Data Structures
Chapter 4

1. Singly Linked List
   - Pointer & Linking
   - **Singly Linked List (SLL)**
   - SLL Basic Operations
   - SLL Advanced Operations
2. Doubly Linked List

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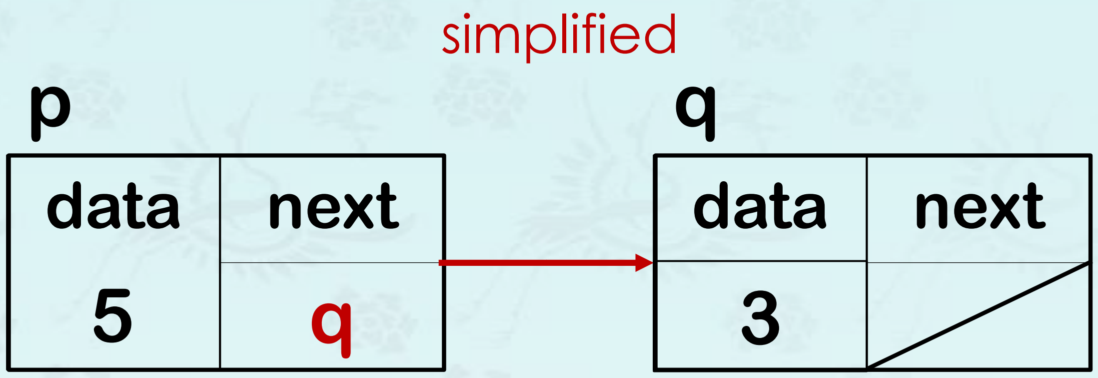
내 아들들을 먼 곳에서 이끌며 내 딸들을 땅 끝에서 오게 하며 내 이름으로 불려지는 모든 자 곧 내가 내 영광을 위하여 창조한 자를 오게 하라 그를 내가 지었고 그를 내가 만들었노라 (사43:6-7)

수고하고 무거운 짐 진 자들아 다 내게로 오라 내가 너희를 쉬게 하리라 나는 마음이 온유하고 겸손하니 나의 멍에를 메고 내게 배우라 그리하면 너희 마음이 쉼을 얻으리니 이는 내 멍에는 쉽고 내 짐은 가벼움이라 하시니라 (마11:28-30)

Pointers Linked

```
class Node {
public:
  int   data;
  Node* next;
};

int main( ) {
  Node* q = new Node{3, nullptr};
  Node* p = new Node{5, q};
}
```



Pointers Linked

```
class Node {
public:
  int   data;
  Node* next;
};

int main( ) {
  Node* p = new Node;
  ...

}
```

constructor, destructor

constructor

destructor

```
struct Node {
  int   data;
  Node* next;

  Node(int i=0, Node* n=nullptr){
    data = i, next = n;
  }
  ~Node() {};
};

int main( ) {
  Node* p = new Node;
  ...

}
```

Linked List

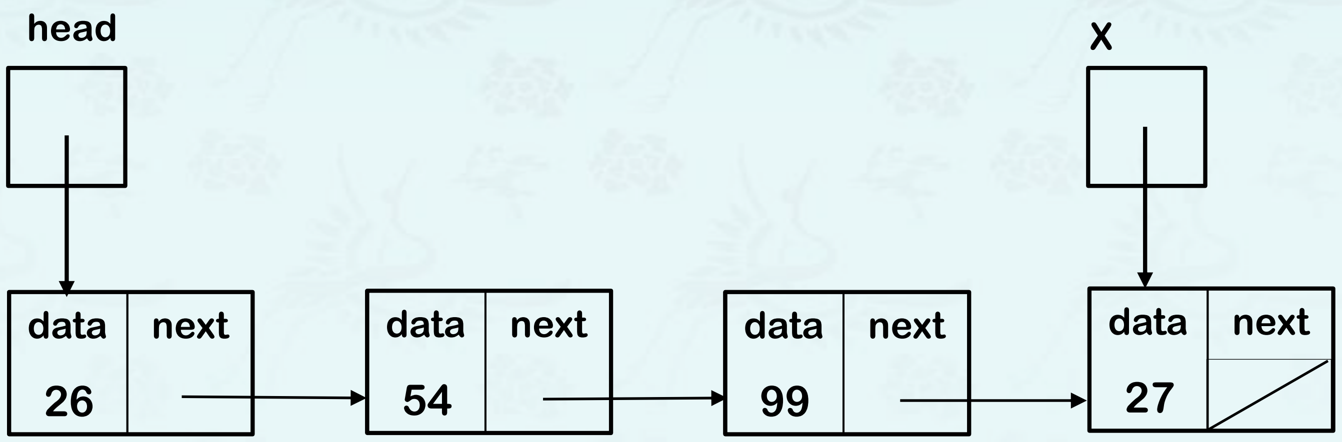
```
struct Node {
  int   data;
  Node* next;
};

...

Node* head, *x, *y;
```

basic member functions

- push_front()
- push_back()
- pop_front()
- pop_back()
- insert()
- remove()
- clear()



Linked List

```
struct Node {
  int   data;
  Node* next;
};

...

Node* head, *x, *y;
```

basic member functions

```
- push_front()
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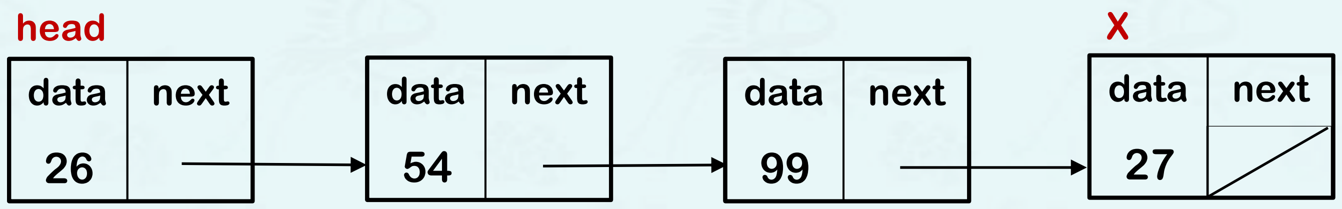
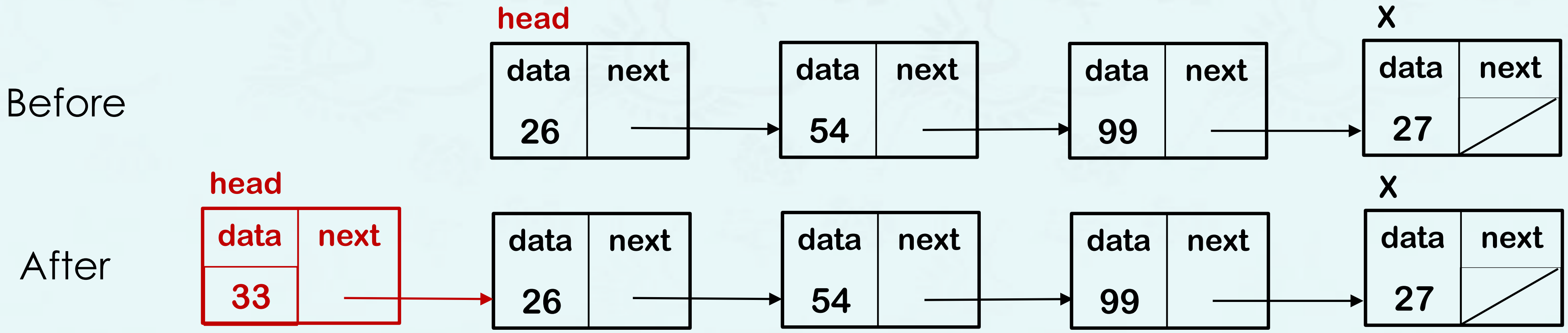


Linked List - push_front()

Let us imagine that we have created a linked list, where **head** points to the head of the list and **x** at the last item in the list (i.e. the one with the nullptr pointer) as shown below.

- Add a node (data = 33) at the **head of list**.



Linked List - push_front()

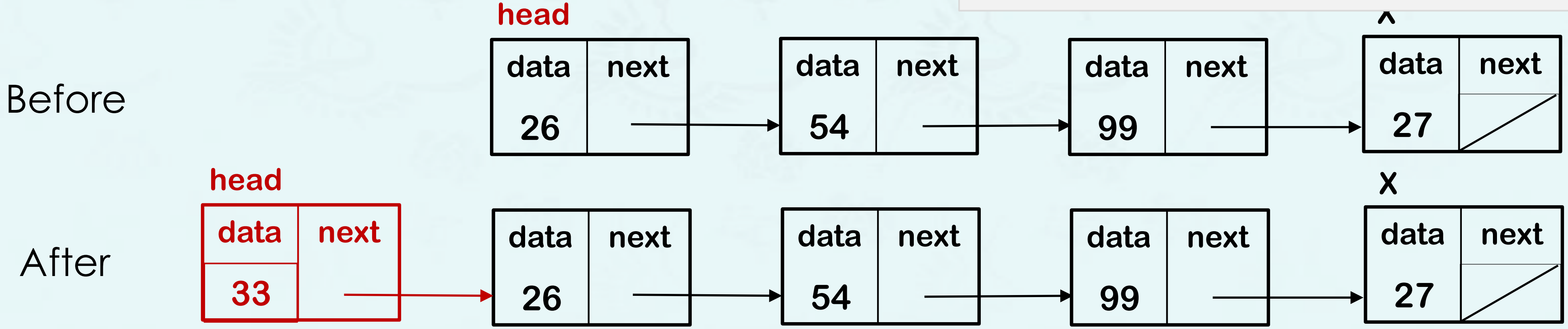
Let us imagine that we have created a linked list, where **head** points to the head of the list and **x** at the last item in the list (i.e. the one with the nullptr pointer) as shown below.

- Add a node (data = 33) at the head of list.

```
Node* push_front(Node* head, int data) {
  Node *y = new Node;
  y->data = data;
  y->next = head;
  return y;
}
```

```
Node* push_front(Node* head, data) {
  Node *y = new Node {data, head};
  return y;
}
```

```
Node* push_front(Node* head, data) {
  return new Node {data, head};
}
```



Linked List - push_back()

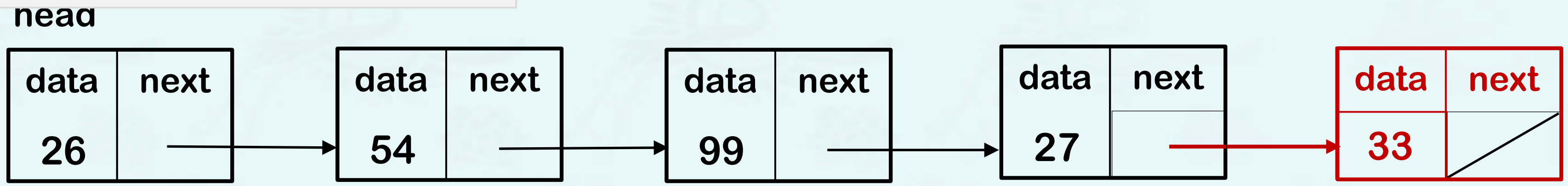
Let us imagine that we have created a linked list, where **head** points to the head of the list and **x** at the last item in the list (i.e. the one with the nullptr pointer) as shown below.

- Add a node (data = 33) at the end of list.

```
Node* push_back(Node* head, int data) {
  Node *y = new Node {data, nullptr};
  Node *x = head;
  while (x->next != nullptr)
    x = x->next;
  x->next = y;
  return head;
}
```

a way to get the last node

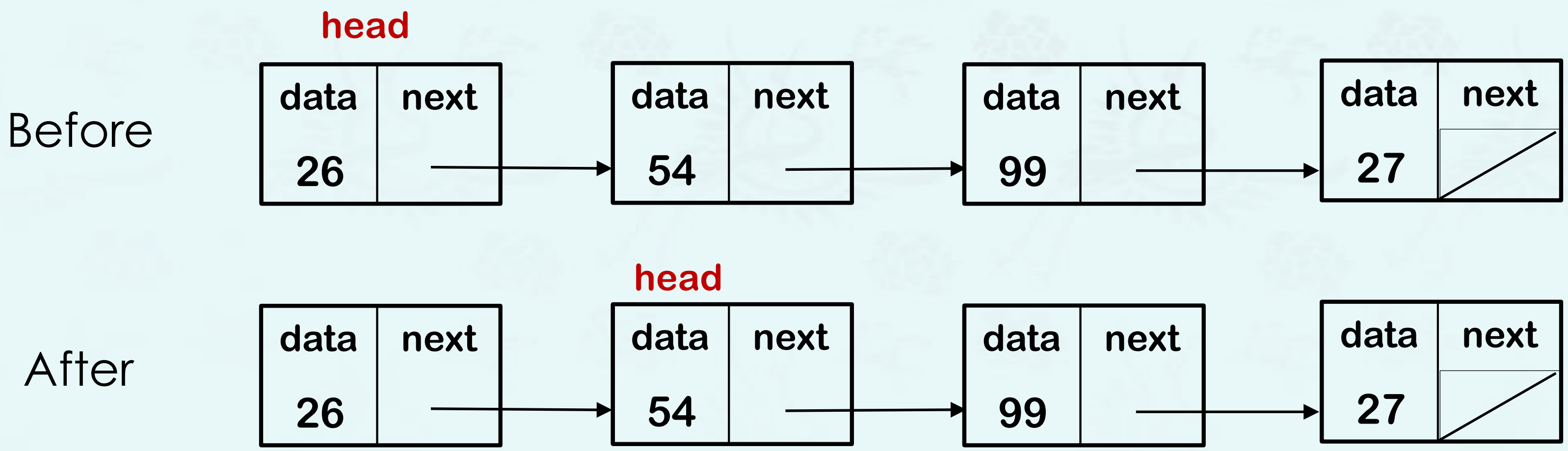
- To get to the tail we have to scroll along the list until the end. We want a pointer that will stop while still pointing at the last node. Thus our termination condition is that the node's next field is **nullptr**. Once we have a pointer to the end of the list, we can make it point to the node we want to add:



Linked List - pop_front()

- Remove the first node or move head to the next node.
  Then what is wrong with the following code?

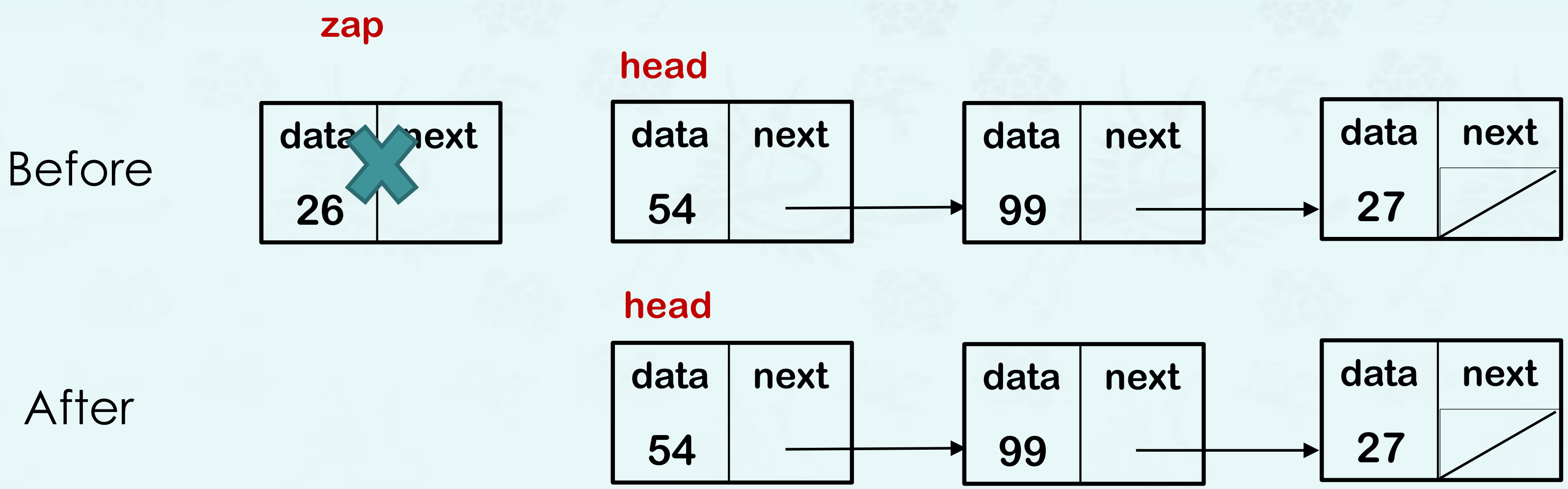
```
Node* pop_front(Node* head) {
  head = head->next;
  return head;
}
```



Linked List - pop_front()

- Remove the first node or move head to the next node.
  Then what is wrong with the following code?
- When removing a node, beware of memory leak; remember to give yourself a pointer to the node that is about to be removed before you lose your pointer to it:

```
Node* pop_front(Node* head) {
    Node* zap = head;
    head = head->next;
    delete zap;
    return head;
}
```

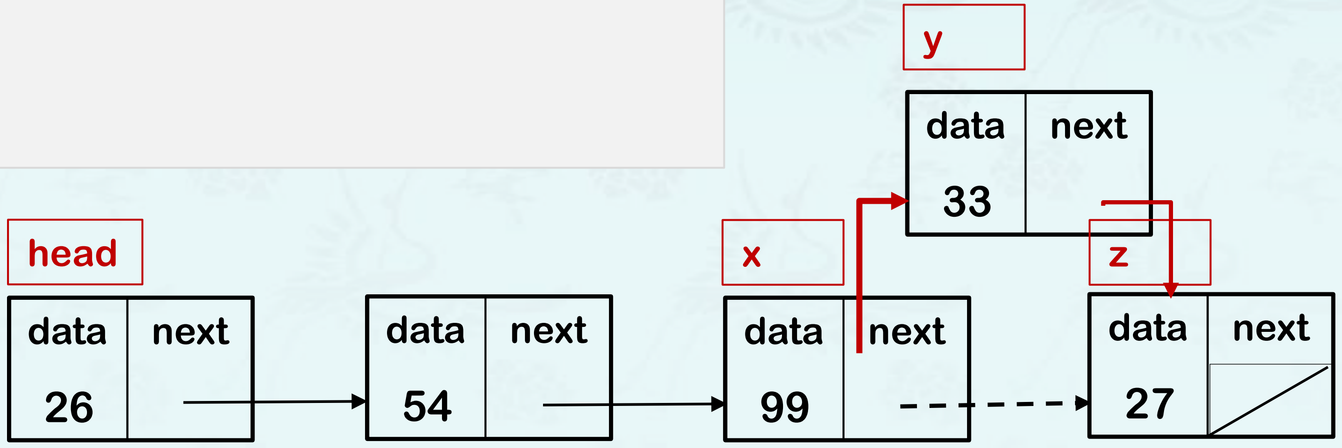


Linked List - insert()

- Insert a new node(data = 33) after the node (key = 99) as shown below.
- Starting from the head node, we have to stop at the node (key = 99) before the insertion point. Remember that a singly-linked list is a one way street!

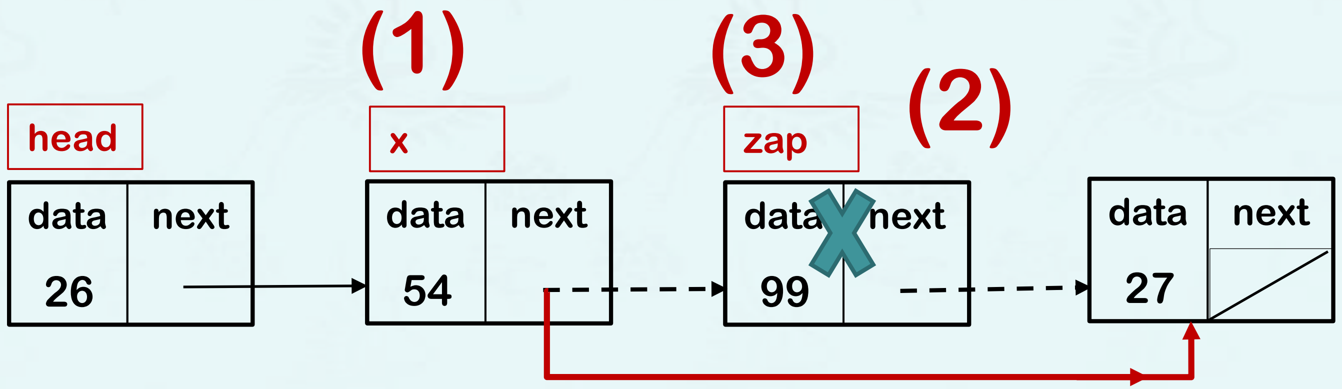
```
Node* insert(Node* head, int key, int data) {
    Node* x = head;
    while (x->data != key)
      x = x->next;
    Node* y = new Node {data, x->next};
    x->next = y;
    return head;
}
```

Where is x pointing after while()?



Linked List - remove()

- Remove a node(key = 99) in the middle of list as shown below.



Linked List - remove()

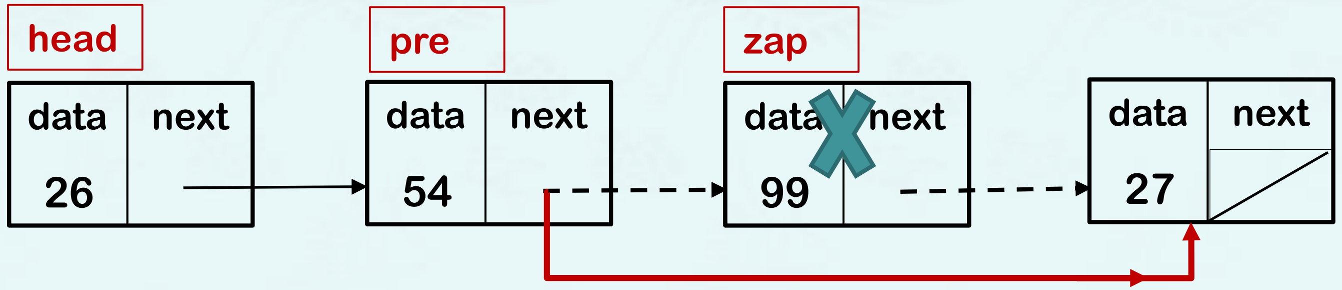
- Remove a node(key = 99) in the middle of list as shown below.

1. use a handle pointer (**zap** here) to keep hold of the unwanted node
2. find the node **before** the unwanted node and make links.
3. delete the unwanted node

```
Node* remove(Node* head, int key) {
    node* pre = head,
    node* zap = head->next;
    while(zap->data!= key) {
      pre = zap;
      zap = zap->next;
    }
    pre->next = zap->next;
    delete zap;
    return head;
}
```

To find both pre and zap.

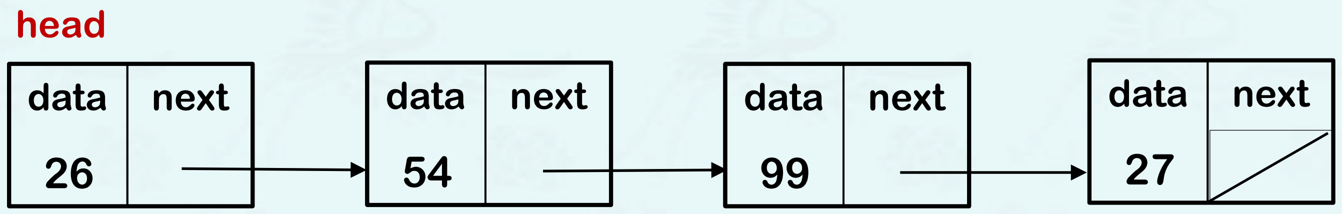
Assuming
(1) there are at least two nodes,
(2) the key is not at the head node, and
(3) there is a key node.



Linked List - clear()

Removes nodes from the list (which are destroyed), and leaving the list with a size of 0.

```
void clear(Node* head) {
    Node *curr = head;
    while(curr != nullptr) {
        ...
        delete ...
    }
}
```



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   - **Singly Linked List (1)**
   - Singly Linked List (2)
   - Singly Linked List Operations
2. Doubly Linked List