

1/4

# Linked Pointers

**Data Structures**  
**C++ for C Coders**

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Singly Linked List Concepts

## Pointer reviewed – Example 1

---

```
int z = 25;    // define an int

int* p;        // declare an integer pointer
p = &z;        // p holds the address of z
               // p points z
```

## Pointer reviewed – Example 1

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??

z

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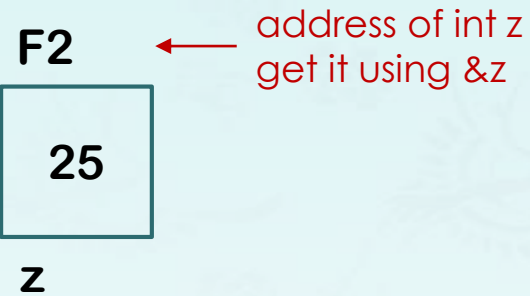
25

z

## Pointer reviewed – Example 1

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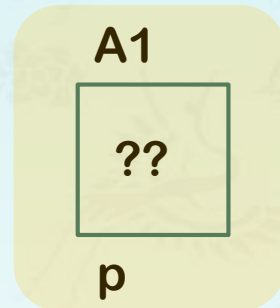
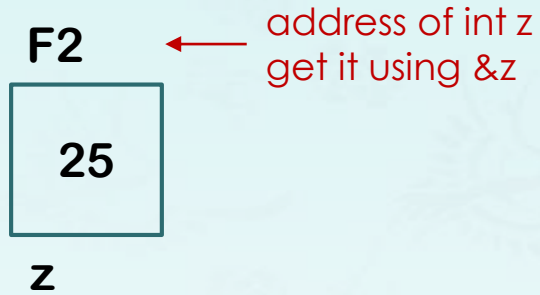
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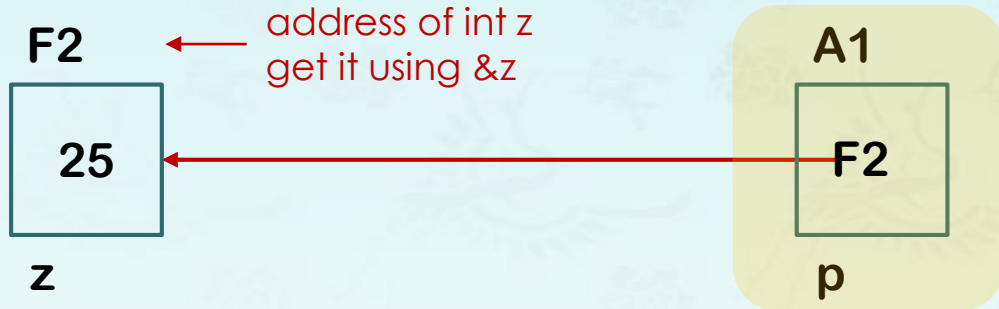
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## Pointer reviewed – Example 1

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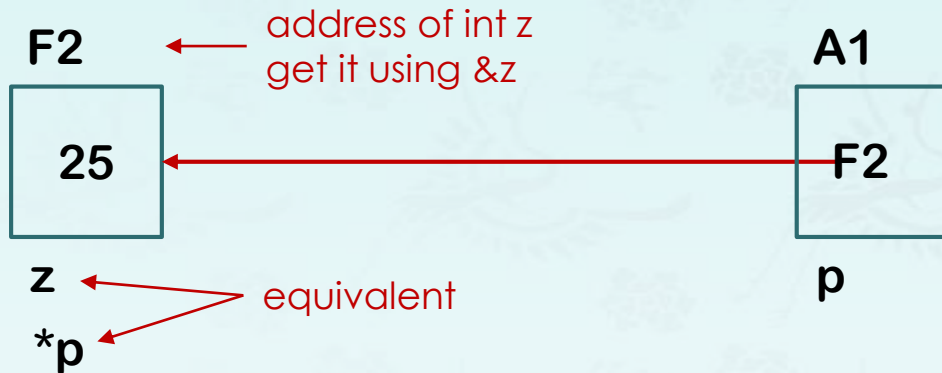


What is \*p?

## Pointer reviewed – Example 1

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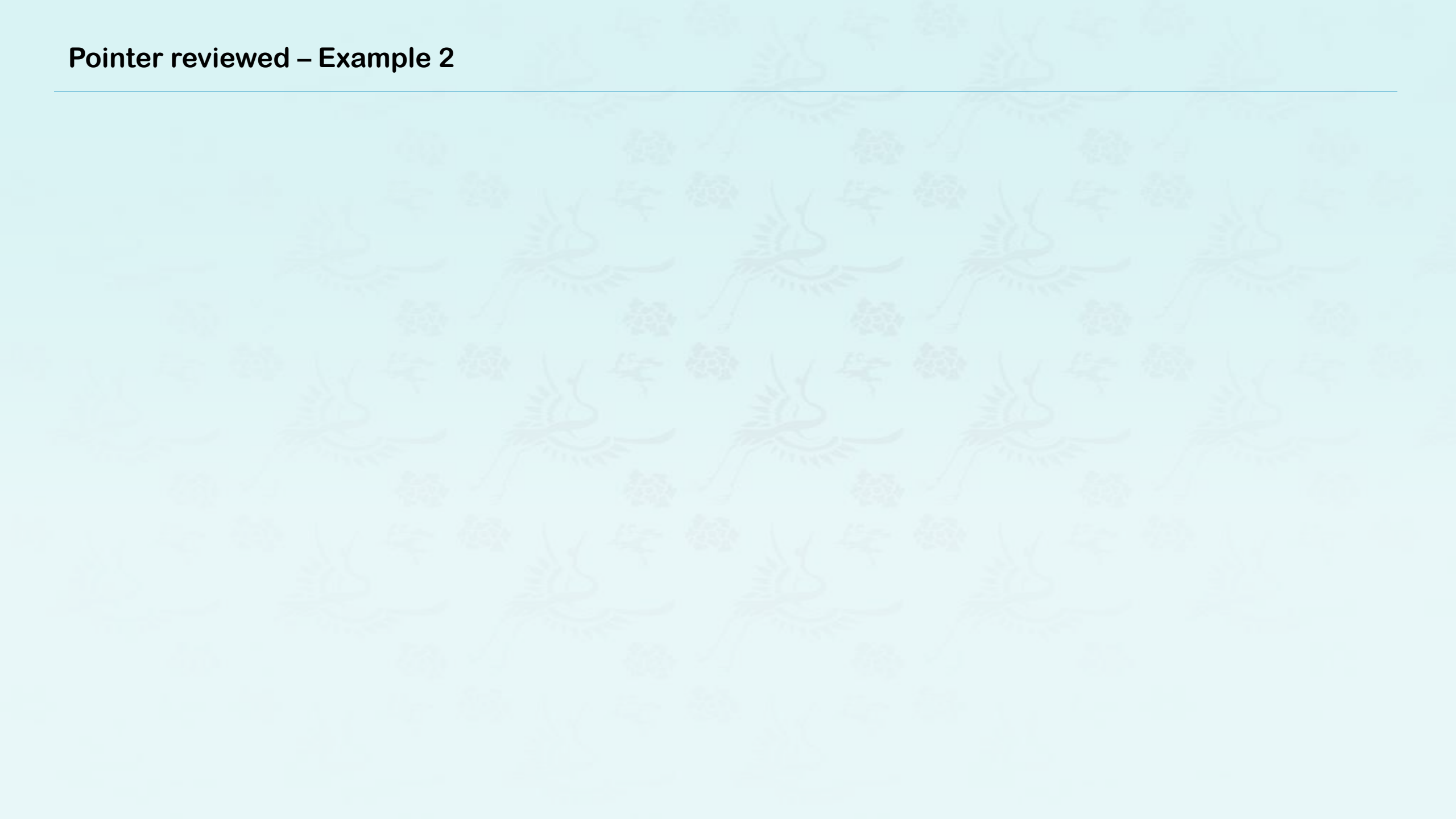


If `p` is a pointer, `*p` is the thing it is pointing at.  
Therefore, `*p = 25`;



## Pointer reviewed – Example 2

---



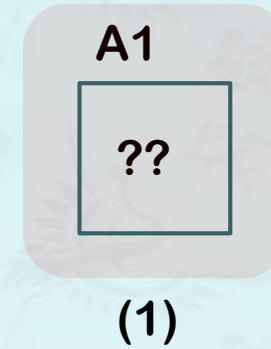
## Pointer reviewed – Example 2

---

```
int* p = new int;
```

## Pointer reviewed – Example 2

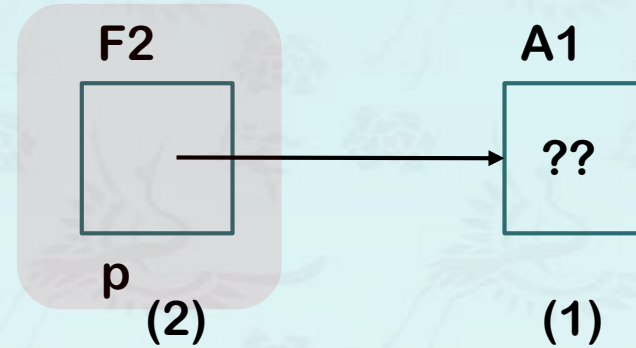
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int* p = new int;
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- 1) `new int;` declares an integer storage space in memory
- 2) `int \*p` makes create a pointer to point an integer storage
- 3) `=` makes the pointer point at an integer storage.

## Pointer reviewed – Example 2

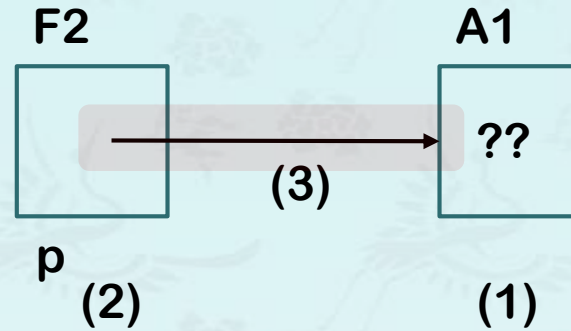
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int* p = new int;
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- 1) `new int;` declares an integer storage space in memory
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## Pointer reviewed – Example 2

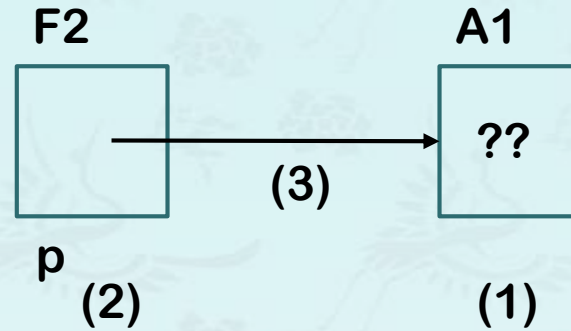
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int* p = new int;
```



- 1) ``new int;`` declares an integer storage space in memory
- 2) ``int *p`` makes create a pointer to point an integer storage
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## Pointer reviewed – Example 2

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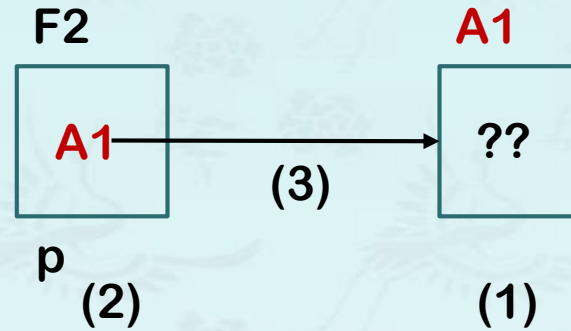


- 1) ``new int;`` declares an integer storage space in memory
- 2) ``int *p`` makes create a pointer to point an integer storage
- 3) ``=`` makes the pointer point at an integer storage.

What is really happening in (3)?

## Pointer reviewed – Example 2

```
int* p = new int;
```

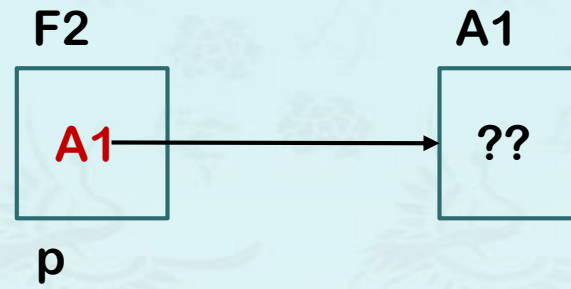


- 1) `new int;` declares an integer storage space in memory
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## Pointer reviewed – Example 2

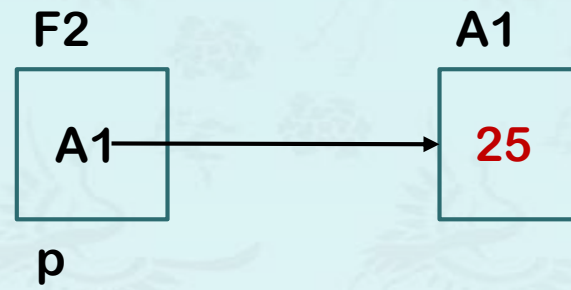
```
int* p = new int;  
*p = 25;
```





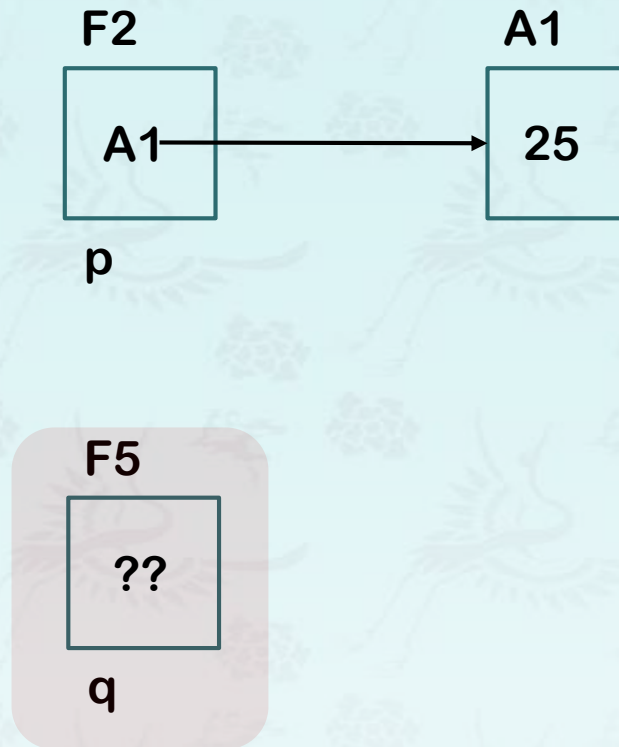
## Pointer reviewed – Example 2

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int* p = new int;  
*p = 25;
```



## Pointer reviewed – Example 2

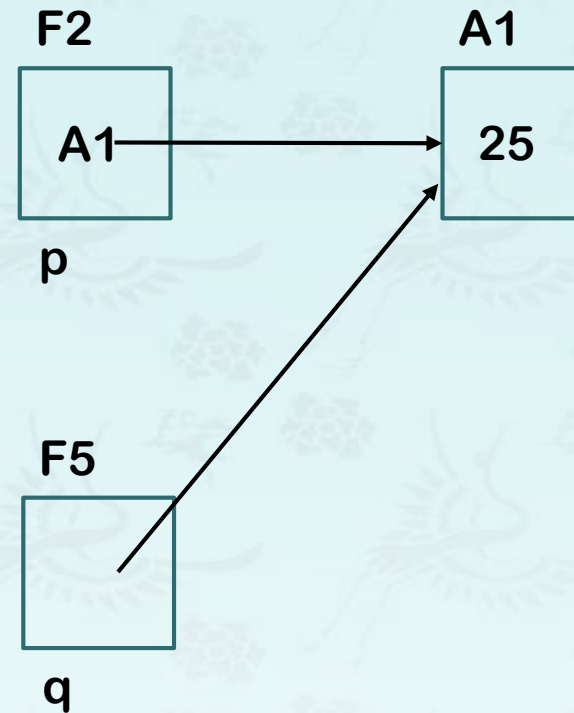
```
int* p = new int;  
*p = 25;  
cout << *p << endl;  
int* q;
```



- 1) `int* q;` declares a pointer,
- 2) but it doesn't point anywhere (it's uninitialized) and
- 3) the statement doesn't assign any memory for the integer data.

## Pointer reviewed – Example 2

```
int* p = new int;  
*p = 25;  
cout << *p << endl;  
int* q;  
q = p;
```

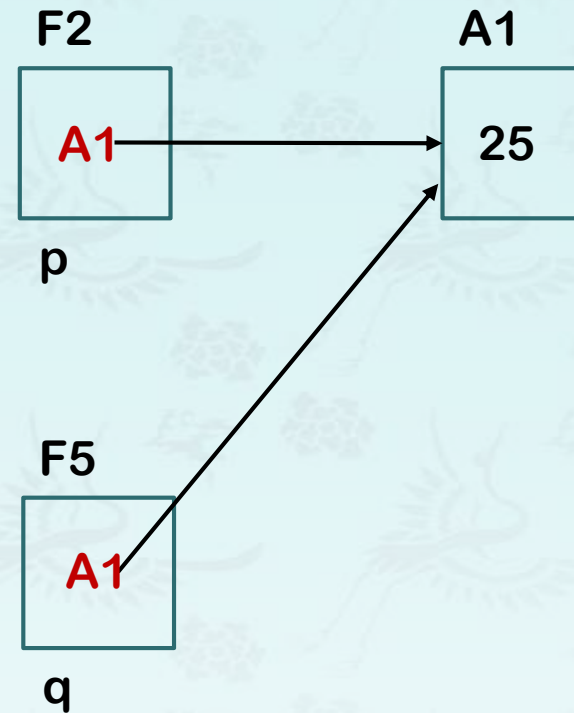


What is really happening in (`q = p`)?

- 1) ``q = p``; means that ``q`` is pointing to the same place ``p`` is pointing at.
- 2) it does not mean that ``q`` is pointing at ``p``.

## Pointer reviewed – Example 2

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int* p = new int;  
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What is really happening in (q = p)?

- 1) `q = p`; means that `q` is pointing to the same place `p` is pointing at.
- 2) it does not mean that `q` is pointing at `p`.

## Pointer reviewed

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int* p = new int;  
*p = 25;  
cout << *p << endl;  
int* q;  
q = p;  
cout << *q;
```



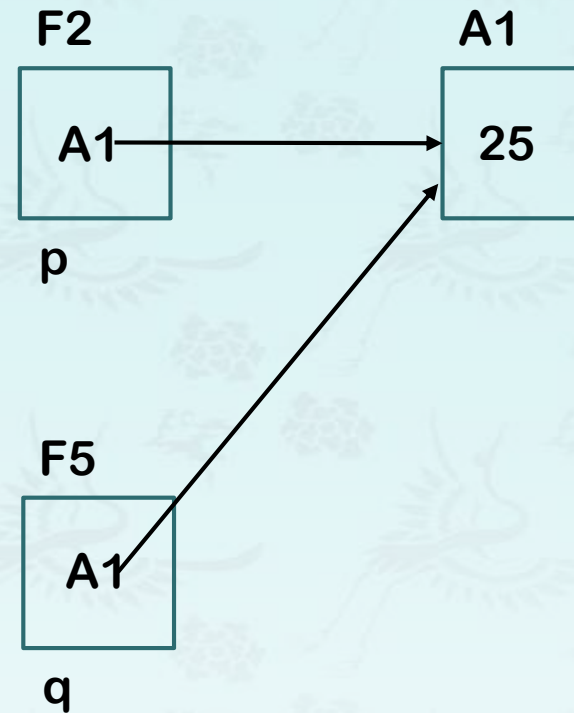
```
int* p = new int(25);  
  
cout << *p << endl;  
int* q = p;  
  
cout << *q;
```

## Pointer reviewed – Quiz

```
int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
cout << *q;  
*q = 34;  
q = new int(56); // don't change  
p = new int(78); // don't change  
delete p;  
delete q;
```

Example 2

1. Complete the memory diagram based on the code above.
2. Debug code.



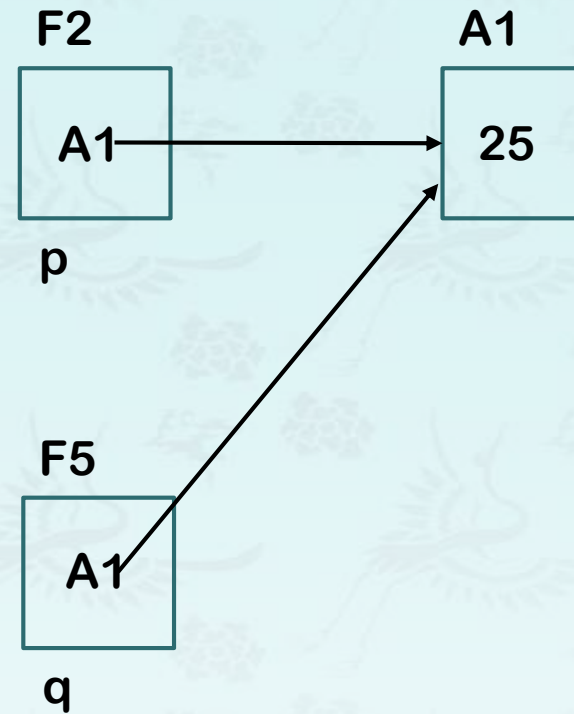
## Pointer reviewed – Quiz

```
int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
cout << *q;
```

Example 2

```
*q = 34;
```

```
q = new int(56);  
p = new int(78);  
delete p;  
delete q;
```



1) What is the effect of assigning a new value to `*q=34`?`

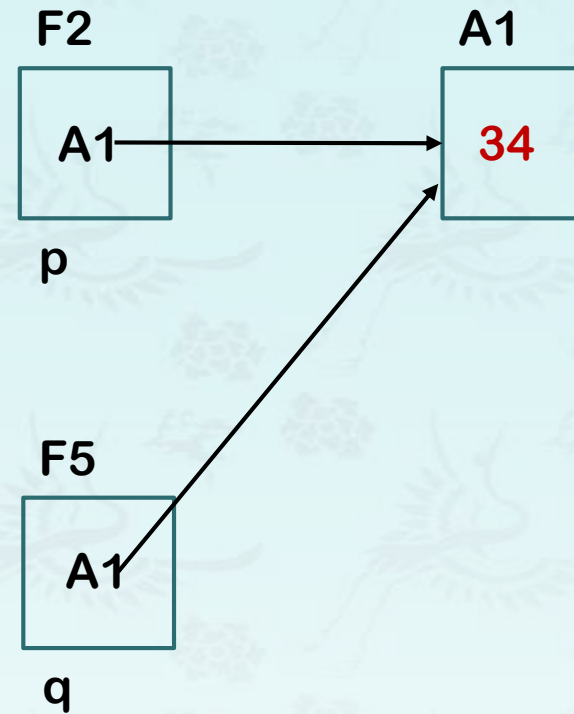
## Pointer reviewed – Quiz

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cout << *p << endl;  
int* q = p;  
cout << *q;
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Example 2

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*q = 34;
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q = new int(56);  
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delete p;  
delete q;
```



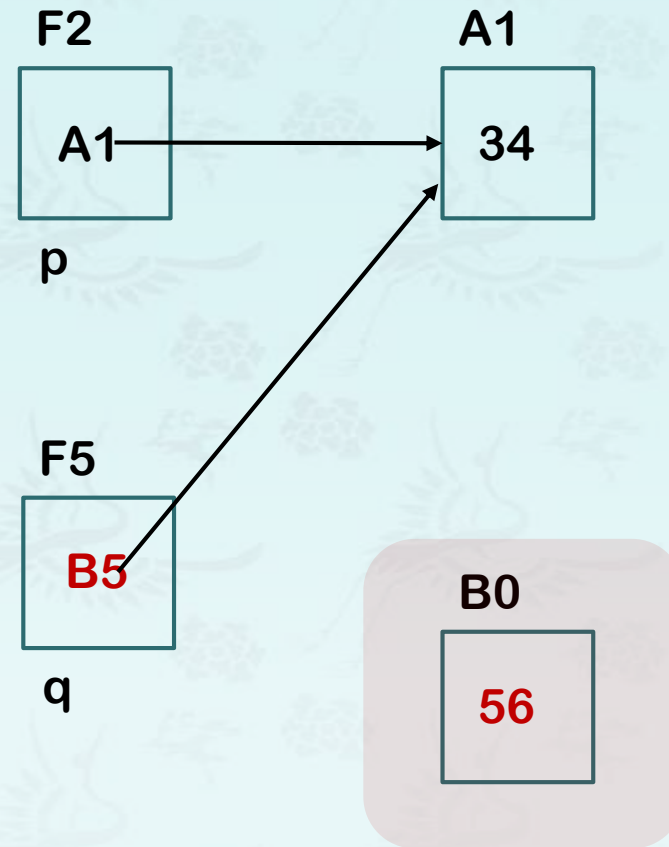
1) What is the effect of assigning a new value to `*q=34`?  
**Any changes to `*q` will also affect `*p`.**



## Pointer reviewed – Quiz

```
int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
cout << *q;  
*q = 34;  
q = new int(56);  
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delete p;  
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```

Example 2

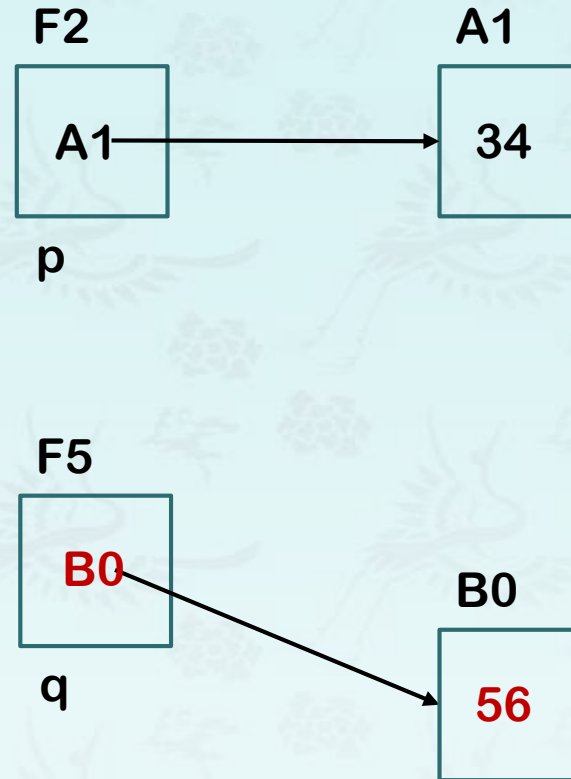


## Pointer reviewed – Quiz

```
int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
cout << *q;  
*q = 34;
```

Example 2

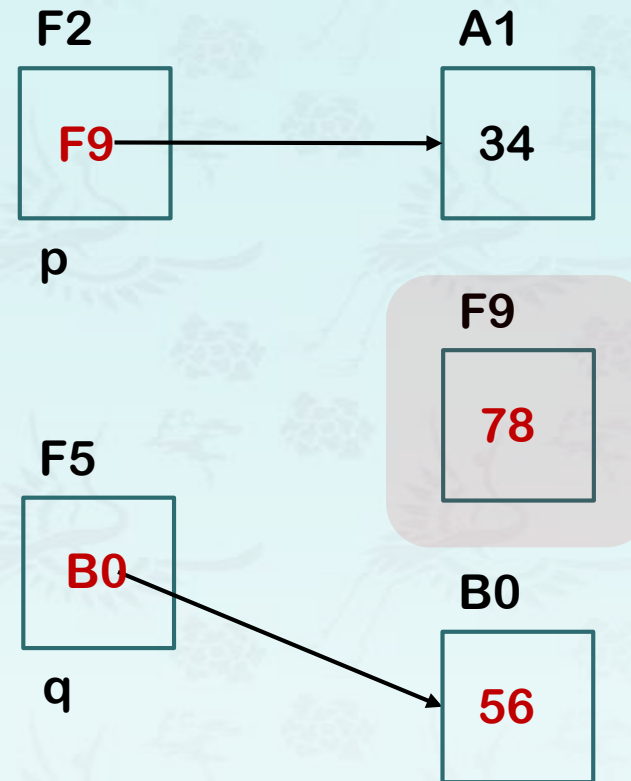
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q = new int(56);  
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```



## Pointer reviewed – Quiz

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int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
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delete p;  
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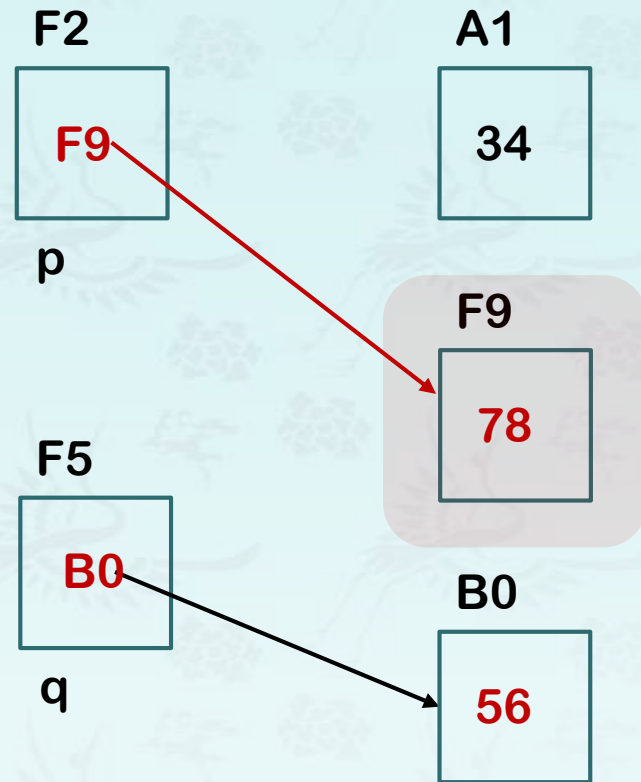
Example 2



## Pointer reviewed – Quiz

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int* p = new int(25);  
cout << *p << endl;  
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Example 2

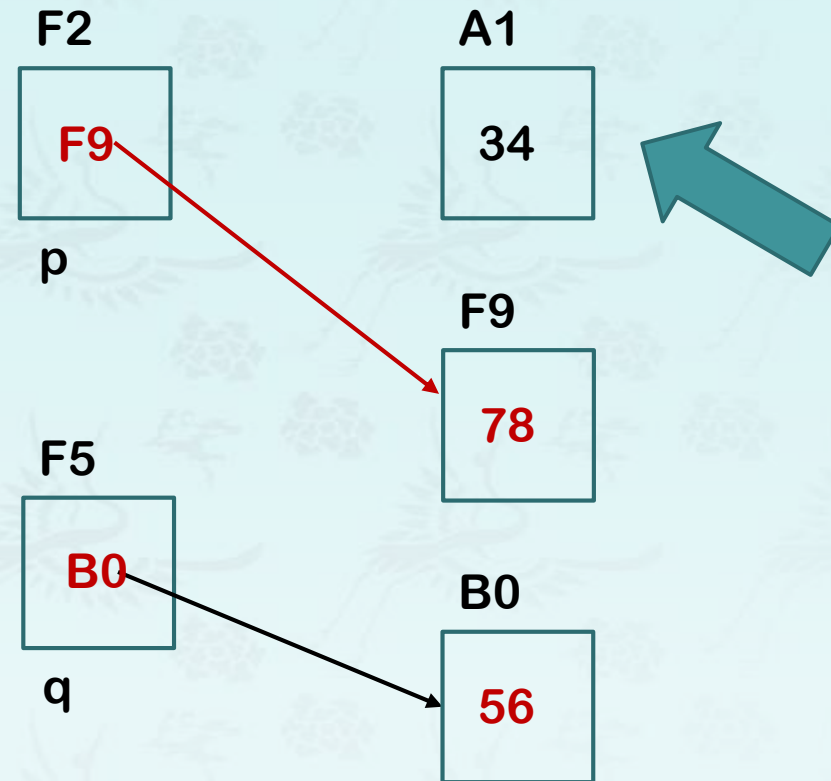


1) What do you observe in result?

## Pointer reviewed – Quiz

```
int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
cout << *q;  
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q = new int(56);  
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delete p;  
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Example 2

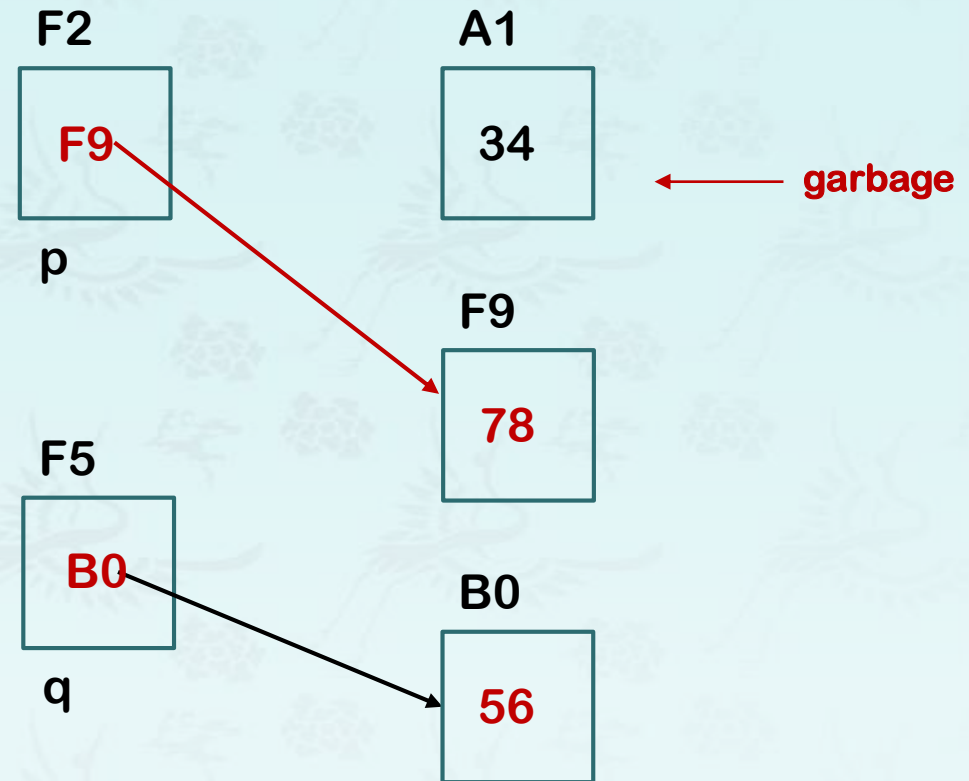


1) What do you observe in result?  
Unfortunately by moving `p` from `34` to `78` we have no way of getting back hold of `34`.

## Pointer reviewed – Quiz

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int* p = new int(25);  
cout << *p << endl;  
int* q = p;  
cout << *q;  
*q = 34;  
q = new int(56);  
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delete p;  
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```

Example 2

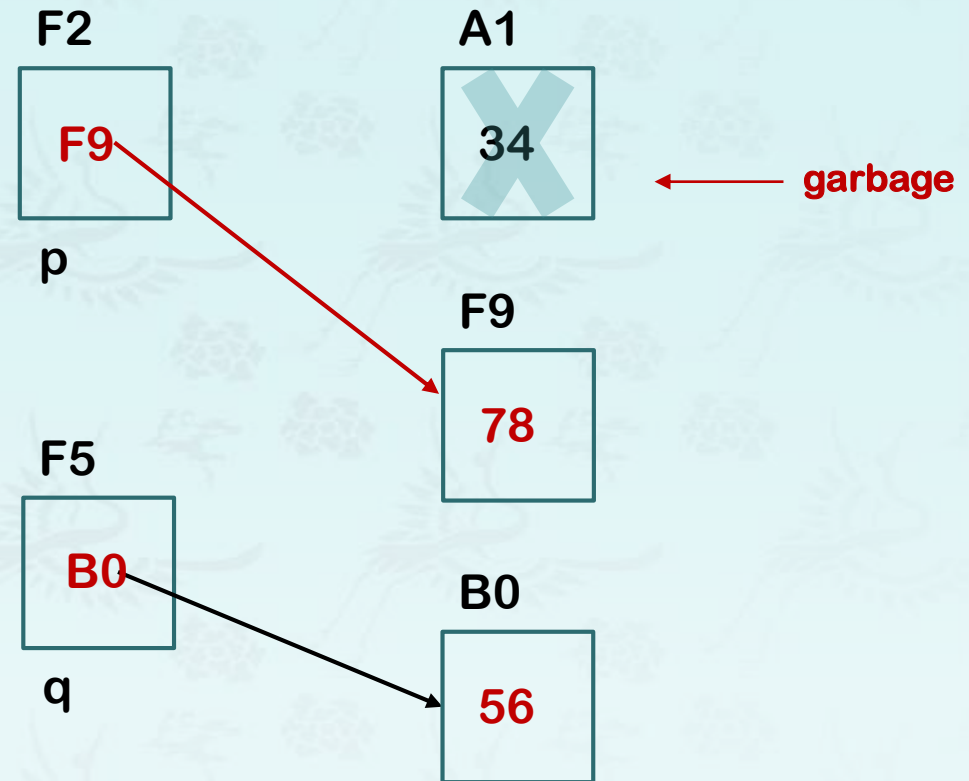


It is now floating in memory, taking up space which we can't re-use. This effect is known as **memory leakage**, and the piece of memory containing the `34` is known as **garbage**. The runtime systems of some languages have garbage collection built in, but C++ doesn't and you have to be careful. If you leak too much memory, the system will run out of RAM and crash!

## Pointer reviewed – Quiz

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int* p = new int(25);  
cout << *p << endl;  
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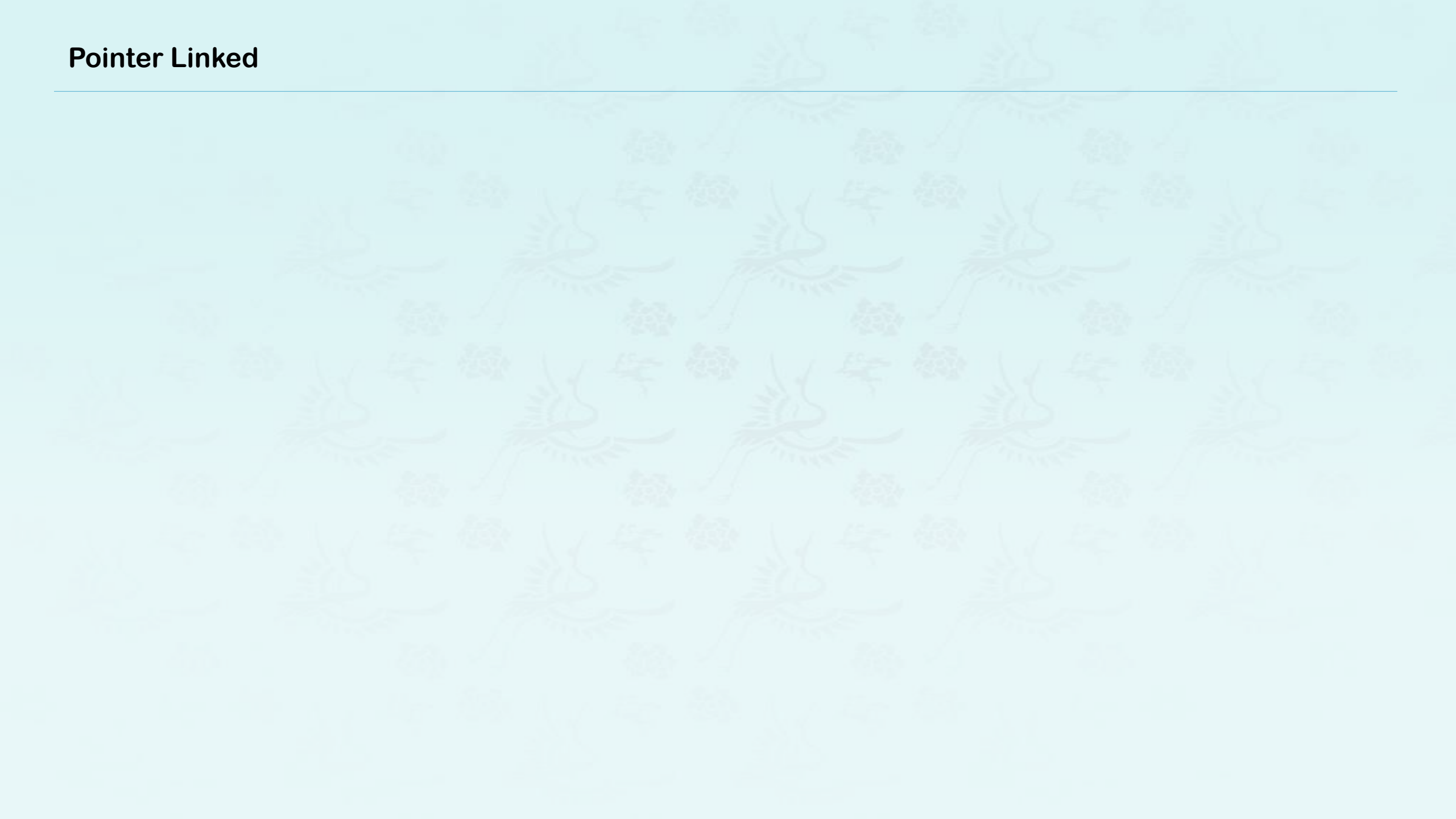
Example 2



Before you let go of the object you are pointing at, you have to **`delete`** it.

## Pointer Linked

---





## Pointer Linked

---

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    ...  
}
```

F2

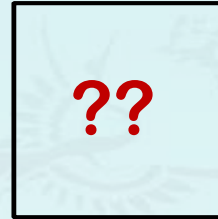


p

## Pointer Linked

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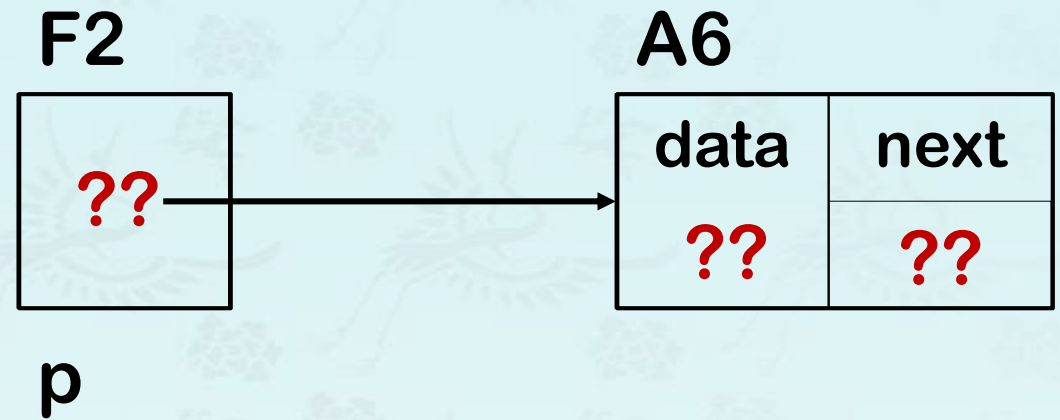


p

- (1) This code declares a **Node pointer, p**, and
- (2) allocate memory space for a **new Node** and
- (3) make **p point at** it.

## Pointer Linked

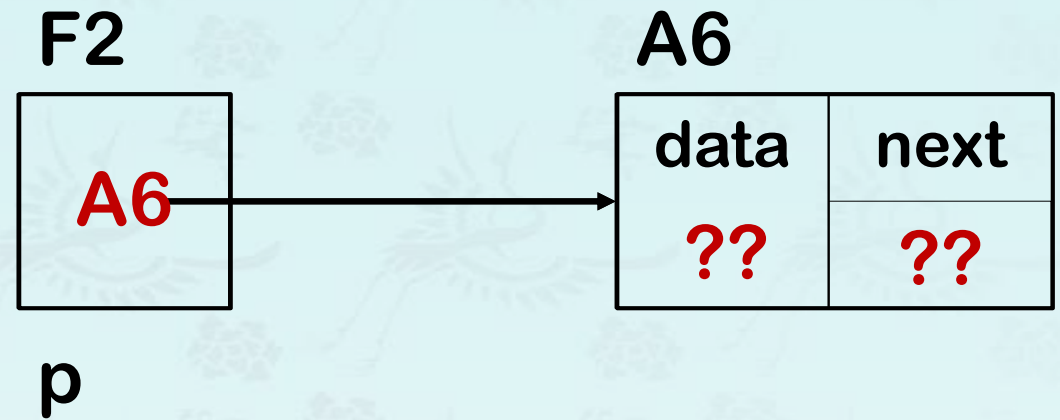
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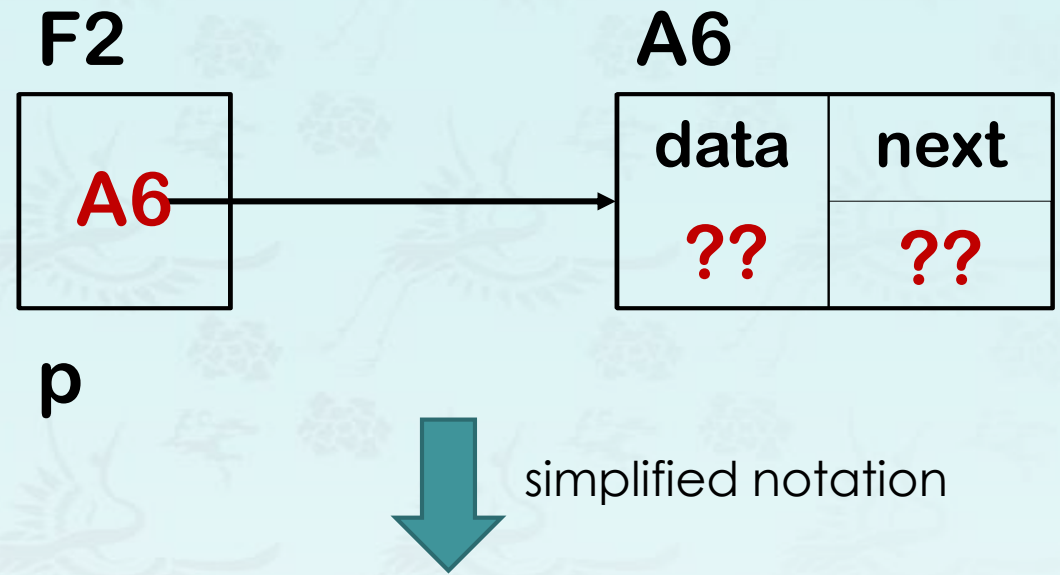
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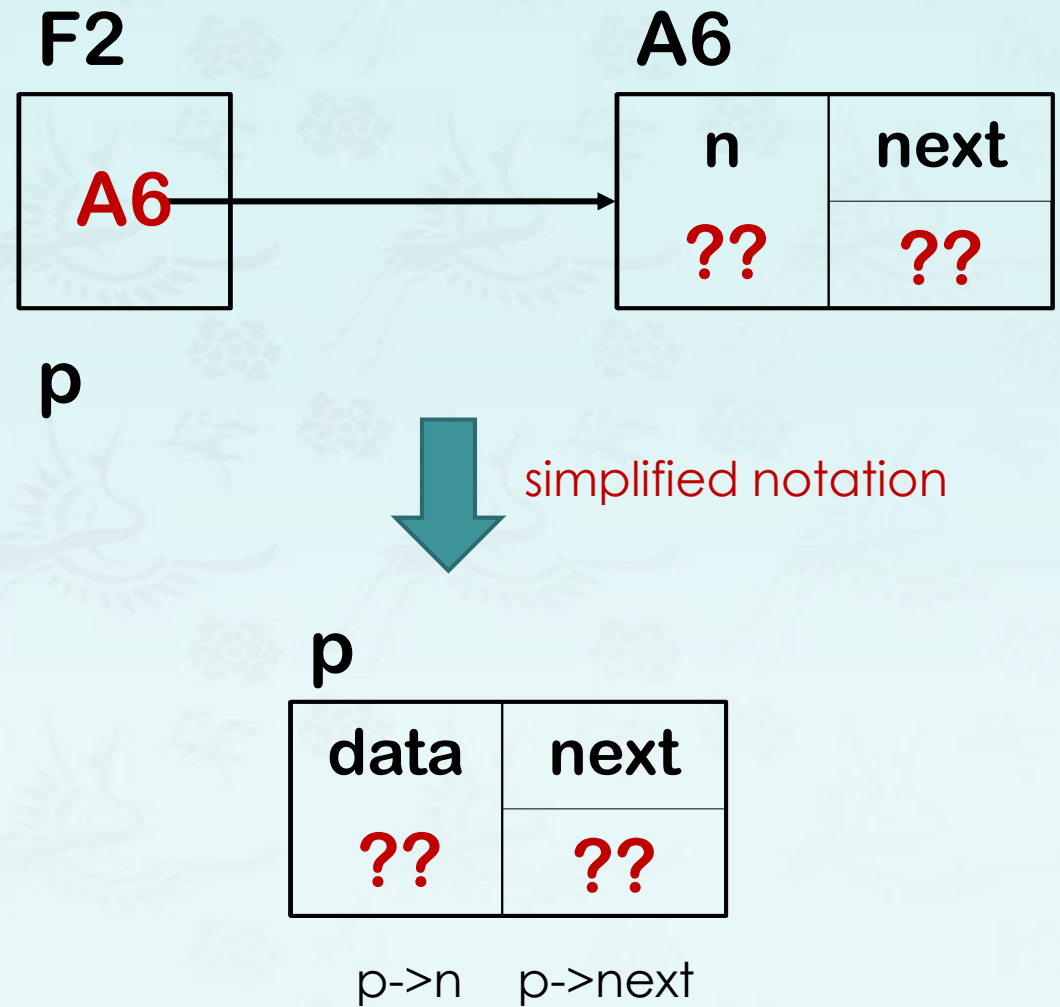
## Pointer Linked

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    p->data = 5;  
    p->next = nullptr;  
    Node* q = new Node;  
    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```



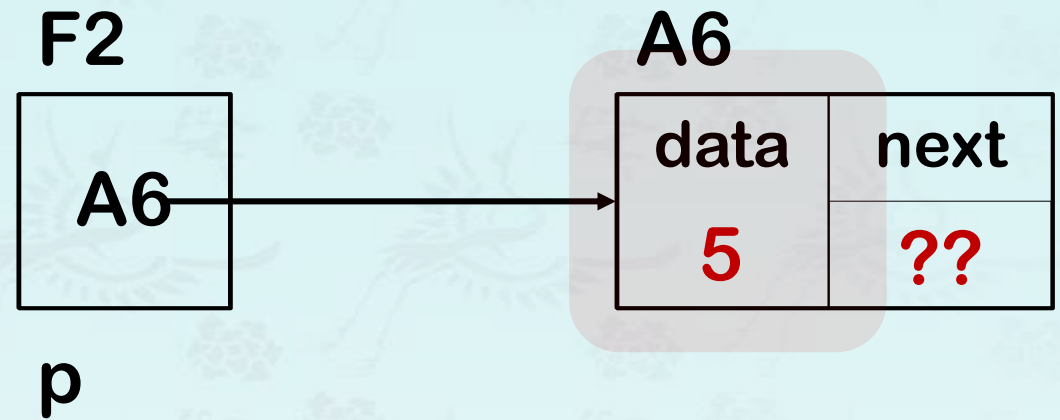
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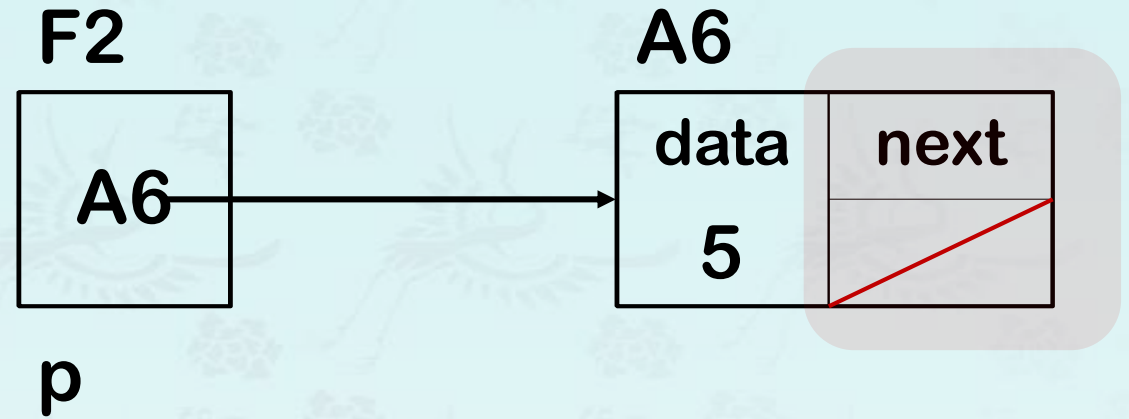
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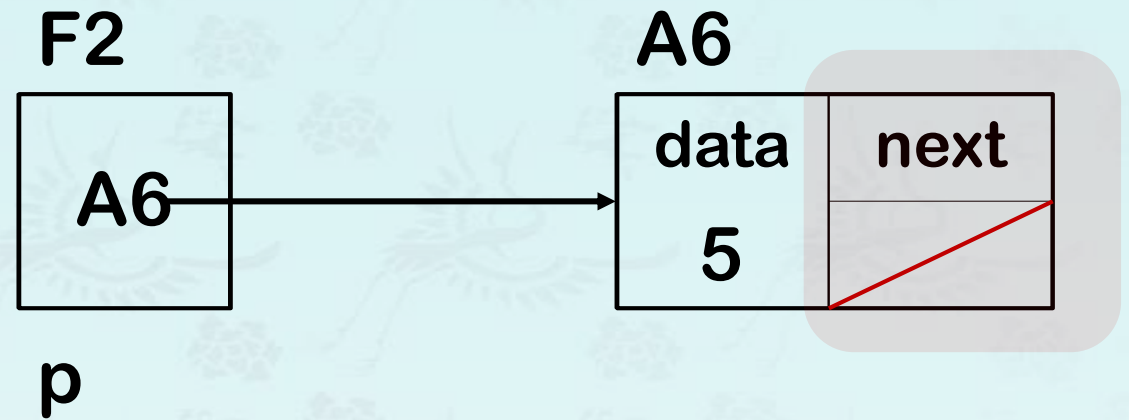
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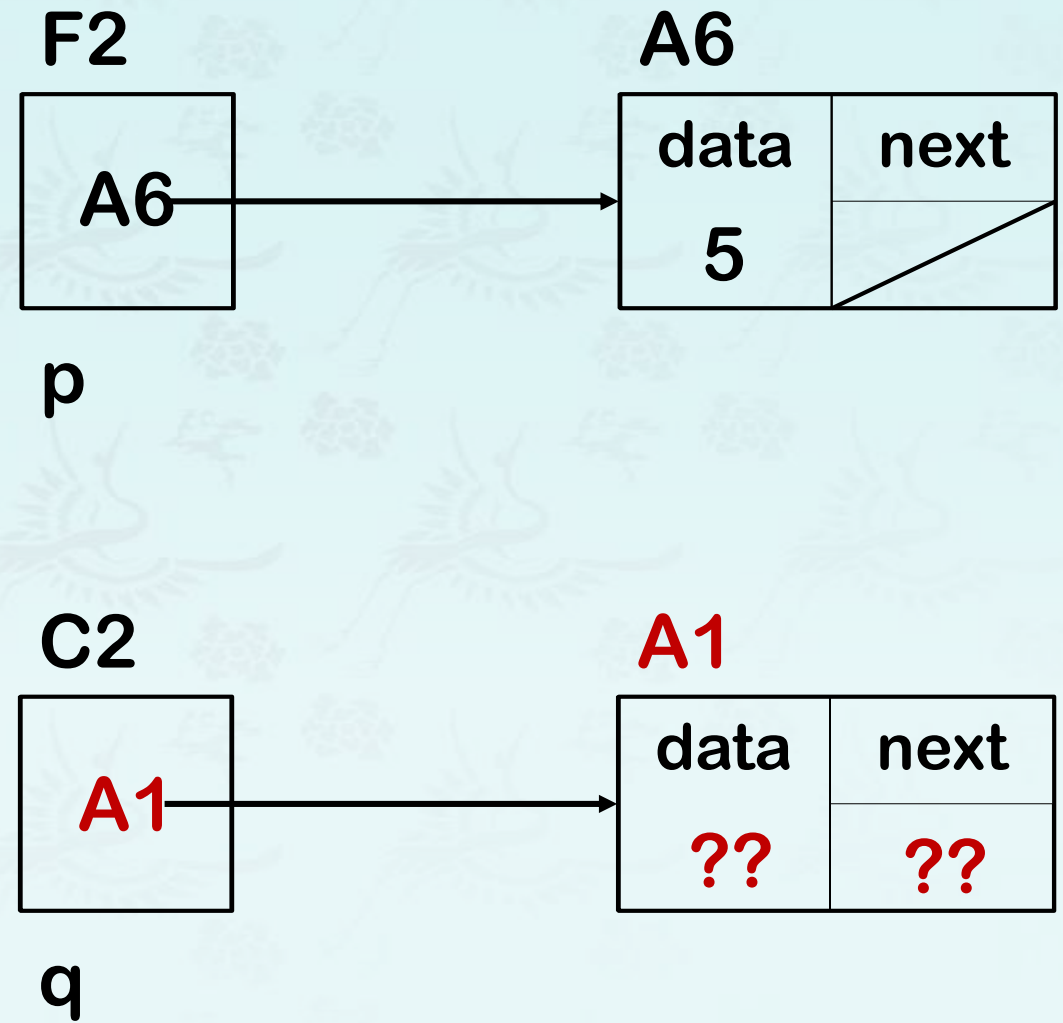
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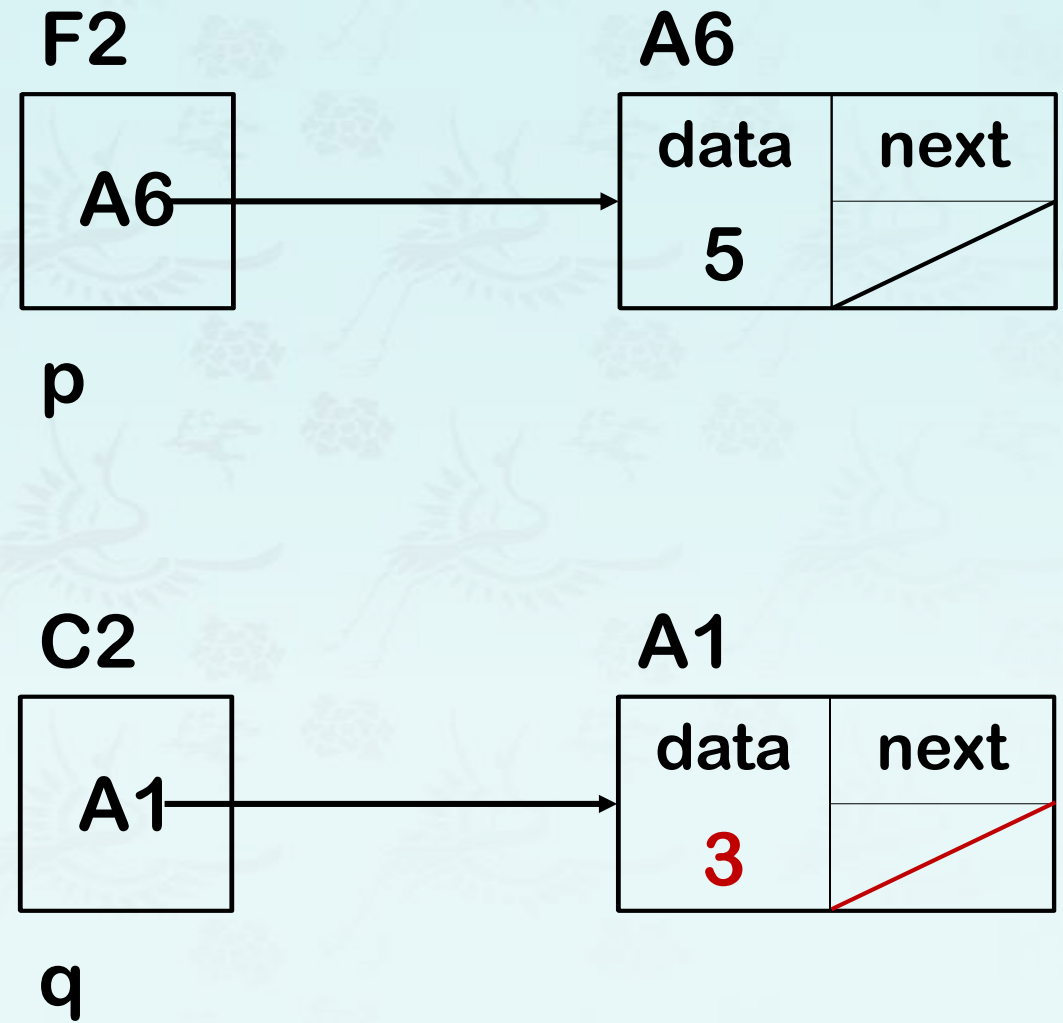
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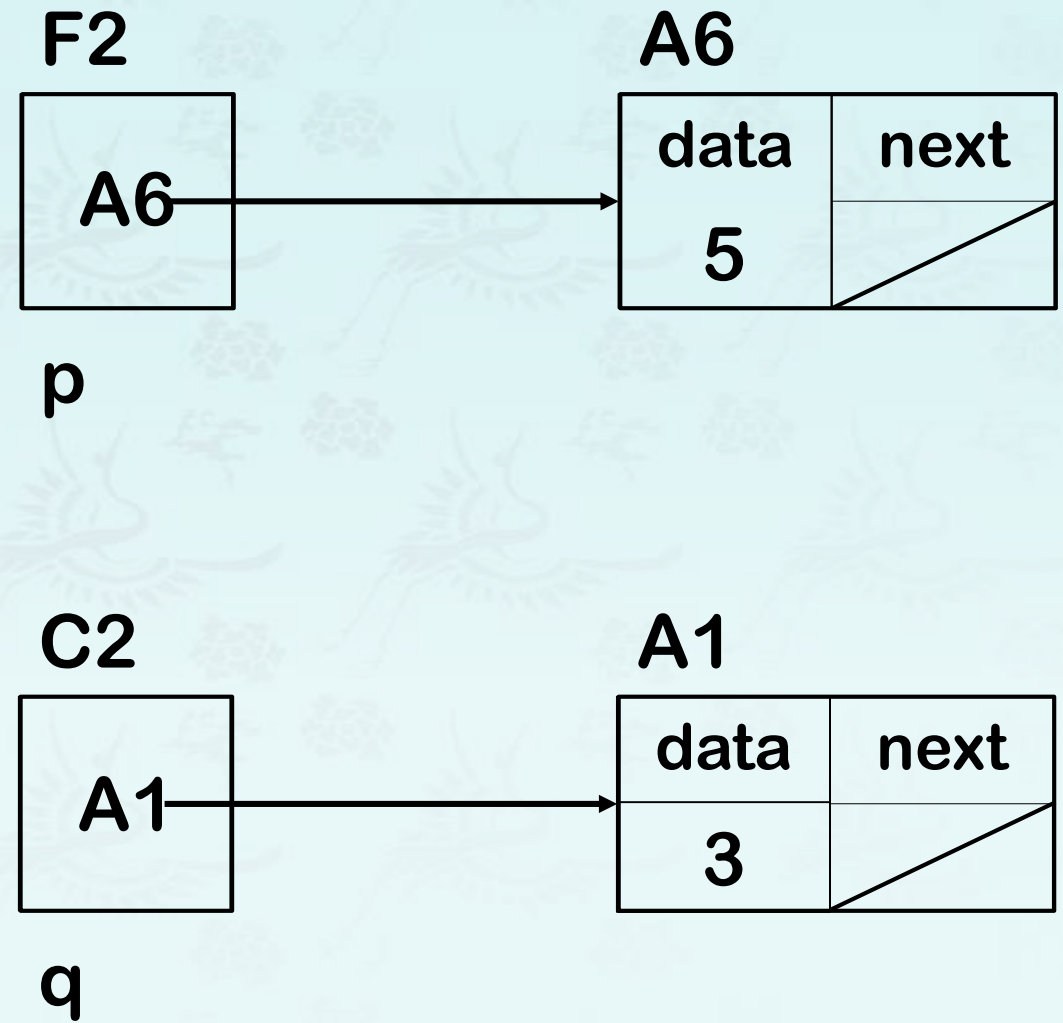
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```



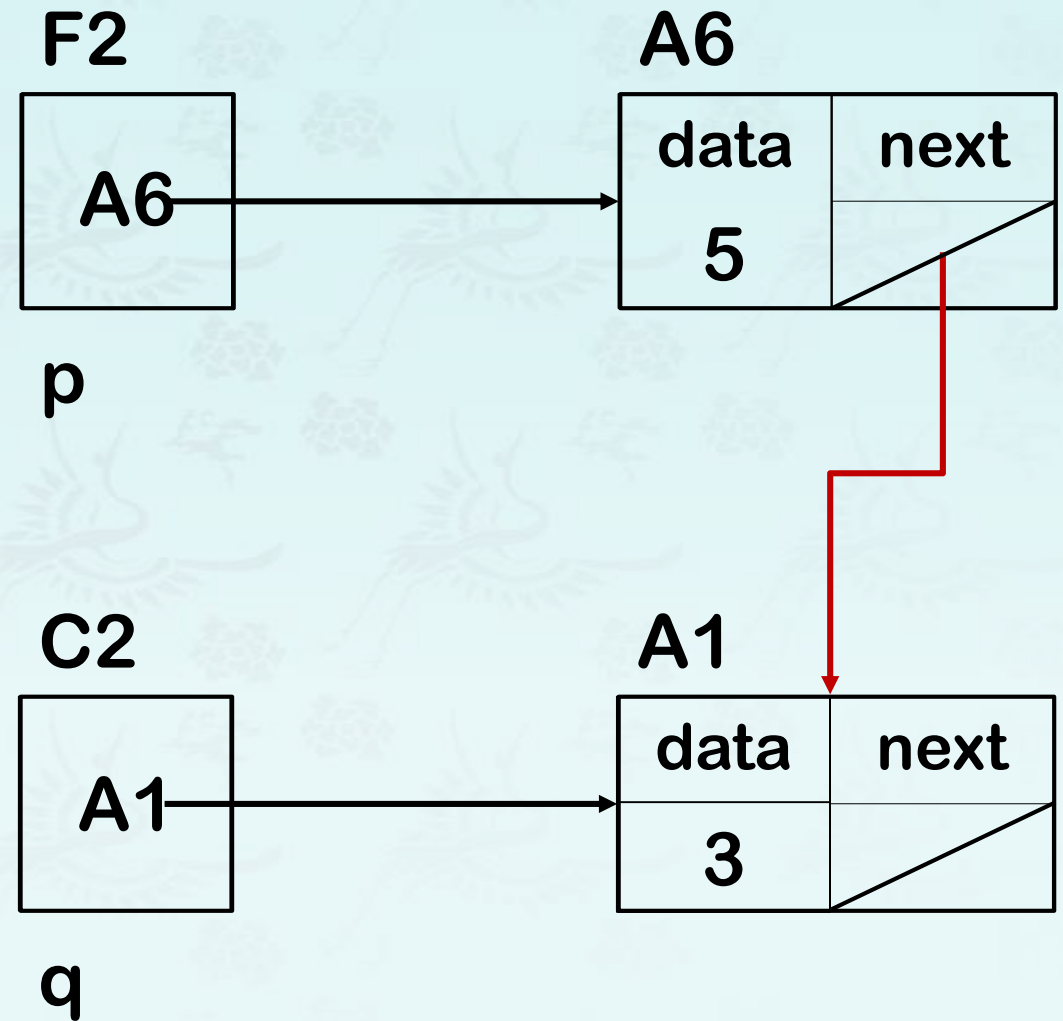
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    p->next = nullptr;  
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    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```



## Pointer Linked

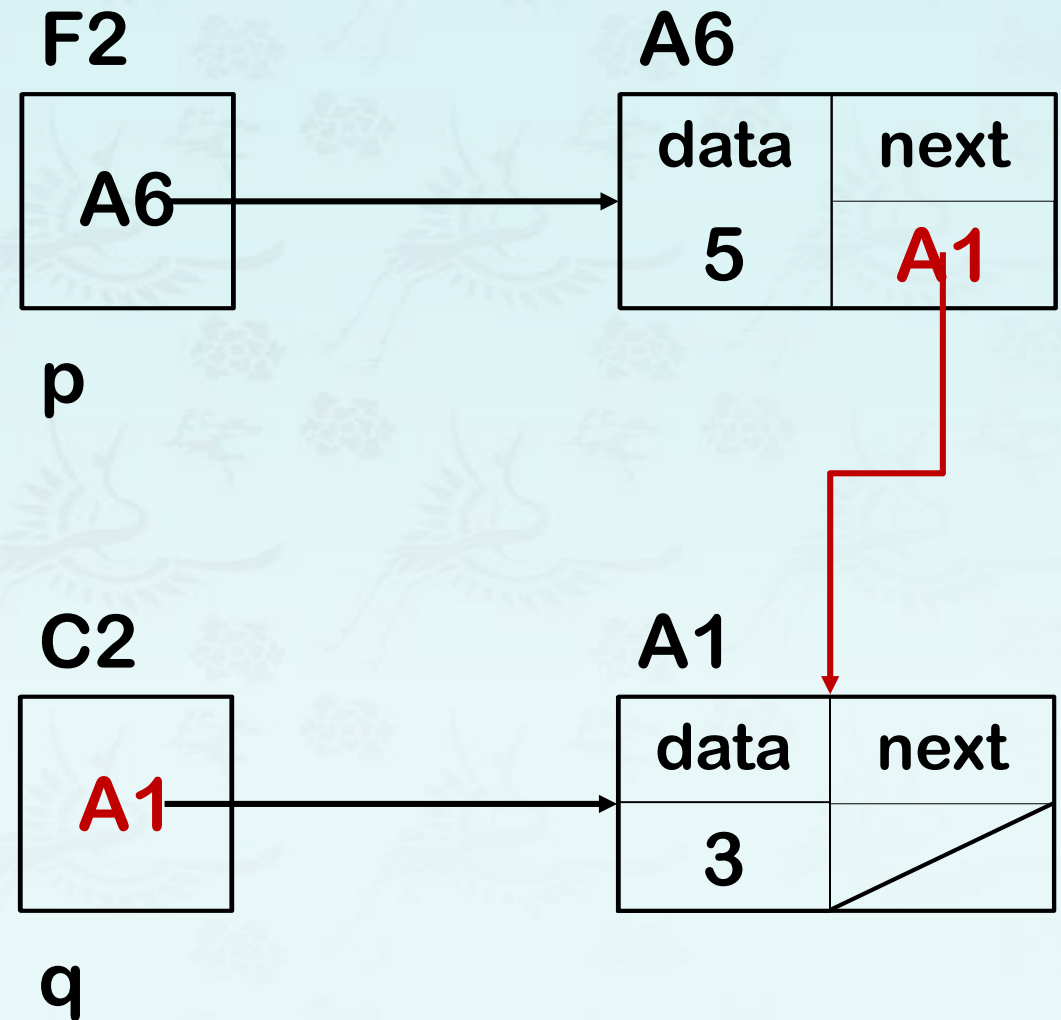
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}
```



What should be corrected in the figure?

## Pointer Linked

```
class Node {  
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    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    p->data = 5;  
    p->next = nullptr;  
    Node* q = new Node;  
    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```

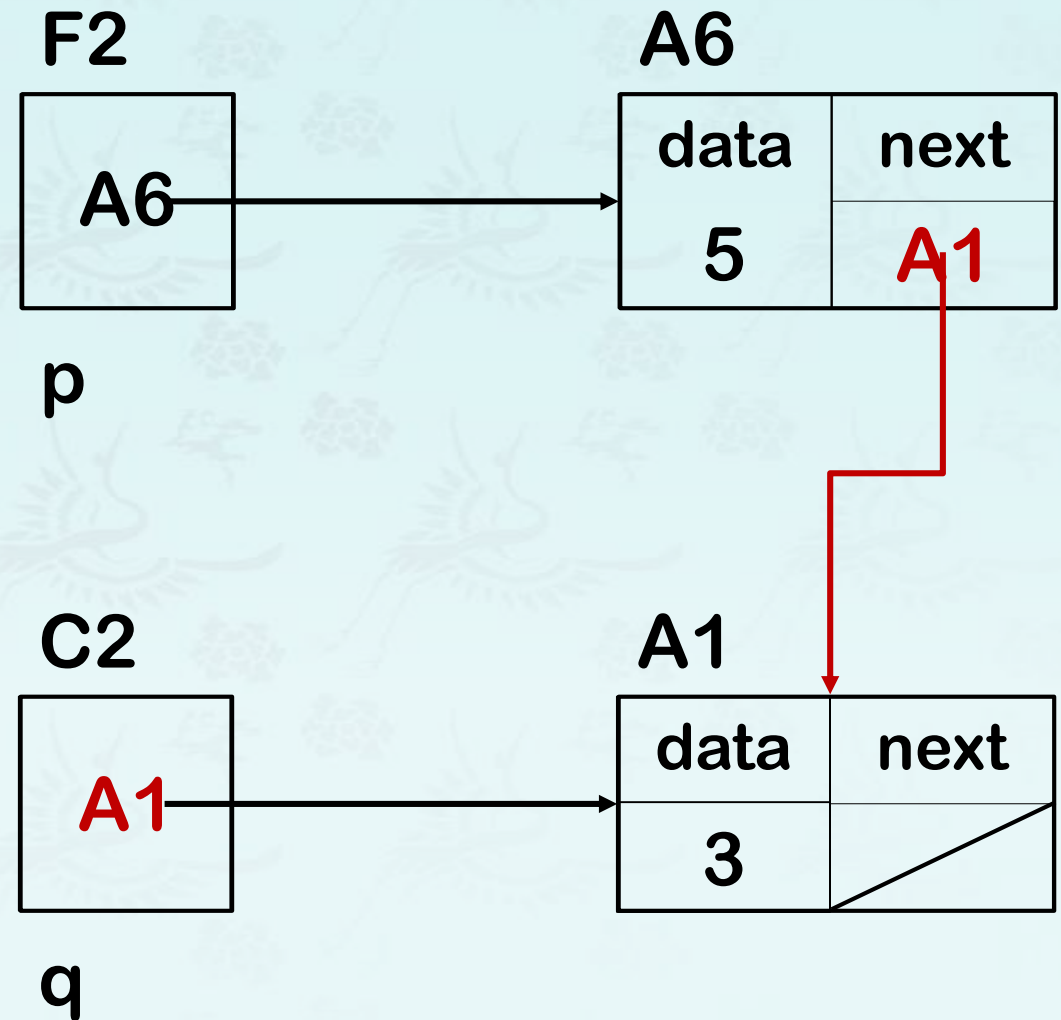


What should be corrected in the figure?

**p->next = A1;**

## Pointer Linked

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class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    p->data = 5;  
    p->next = nullptr;  
    Node* q = new Node;  
    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```



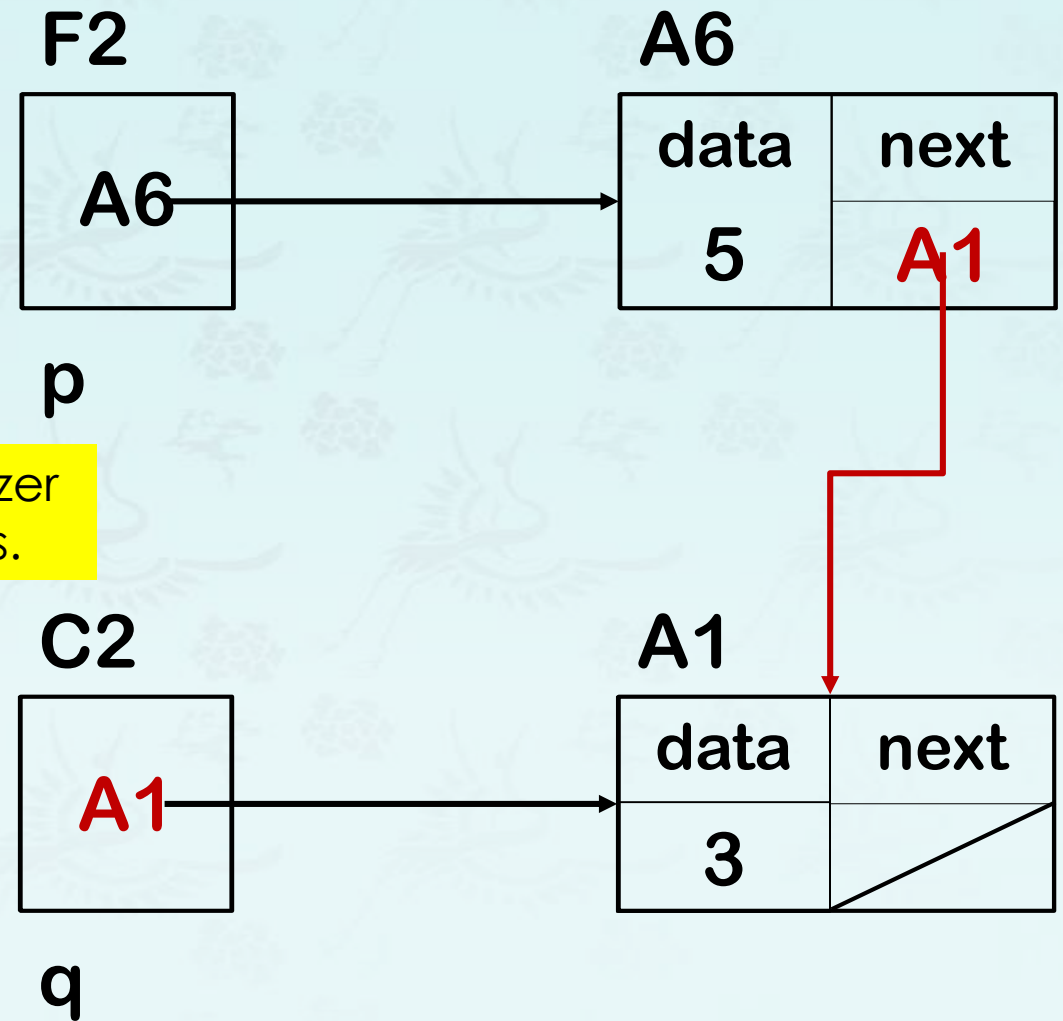
What should be corrected in the figure?

**p->next = A1;      p->next = q;**

## Pointer Linked

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    p->data = 5;  
    p->next = nullptr;  
    Node* q = new Node;  
    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```

Recode this using initializer  
(constructor) in two lines.



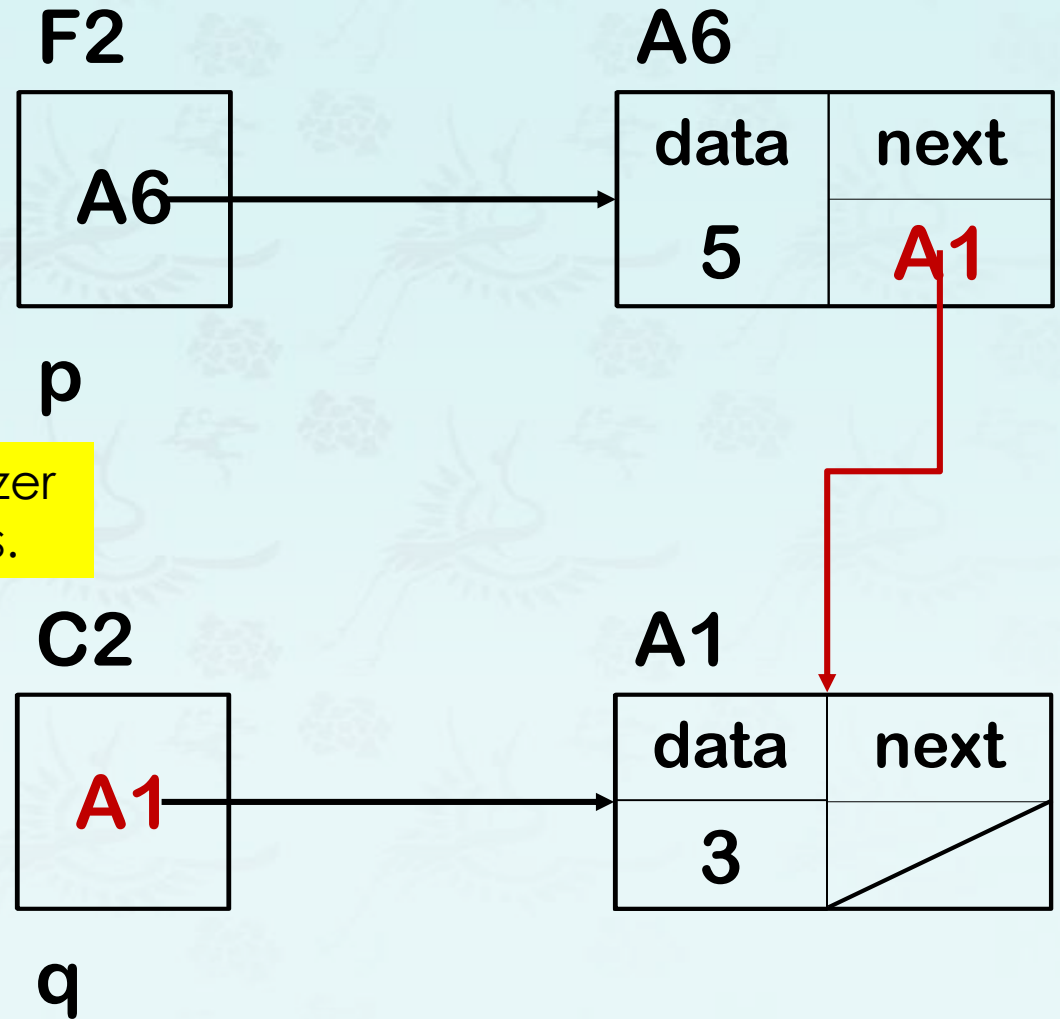


## Pointer Linked

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    p->data = 5;  
    p->next = nullptr;  
    Node* q = new Node;  
    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```

Recode this using initializer  
(constructor) in two lines.

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



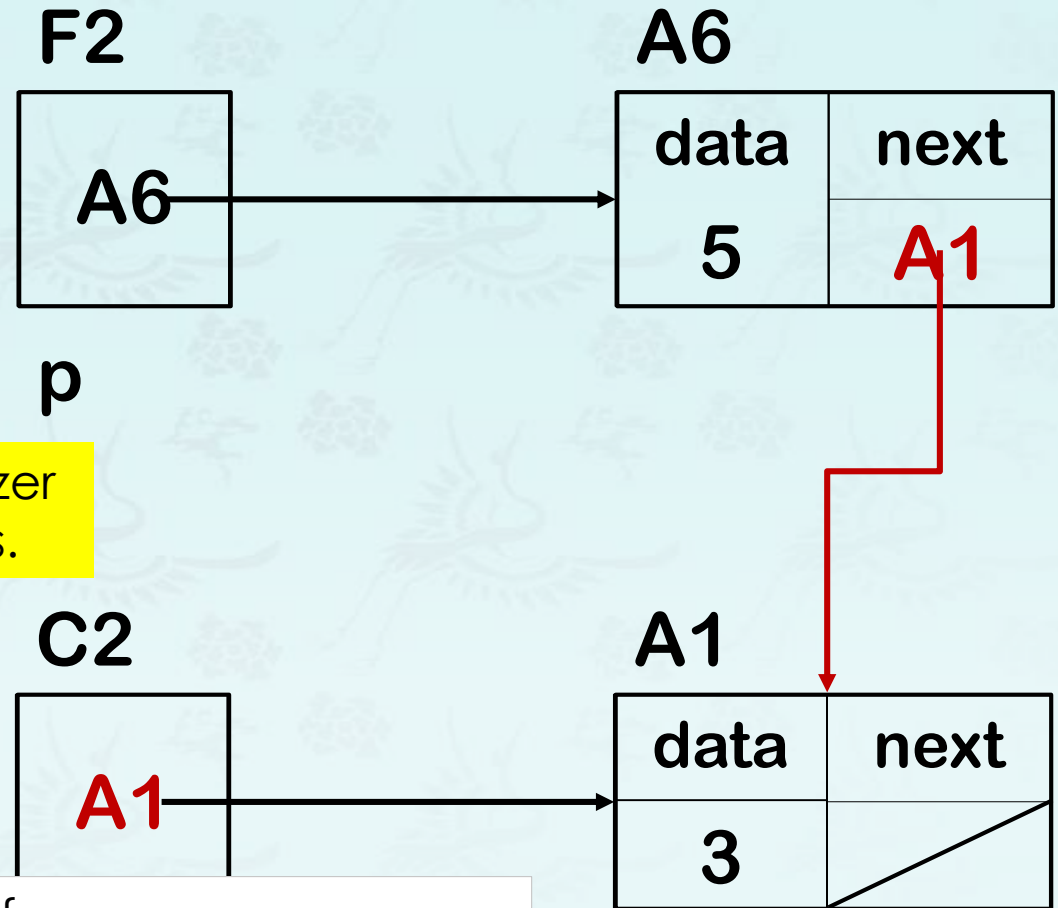
## Pointer Linked

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* p = new Node;  
    p->data = 5;  
    p->next = nullptr;  
    Node* q = new Node;  
    q->data = 3;  
    q->next = nullptr;  
    p->next = q;  
}
```

Recode this using initializer  
(constructor) in two lines.

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

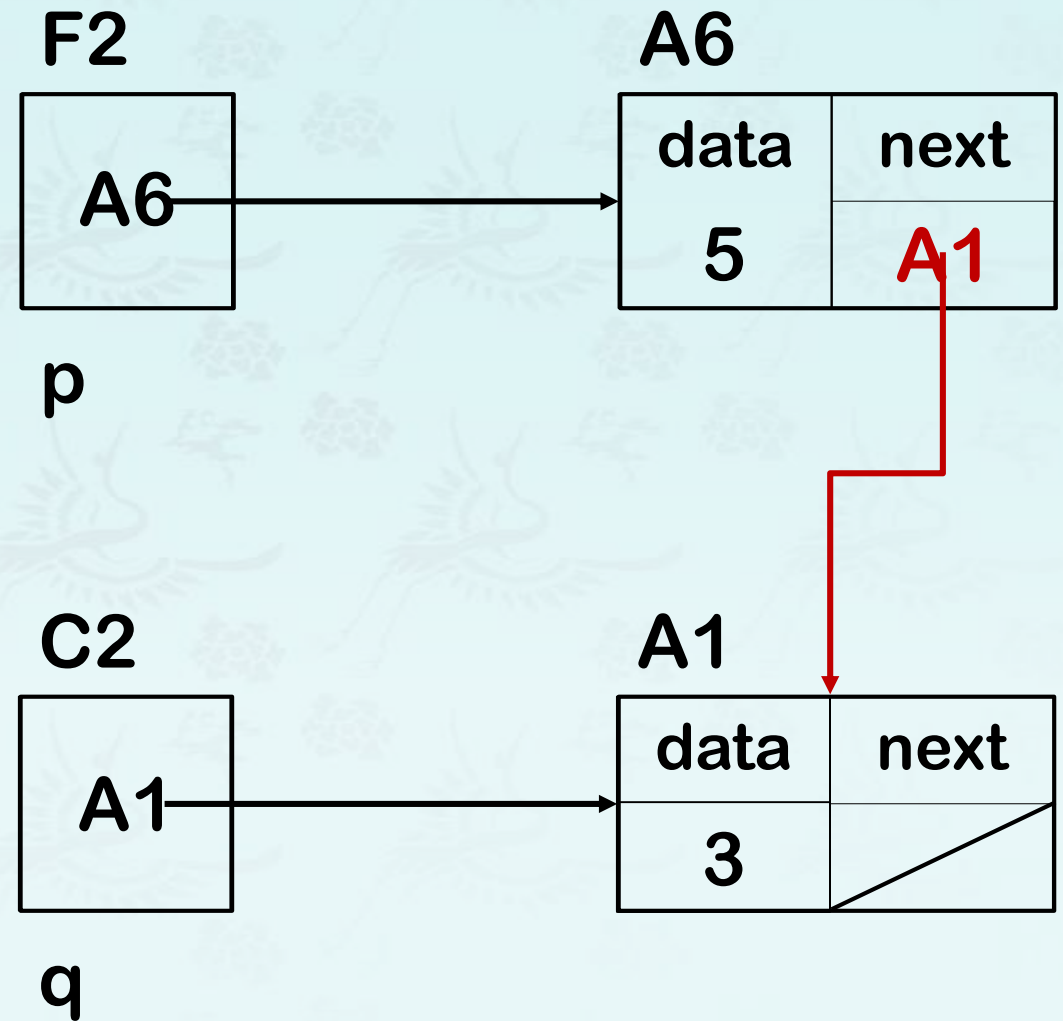
```
int main( ) {  
    Node* q = new Node{3, nullptr};  
    Node* p = new Node{5, q};  
}
```



## Pointer Linked

By stringing many of these Node objects together we can create a structure called a **singly-linked list**;

Hide p and q, and you may see a singly linked list clearly.

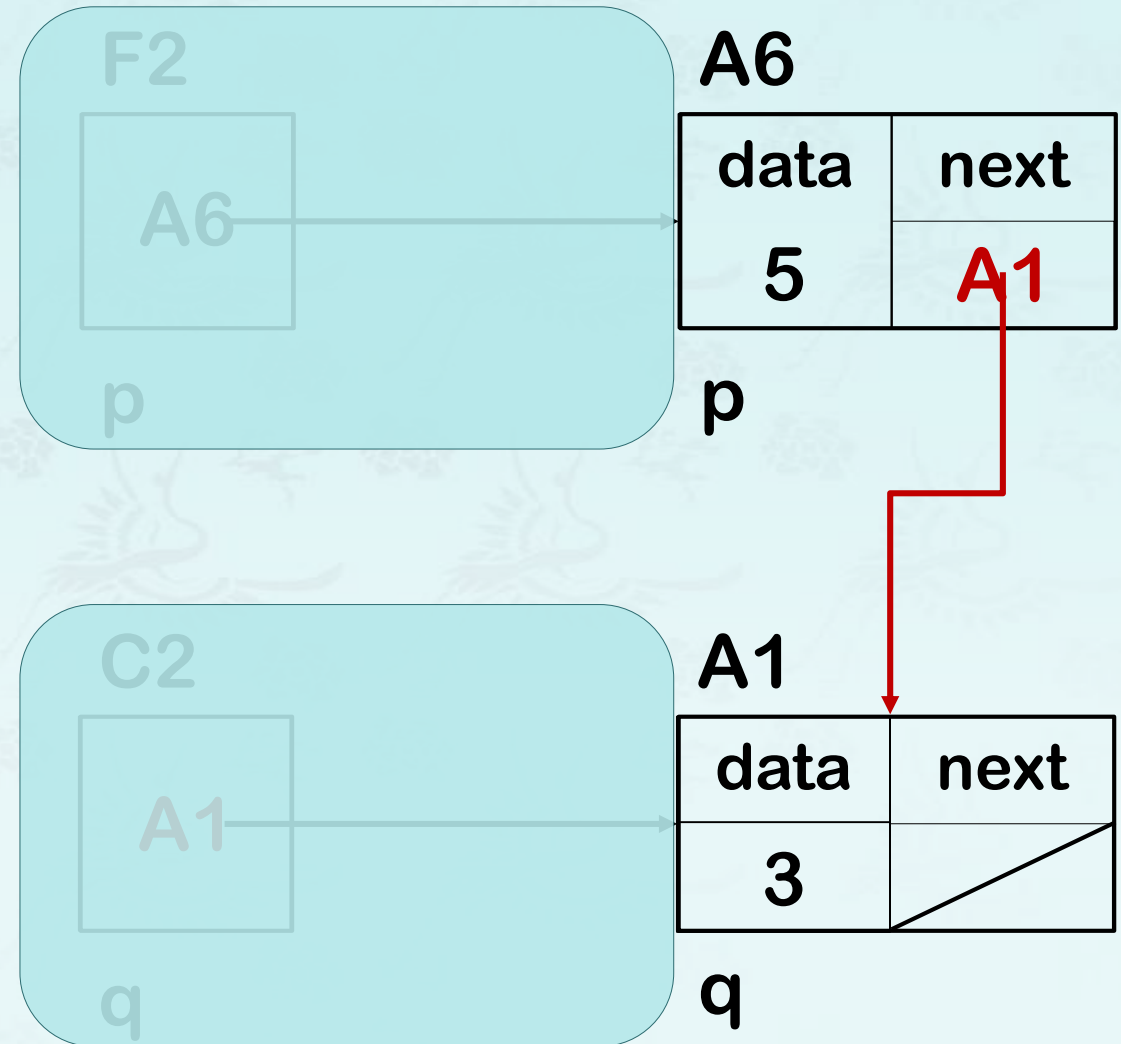


## Pointer Linked

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

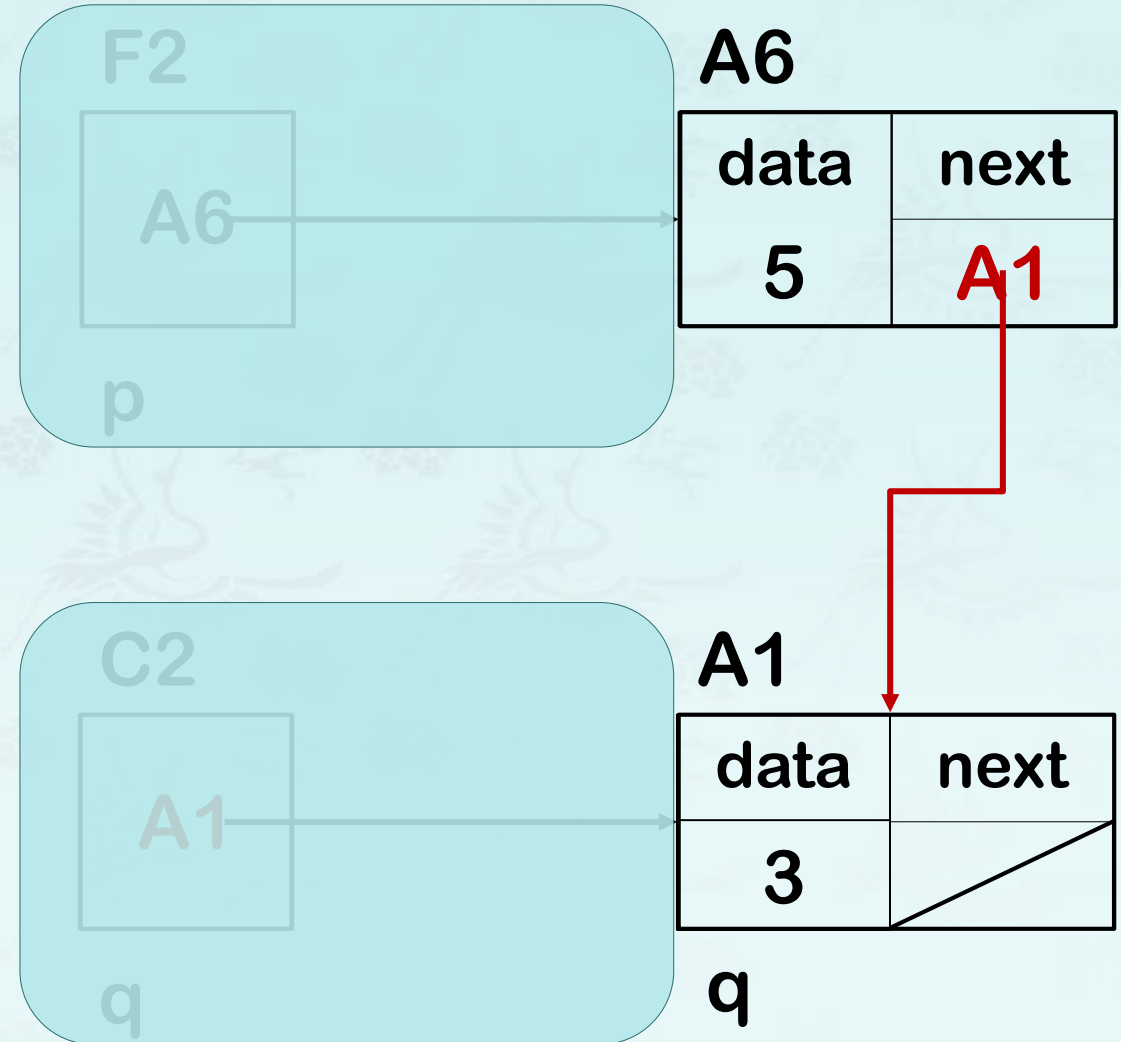
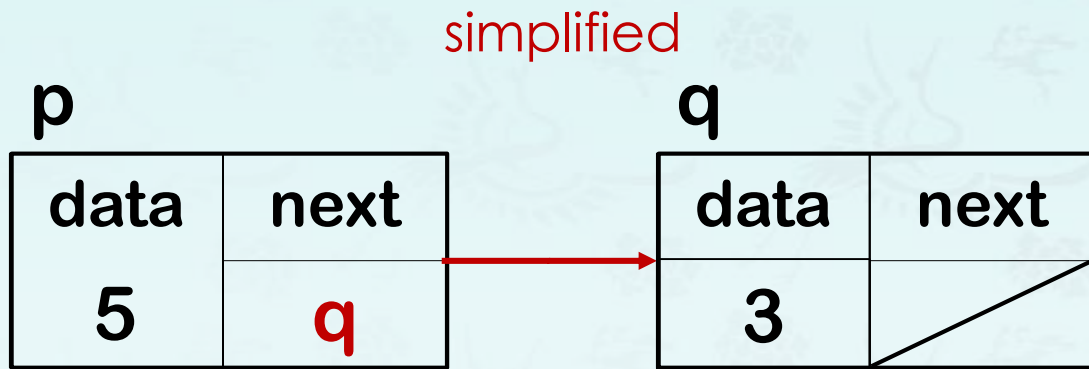
int main( ) {
    Node* q = new Node{3, nullptr};
    Node* p = new Node{5, q};
}
```

Hide p and q, and you may see a singly linked list clearly.



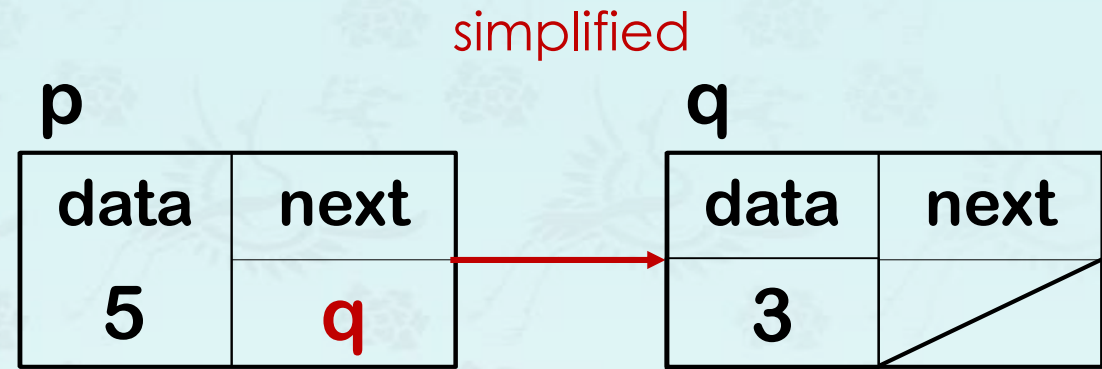
## Pointer Linked

By stringing many of these Node objects together we can create a structure called a **singly-linked list**;



## Pointer Linked

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
int main( ) {  
    Node* q = new Node{3, nullptr};  
    Node* p = new Node{5, q};  
}
```



## Pointer Linked – Quiz and Lab

```
#include <iostream>
using namespace std;
class Node {
public:
    char ch;
    Node* next;
};

int main( ) {
    Node* p = nullptr, *q = nullptr;
    char ch;
    while (cin.get(ch) && ch != '\n') {
        p = new Node;
        p->ch = ch;
        p->next = q;
        q = p;
    }
    while (p != nullptr) {
        cout.put(p->ch);
        p = p->next;
    }
    cout << endl;
}
```

Assuming the input A, B, C, D to this program, what would be the data structure after the input?

Draw a figure to represent the data structure in memory. Use a mnemonic memory address to represent each node such as A2, B5, C1, ..., etc.

## Pointer Linked – Lab

```
#include <iostream>
using namespace std;
class Node {
public:
    char ch;
    Node* next;
};

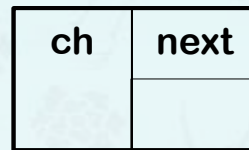
int main( ) {
    Node* p = nullptr, *q = nullptr;
    char ch;
    while (cin.get(ch) && ch != '\n') {
        p = new Node;
        p->ch = ch;
        p->next = q;
        q = p;
    }
    while (p != nullptr) {
        cout.put(p->ch);
        p = p->next;
    }
    cout << endl;
}
```

Assuming the input A, B, C, D to this program, what would be the data structure after the input?

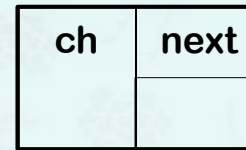
Draw a figure to represent the data structure in memory. Use a mnemonic memory address to represent each node such as A2, B5, C1, ..., etc.



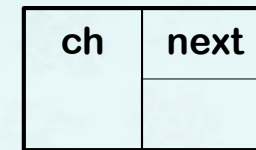
p  
D3



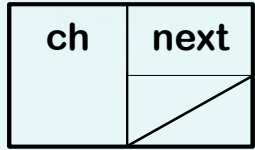
C1



B5



A2



q

**What is missing in the figure?**



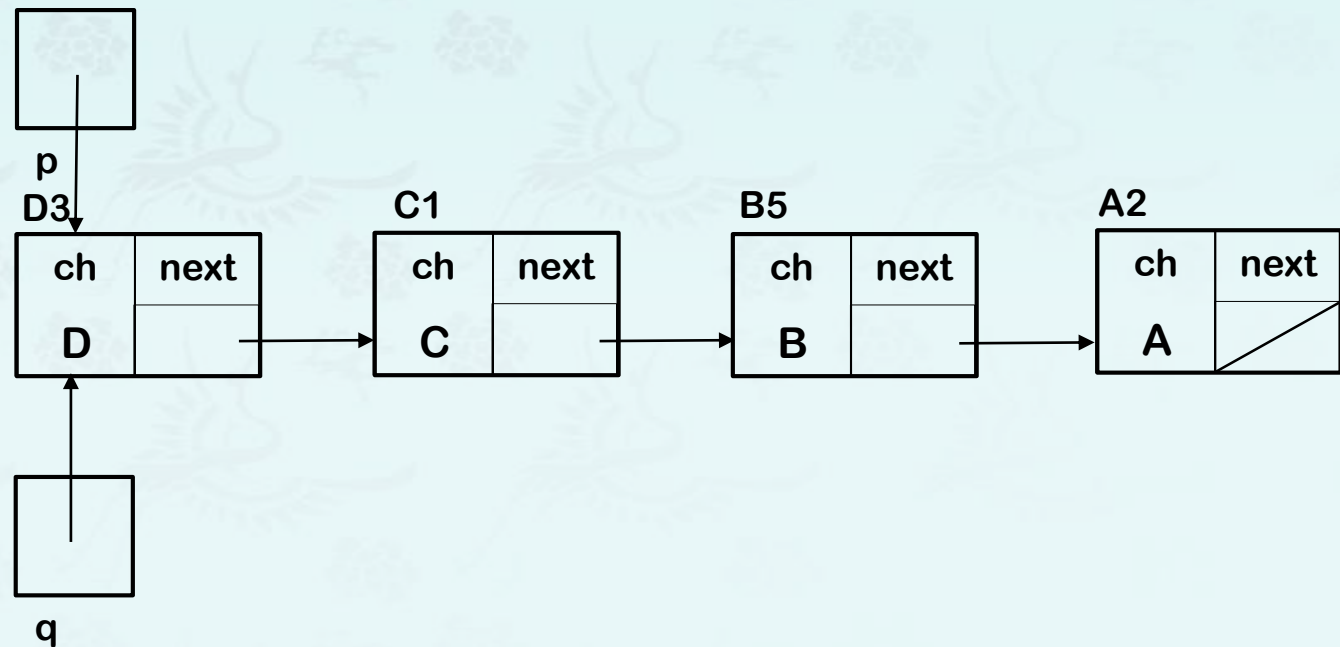
## Pointer Linked – Lab

```
#include <iostream>
using namespace std;
class Node {
public:
    char ch;
    Node* next;
};

int main( ) {
    Node* p = nullptr, *q = nullptr;
    char ch;
    while (cin.get(ch) && ch != '\n') {
        p = new Node;
        p->ch = ch;
        p->next = q;
        q = p;
    }
    while (p != nullptr) {
        cout.put(p->ch);
        p = p->next;
    }
    cout << endl;
}
```

Assuming the input A, B, C, D to this program, what would be the data structure after the input?

Draw a figure to represent the data structure in memory. Use a mnemonic memory address to represent each node such as A2, B5, C1, ..., etc.



What is missing in the figure?

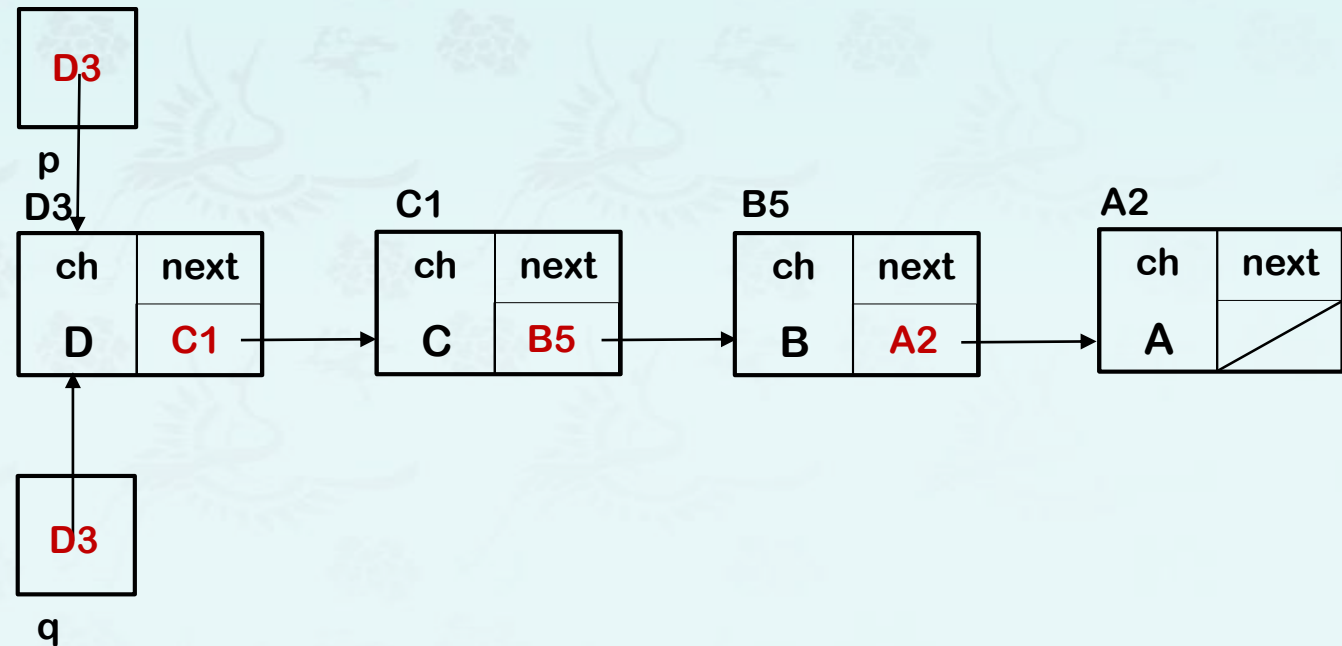
## Pointer Linked – Lab

```
#include <iostream>
using namespace std;
class Node {
public:
    char ch;
    Node* next;
};

int main( ) {
    Node* p = nullptr, *q = nullptr;
    char ch;
    while (cin.get(ch) && ch != '\n') {
        p = new Node;
        p->ch = ch;
        p->next = q;
        q = p;
    }
    while (p != nullptr) {
        cout.put(p->ch);
        p = p->next;
    }
    cout << endl;
}
```

Assuming the input A, B, C, D to this program, what would be the data structure after the input?

Draw a figure to represent the data structure in memory. Use a mnemonic memory address to represent each node such as A2, B5, C1, ..., etc.

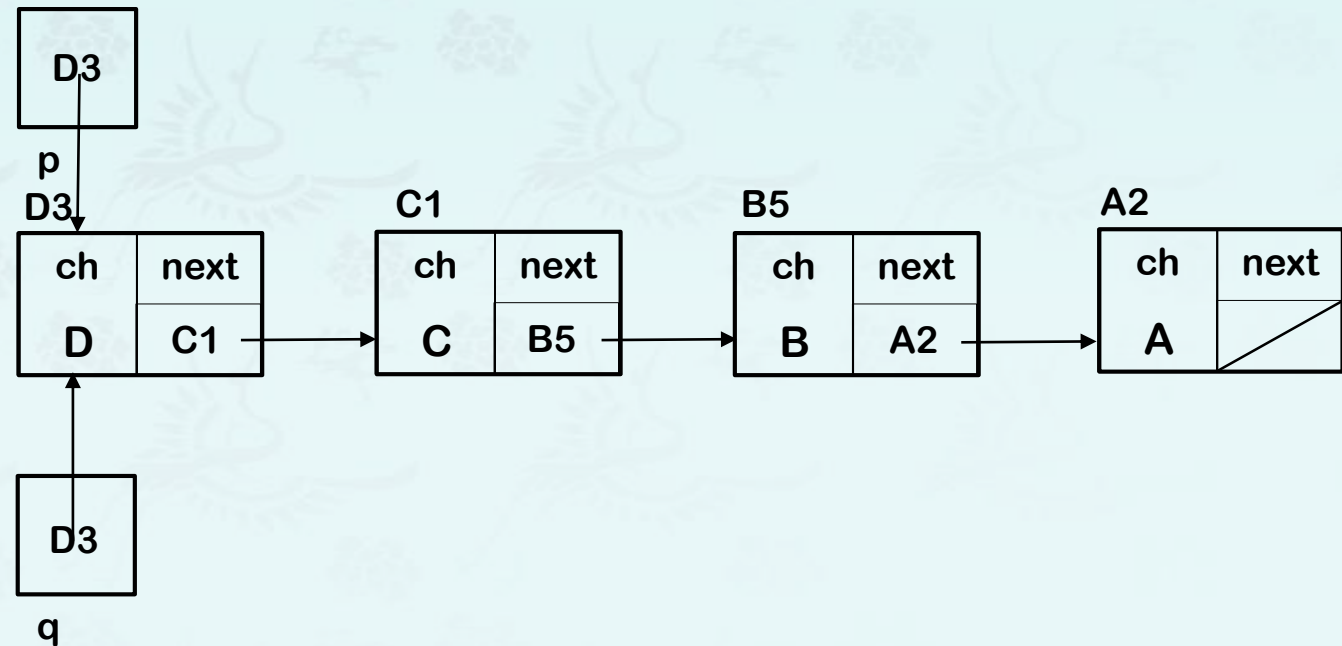


## Pointer Linked – Quiz

```
#include <iostream>
using namespace std;
class Node {
public:
    char ch;
    Node* next;
};

int main( ) {
    Node* p = nullptr, *q = nullptr;
    char ch;
    while (cin.get(ch) && ch != '\n') {
        p = new Node;
        p->ch = ch;
        p->next = q;
        q = p;
    }
    while (p != nullptr) {
        cout.put(p->ch);
        p = p->next;
    }
    cout << endl;
}
```

After executing the while loop,  
What is the output?  
What is the values of p and q?



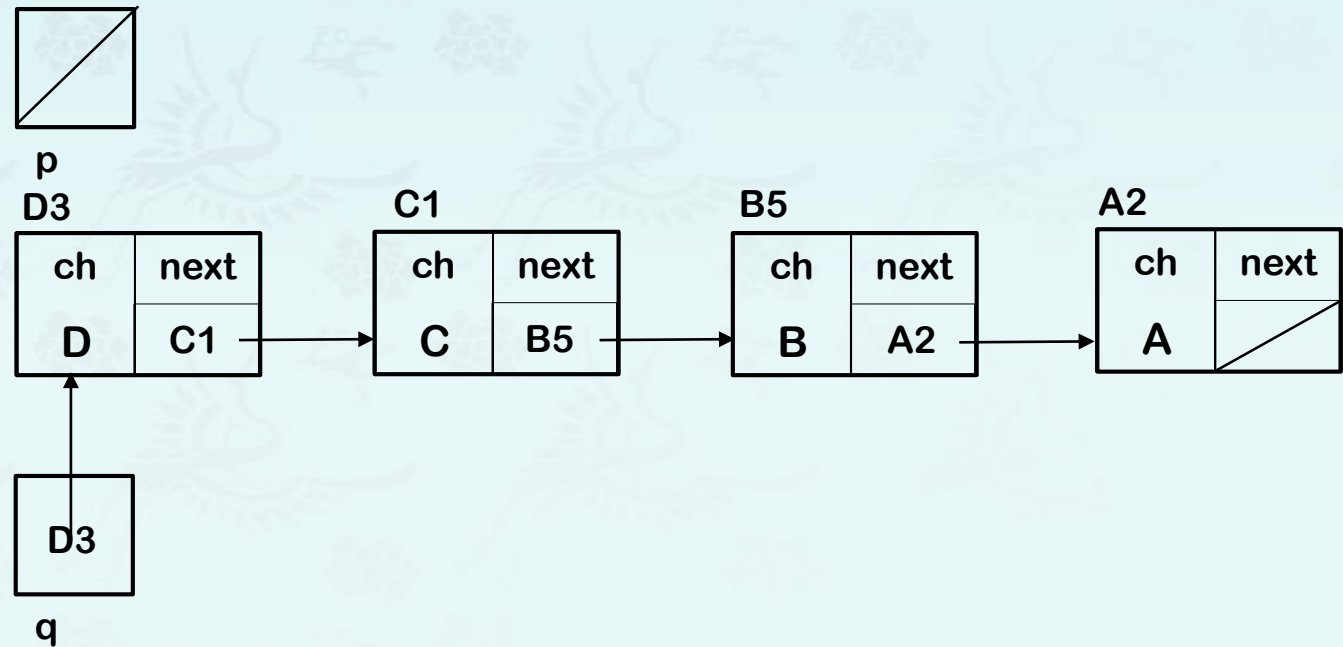
## Pointer Linked – Quiz

```
#include <iostream>
using namespace std;
class Node {
public:
    char ch;
    Node* next;
};

int main( ) {
    Node* p = nullptr, *q = nullptr;
    char ch;
    while (cin.get(ch) && ch != '\n') {
        p = new Node;
        p->ch = ch;
        p->next = q;
        q = p;
    }
    while (p != nullptr) {
        cout.put(p->ch);
        p = p->next;
    }
    cout << endl;
}
```

If you run the code shown below at the end, what would be output?

```
cout << q->next->ch;
```

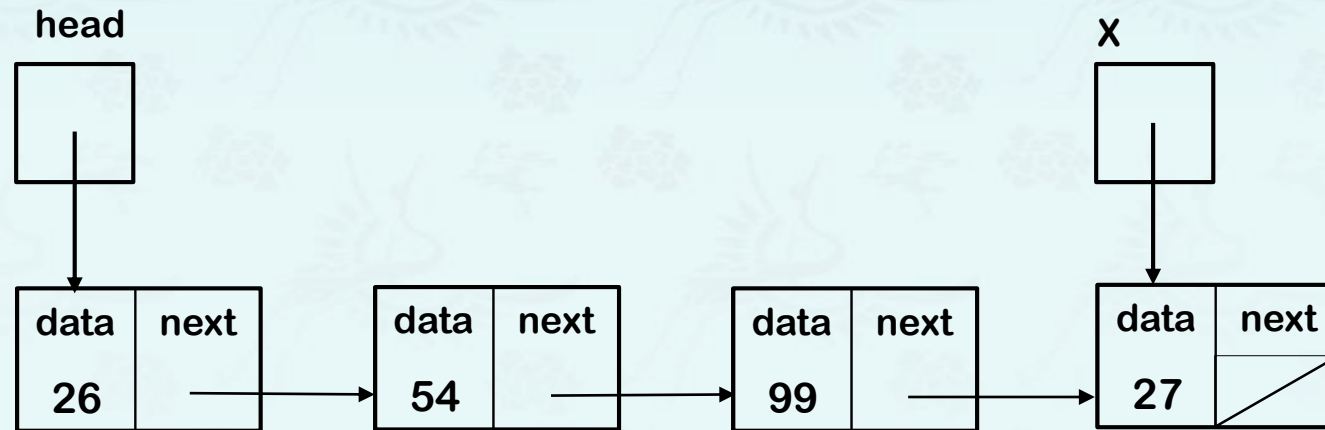


# Dynamic Data Structures

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

## basic member functions

- push\_front()
- push\_back()
- pop\_front()
- pop\_back()
- insert()
- remove()
- clear()

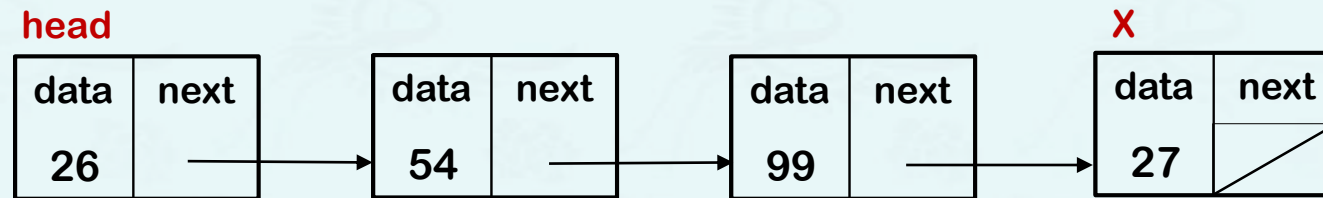


# Dynamic Data Structures

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

## basic member functions

- push\_front()
- push\_back()
- pop\_front()
- pop\_back()
- insert()
- remove()
- clear()

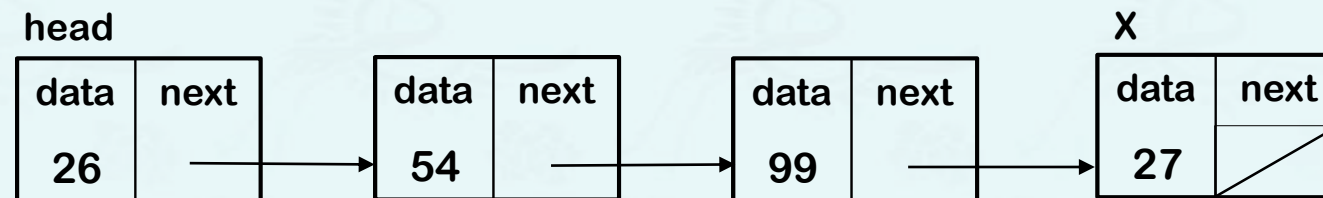


## Dynamic Data Structures – **push\_front()**

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 10) at the head of list.



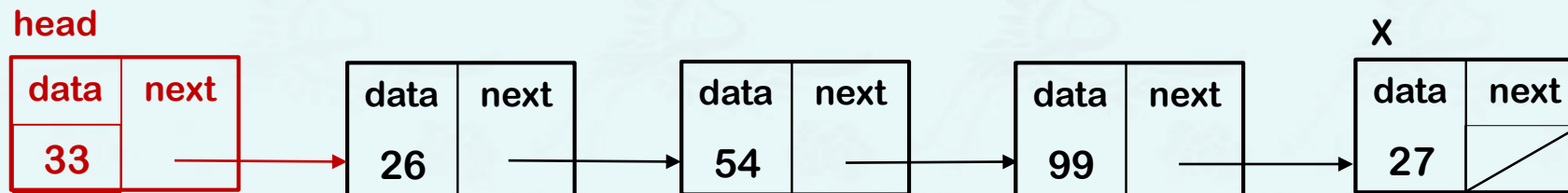
## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next =
```





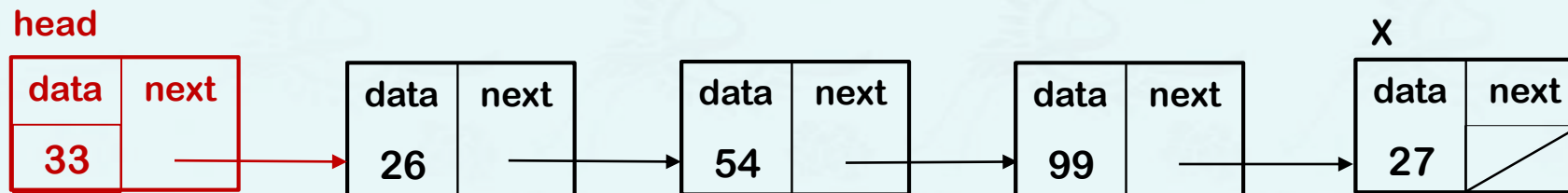
## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next = head;
```



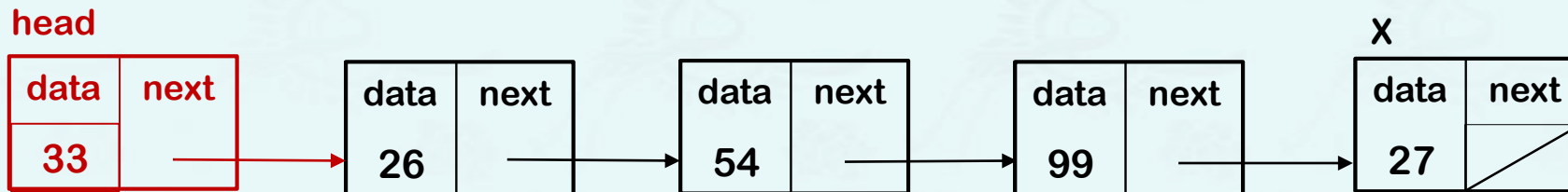
## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next = head;  
head =
```



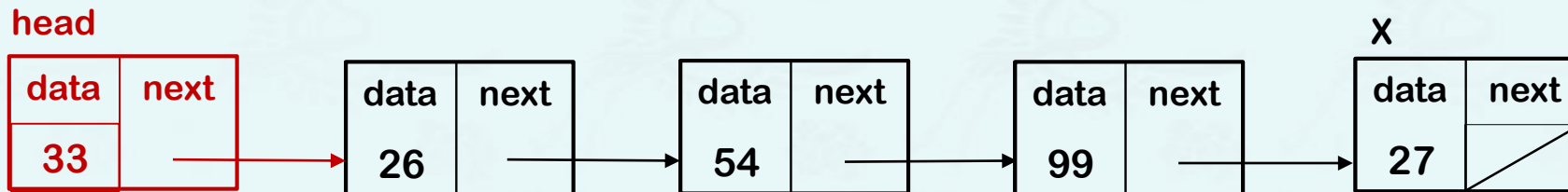
## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next = head;  
head = y;
```



## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

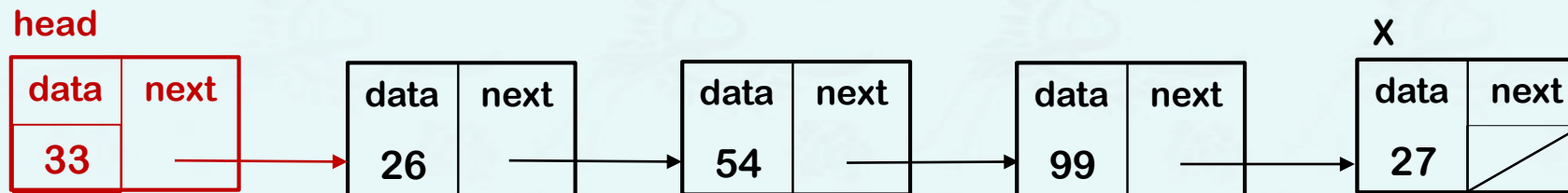
Let us imagine that we have created a linked list, where **head** points to the head of the list and **x** at the last item in the list (i.e. the one with the nullptr pointer) as shown below.

- Add a node (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next = head;  
head = y;
```



```
y = new Node {33, head};  
head = y;
```



## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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.

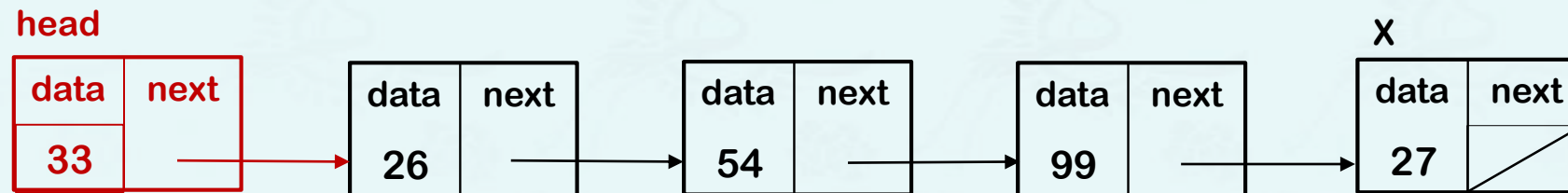
- Add a node (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next = head;  
head = y;
```



```
y = new Node {33, head};  
head = y;
```

How do you code it in a function, push\_front()?



## Dynamic Data Structures – push\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
...  
Node* head, *x, *y;  
...  
head = push_front(head, 33);
```

```
Node push_front(Node h, int d) {  
    ...  
    Node y = new Node{d, h};  
    ...  
    return y;  
}
```

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.

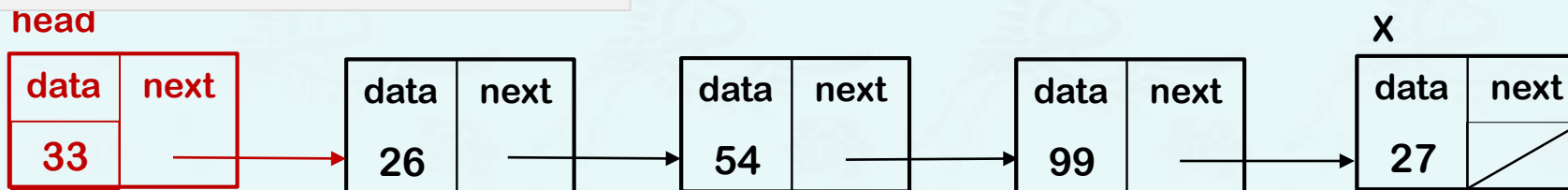
- Add a node (n = 33) at the head of list.
  - create a node and initialized with n = 10.
  - let head point to the new node

```
y = new Node;  
y->data = 33  
y->next = head;  
head = y;
```



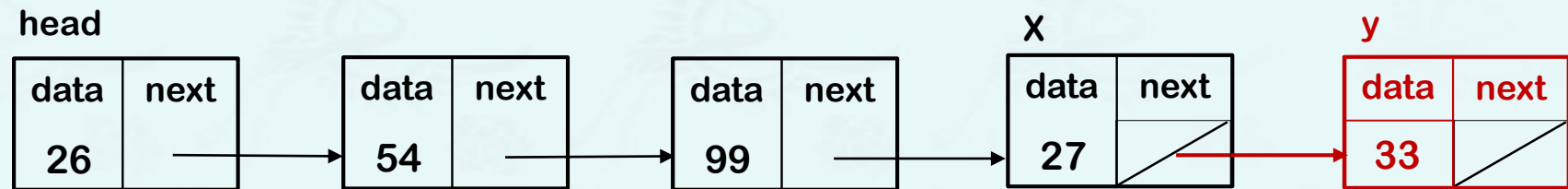
```
y = new Node {33, head};  
head = y;
```

How do you code it in a function, push\_front()?



## Dynamic Data Structures – **push\_back()**

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```





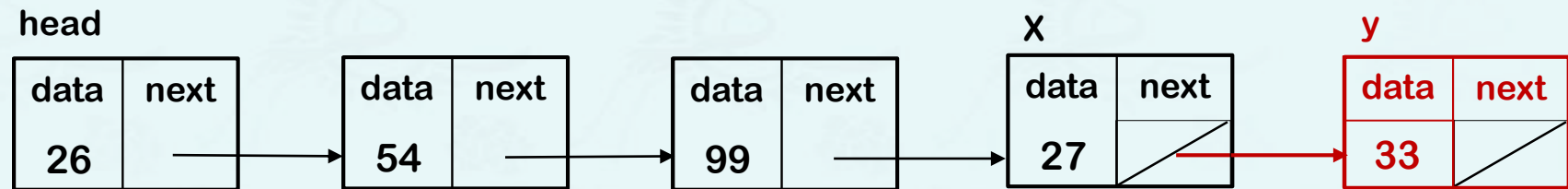
## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the end of list.

```
y = new Node;
```





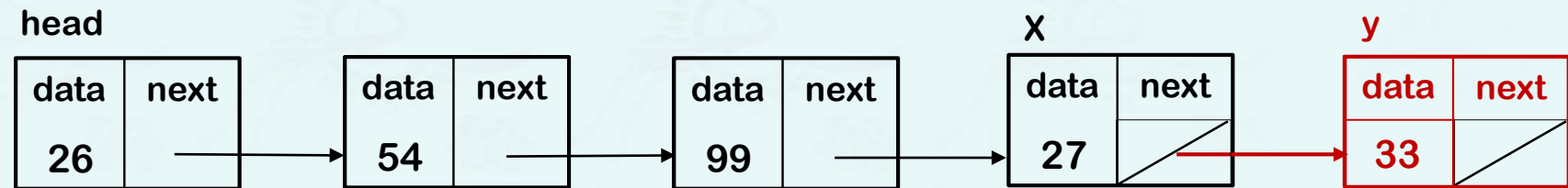
## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the end of list.

```
y = new Node;  
y->data = 33  
y->next = nullptr;
```



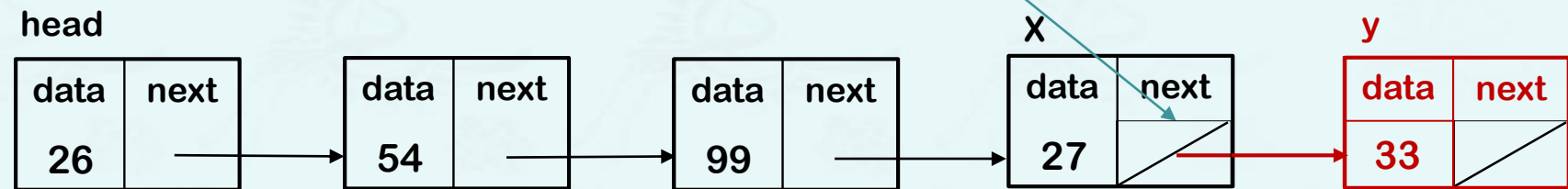
## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the end of list.

```
y = new Node;  
y->data = 33  
y->next = nullptr;
```



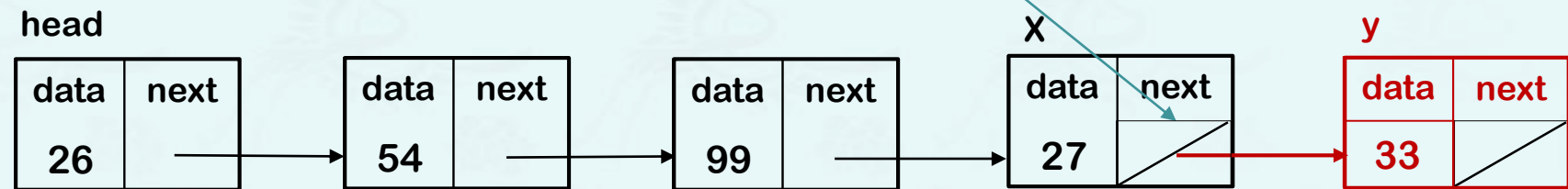
## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the end of list.

```
y = new Node;  
y->data = 33  
y->next = nullptr;  
x->next
```



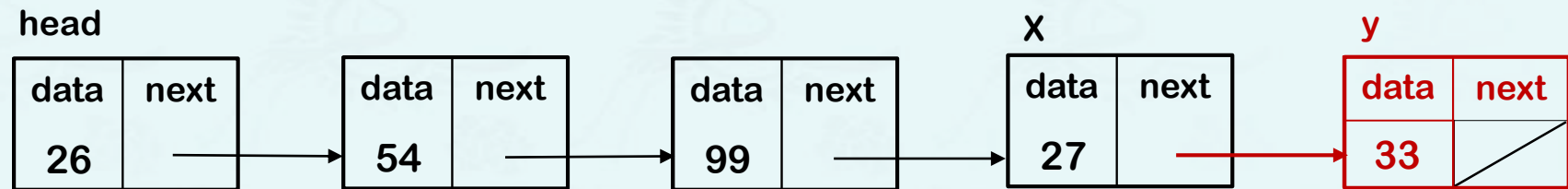
## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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 (n = 33) at the end of list.

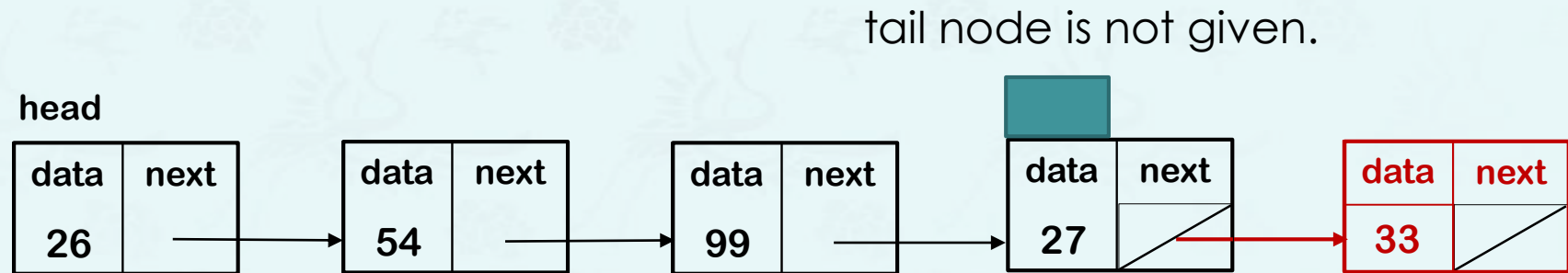
```
y = new Node;  
y->data = 33  
y->next = nullptr;  
x->next = y;
```



## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

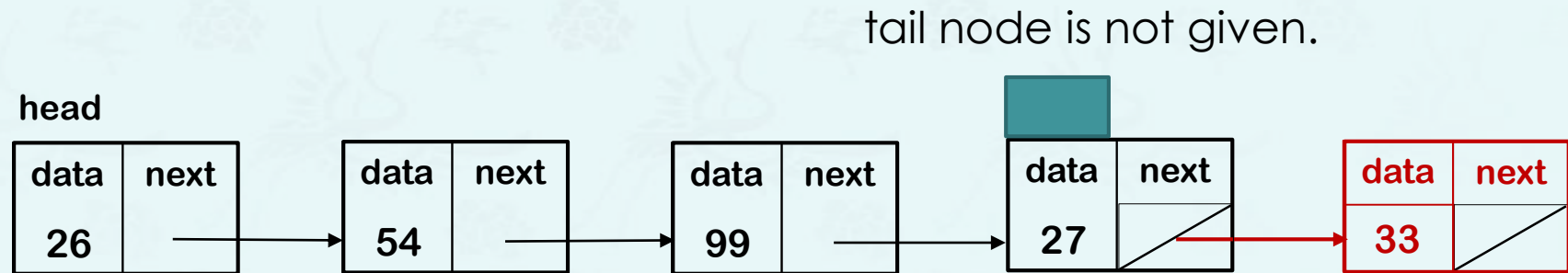
- Add a node (n = 33) at the end of list, where **only head** of the list is given as shown below.



## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- Add a node (n = 33) at the end of list, where **only head** of the list is given as shown below.
- 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:



## Dynamic Data Structures – push\_back()

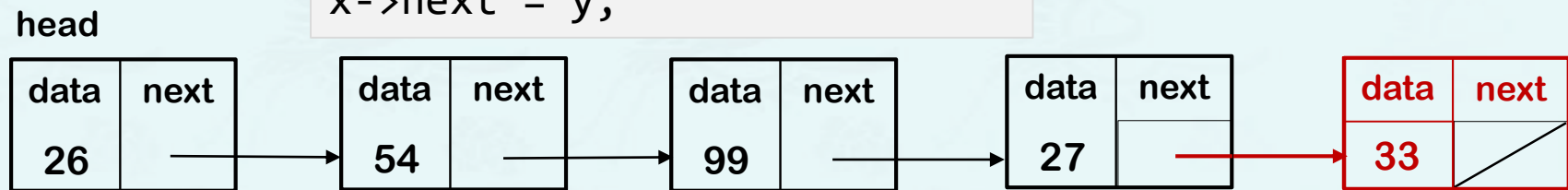
```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- Add a node (n = 33) at the end of list, where **only head** of the list is given as shown below.
- 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:

```
y = new Node;  
y->data = 33  
y->next = nullptr;
```

```
x = head;  
while (x->next != nullptr)  
    x = x->next;
```

```
x->next = y;
```





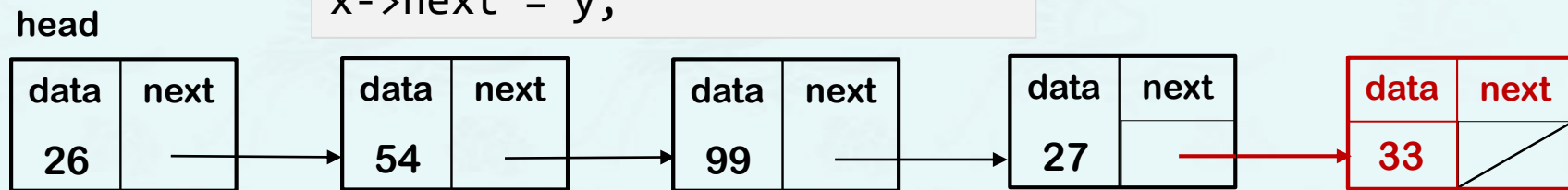
## Dynamic Data Structures – push\_back()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- Add a node (n = 33) at the end of list, where **only head** of the list is given as shown below.
- 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:

```
y = new Node;  
y->data = 33  
y->next = nullptr;  
x = head;  
while (x->next != nullptr)  
    x = x->next;  
x->next = y;
```

a way to get the last node



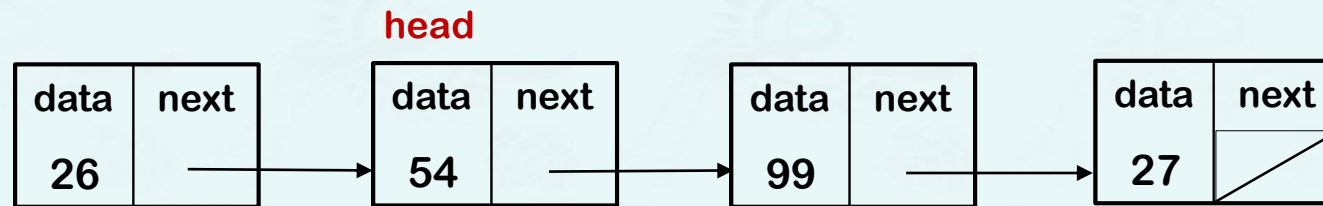


## Dynamic Data Structures – **pop\_front()**

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

```
head = head->next;
```

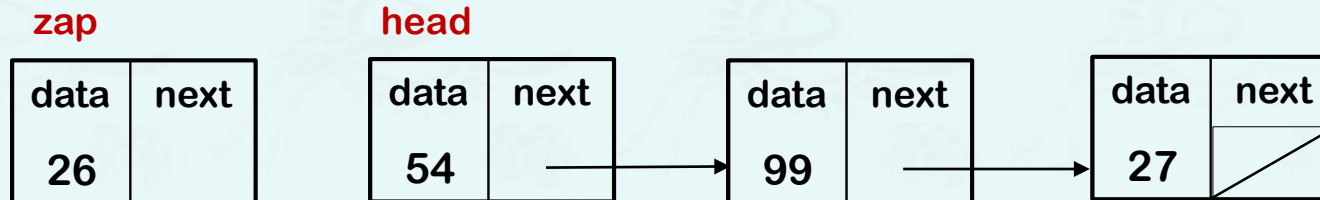


## Dynamic Data Structures – pop\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- 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* zap = head;  
head = head->next;
```

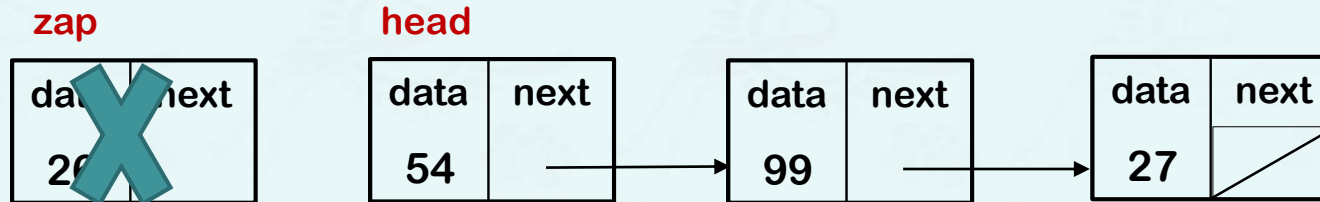


## Dynamic Data Structures – pop\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- 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* zap = head;  
head = head->next;
```

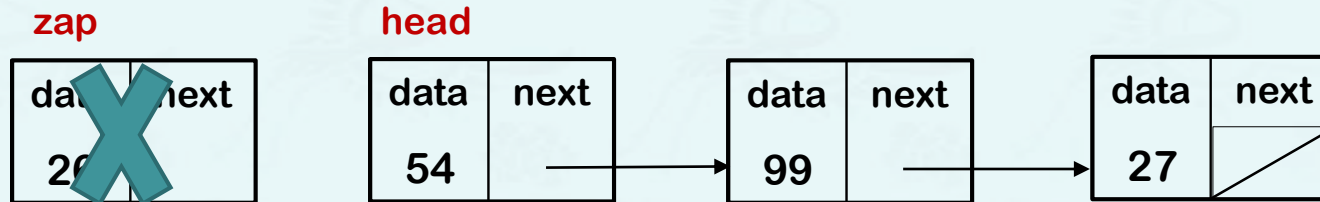


## Dynamic Data Structures – pop\_front()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- 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:

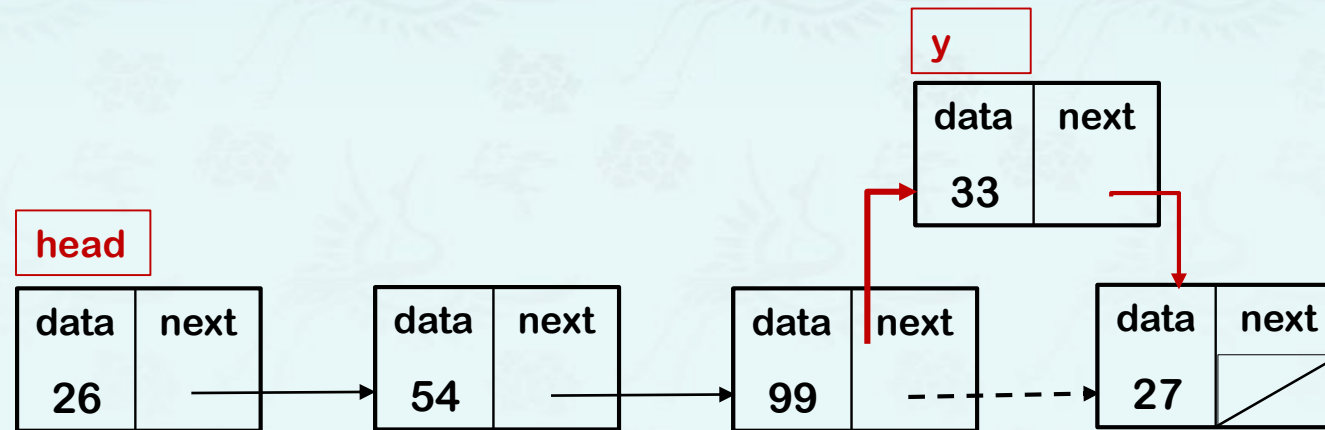
```
Node* zap = head;  
head = head->next;  
delete zap;
```



## Dynamic Data Structures – insert()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

- Insert a node(n = 33) after the node (n = 99) as shown below.

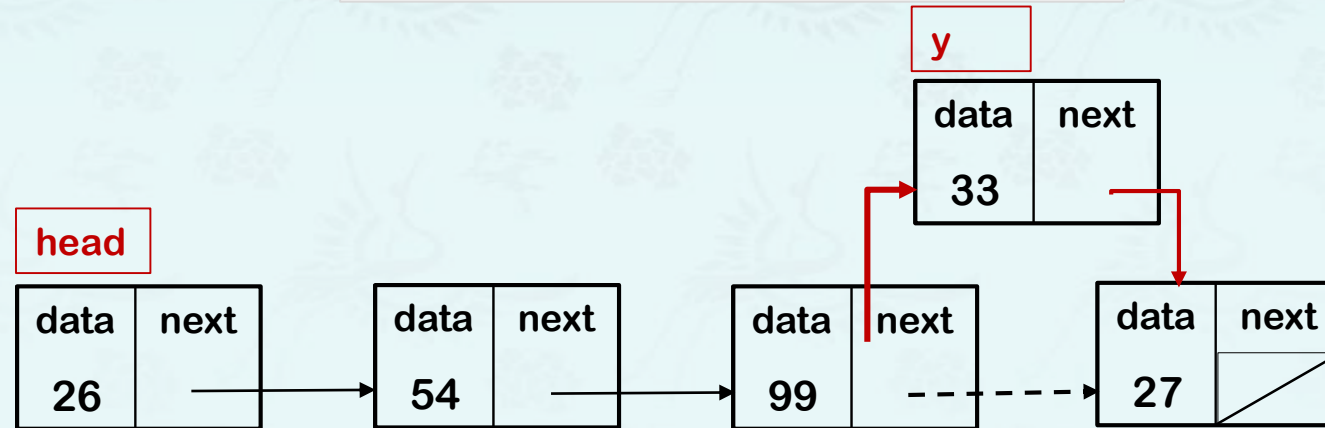


## Dynamic Data Structures – insert()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

```
x = head;
```



## Dynamic Data Structures – insert()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

```
x = head;  
while (x->data != 99)  
    x = x->next;
```

Where is x pointing after while()?



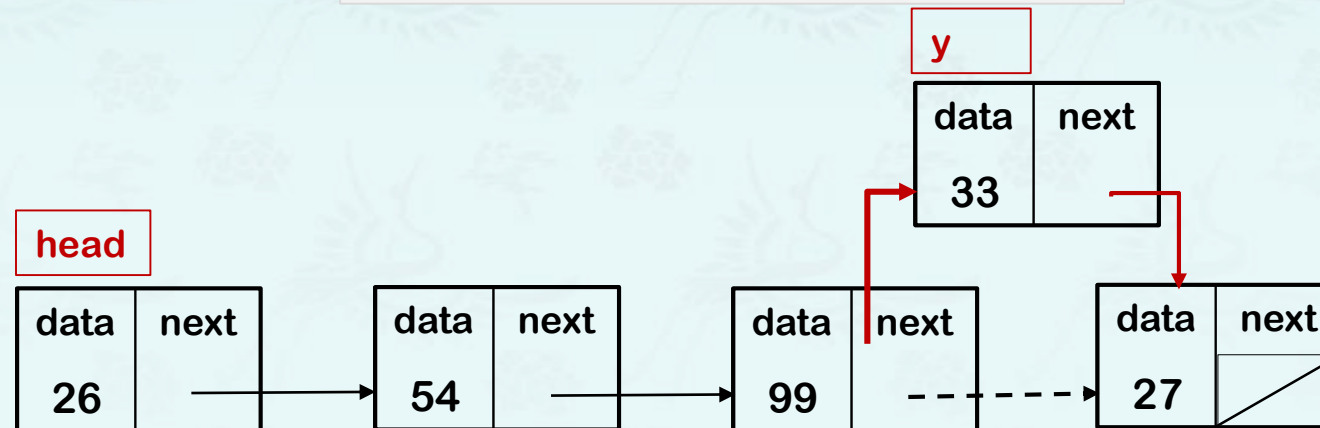
## Dynamic Data Structures – insert()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

```
x = head;  
while (x->data != 99)  
    x = x->next;  
y->next =
```

Where is x pointing after while()?



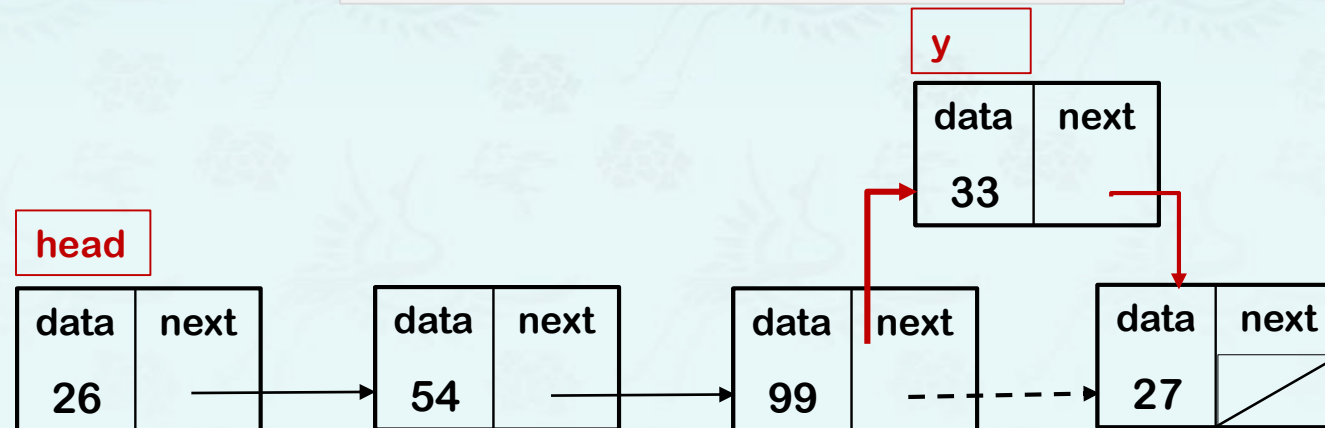


## Dynamic Data Structures – insert()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

```
x = head;  
while (x->data != 99)  
    x = x->next;  
y->next = x->next;  
x->next =
```

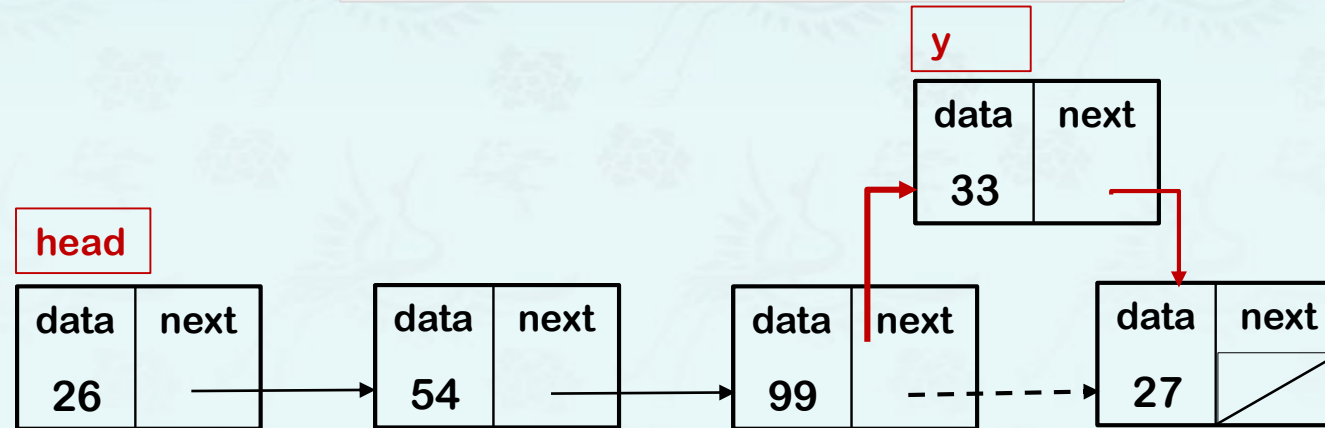


## Dynamic Data Structures – insert()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

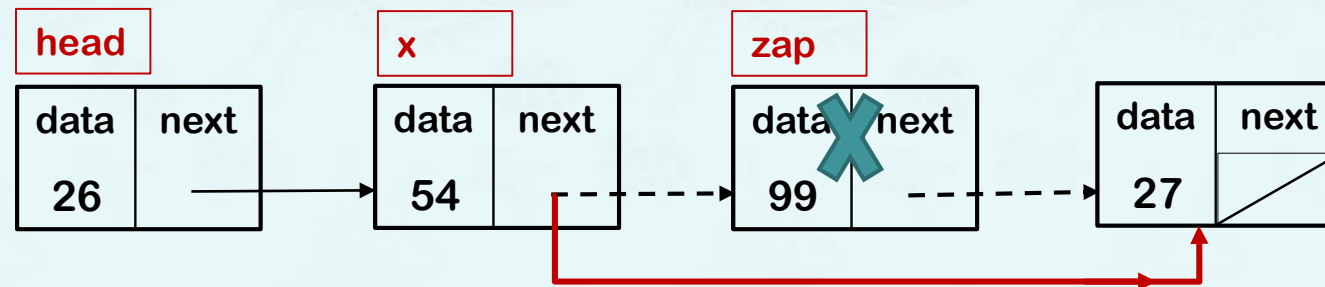
```
x = head;  
while (x->data != 99)  
    x = x->next;  
y->next = x->next;  
x->next = y;
```



## Dynamic Data Structures – remove()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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



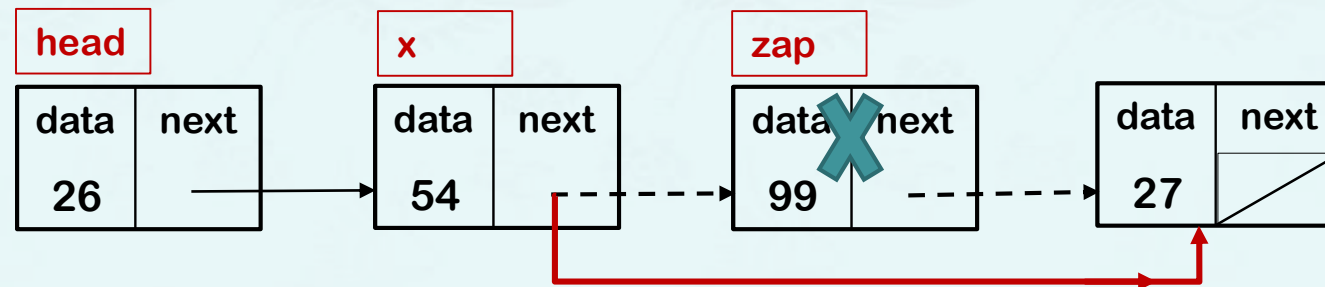
## Dynamic Data Structures – remove()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

To remove a node from a list we have to do three things:

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



## Dynamic Data Structures – remove()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

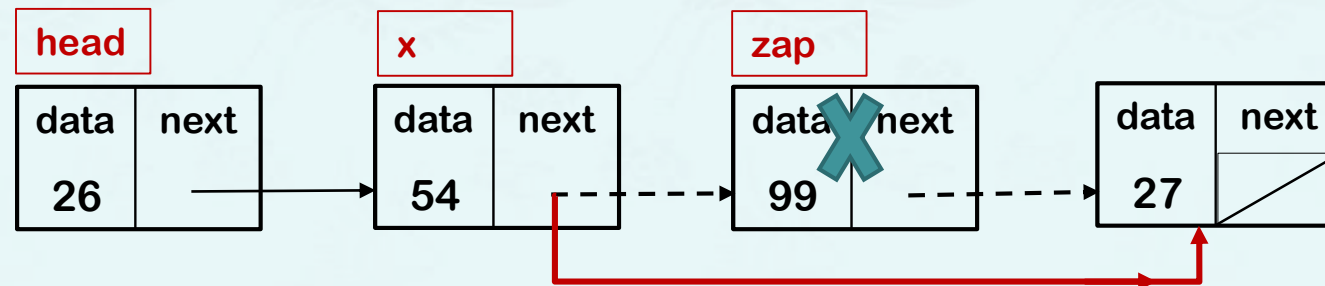
To remove a node from a list we have to do three things:

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

```
node* x = head, *zap = head->next;  
while(zap->data != 99) {  
    x = zap;  
    zap = zap->next;  
}
```

→ To find both x and zap.

Assuming (1) there are at least two nodes,  
(2) 99 is not the head node, and  
(3) there is a 99 node.



## Dynamic Data Structures – remove()

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

...

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

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

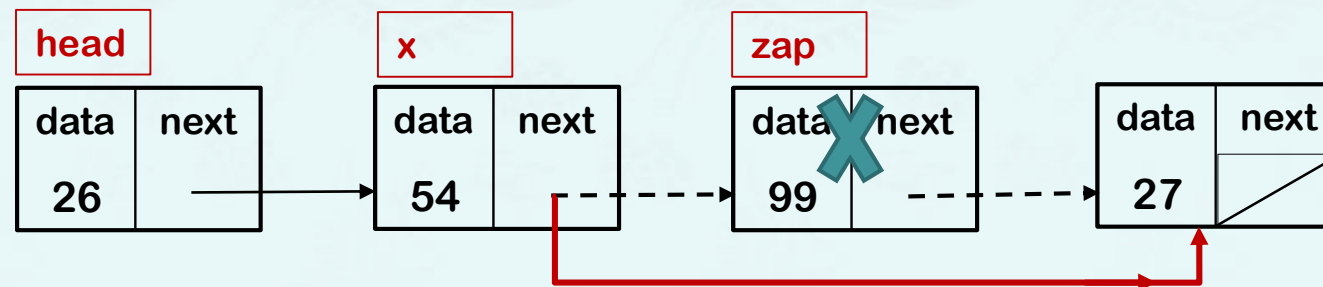
To remove a node from a list we have to do three things:

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

```
node* x = head, *zap = head->next;
while(zap->data != 99) {
    x = zap;
    zap = zap->next;
}
x->next =
```

→ To find both **x** and **zap**.

Assuming (1) there are at least two nodes,  
(2) 99 is not the head node, and  
(3) there is a 99 node.



## Dynamic Data Structures – remove()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

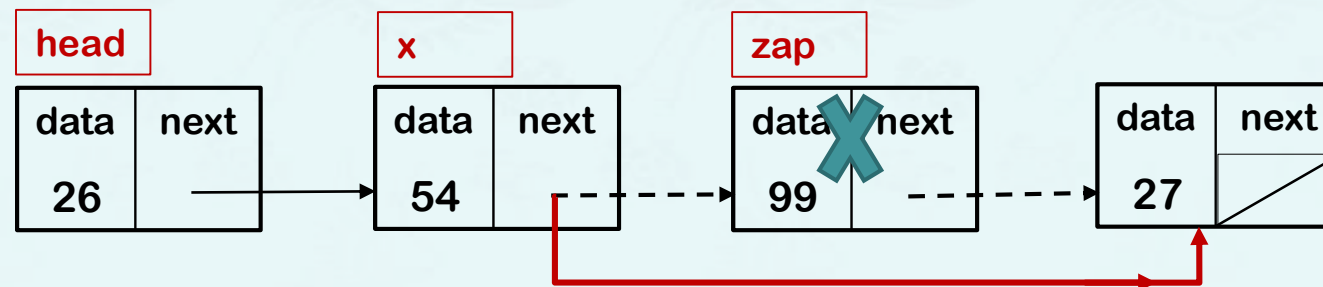
To remove a node from a list we have to do three things:

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

```
node* x = head, *zap = head->next;  
while(zap->data != 99) {  
    x = zap;  
    zap = zap->next;  
}  
x->next = zap->next;
```

→ To find both x and zap.

Assuming (1) there are at least two nodes,  
(2) 99 is not the head node, and  
(3) there is a 99 node.





## Dynamic Data Structures – remove()

```
class Node {  
public:  
    int    data;  
    Node* next;  
};  
  
...  
  
Node* head, *x, *y;
```

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

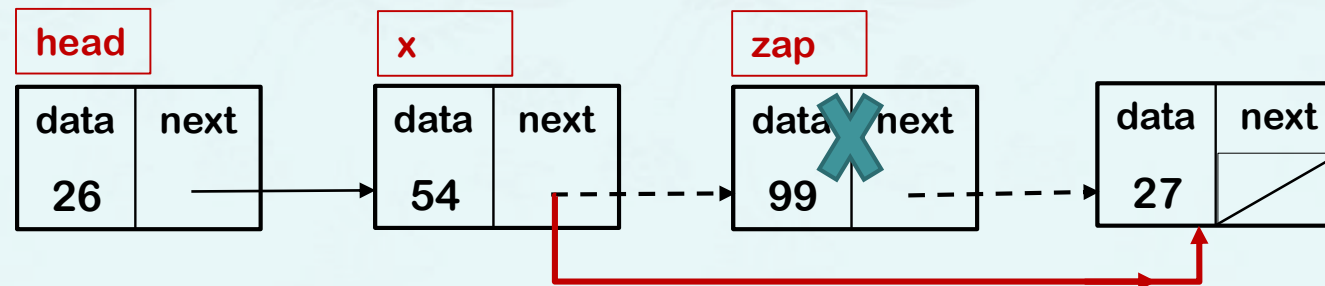
To remove a node from a list we have to do three things:

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

```
node* x = head, *zap = head->next;  
while(zap->data != 99) {  
    x = zap;  
    zap = zap->next;  
}  
x->next = zap->next;  
delete zap;
```

→ To find both **x** and **zap**.

Assuming (1) there are at least two nodes,  
(2) 99 is not the head node, and  
(3) there is a 99 node.







Summary

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