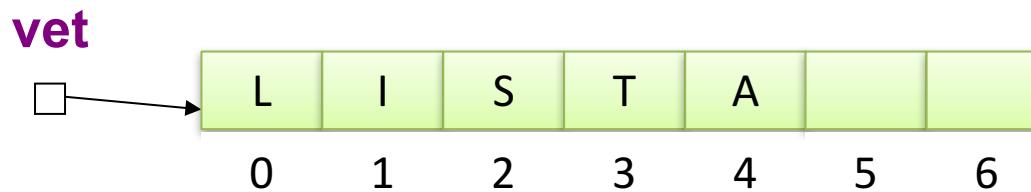


# Estrutura de Dados e Algoritmos

## Listas Encadeadas

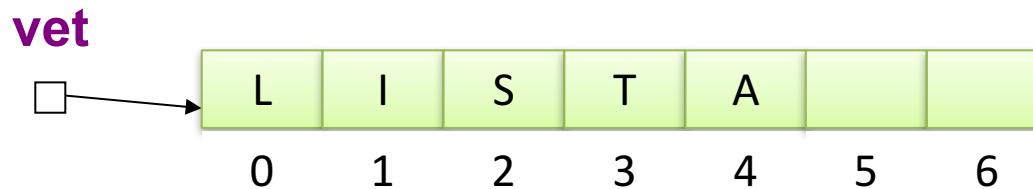
- Uma lista é uma representação de uma sequência de objetos na memória do computador;
- Cada elemento da lista é armazenado em um nó ou célula: o primeiro elemento na primeira célula, o segundo na segunda e assim por diante.

- Conjunto de itens organizados (vetor)
  - A organização é implícita (pela posição):



- **vet** representa a lista → A lista está armazenada em células contíguas da memória.

- Desvantagens: Quantidade de Nós pré-definida:
  - memória alocada sem uso;
  - impossibilidade de alocar mais memória.

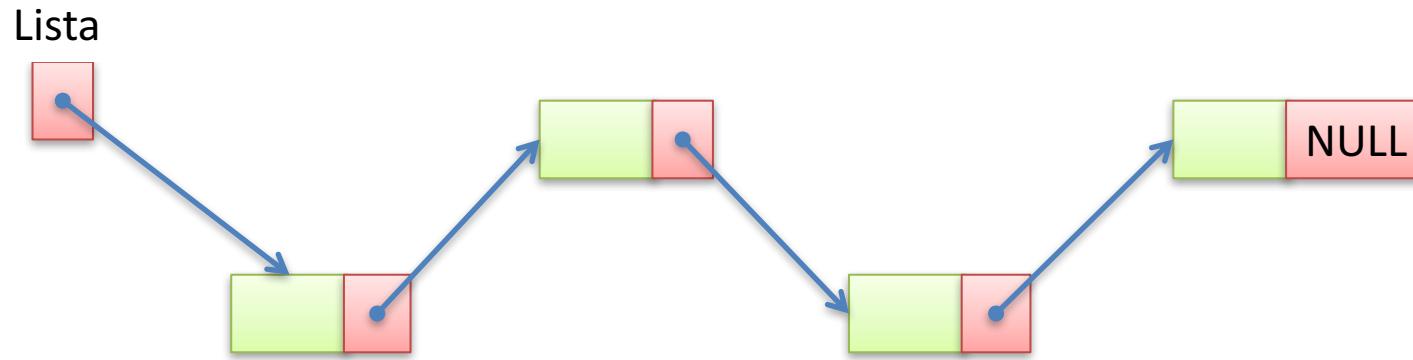


- Solução:
  - Utilizar Estruturas de Dados que cresçam e diminuam na medida da necessidade → Estruturas Dinâmicas;
  - Alocação dinâmica de memória conforme demanda.

## Listas Encadeadas

- Podem crescer e diminuir dinamicamente;
  - Tamanho máximo não precisa ser definido previamente;
  - Proveem flexibilidade, permitindo que os itens sejam rearranjados eficientemente;
  - Também chamadas de Listas Ligadas.
- 
- O acesso a um nó é feito de forma sequencial →  $O(n)$ . Diferente de vetor →  $O(1)$ ;

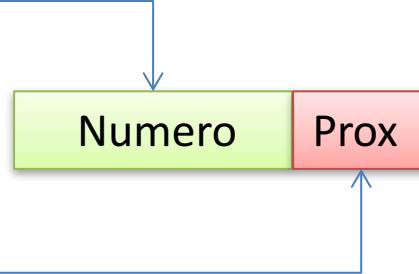
- Uma lista encadeada é uma sequência de nós não contíguos;
- Cada nó contém um objeto de algum tipo e, no mínimo, o endereço do nó seguinte;
- Uma lista encadeada deve ter um ponteiro para o início da lista (primeiro nó);



```
struct TNo
```

```
{
```

```
    int Numero;
```



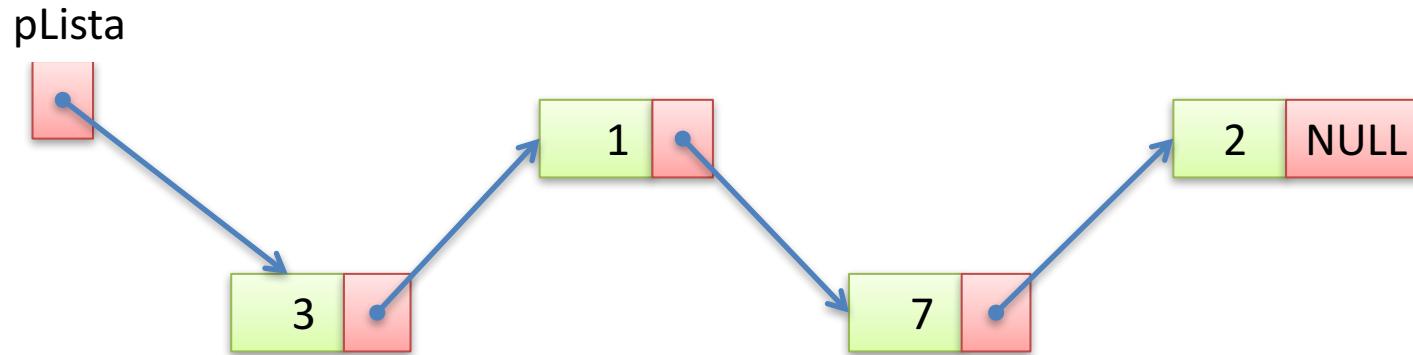
```
    TNo *Prox;
```

```
};
```

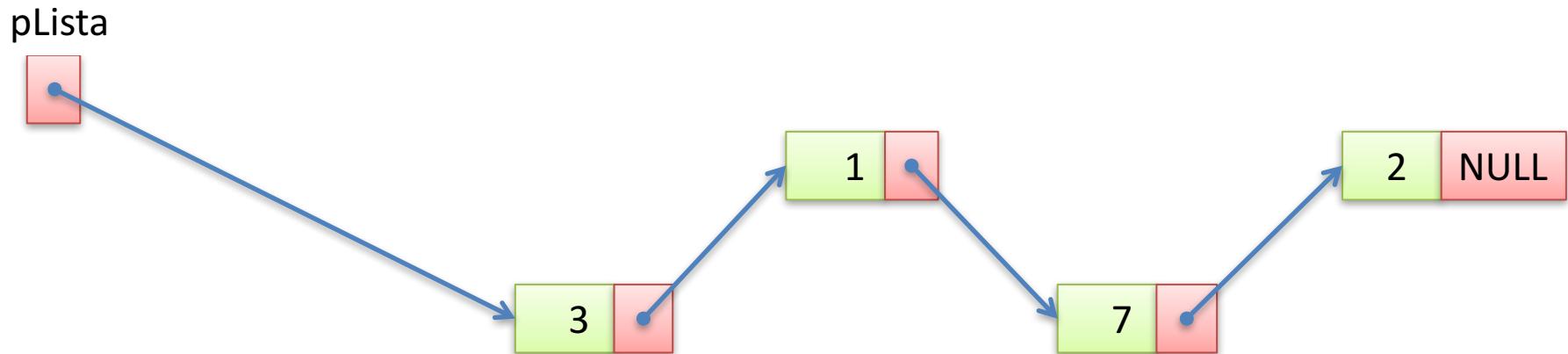
```
bool Vazia(TNo *pLista)
{
    if(pLista == NULL)
        return true;
    else
        return false;
}
```

Lista

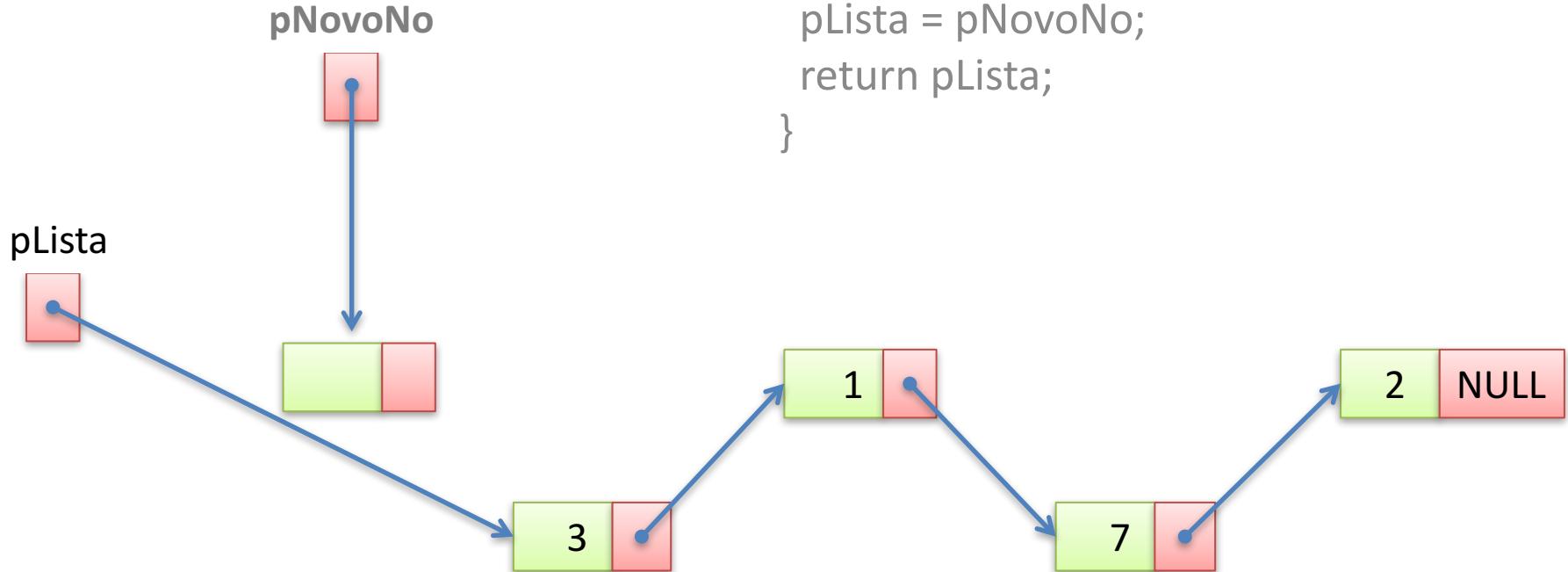
NULL



```
TNo *IncluiCabeca(TNo *pLista, int pValor)
{
    TNo *pNovoNo;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = pLista;
    pLista = pNovoNo;
    return pLista;
}
```

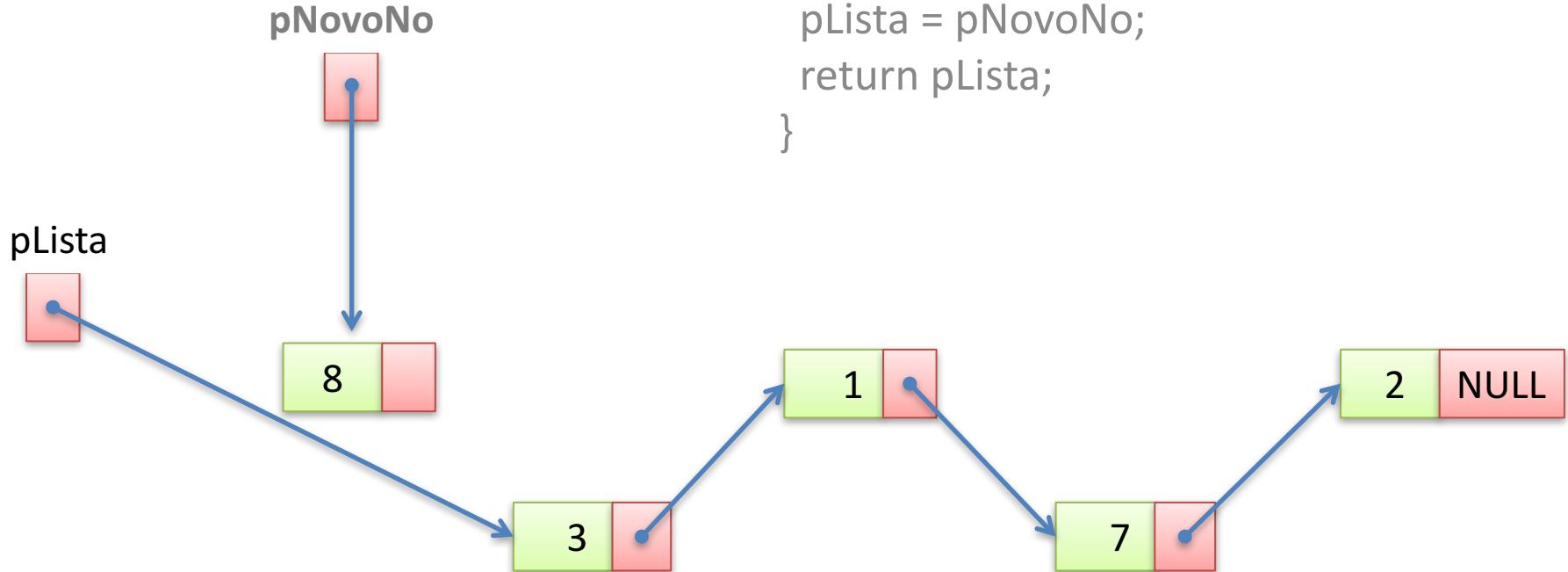


```
TNo *IncluiCabeca(TNo *pLista, int pValor)
{
    TNo *pNovoNo;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = pLista;
    pLista = pNovoNo;
    return pLista;
}
```

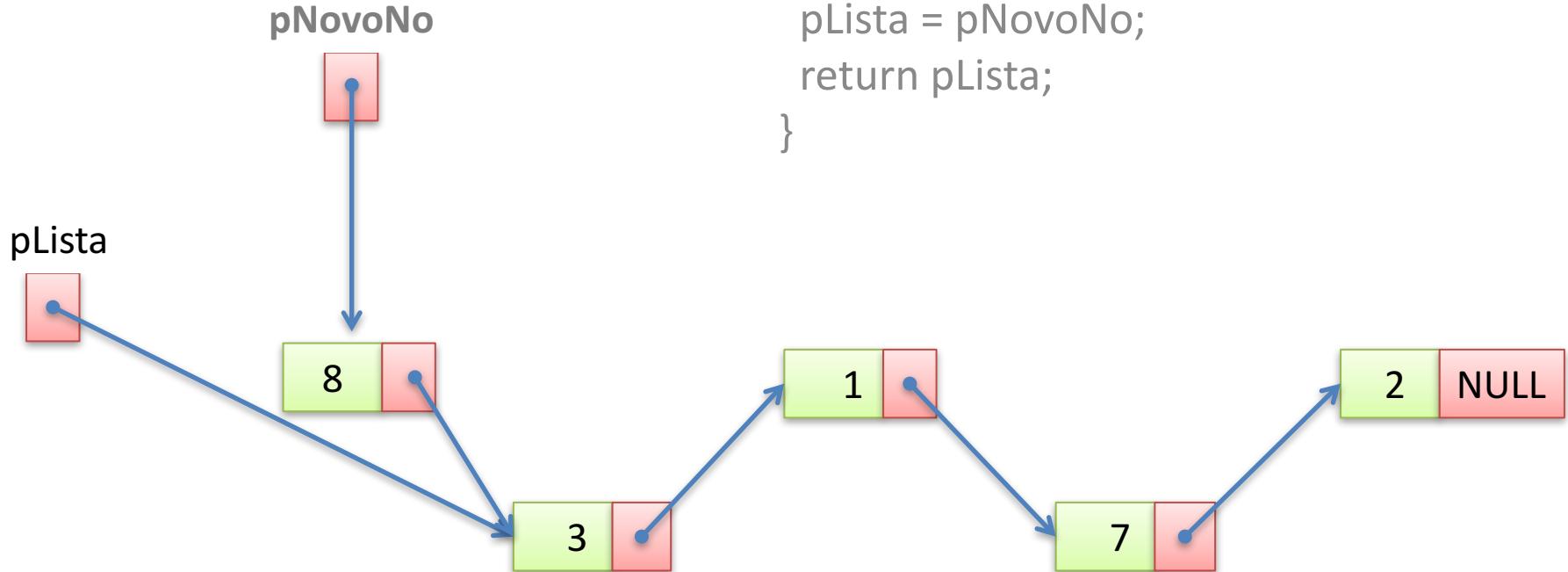


# Lista Encadeada – Inclusão na Cabeça

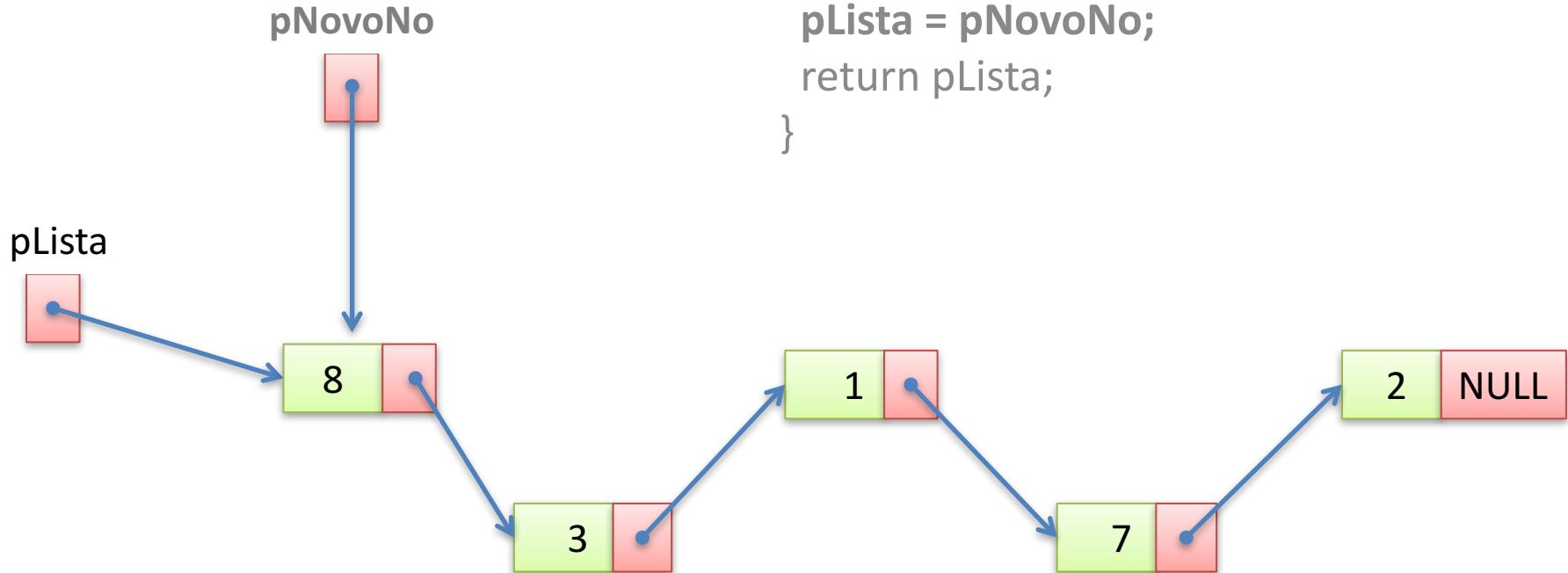
```
TNo *IncluiCabeca(TNo *pLista, int pValor)
{
    TNo *pNovoNo;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = pLista;
    pLista = pNovoNo;
    return pLista;
}
```



```
TNo *IncluiCabeca(TNo *pLista, int pValor)
{
    TNo *pNovoNo;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = pLista;
    pLista = pNovoNo;
    return pLista;
}
```

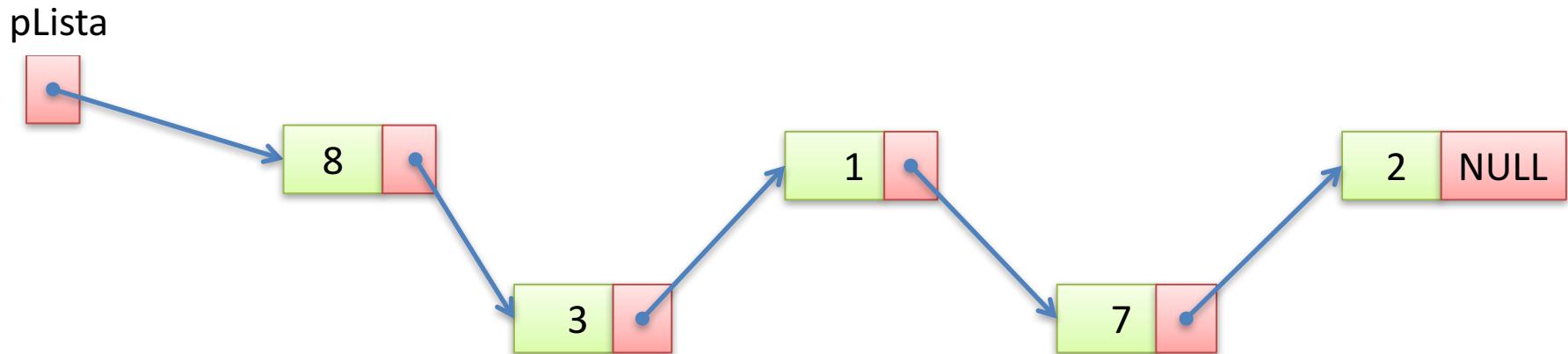


```
TNo *IncluiCabeca(TNo *pLista, int pValor)
{
    TNo *pNovoNo;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = pLista;
    pLista = pNovoNo;
    return pLista;
}
```



O(1)

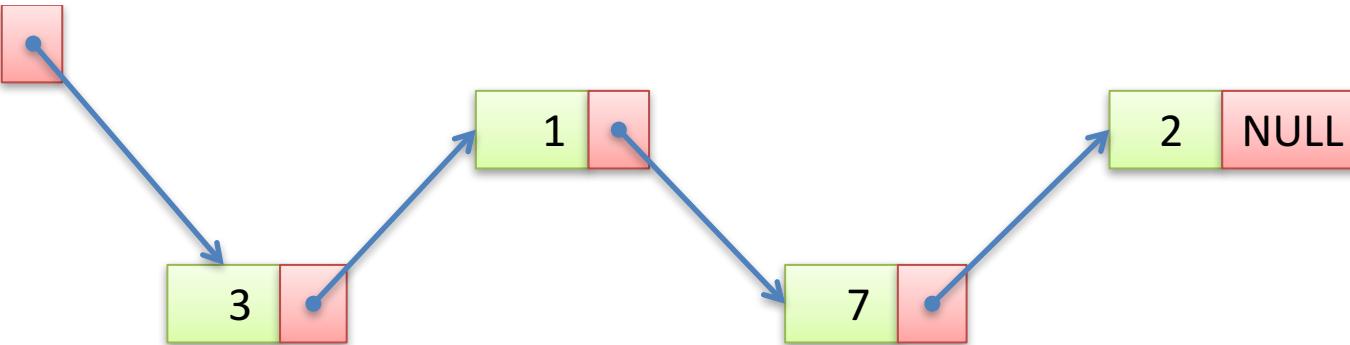
```
TNo *IncluiCabeca(TNo *pLista, int pValor)
{
    TNo *pNovoNo;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = pLista;
    pLista = pNovoNo;
    return pLista;
}
```



# Lista Encadeada – Inclusão na Calda

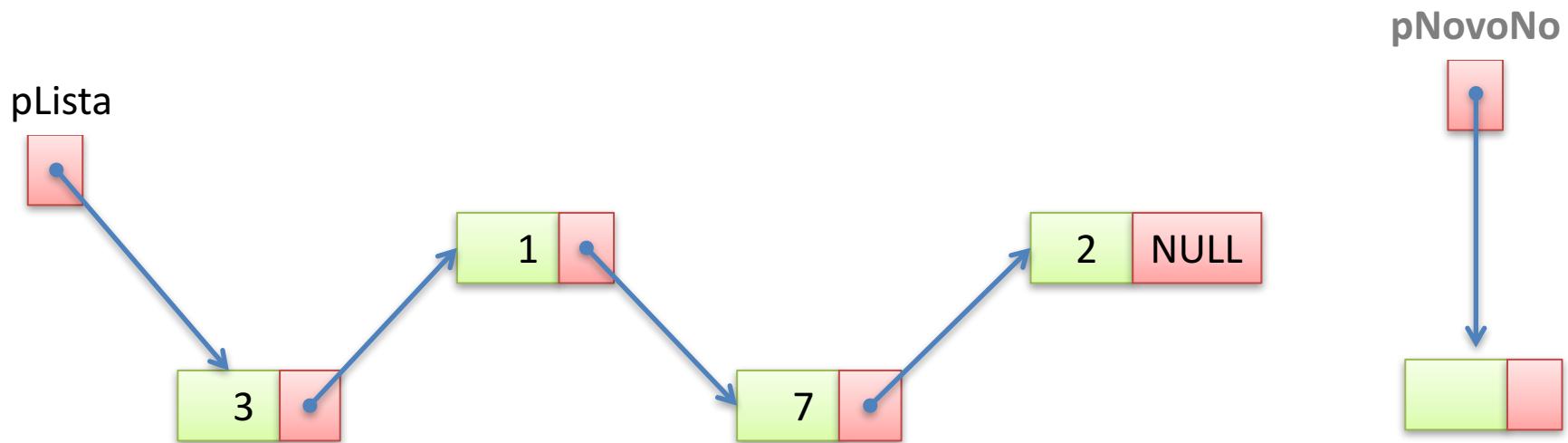
```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

pLista



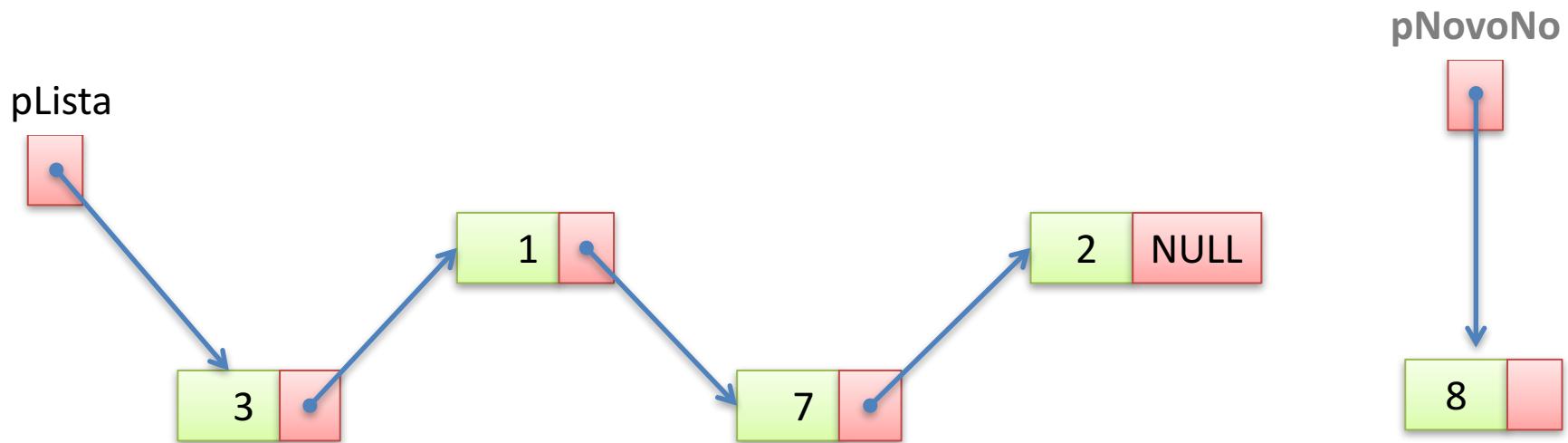
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



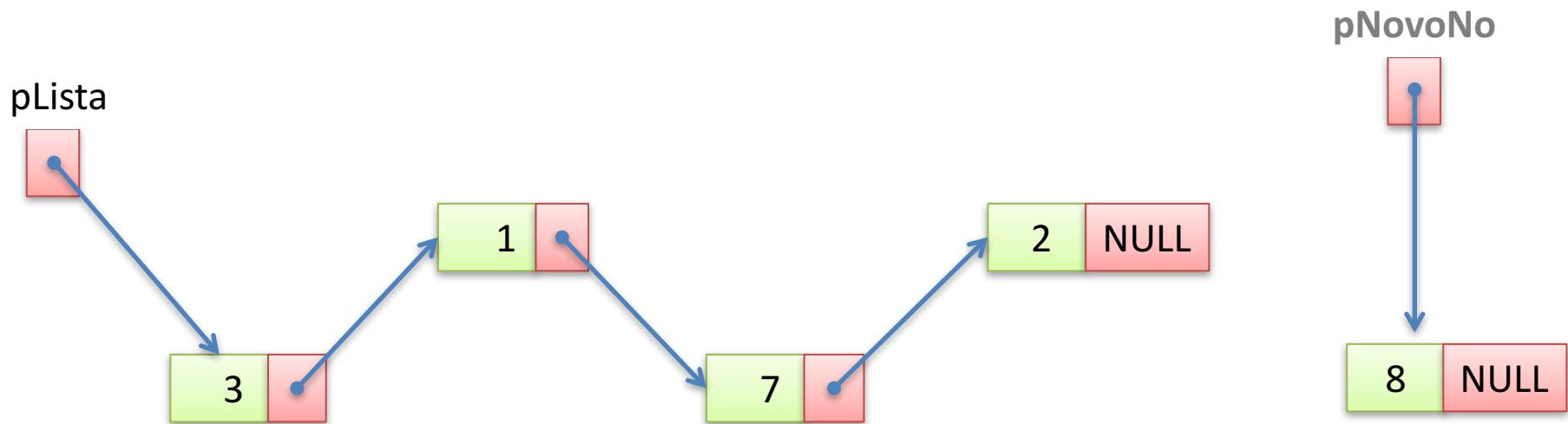
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



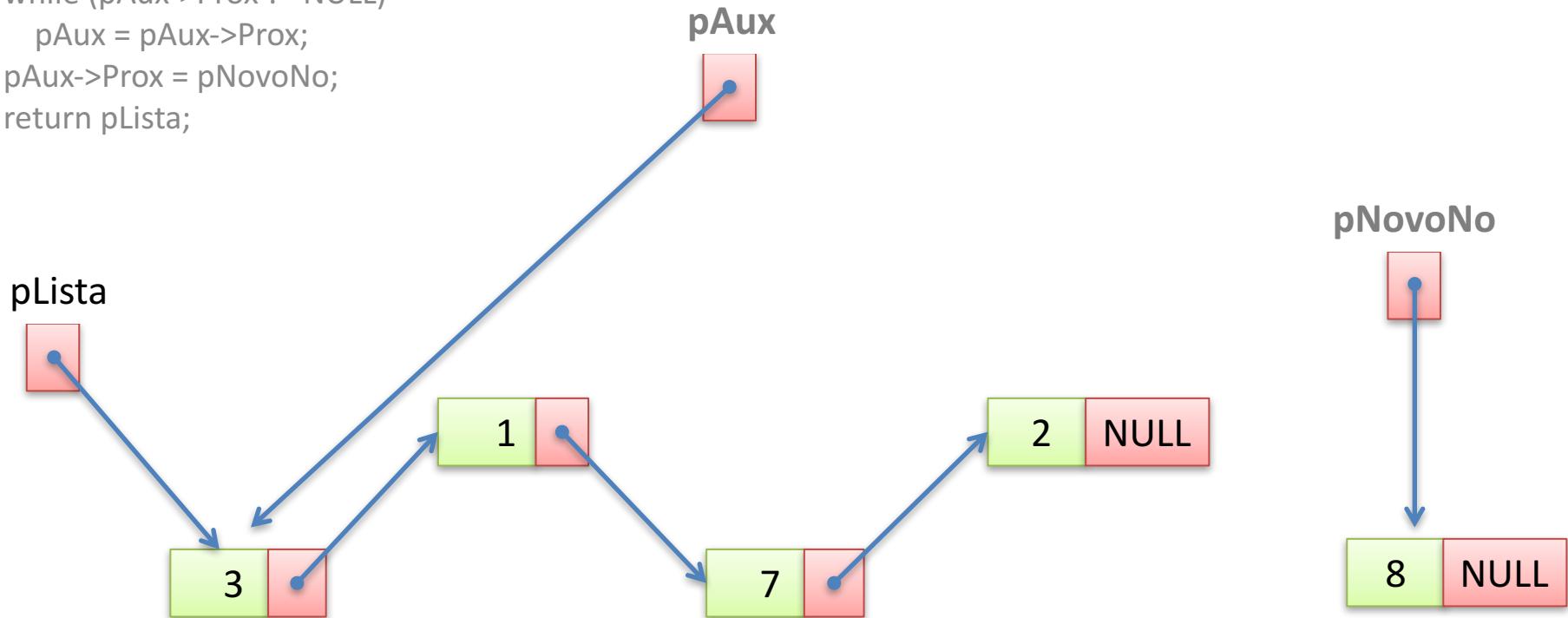
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



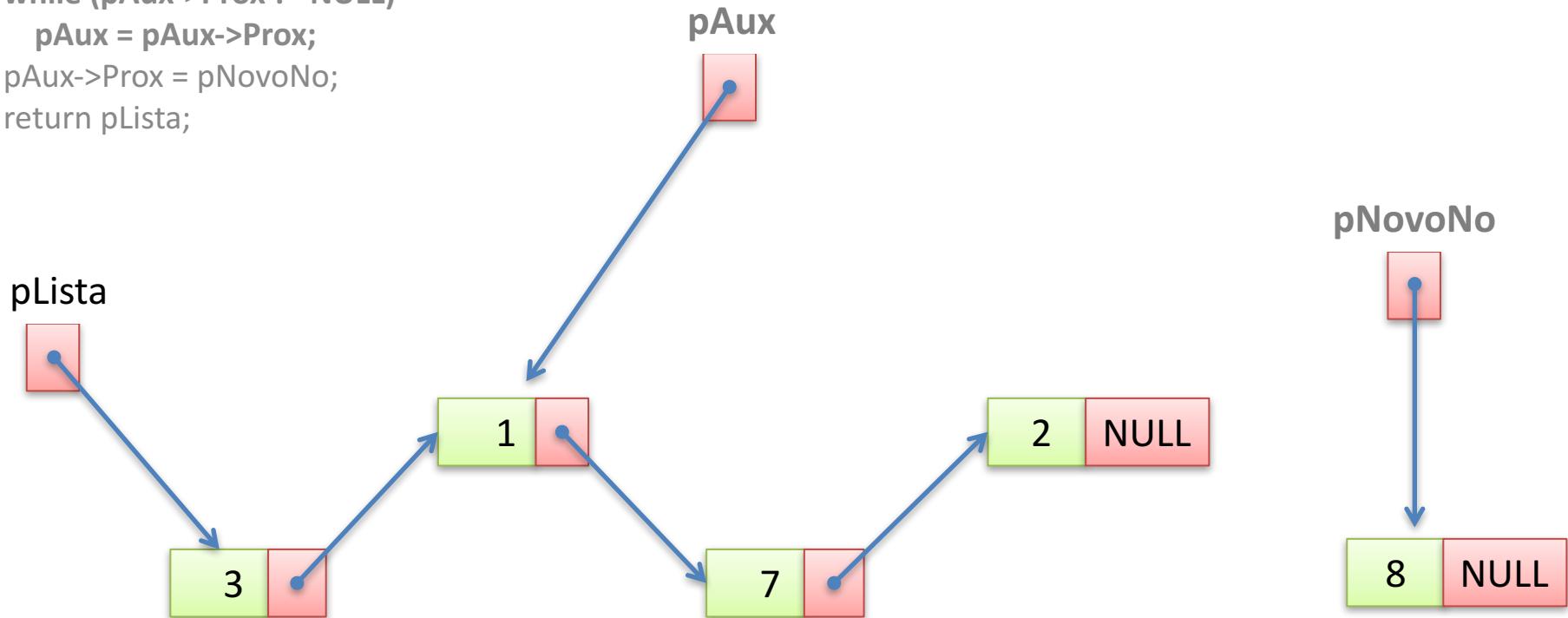
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



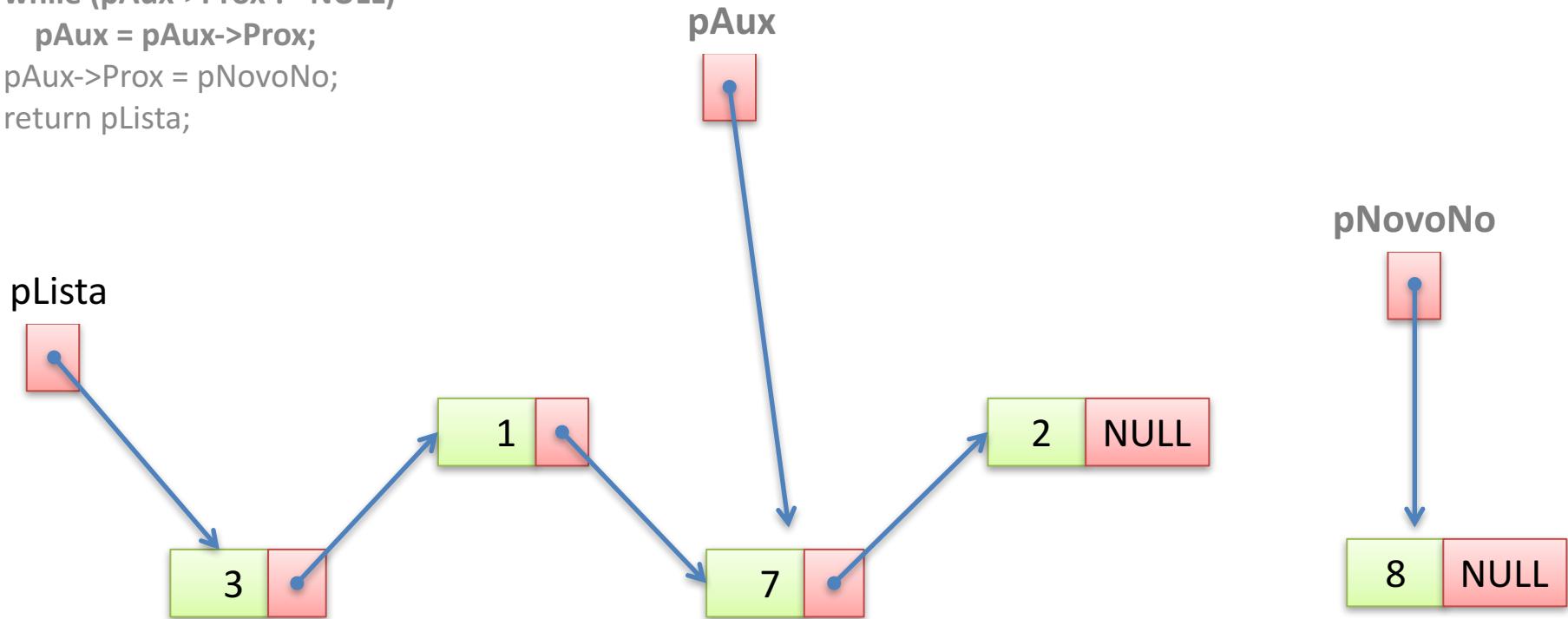
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



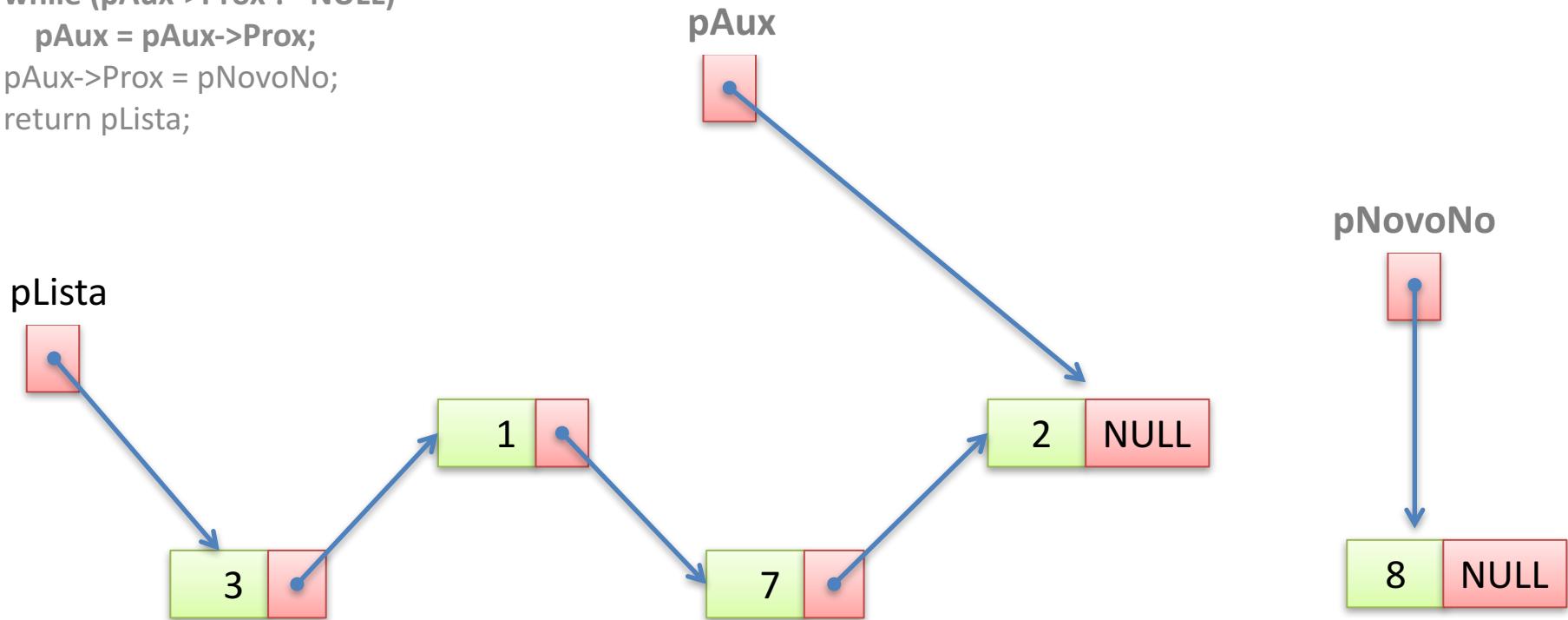
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



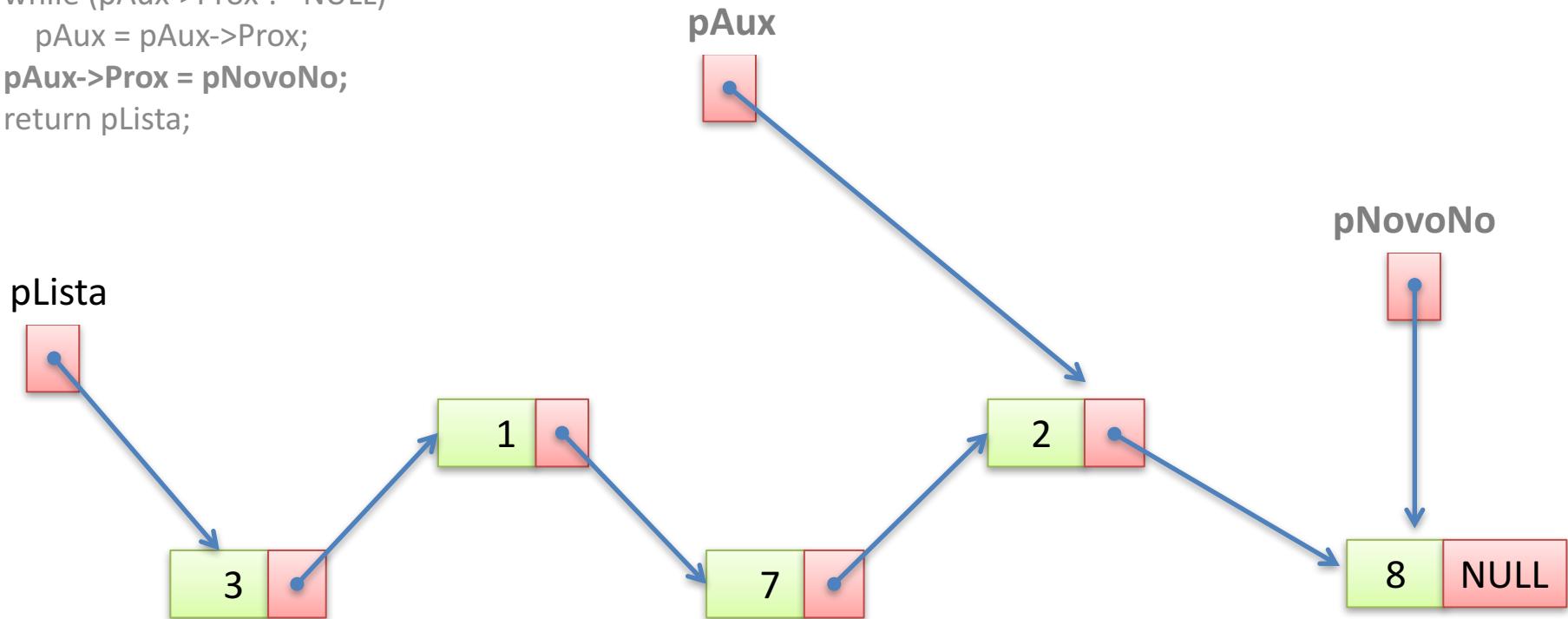
# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



# Lista Encadeada – Inclusão na Calda

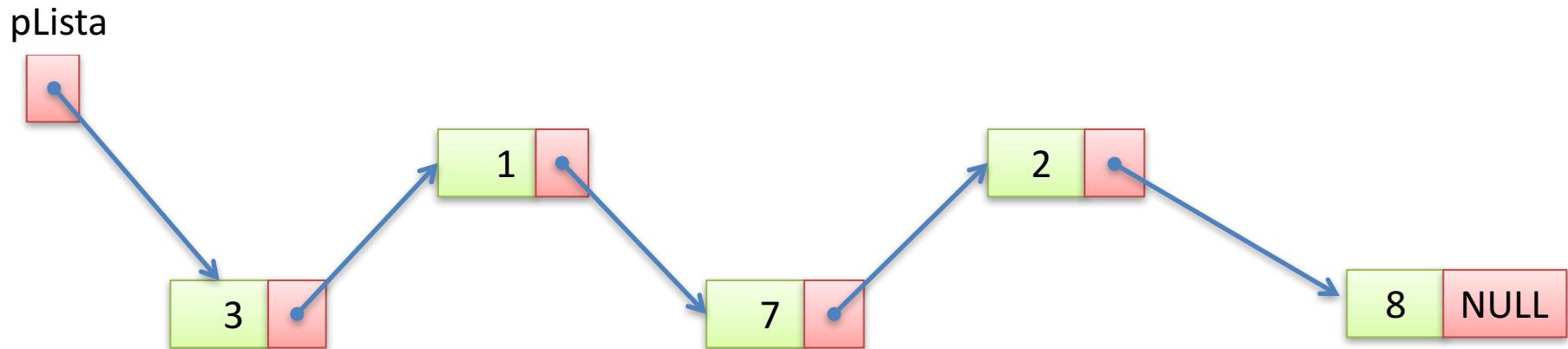
```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```



# Lista Encadeada – Inclusão na Calda

```
TNo *IncluiCalda(TNo *pLista, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pNovoNo->Prox = NULL;
    pAux = pLista;
    while (pAux->Prox != NULL)
        pAux = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**O(n)**

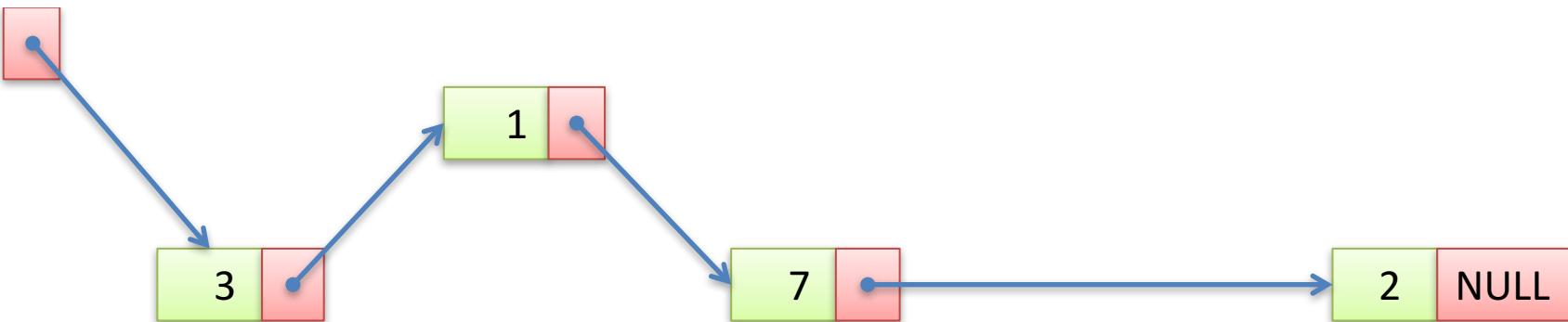


```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
```

```
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

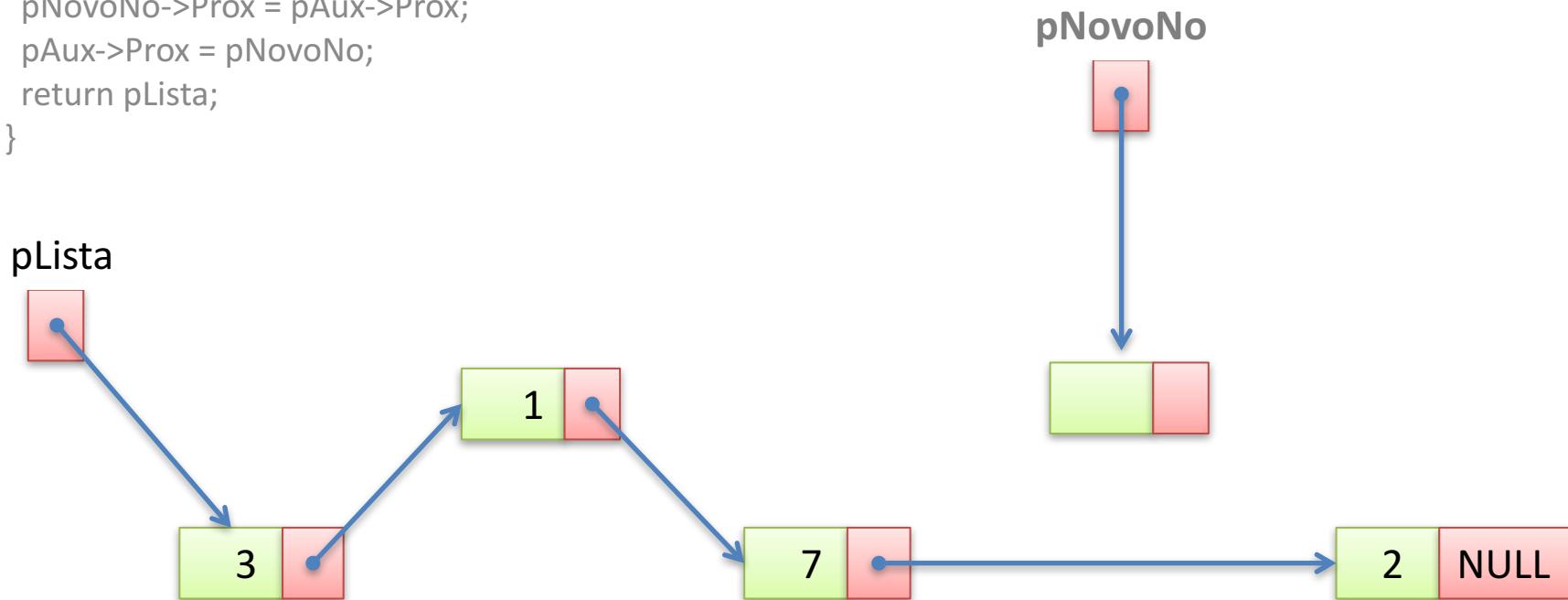
**pChave = 2**

**pLista**



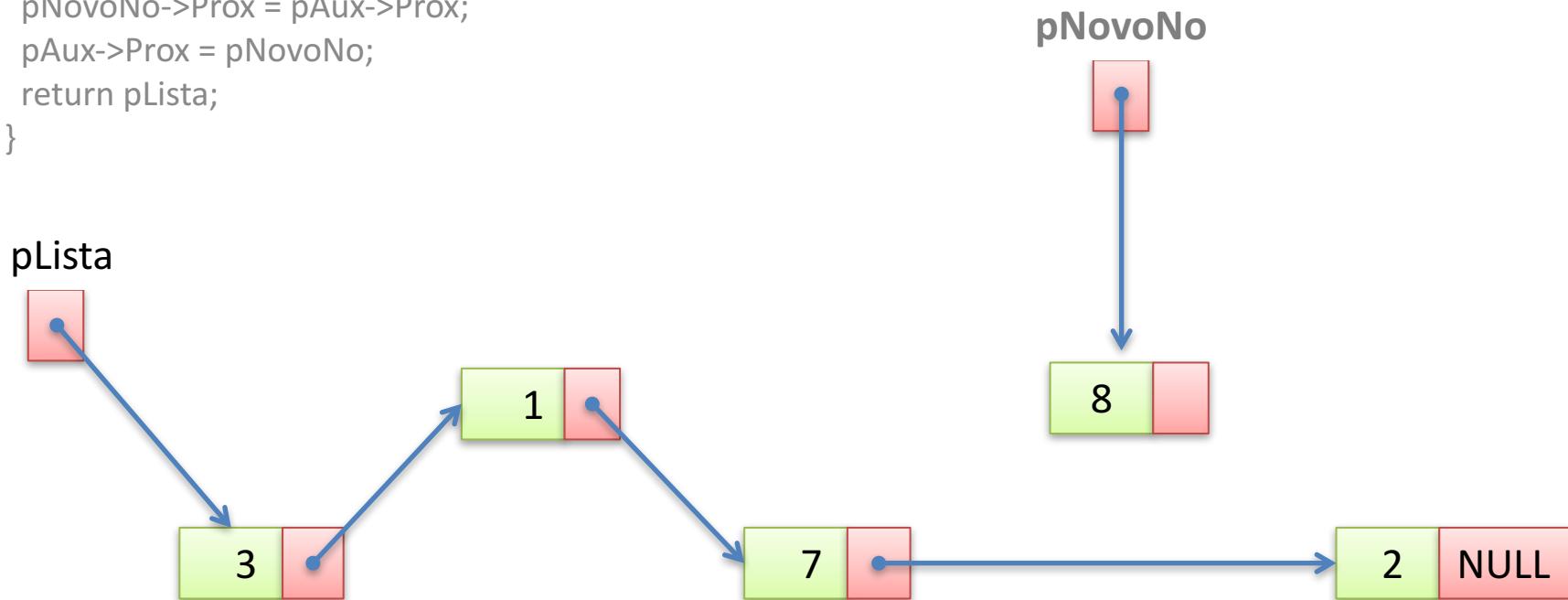
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



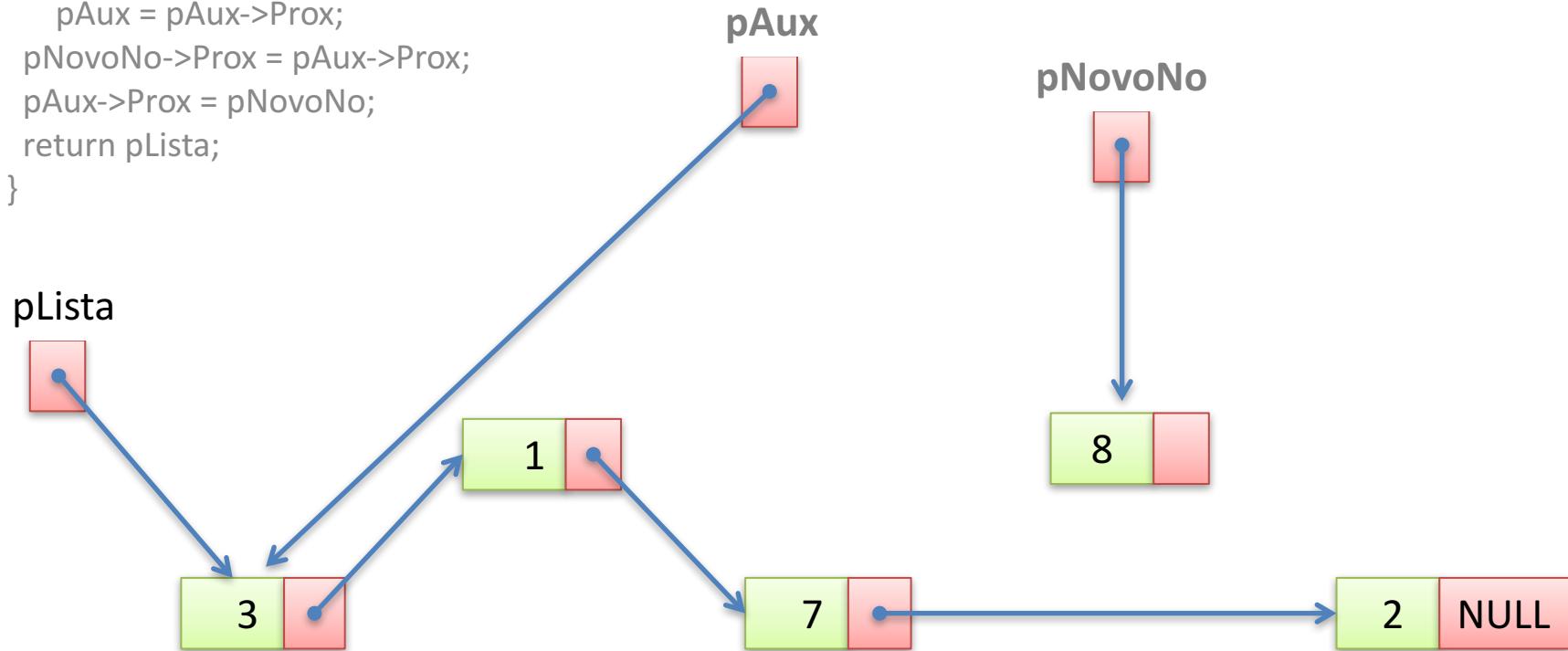
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



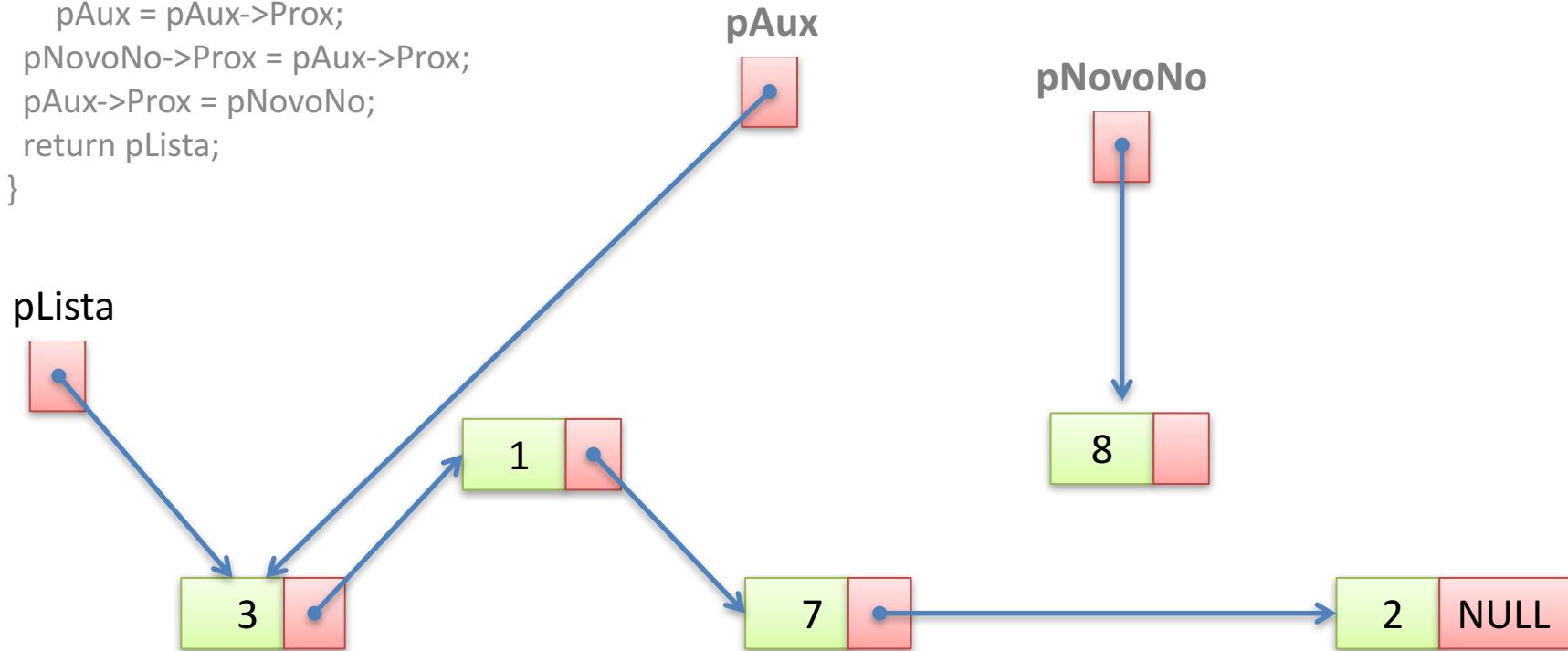
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



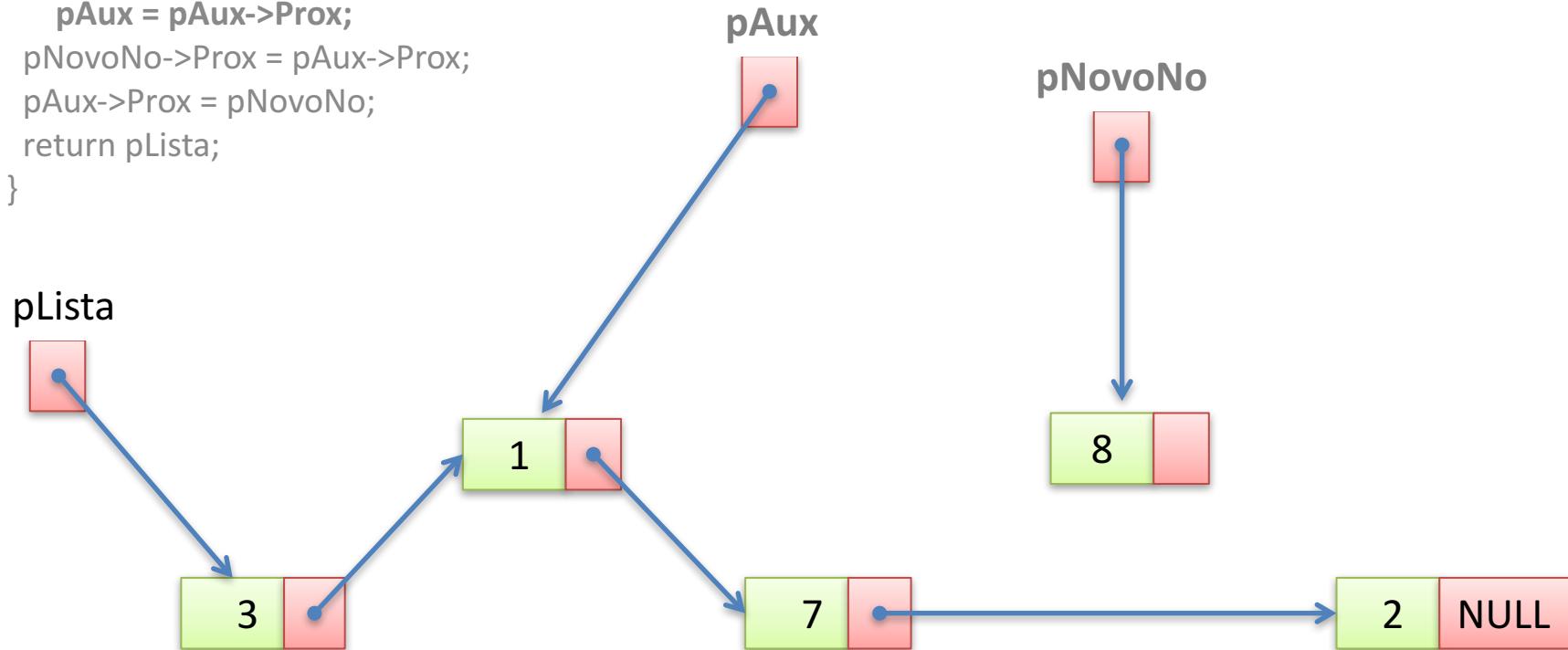
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



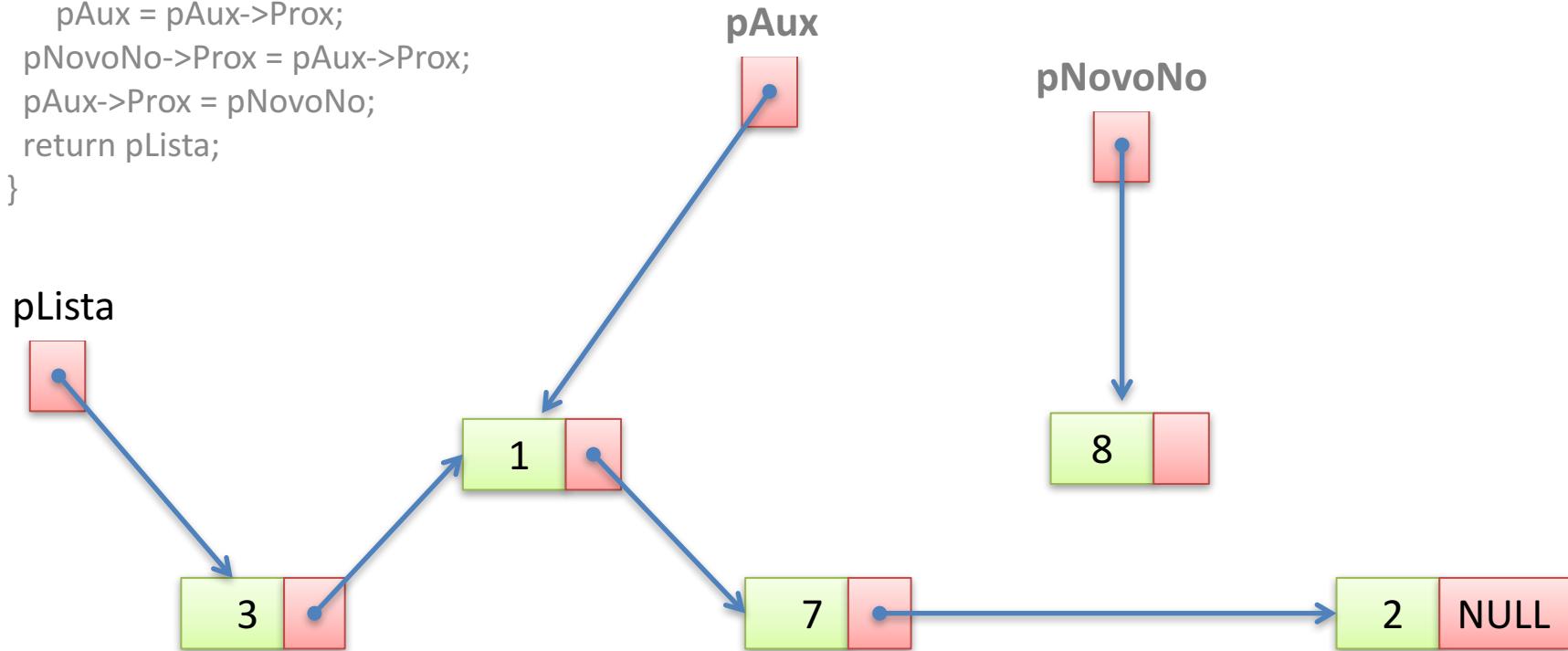
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



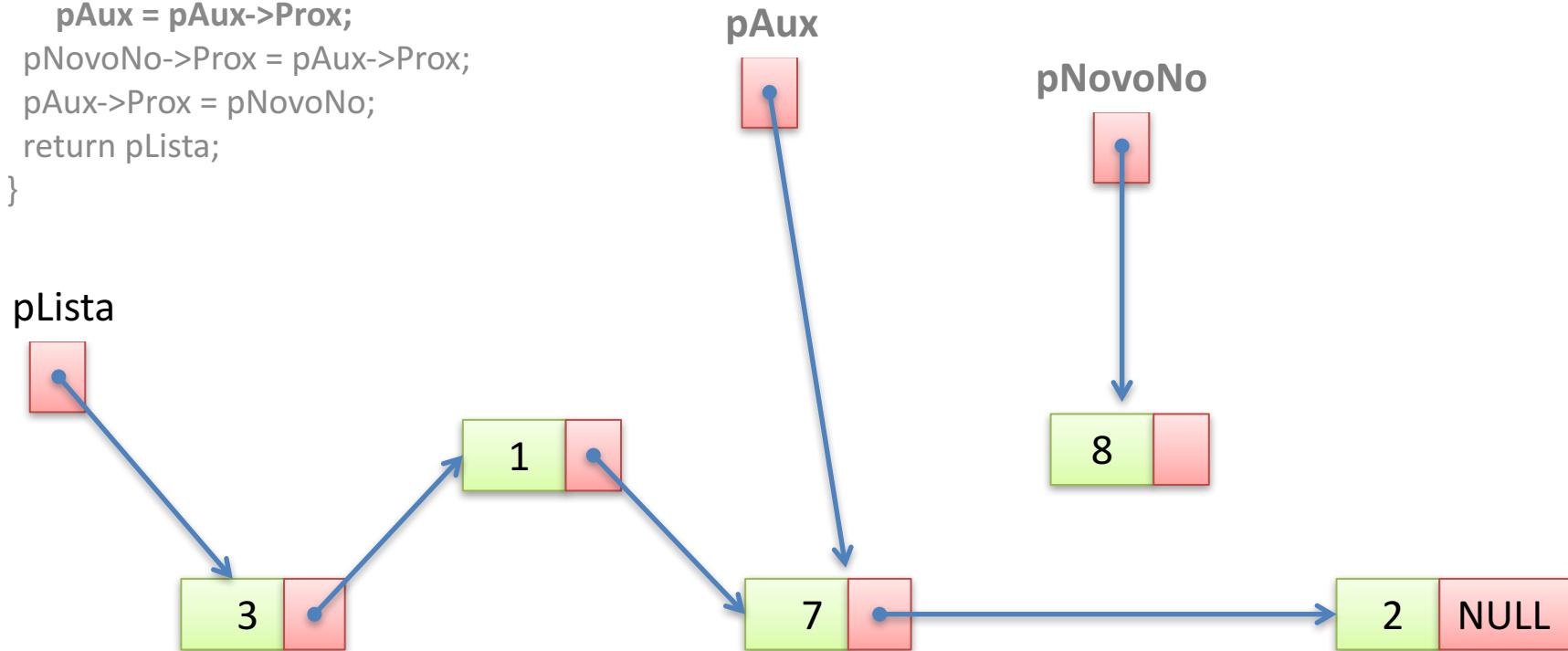
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



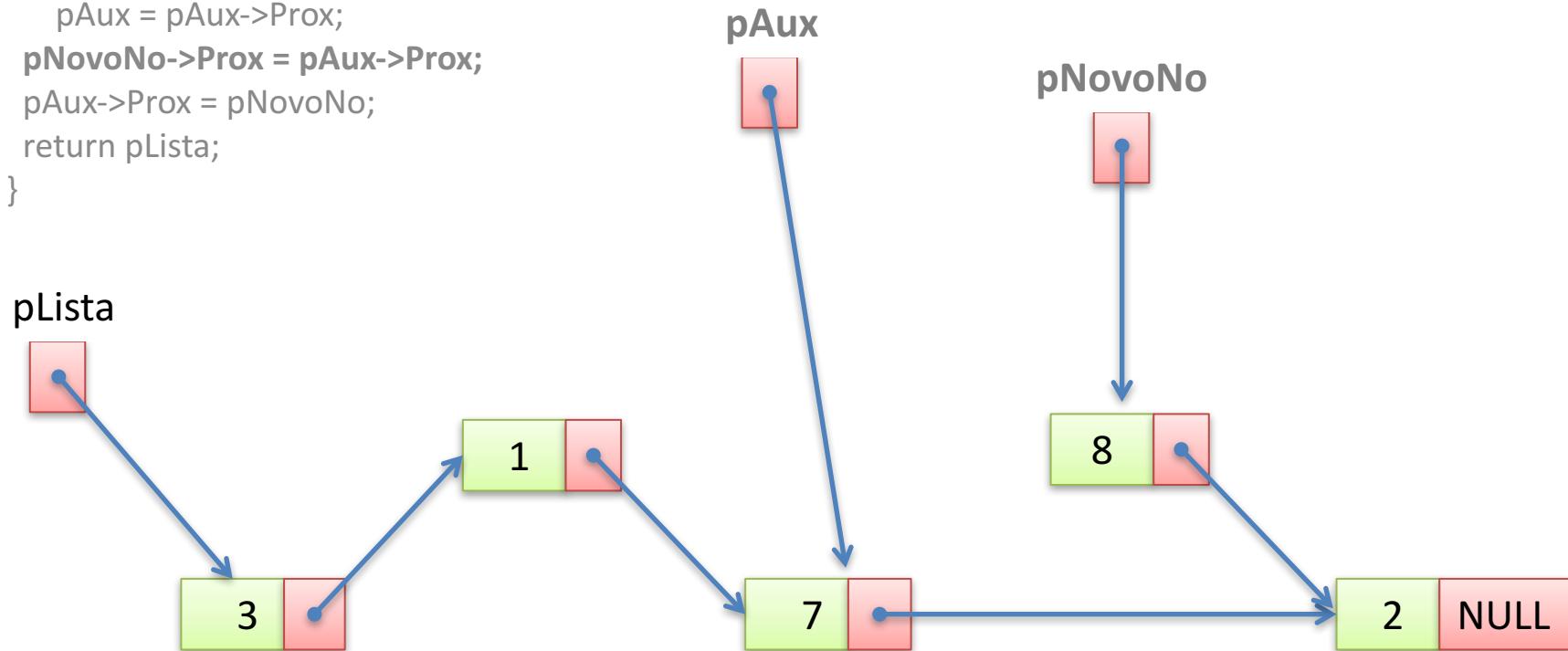
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



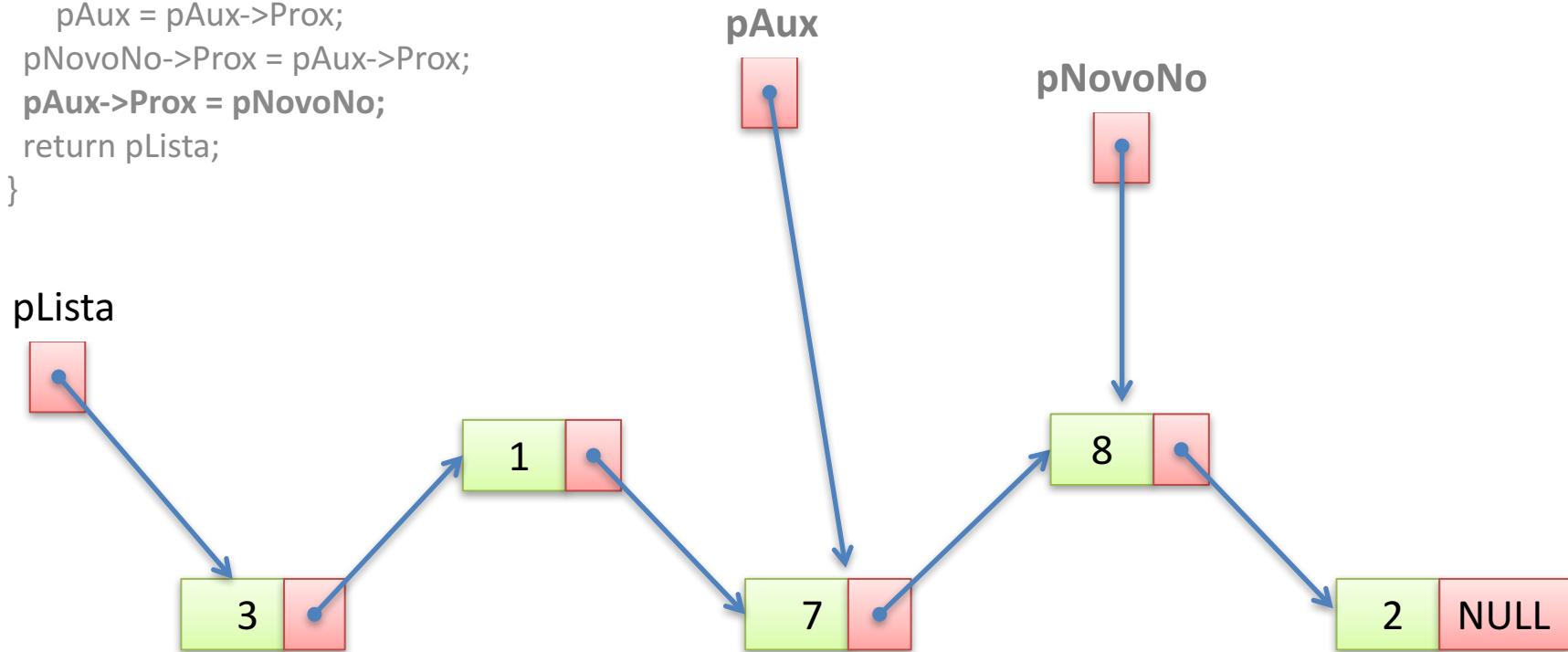
```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**pChave = 2**



```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

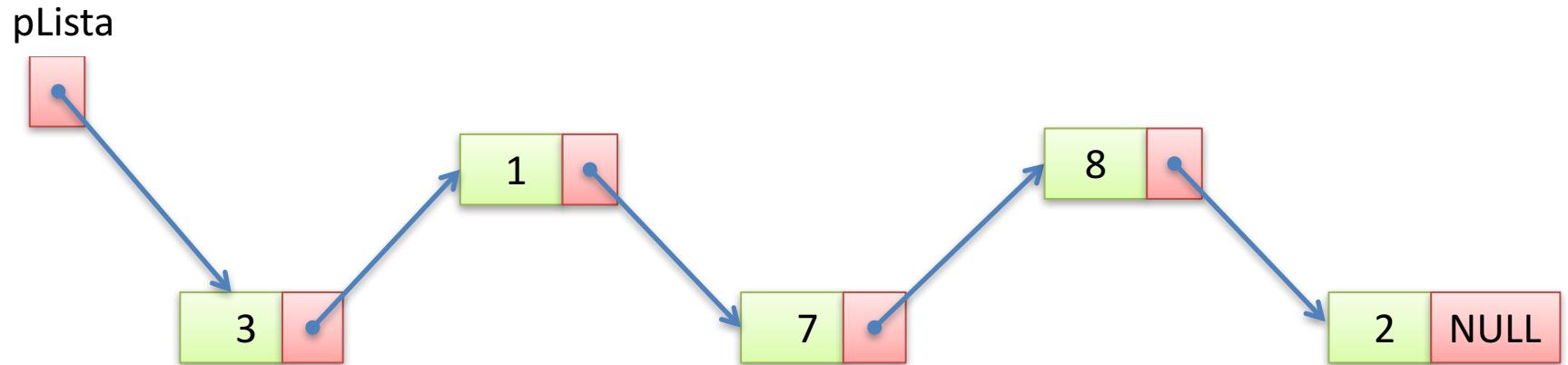
**pChave = 2**



```
TNo *IncluiAntes(TNo *pLista, int pChave, int pValor)
```

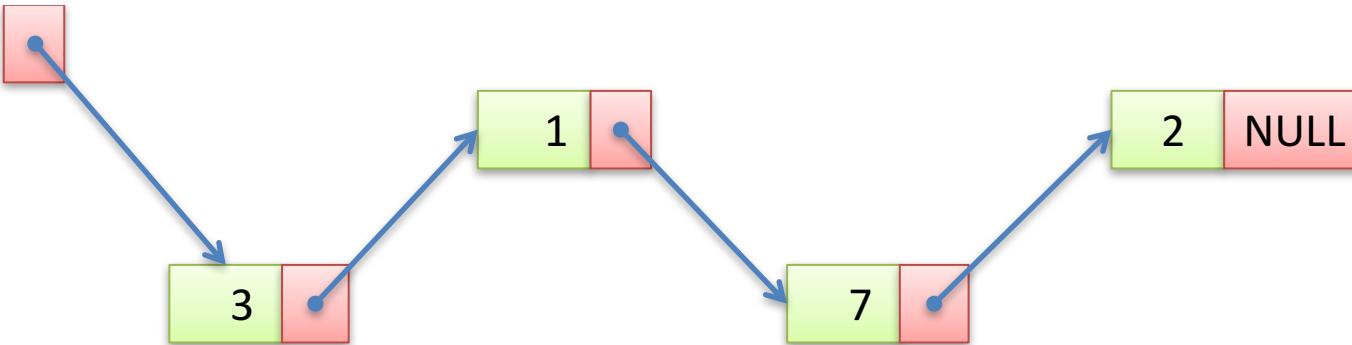
```
{
    TNo *pNovoNo, *pAux;
    pNovoNo = (TNo *) malloc(sizeof(TNo));
    pNovoNo->Numero = pValor;
    pAux = pLista;
    while (pAux->Prox->Valor != pChave)
        pAux = pAux->Prox;
    pNovoNo->Prox = pAux->Prox;
    pAux->Prox = pNovoNo;
    return pLista;
}
```

**O(n)**

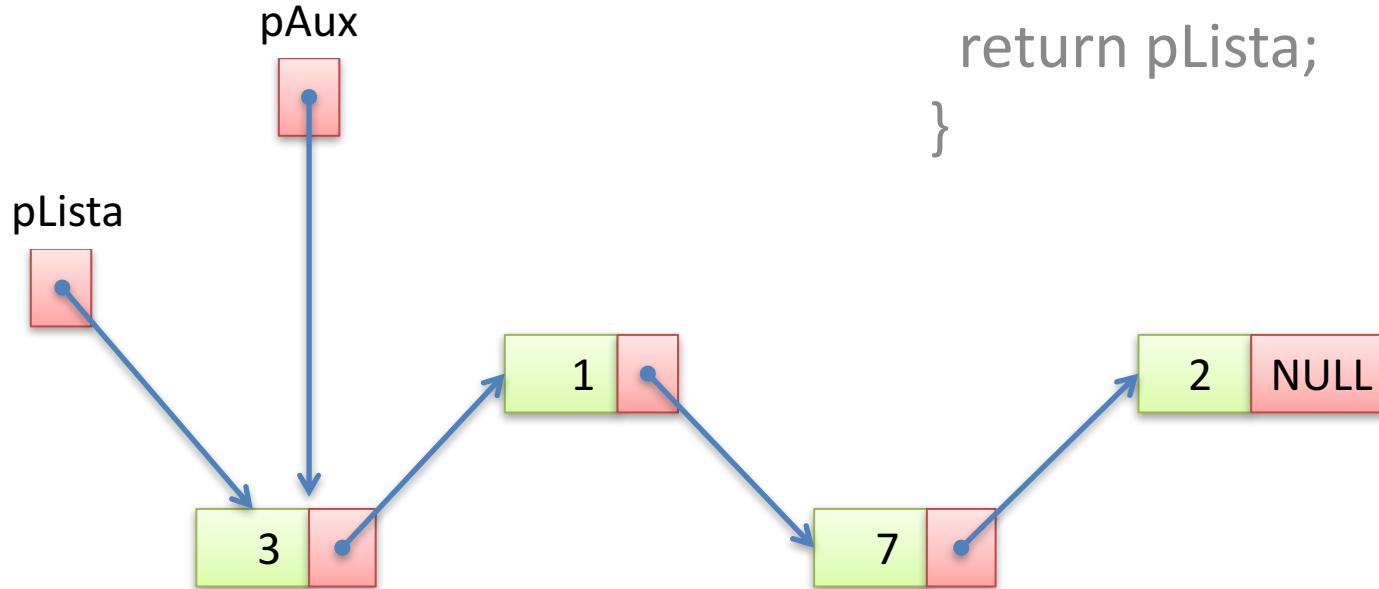


```
TNo *ExcluiCabeca(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    pLista = pLista->Prox;
    free(pAux);
    return pLista;
}
```

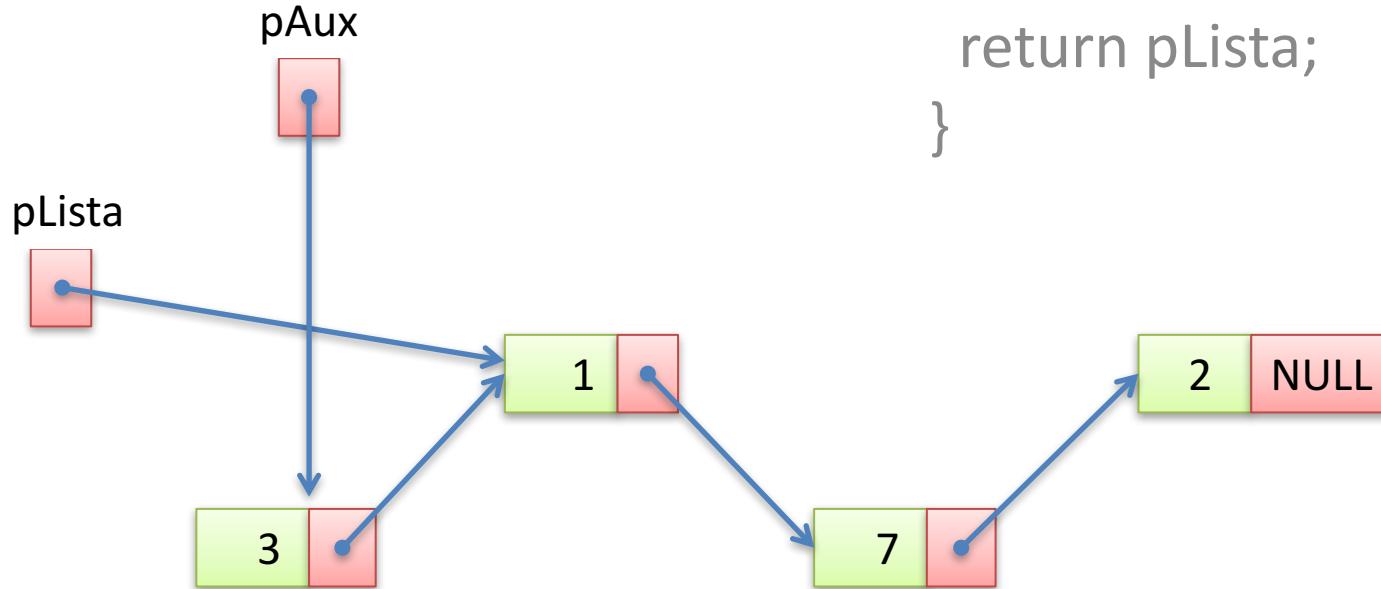
pLista



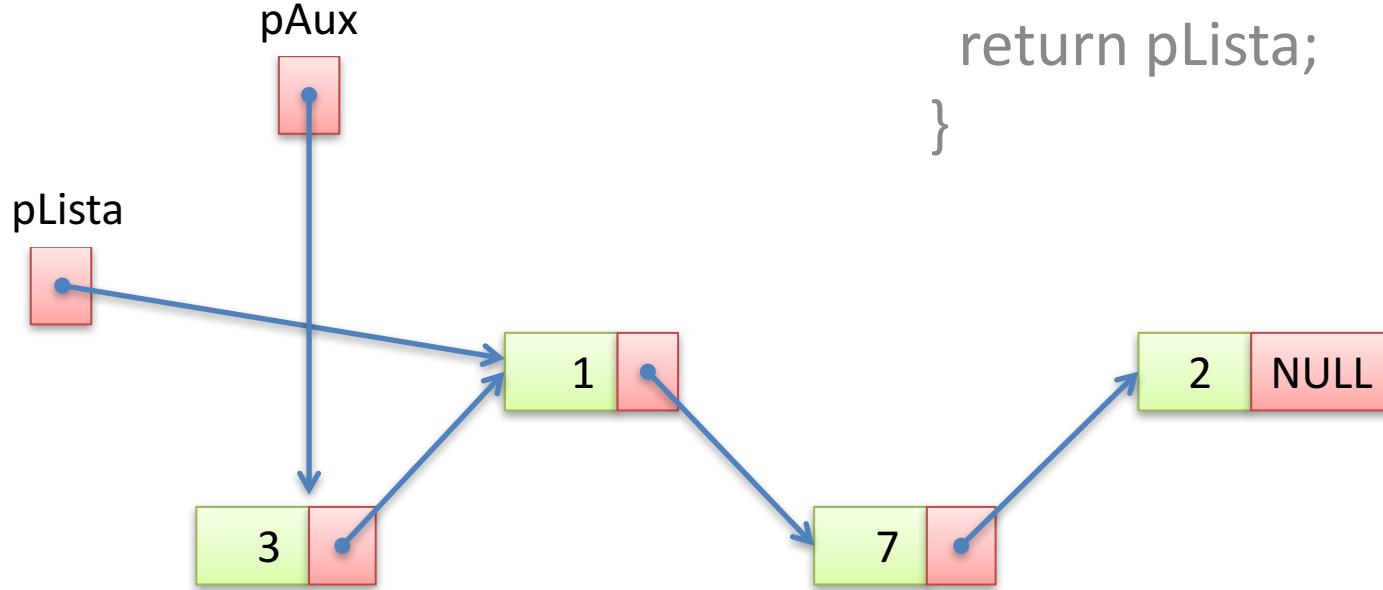
```
TNo *ExcluiCabeca(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    pLista = pLista->Prox;
    free(pAux);
    return pLista;
}
```



```
TNo *ExcluiCabeca(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    pLista = pLista->Prox;
    free(pAux);
    return pLista;
}
```

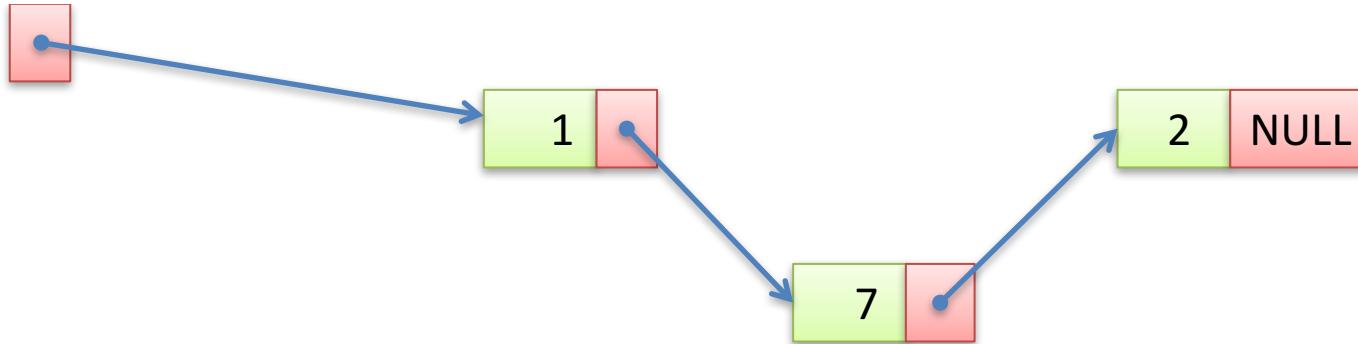


```
TNo *ExcluiCabeca(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    pLista = pLista->Prox;
    free(pAux);
    return pLista;
}
```



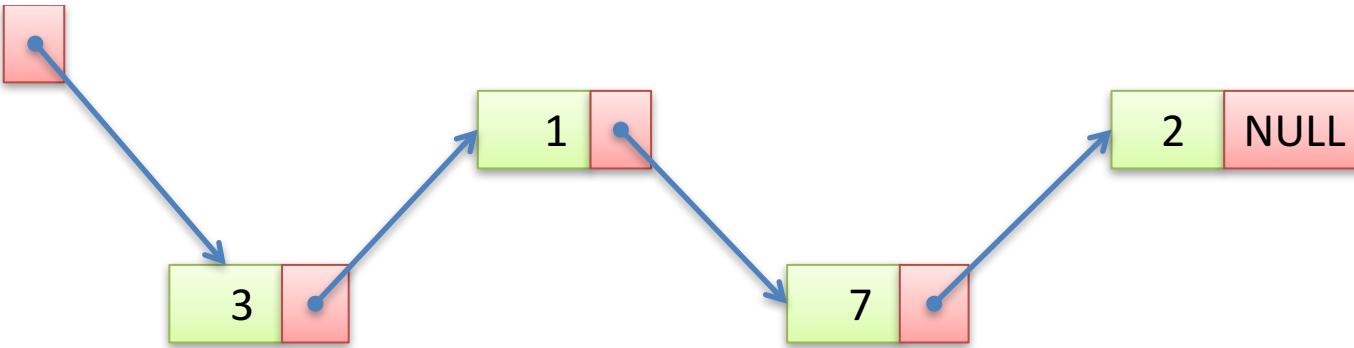
```
TNo *ExcluiCabeca(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    pLista = pLista->Prox;
    free(pAux);
    return pLista;
}
```

pLista

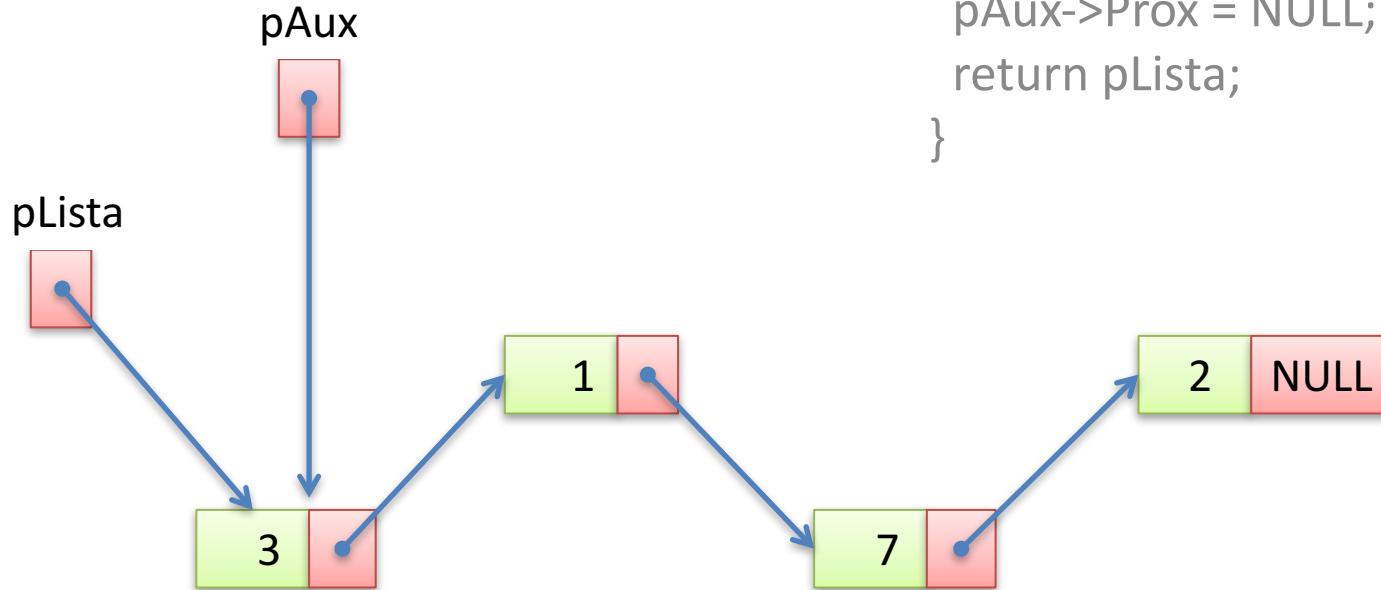


```
TNo *ExcluiCauda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```

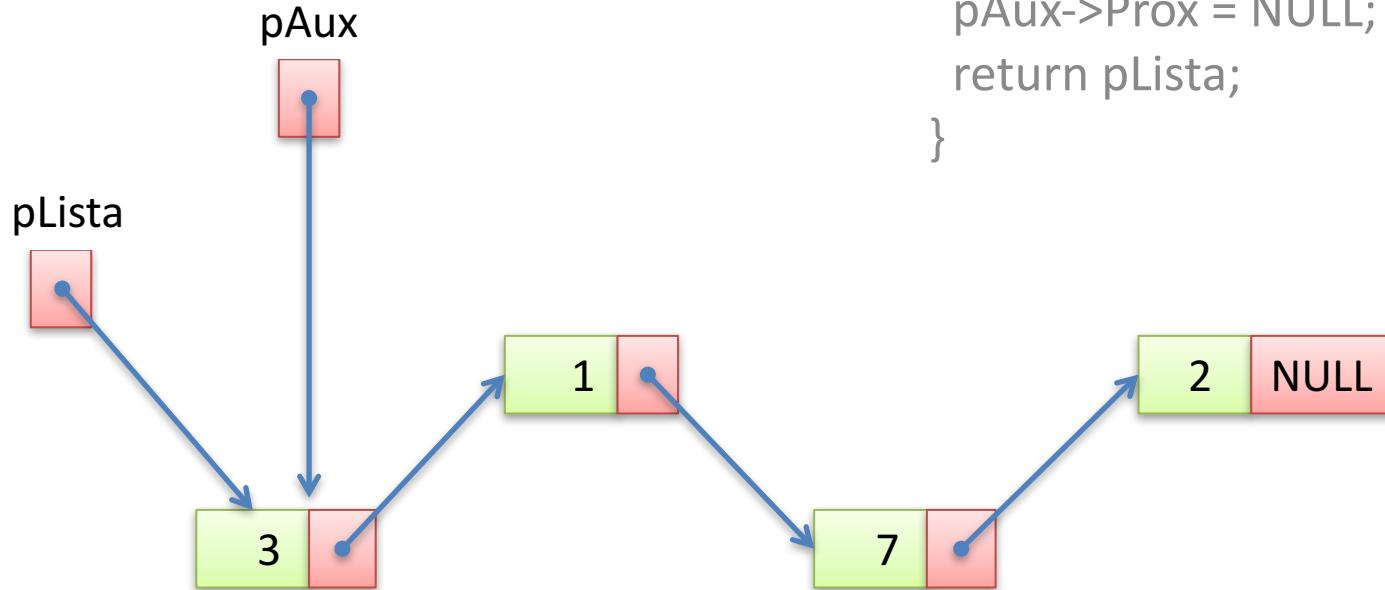
pLista



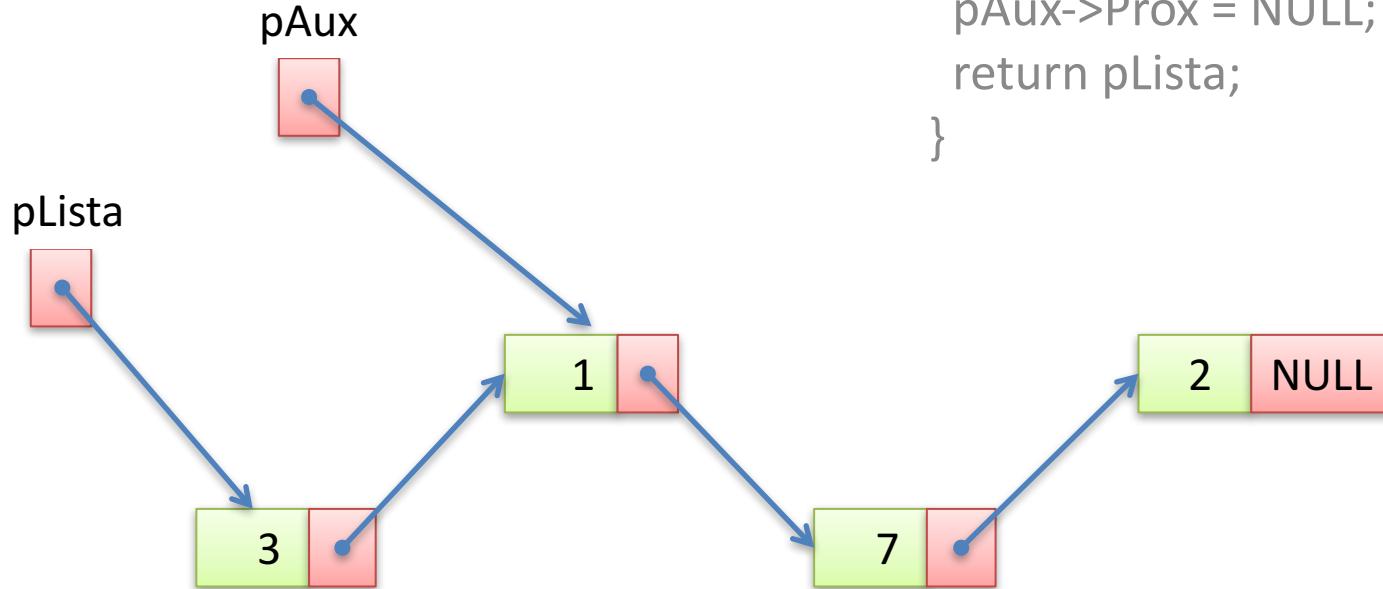
```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```



```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```

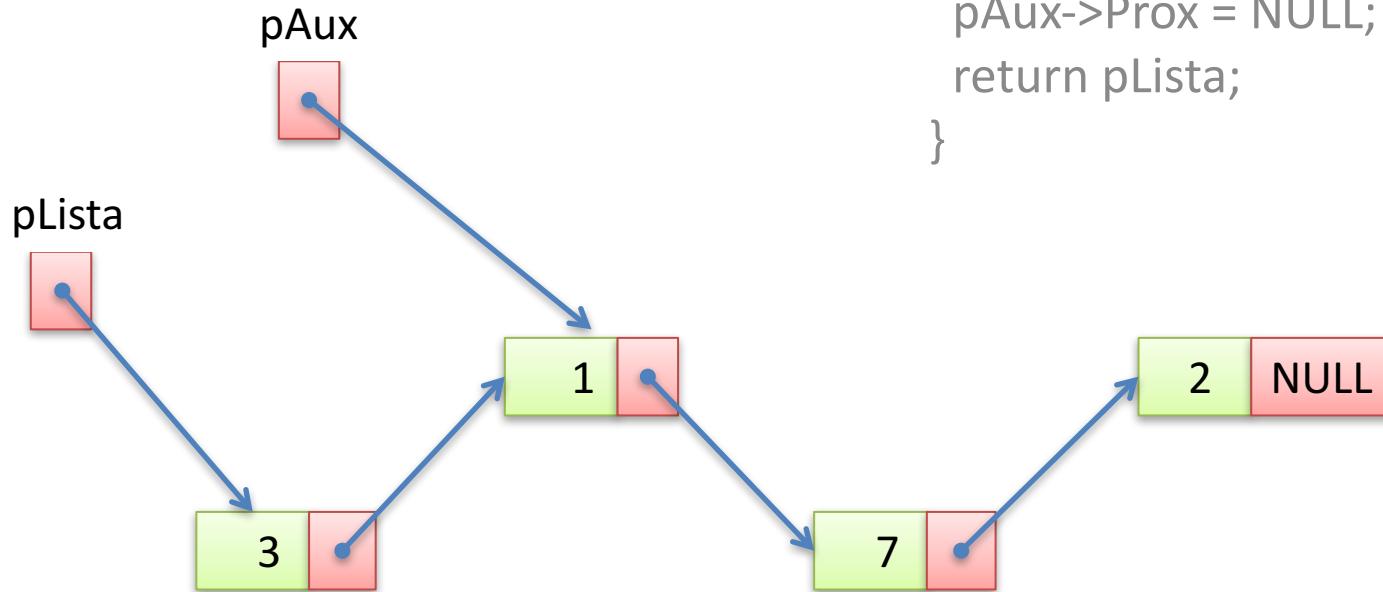


```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```

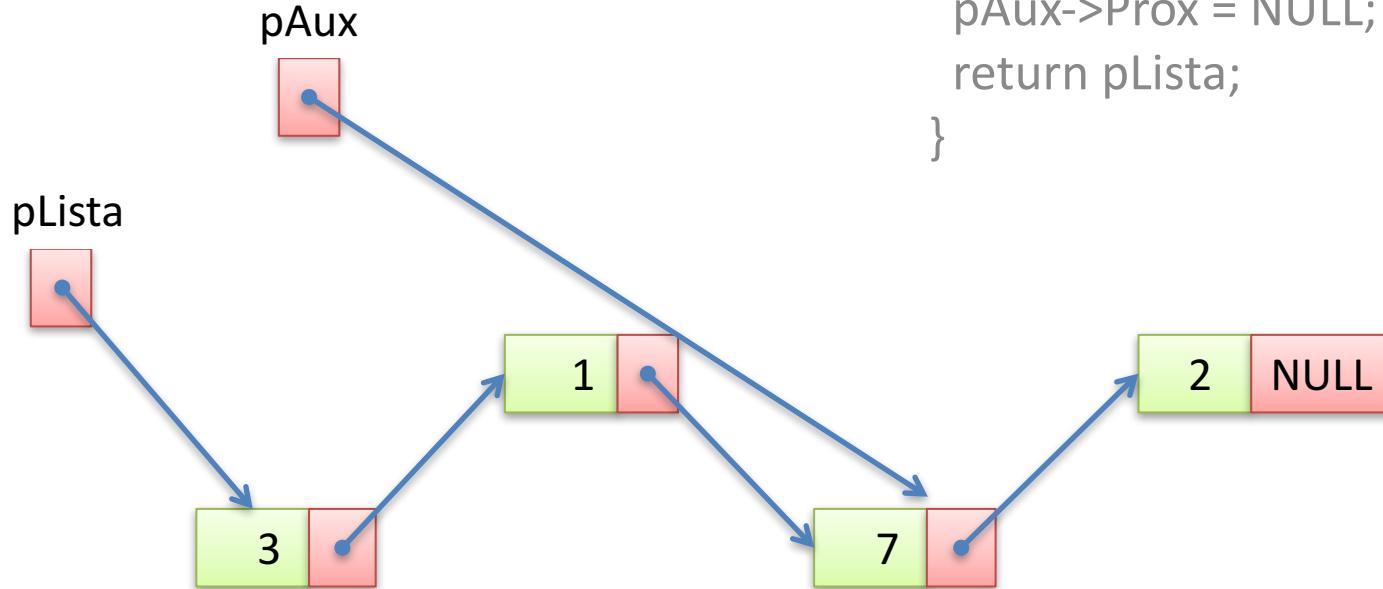


```

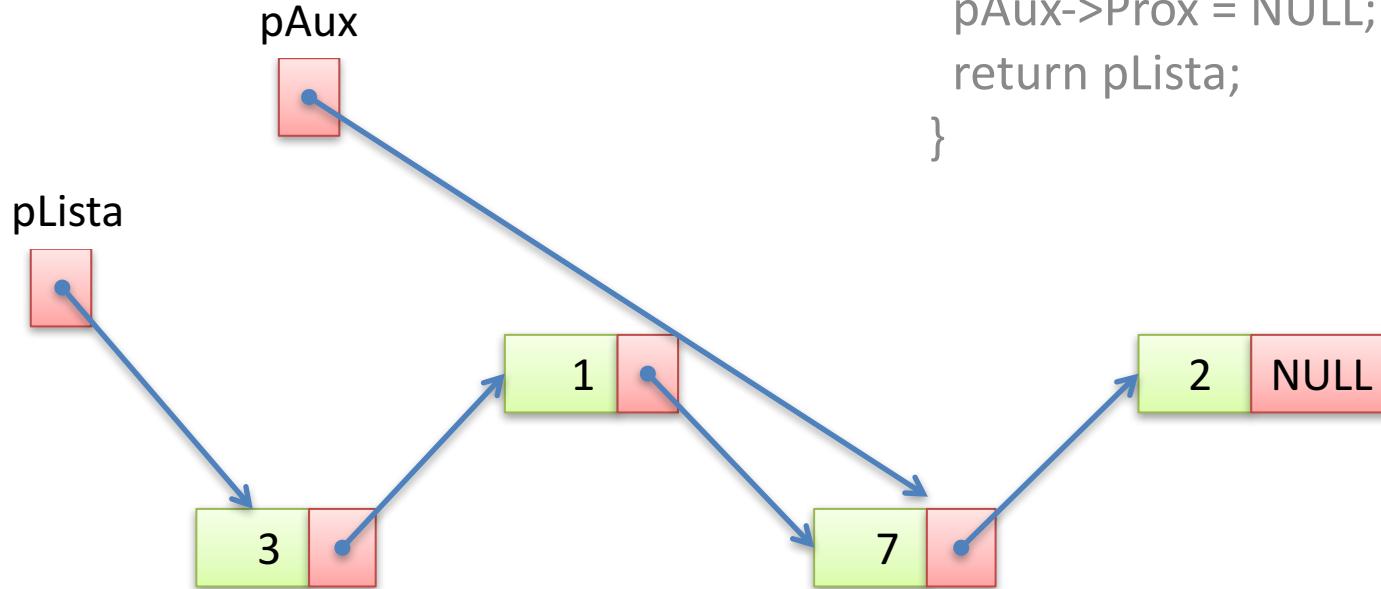
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
  
```



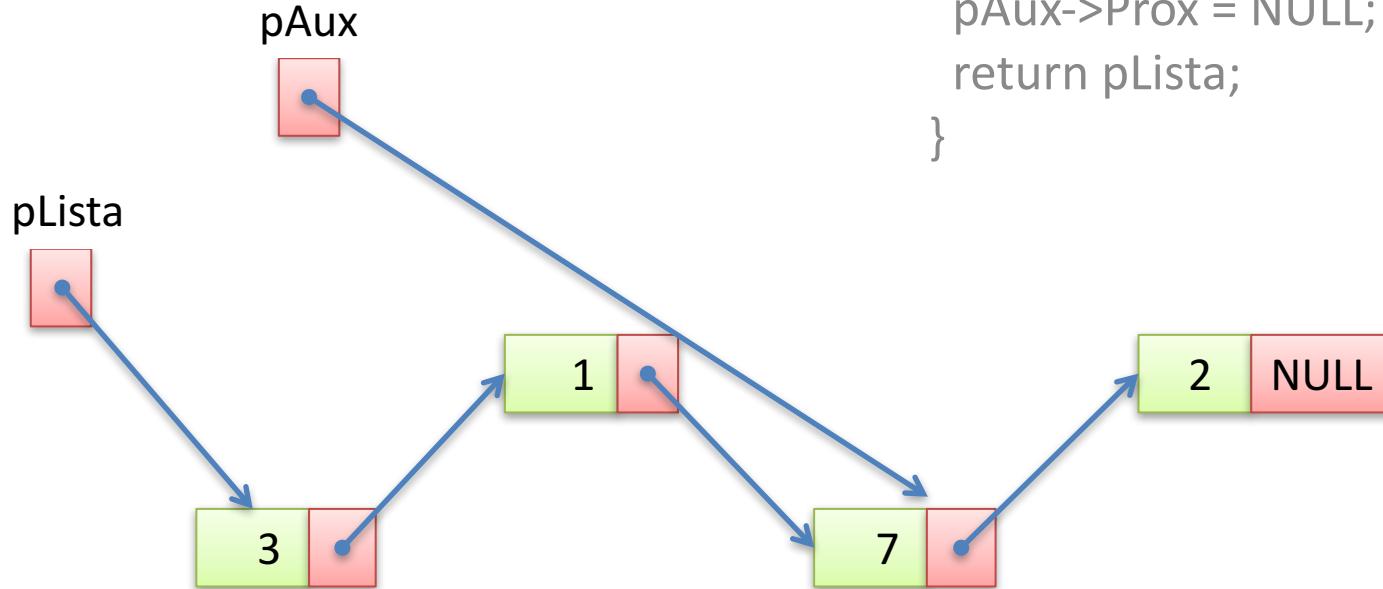
```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```



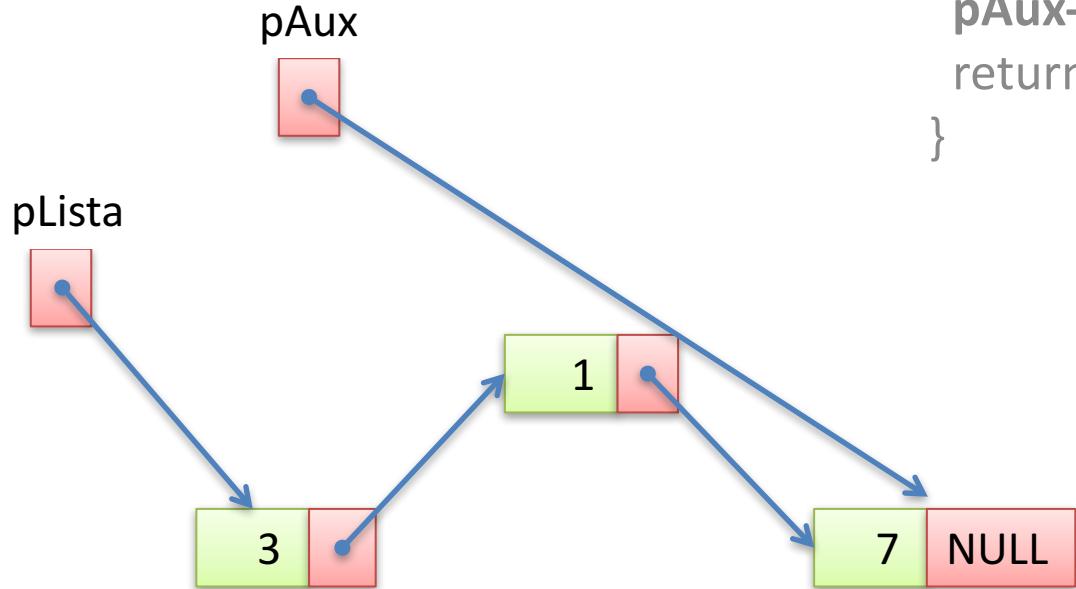
```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```



```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```

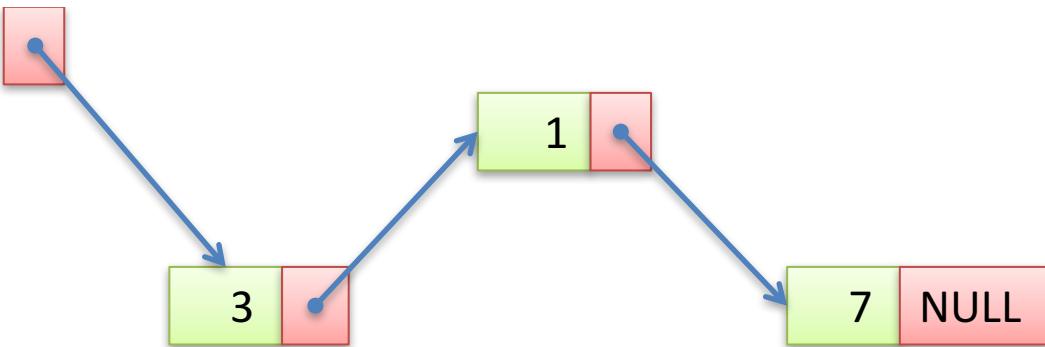


```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```



```
TNo *ExcluiCalda(TNo *pLista)
{
    TNo *pAux;
    pAux = pLista;
    while (pAux->Prox->Prox != NULL)
        pAux = pAux->Prox;
    free(pAux->Prox);
    pAux->Prox = NULL;
    return pLista;
}
```

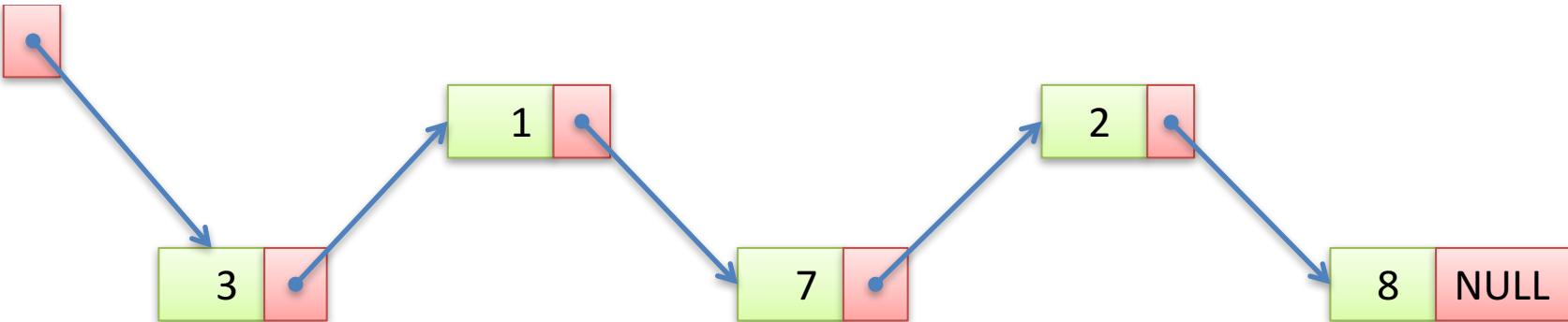
pLista



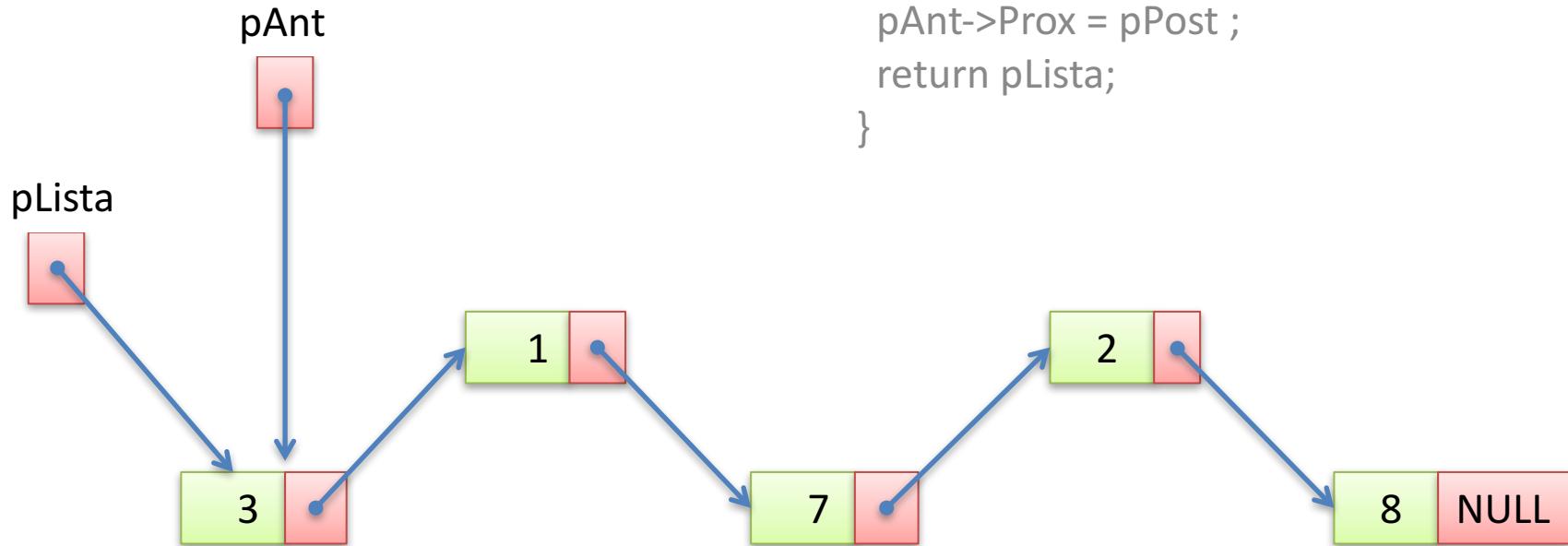
pChave = 7

```
TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
```

pLista

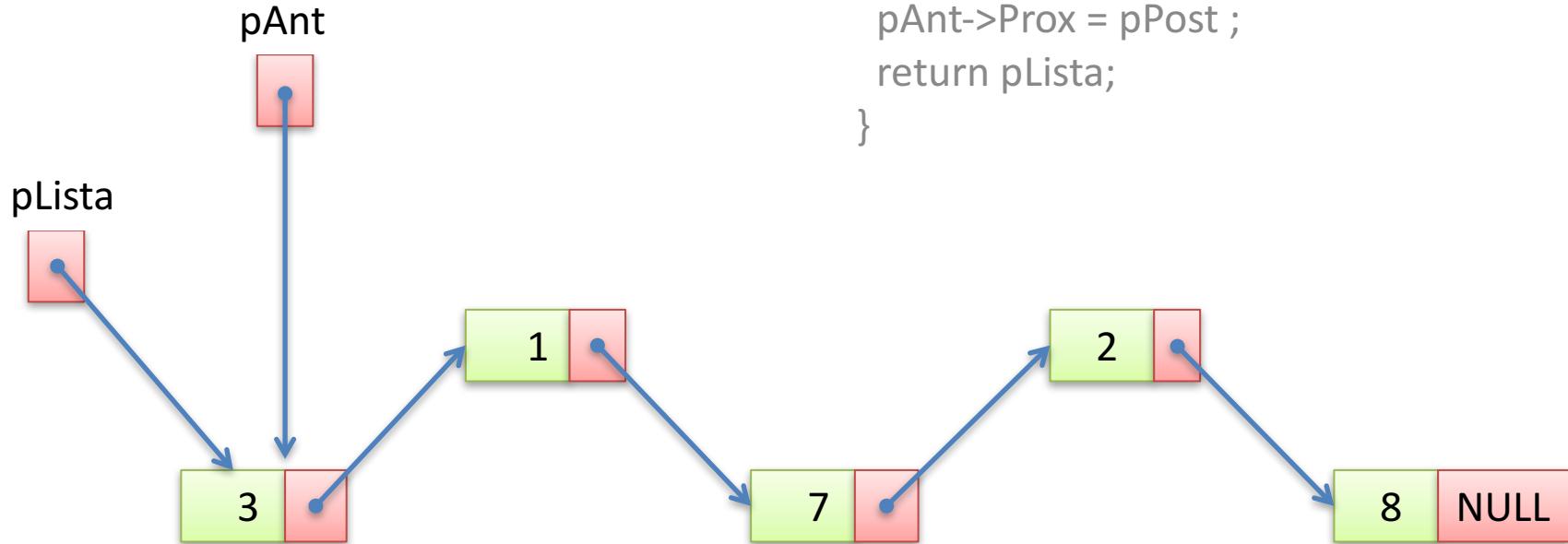


pChave = 7



```
TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
```

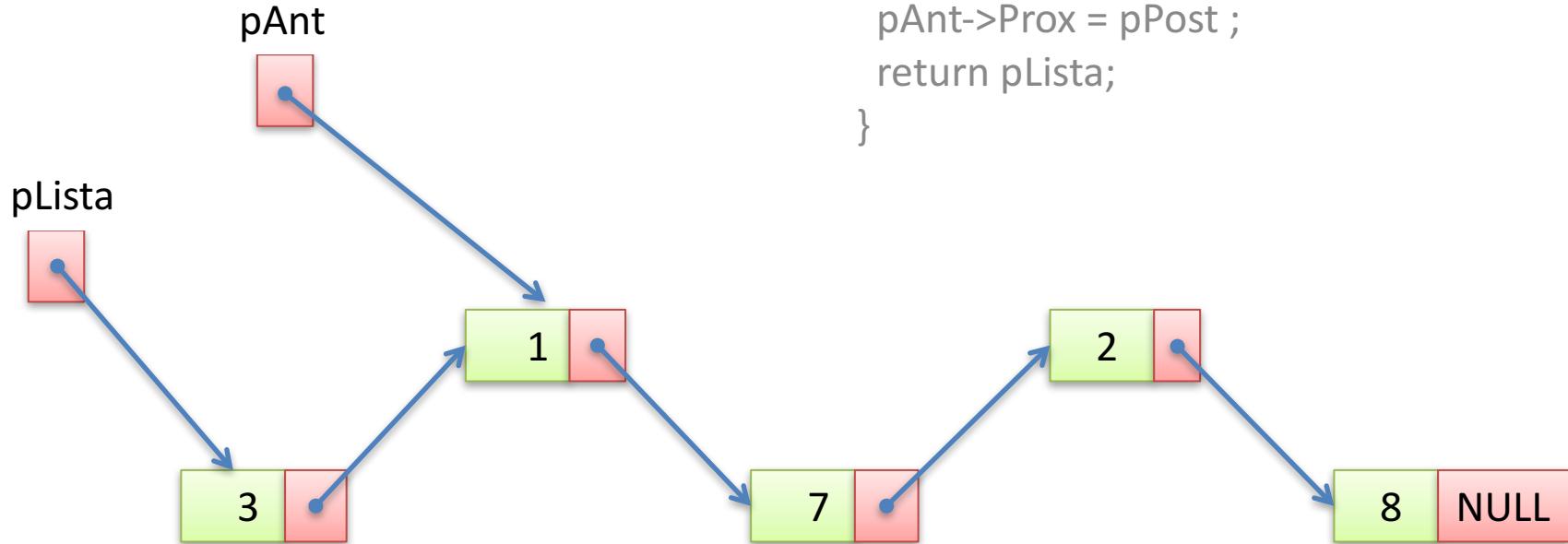
pChave = 7



```

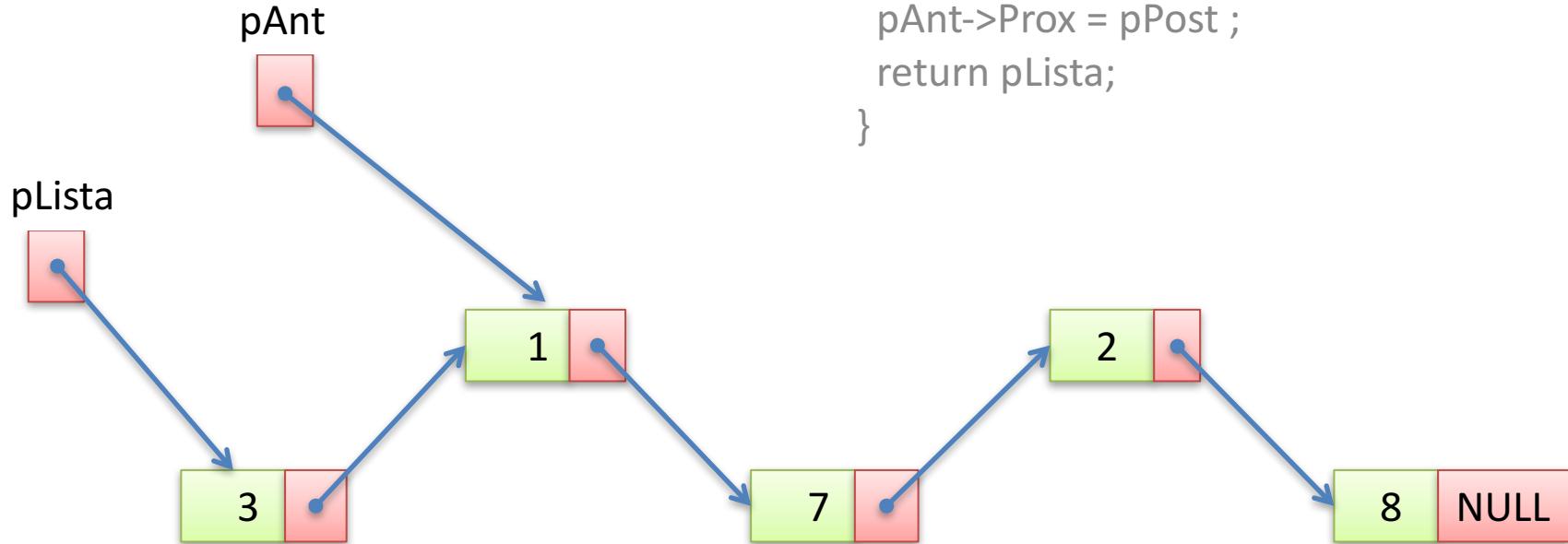
TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
    
```

pChave = 7



```
TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
```

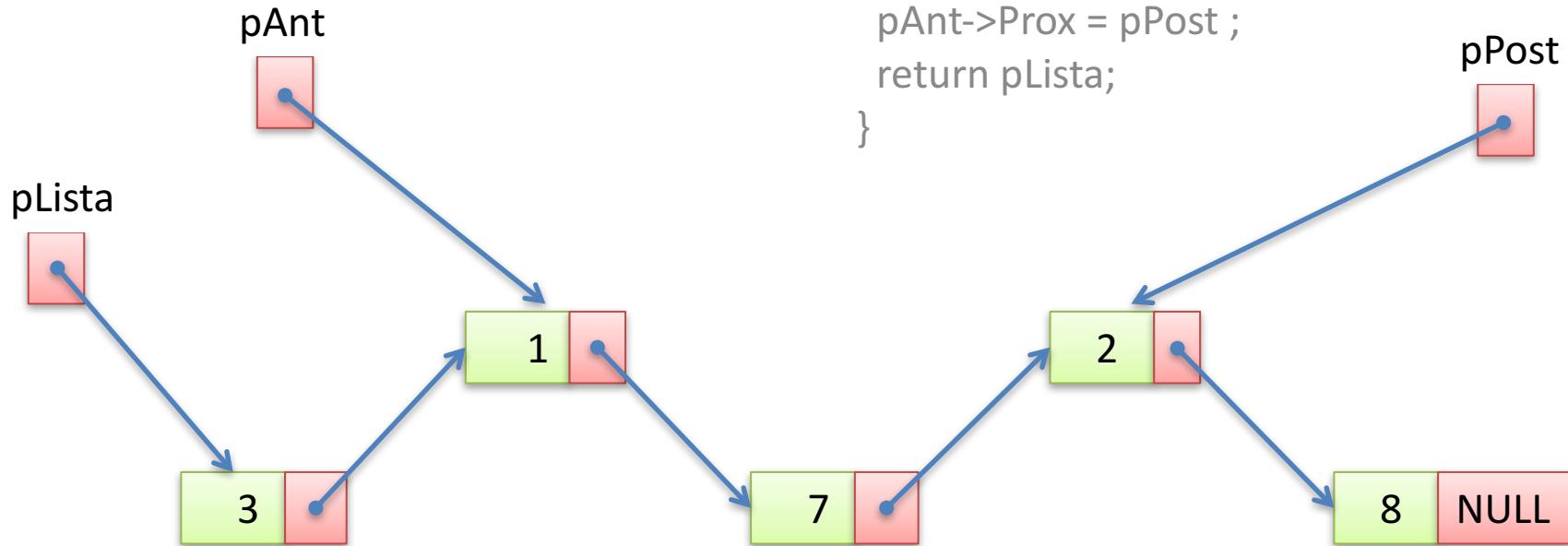
pChave = 7



```

TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
  
```

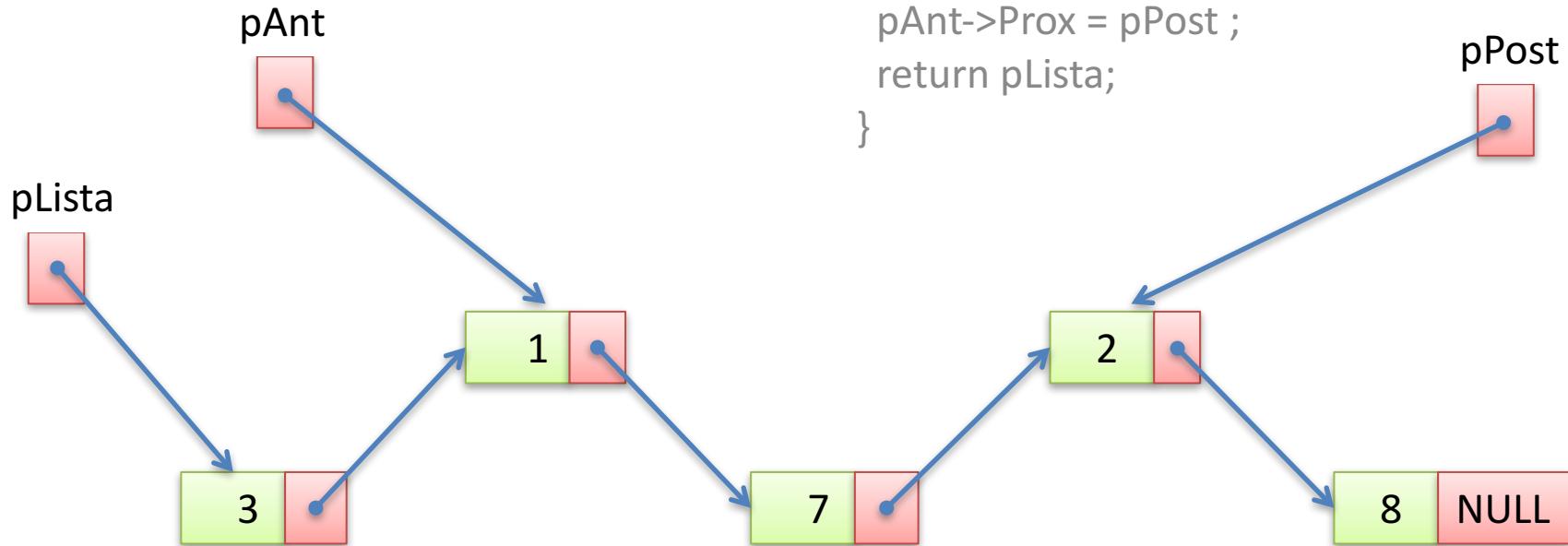
pChave = 7



```

TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
  
```

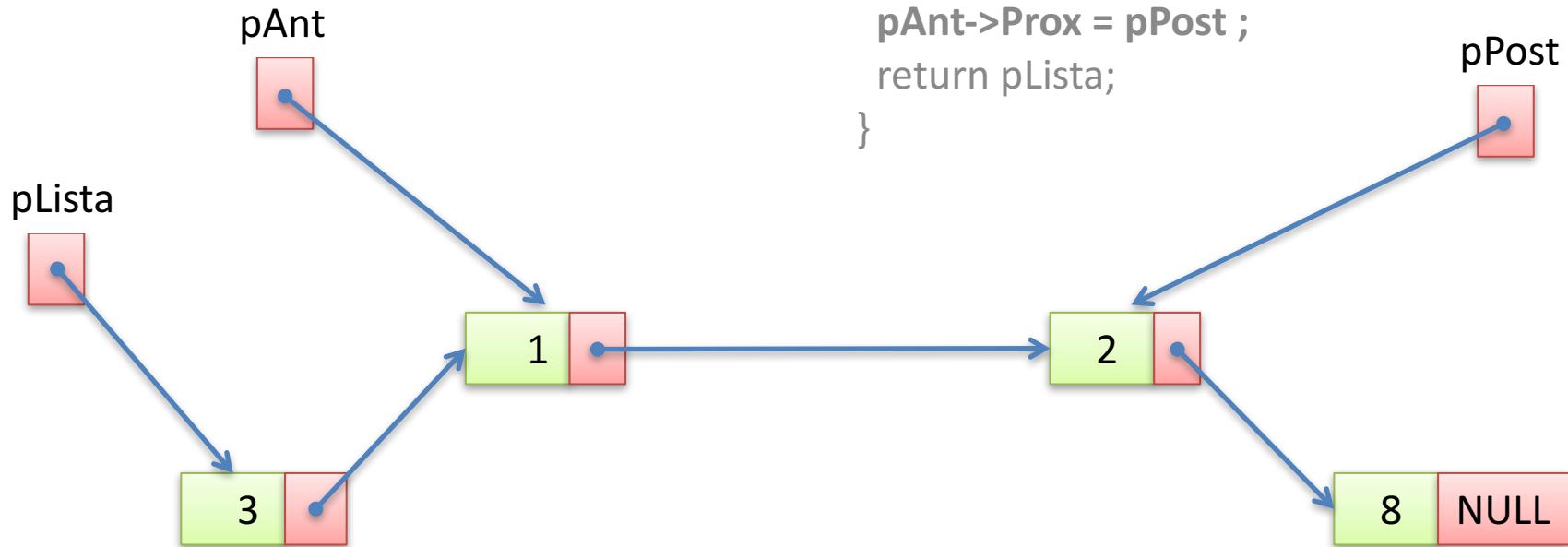
pChave = 7



```

TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
  
```

pChave = 7

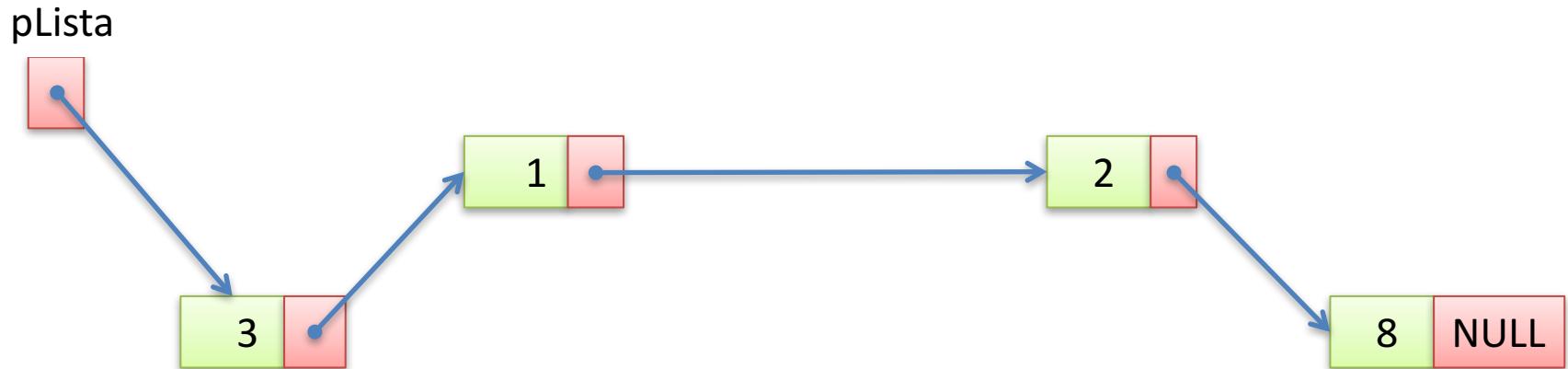


```

TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
  
```

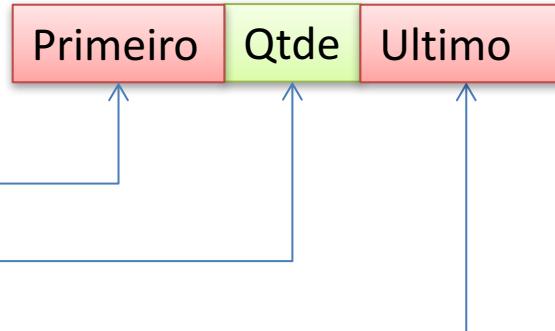
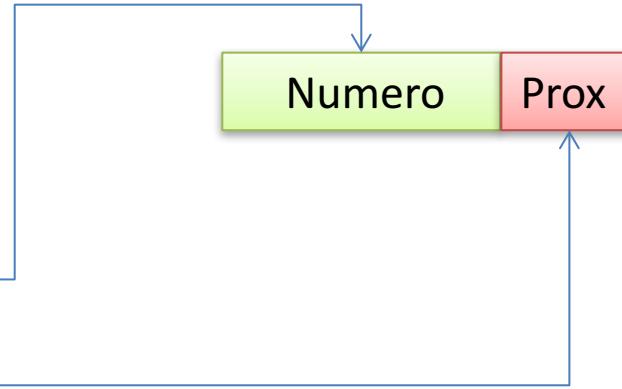
pChave = 7

```
TNo *ExcluiChave(TNo *pLista, int pChave)
{
    TNo *pAnt, *pPost;
    pAnt = pLista;
    while (pAnt->Prox->Numero != pChave)
        pAnt = pAnt->Prox;
    pPost = pAnt->Prox->Prox;
    free(pAnt->Prox);
    pAnt->Prox = pPost ;
    return pLista;
}
```



```
struct TNo
{
    int Numero;
    TNo *Prox;
};
```

```
struct TLista
{
    TNo *Primeiro;
    int Qtde;
    TNo *Ultimo;
};
```



# Lista Encadeada

