Const Correctness

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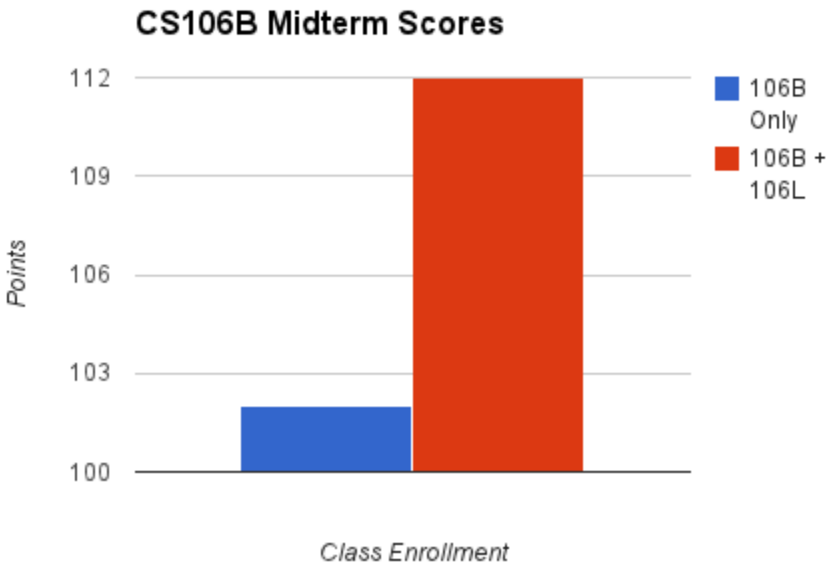
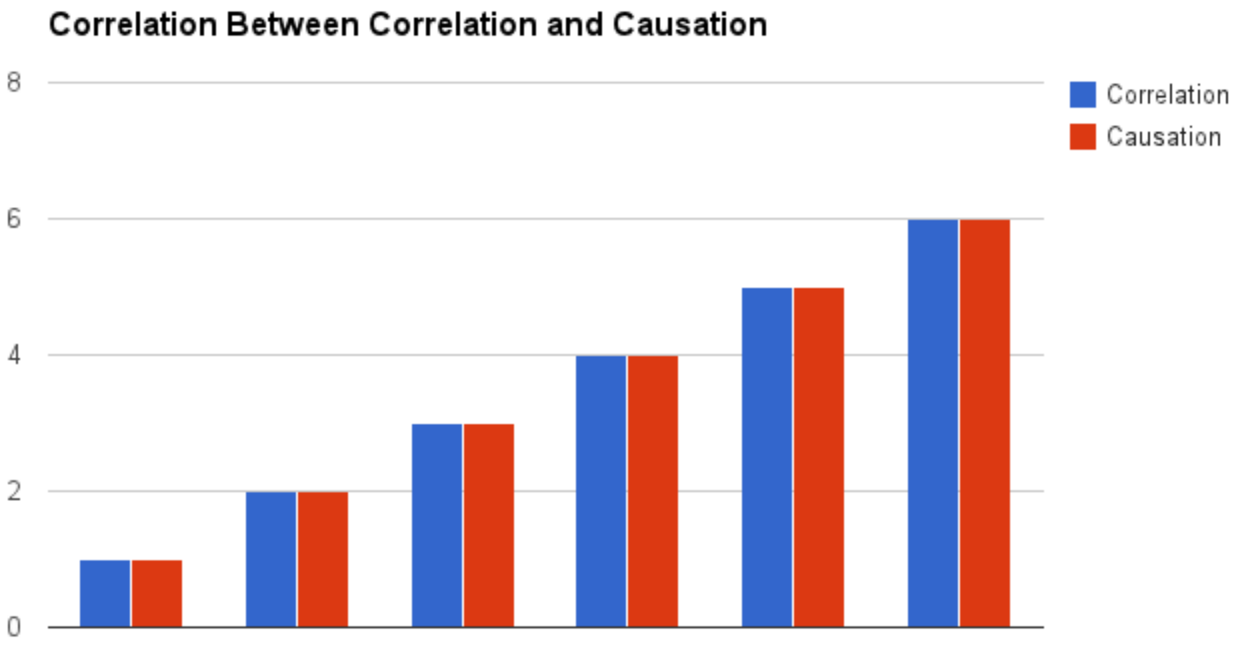
Administrivia

I'd like to start with a graph



Administrivia

This graph is great too:



Administrivia

Keep working on Evil Hangman

Vector

Before we jump into const I want to finish mentioning a few details from last lecture

Vector

```
// Reserve enough capacity for ‘minimum’ elements without
// changing the logical size of the vector
template <typename ElemType>
void Vector<ElemType>::reserve(std::size_t minimum);
```

Vector

```
template <typename ElemType>
void Vector<ElemType>::reserve(std::size_t minimum) {
  if (allocatedSize < minimum) {
    do {
      allocatedSize *= 2;
    } while (allocatedSize < minimum);

    ElemType* newElems = new ElemType[capacity()];
    std::copy(begin(), end(), newElems);

    delete[] elems;
    elems = newElems;
  }
}
```

Vector

```
// Insert ‘element’ into the Vector at the location preceding
// ‘position’
template <typename ElemType>
typename Vector<ElemType>::iterator Vector<ElemType>::insert
(iterator position, ElemType element);
```

Vector

```
template <typename ElemType>
typename Vector<ElemType>::iterator Vector<ElemType>::insert
(iterator position, ElemType element) {
  std::size_t index = position - begin();
  reserve(size() + 1);
  position = begin() + index;

  std::copy_backward(position, end(), end() + 1);

  *position = element;
  ++logicalSize;
  return position;
}
```

Why Const?

"I still sometimes come across programmers who think const isn't worth the trouble. "Aw, const is a pain to write everywhere," I've heard some complain. "If I use it in one place, I have to use it all the time. And anyway, other people skip it, and their programs work fine. Some of the libraries that I use aren't const-correct either. Is const worth it?"

We could imagine a similar scene, this time at a rifle range: "Aw, this gun's safety is a pain to set all the time. And anyway, some other people don't use it either, and some of them haven't shot their own feet off..."

Safety-incorrect riflemen are not long for this world. Nor are const-incorrect programmers, carpenters who don't have time for hard-hats, and electricians who don't have time to identify the live wire. **There is no excuse for ignoring the safety mechanisms provided with a product, and there is particularly no excuse for programmers too lazy to write const-correct code**."

- Herb Sutter, generally cool dude

Why Const?

Instead of asking why you think **const** is important, I want to start with a different question.

Why don't we use global variables?

Why Const?

- "Global variables can be read or modified by any part of the program, making it difficult to remember or reason about every possible use"
- "A global variable can be get or set by any part of the program, and any rules regarding its use can be easily broken or forgotten"

Why Const?

- "Non-const variables can be read or modified by any part of the function, making it difficult to remember or reason about every possible use"
- "A non-const variable can be get or set by any part of the function, and any rules regarding its use can be easily broken or forgotten"

Why Const?

Find the bug in this code:

```
void f(int x, int y) {
  if ((x==2 && y==3)||(x==1))
     cout << 'a' << endl;
  if ((y==x-1)&&(x==-1||y=-1))
     cout << 'b' << endl;
  if ((x==3)&&(y==2*x))
    cout << 'c' << endl;
}
```

Why Const?

Find the bug in this code:

```
void f(int x, int y) {
  if ((x==2 && y==3)||(x==1))
     cout << 'a' << endl;
  if ((y==x-1)&&(x==-1||y=-1))
     cout << 'b' << endl;
  if ((x==3)&&(y==2*x))
    cout << 'c' << endl;
}
```

Why Const?

Find the bug in this code:

```
void f(const int x, const int y) {
  if ((x==2 && y==3)||(x==1))
     cout << 'a' << endl;
  if ((y==x-1)&&((x==-1)||(y=-1)))
     cout << 'b' << endl;
  if ((x==3)&&(y==2*x))
    cout << 'c' << endl;
}
```

Why Const?

The compiler finds the bug for us!

```
test.cc:7:29: error: assignment of read-only
parameter ‘y’
```

Why Const?

That's a fairly basic use case though, is that really all that const is good for?

The const Model

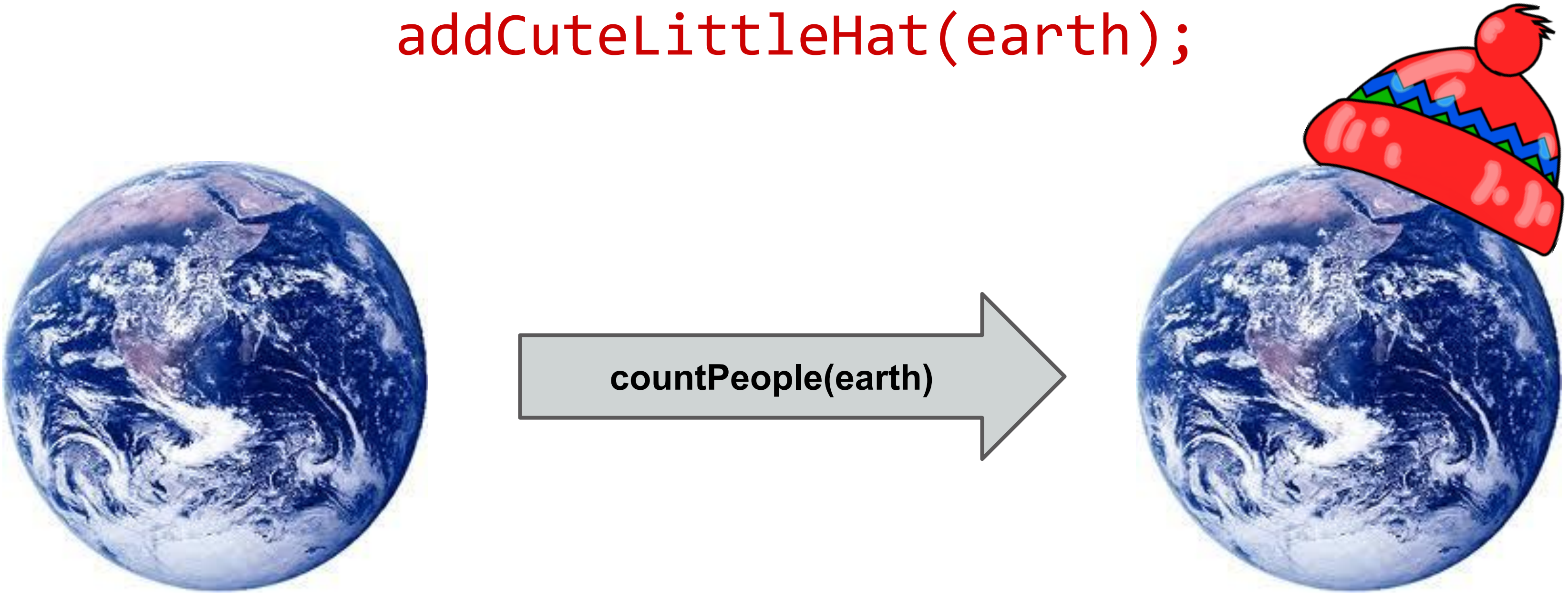
```
Planet earth;
```

The const Model

```
long int countPeople(Planet& p);

long int population = countPeople(earth);
```

The const Model



```
addCuteLittleHat(earth);
```

countPeople(earth)

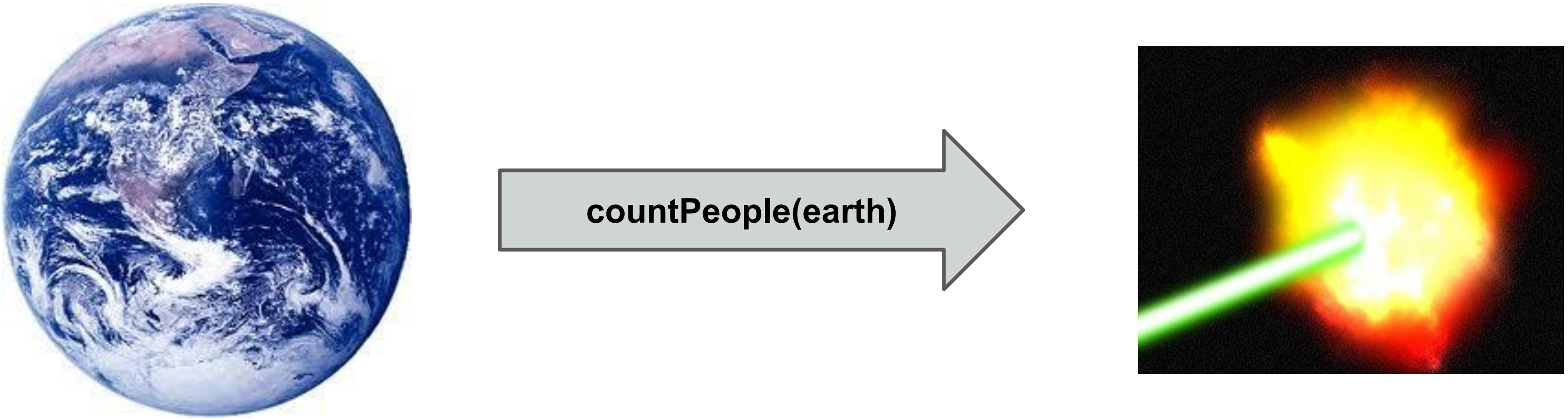
The const Model

```
marsify(earth);
```

countPeople(earth)

The const Model

```
deathStar(earth);
```



countPeople(earth)

Why Const?

How did this happen?

The const Model

```
long int countPopulation(Planet& p) {
   // I don't like people not wearing hats
  addCuteLittleHat(p);

  // Mars-like planets are easier to deal with
  marsify(p);

  // Optimization: destroy planet
  // This makes population counting O(1)
  deathStar(p);
  return 0;
}
```

The const model

What would happen if I made that a const method?

The const Model

```
long int countPopulation(const Planet& p) {
   // I don't like people not wearing hats
  addCuteLittleHat(p);

  // Mars-like planets are easier to deal with
  marsify(p);

  // Optimization: destroy planet
  // This makes people counting O(1)
  deathStar(p);
  return 0;
}
```

The const Model

```
test.cc: In function ‘long int countPopulation(const Planet&)’:

test.cc:9:21: error: invalid initialization of reference of type
‘Planet&’ from expression of type ‘const Planet’
test.cc:3:6: error: in passing argument 1 of ‘void addCuteLittleHat
(Planet&)’

test.cc:12:12: error: invalid initialization of reference of type
‘Planet&’ from expression of type ‘const Planet’
test.cc:4:6: error: in passing argument 1 of ‘void marsify(Planet&)’

test.cc:16:14: error: invalid initialization of reference of type
‘Planet&’ from expression of type ‘const Planet’
test.cc:5:6: error: in passing argument 1 of ‘void deathStar(Planet&)’
```

The const Model

const allows us to reason about whether a variable will be changed.

The const Model

```
void f(int& x) {
  // The value of x here
  aConstMethod(x);
  anotherConstMethod(x);
  // Is the same value of x here
}
```

The const Model

```
void f(const int& x) {
  // Anything whatsoever
}
void g() {
  int x = 2;
  f(x);
  // x is still equal to two
}
```

const and Classes

This is great for things like `int`s, but how does `const` interact with classes?

How do we define `const` member functions?

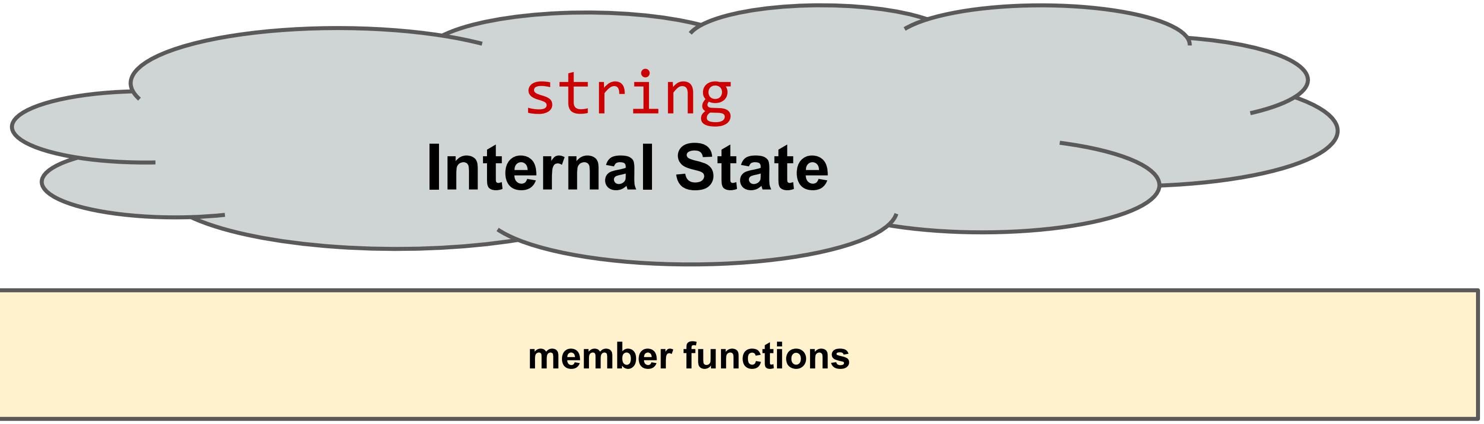
const and Classes

`string`

Internal State

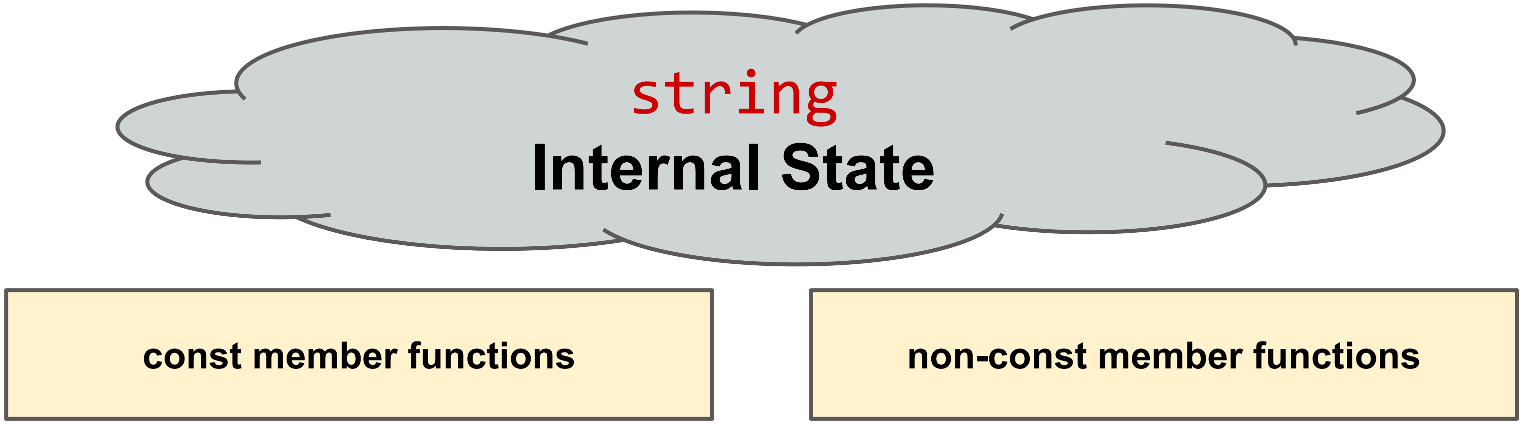
Let's have this cloud represent the member variables of a certain string

const and Classes



Previously, we thought that you just used member functions to interact with an instance of an object

const and Classes



string

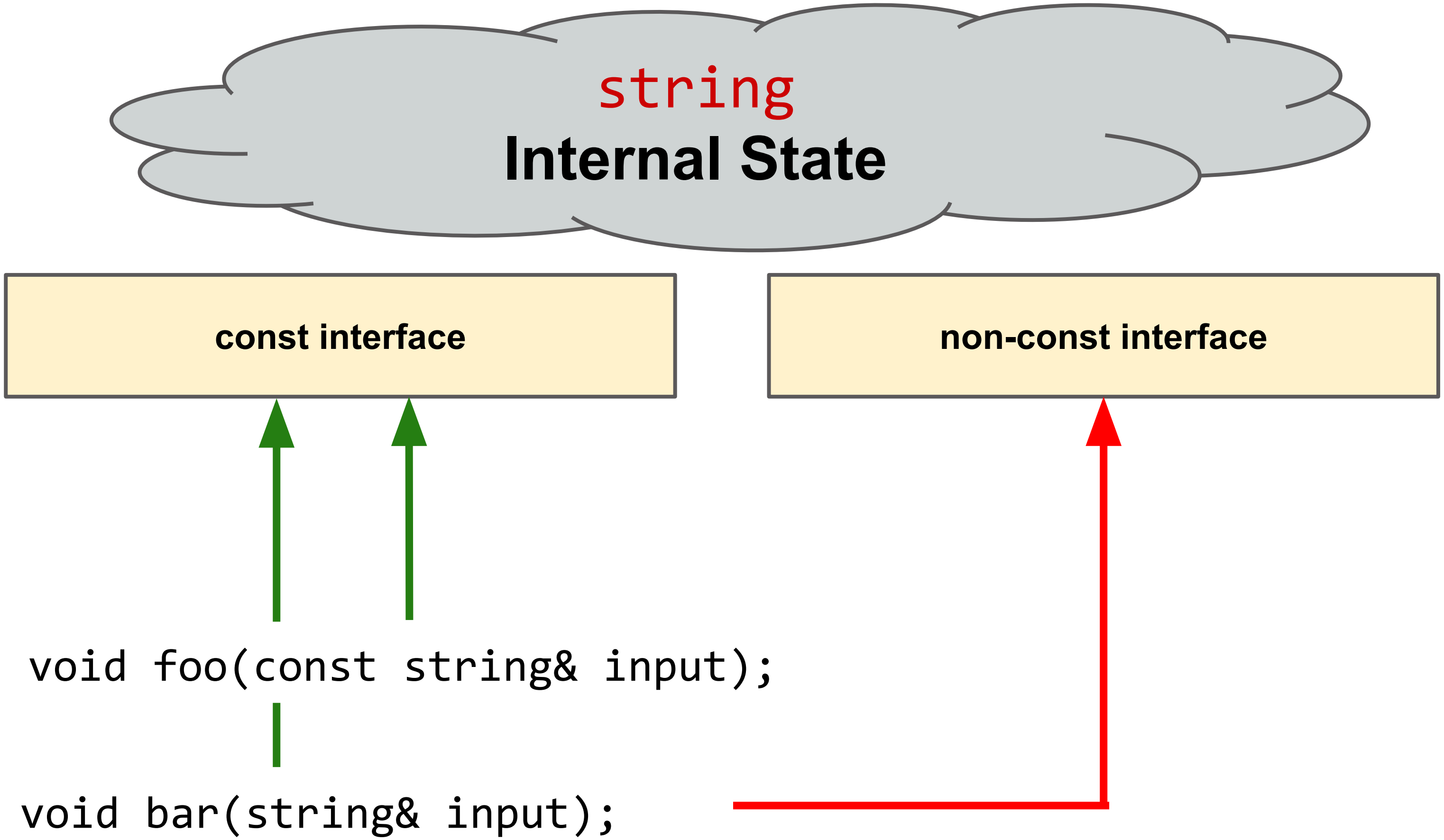
Internal State

const member functions

non-const member functions

Now we see that there are both const and non-const member functions, and const objects can't use non-const member functions

const and Classes



string

Internal State

const interface

non-const interface

```
void foo(const string& input);

void bar(string& input);
```

The const Model

```
// Defining const member functions
struct Planet {
  int countPopulation() const;
  void deathStar();
};
int Plant::countPopulation() const {
  return 42; // seems about right
}
void Planet::deathStar() {
  cout << "BOOM" << endl;
}
```

The const Model

```
// using const member functions
struct Planet {
  int countPopulation() const;
  void deathStar();
};
void evil(const Planet &p) {
  // OK: countPopulation is const
   cout << p.countPopulation() << endl;
  // NOT OK: deathStar isn't const
  p.deathStar();
}
```

Adding Const to Vector

Let's go through as much of const as we can on vector