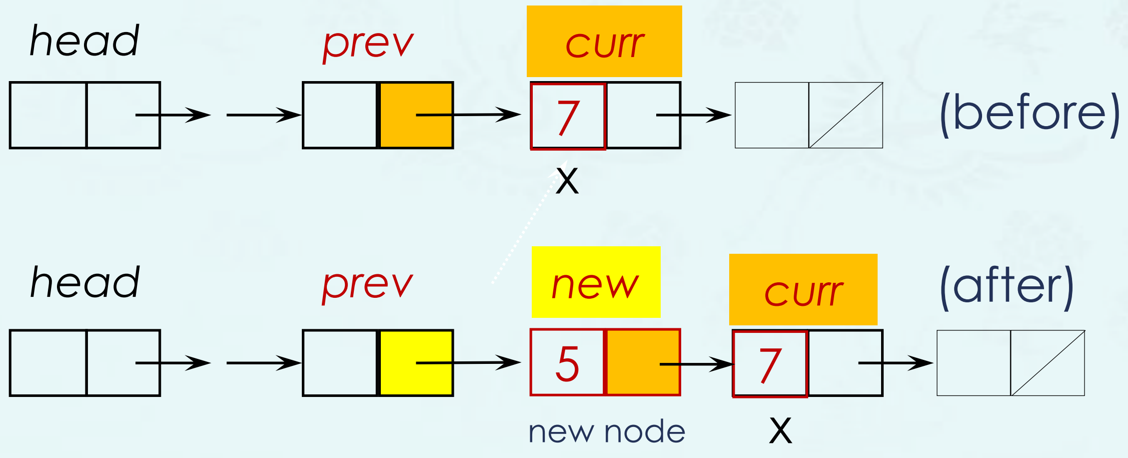



return ________;
```

Linked List – insert()

TASK: Code a function that inserts a node(5) **at a node position x** specified by a value(7).

- If the first node(or **head**) is the position, then just invoke **push_front().**
- As observed below, we must to know **the pointer x** which is stored in the **previous node** of node x.




```
pNode insert(pNode head, int val, int x)
if (head->data == x)
  return push_front(val, head);

pNode curr = head;
pNode prev = nullptr;
while (curr != nullptr) {



  prev = curr;
  curr = curr->next;
}
return head;
```

Linked List – insert()

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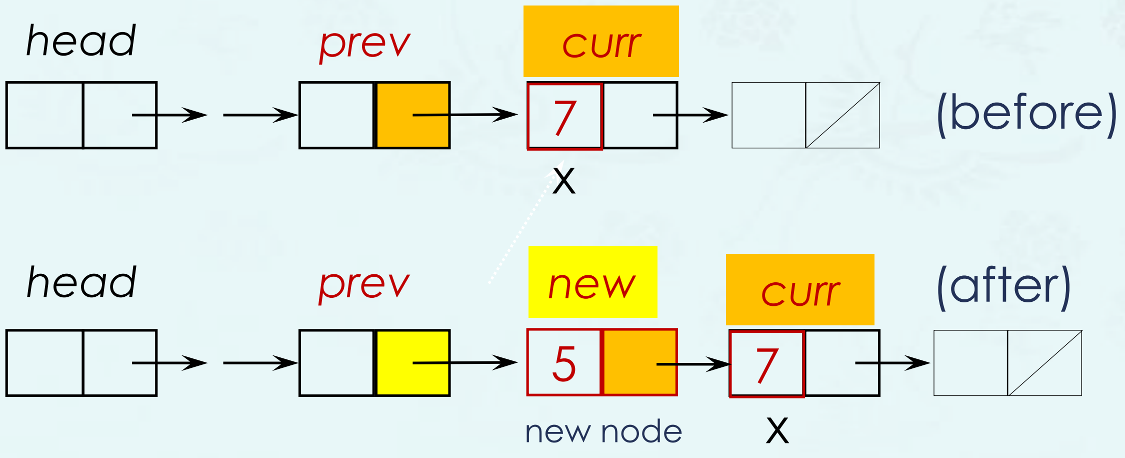


```
pNode insert(pNode head, int val, int x)
if (head->data == x)
  return push_front(val, head);

pNode curr = head;
pNode prev = nullptr;
while (curr != nullptr) {
  if (curr->data == x) {
                = new Node{                };
    return head;
  }
  prev = curr;
  curr = curr->next;
}
return head;
```

Linked List – insert()

TASK: Code a function that inserts a node(5) **at a node position x** specified by a value(7).

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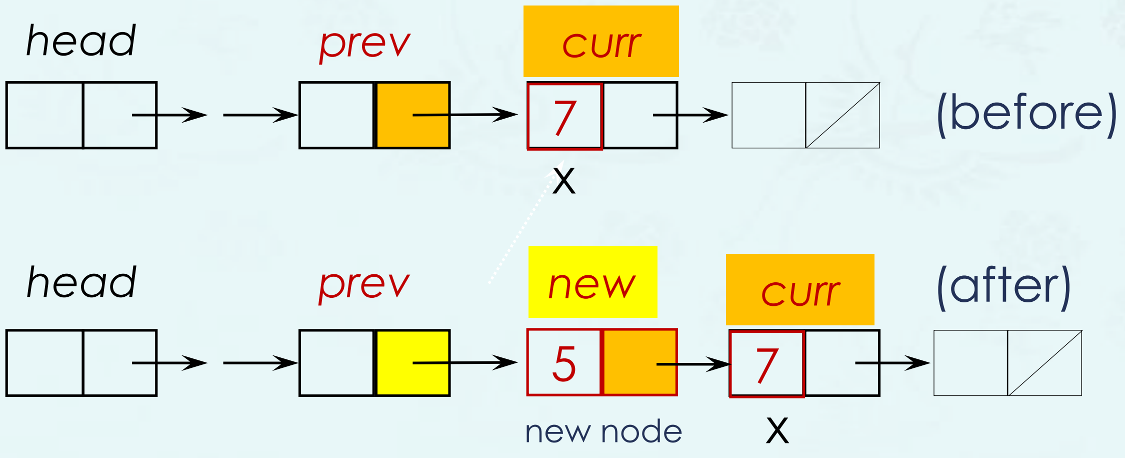
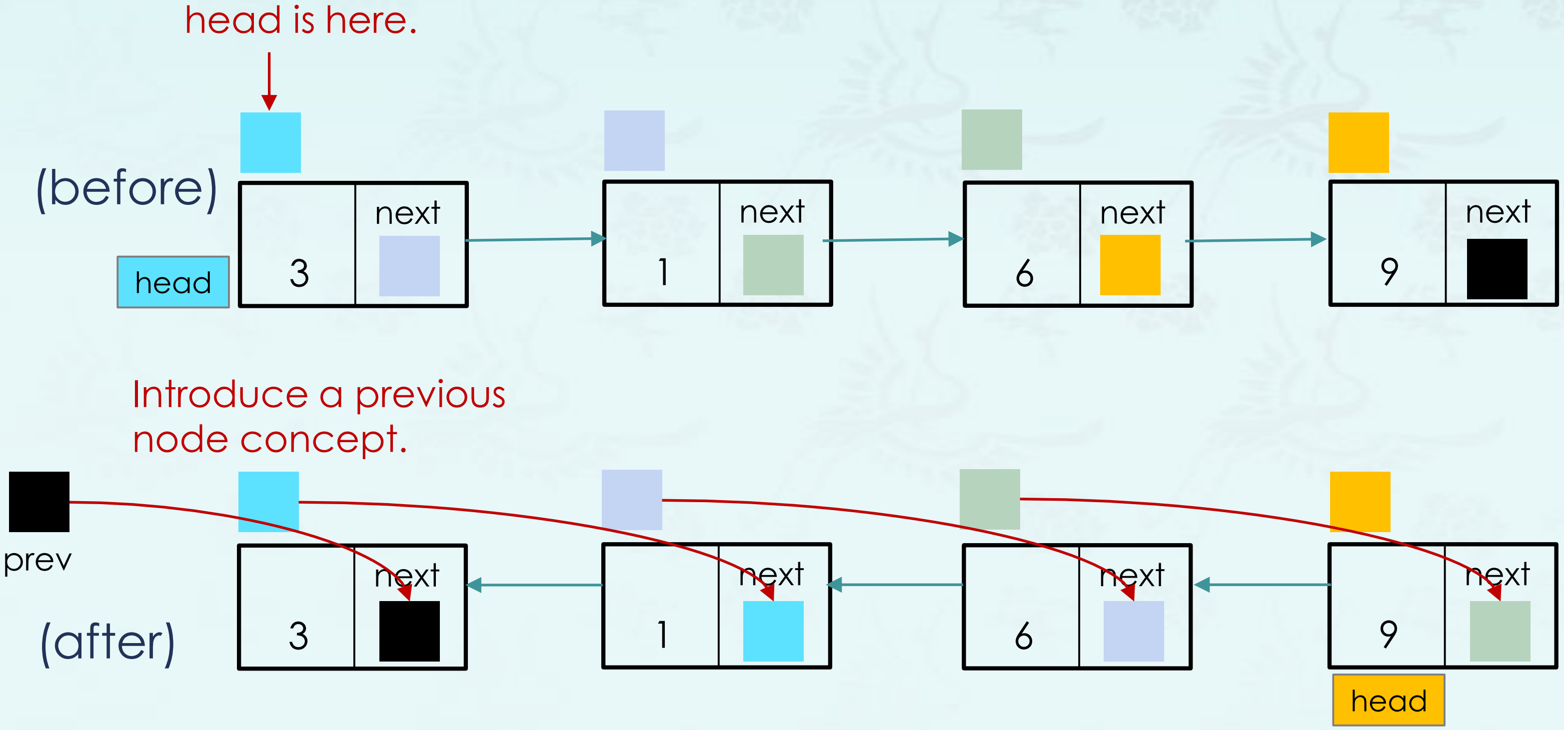



```
pNode insert(pNode head, int val, int x)
if (head->data == x)
  return push_front(val, head);

pNode curr = head;
pNode prev = nullptr;
while (curr != nullptr) {
  if (curr->data == x) {
    prev->next = new Node{val, prev->next};
    return head;
  }
  prev = curr;
  curr = curr->next;
}
return head;
```

Linked List – reverse in-place

1. We want to overwrite **head->next** with **prev**
   But before overwriting we must save **head->next** .
   because we it is the next node we need to process.




```
pNode reverse(pNode head)
if (empty(head)) return nullptr;

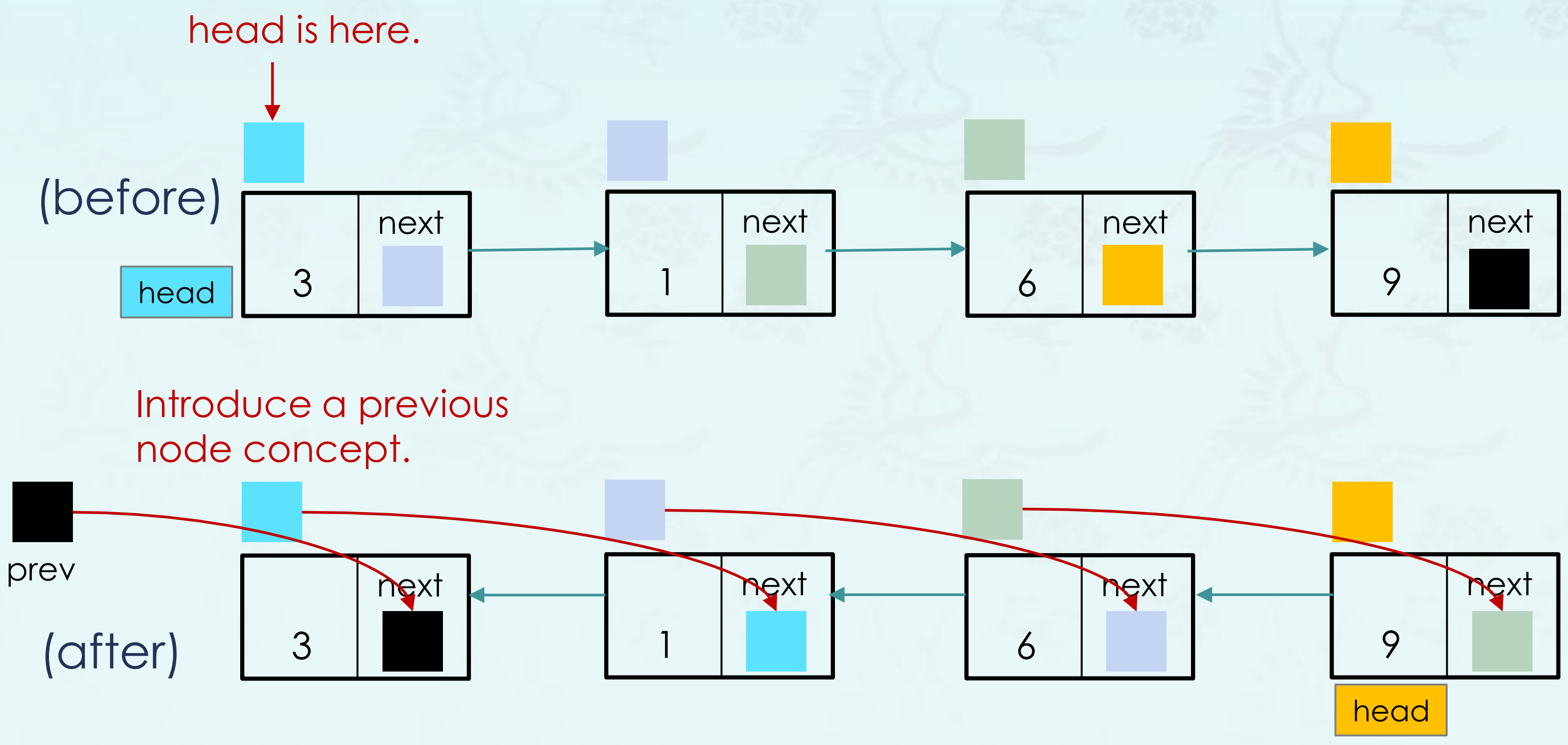
pNode prev = nullptr;
while (head != nullptr) {
(1)



}
return _____________;
```

Linked List – reverse in-place

1. We want to overwrite **head->next** with **prev**
   But before overwriting we must save **head->next** .
   because we it is the next node we need to process.
2. Once we overwrite **head->next** with **prev** ,



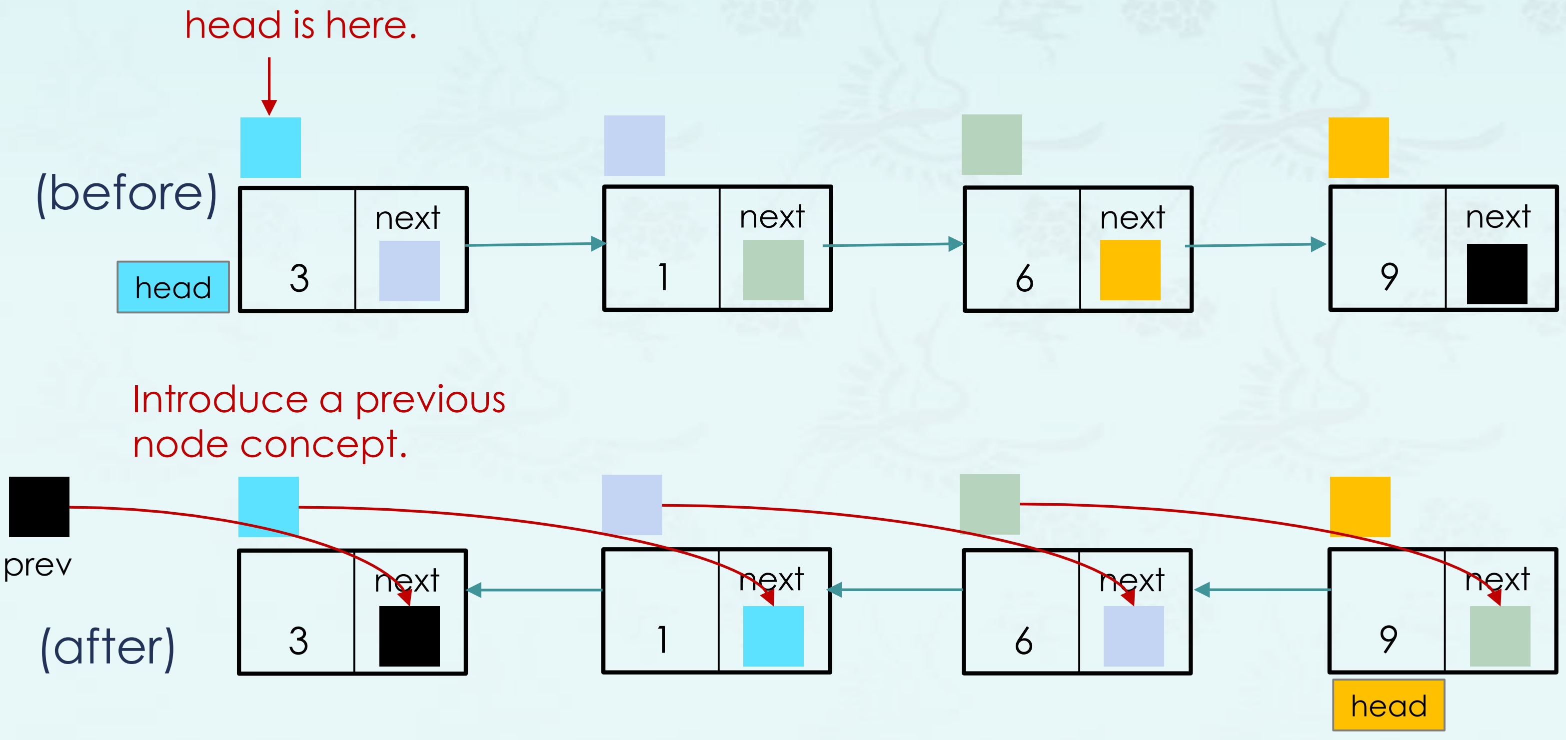

```
pNode reverse(pNode head)
if (empty(head)) return nullptr;

pNode prev = nullptr;
while (head != nullptr) {
(1)
(2)


}
return ________;
```

Linked List – reverse in-place

1. We want to overwrite **head->next** with **prev**
   But before overwriting we must save **head->next** .
   because we it is the next node we need to process.
2. Once we overwrite **head->next** with **prev** ,
3. be ready to process the next node by setting
   prev as and **head** as .




```
pNode reverse(pNode head)
if (empty(head)) return nullptr;

pNode prev = nullptr;
while (head != nullptr) {
(1)
(2)
(3)
(3)
}
return ________;
```

Linked List – reverse in-place

1. We want to overwrite **head->next** with **prev**
   But before overwriting we must save **head->next** .
   because we it is the next node we need to process.
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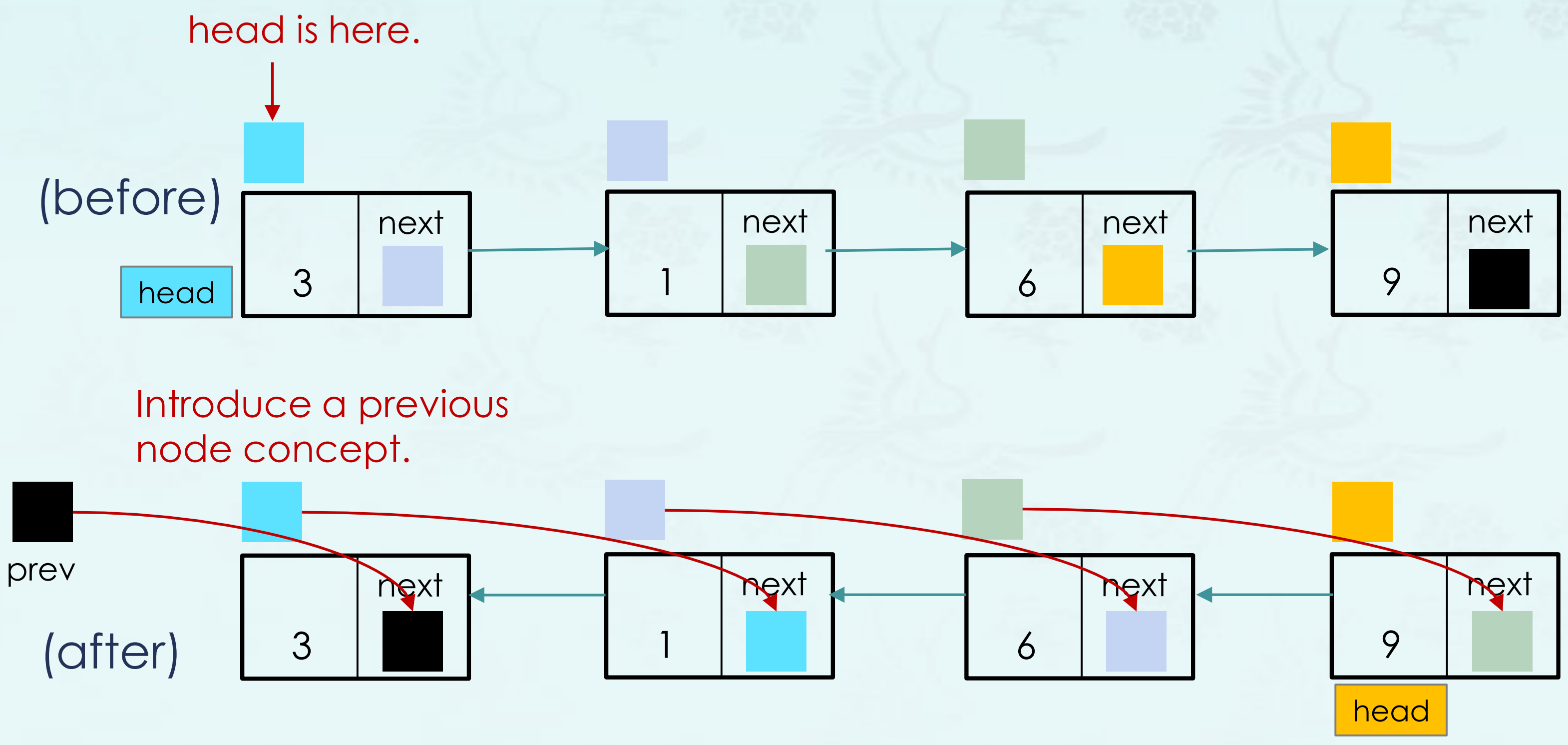


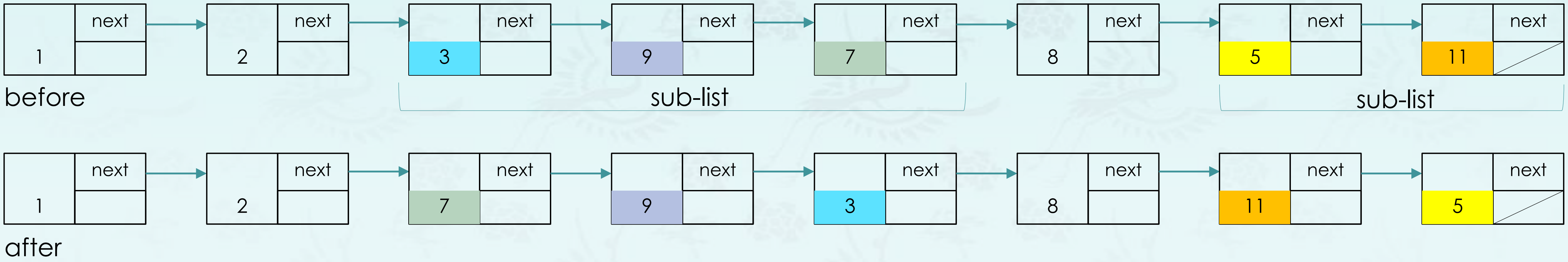

```
pNode reverse(pNode head)
if (empty(head)) return nullptr;

pNode prev = nullptr;
while (head != nullptr) {
(1)
(2)
(3)
(3)
}
return ________;
```

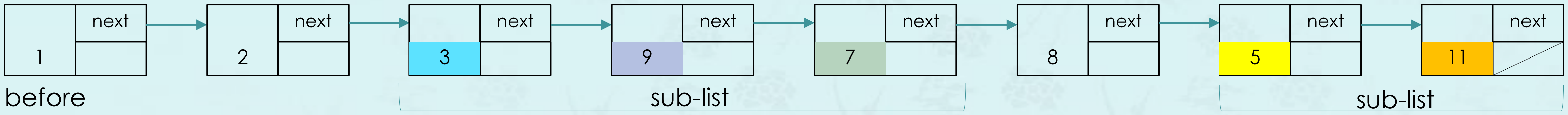
Which one has the last node address to return as a new head after while loop?

Linked List – reverse elements in sub-lists of odd numbers

TASK: Reverse elements in sub-lists of odd numbers only in a singly-linked list.
Given a linked list that contains N integers, select all the sub-lists contain only odd integers. Reverse elements in those sub lists only.
For example, if the list is {1, 2, 3, 9, 7, 8, 5, 11}, then the selected sub-lists are {3, 9, 7} and {5, 11}. Reverse elements in those list such as {7, 9, 3} and {11, 5}. Now, this function returns the original list except odd numbers reversed in the sub-lists. In this example, it returns {1, 2, 7, 9, 3, 8, 11, 5}



Linked List – reverse elements in sub-lists of odd numbers (version 1 – O(n^2))



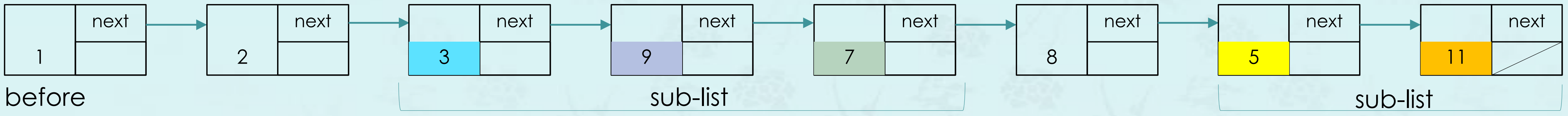
version 1 – O(n^2)

```
while (head != nullptr) {
  if the node is odd {
    push it to odd_stack
    go for the next node
    continue
  }
  // even node encountered
  while (odd_stack is not empty) {
    get top of odd_stack & pop
    push_back to the head2
  }
  add even node to head2          added
  go for the next node
}

while( odd_stack is not empty) {
  get top of odd_stack & pop
  push_back to the head2
}
clear head
return head2
```

- For the sake of the simplicity of coding, we use `push_back()`.
- `head` is the original list `head`.
- `head2` is the new list as a result.
- `odd_stack` stacks up odd(s) until an even shows up.
- You may use either `stack<Node*>` or `stack<int>` but recall that `push_back()` takes a data item, not a node itself.

Linked List – reverse elements in sub-lists of odd numbers (version 2 – O(n))



version 2 – O(n)

```
while (head != nullptr) {
  if the node is odd {
    push it to odd_stack
    go for the next node
    continue
  } // even node encountered
  while (odd_stack is not empty) {
    get top of odd_stack & pop
    head2 is null, set head2
    add it to the tail2 & set tail2
  }
  head2 is null, set head2
  add even node to tail2 & set tail2
  go for the next node
}
while( odd_stack is not empty) {
  get top of odd_stack & pop
  head2 is null, set head2
  add it to the tail2 & set tail2
}  // no clear head necessary
return head2
```

- For the sake of the speed of the code, do not use `push_back()`. Use almost the same algorithm, but manage to add a node at the `head2` and `tail2` by yourself instead of calling `push_back()`.
- `head` is the original list `head`.
- `head2` is the new list as a result.
- `tail2` is the tail node of the `head2`.
- `odd_stack` stacks up odd(s) until an even shows up.
- Do not use `stack<int>`, but `stack<Node*>` to reuse the nodes.
- Do not clear `head` since all nodes are reused.

Summary &

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Data Structures
Chapter 4

1. Singly Linked List
   - Pointer Reviewed & Linked
   - Linked List (1)
   - Linked List (2)
   - **Reverse**
2. Doubly Linked List

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