Inheritance

Bad Dad Joke of the Day:

- What do you call a cow in a suit of armor?
- Sirloin!

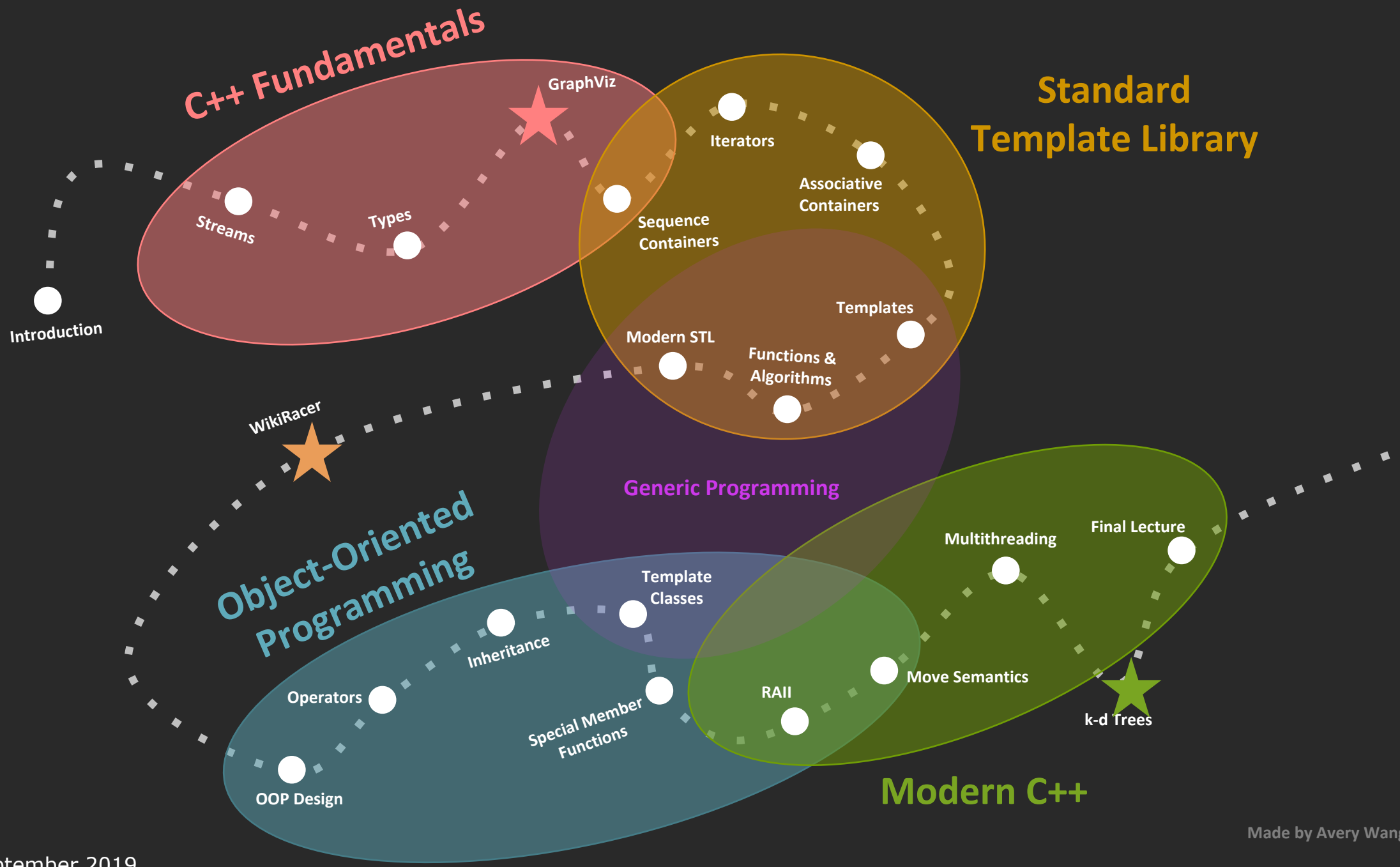
Creds: NS

Game Plan

- Recap
- Announcements
- Namespaces
- Inheritance

T-minus four lectures left!

(No class during Week 10 - enjoy your true Dead Week!)



Made by Avery Wang

Review from Last Time

- Operators
  - https://en.cppreference.com/w/cpp/language/operators

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  - Operators tend to be written in terms of other operators!
  - Use the reference to remember what assumptions your operator overload should satisfy

- Better explanation for: Why learn about `move`?
  - There was a lot of hype for C++11

Challenge Mode:

```
const int* const myClassMethod(const int* const & param) const;
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This function takes in a const pointer...

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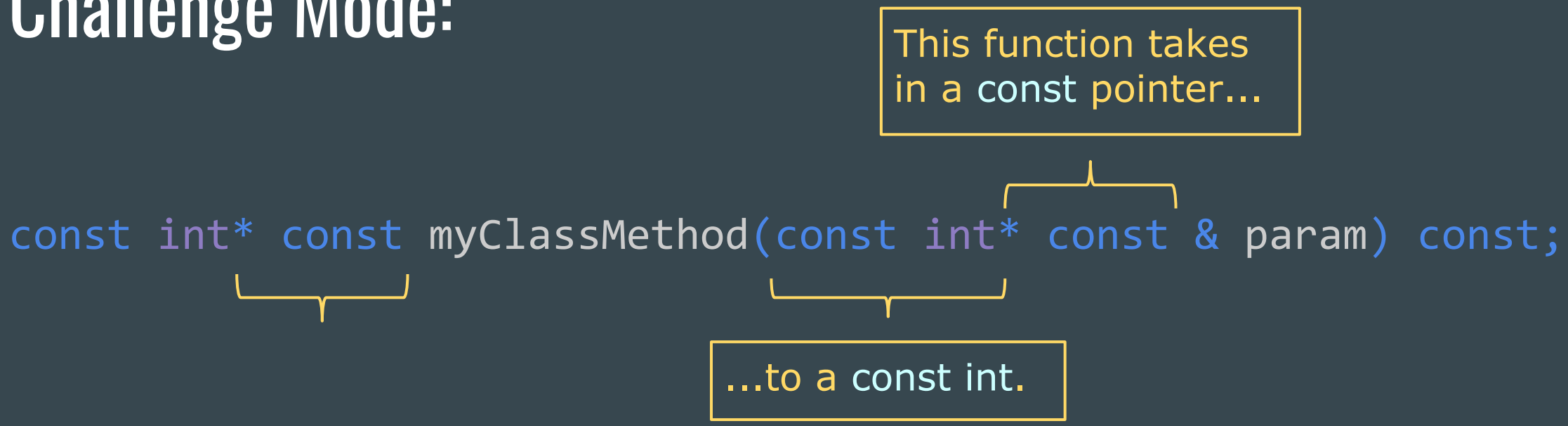

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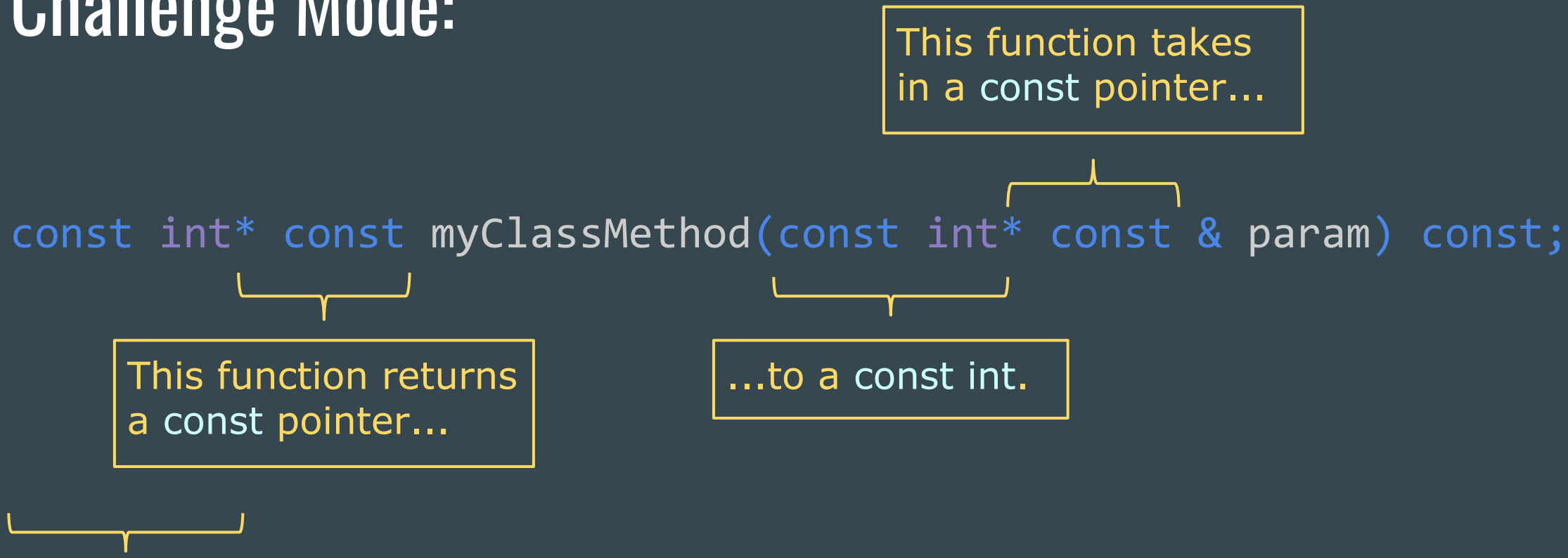

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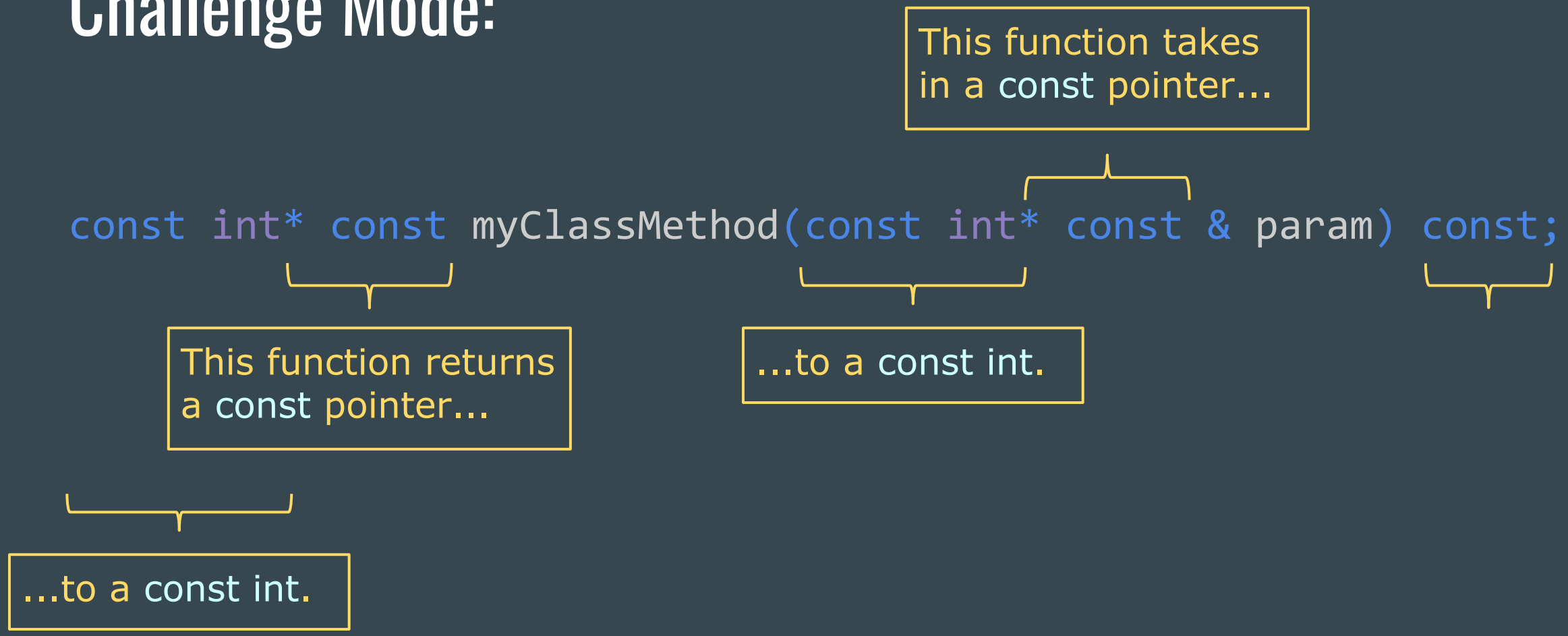

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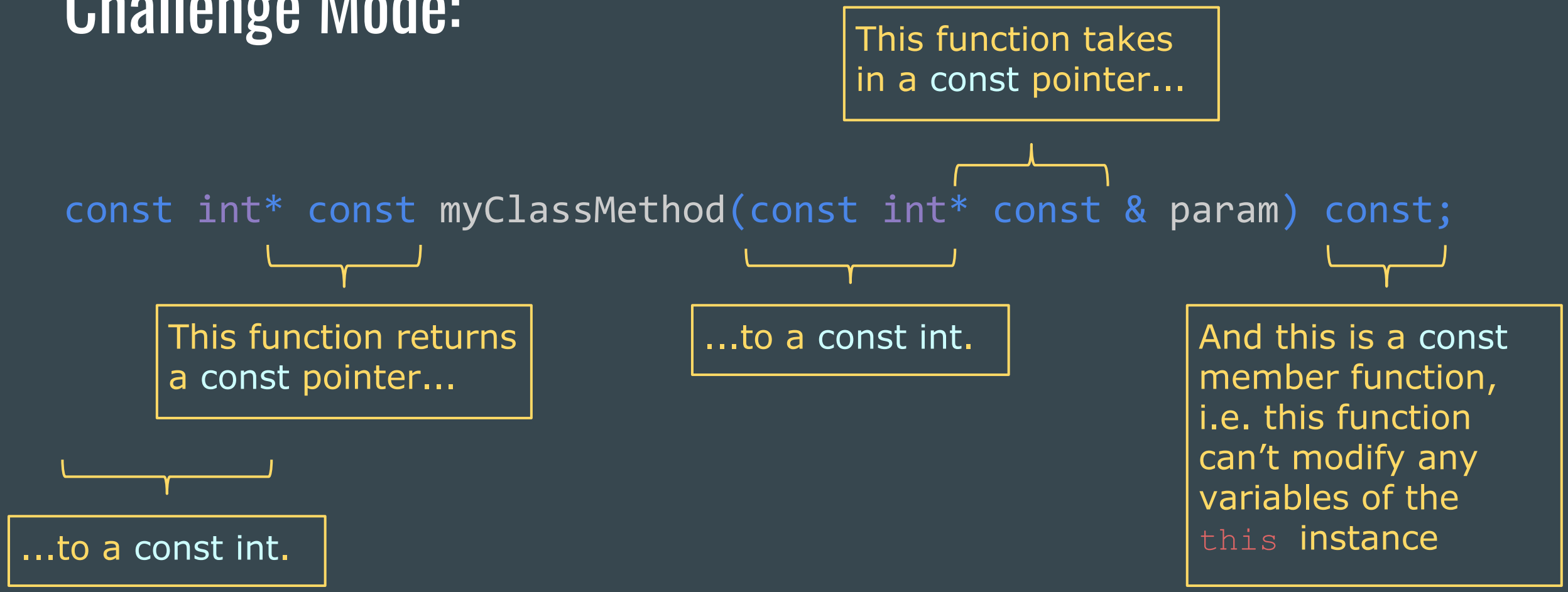

Challenge Mode:

This function takes in a const pointer...

```
const int* const myClassMethod(const int* const & param) const;
```

This function returns a const pointer...

...to a const int.

...to a const int.

And this is a const member function, i.e. this function can't modify any variables of the `this` instance

When to use each?

https://stackoverflow.com/questions/15999123/const-before-parameter-vs-const-after-function-name-c

Announcements

Announcements

- Assignment 2 is due this Thursday!
  - Wednesday (11/13), 10 am - 12 pm, in Lathrop Tech Lounge
  - Wednesday (11/13), 3:30 - 4:20 pm, in Huang basement*
  - Wednesday (11/13), 9:30 - 11:30 pm, in Huang basement*
  - Thursday (11/14), 7 - 7:45 pm, in Huang basement*
  - *for Huang basement, meet by the Google server under the big stairs
  - Check the Piazza for a full list of office hours.
- Remember you have four late days to use throughout the quarter.

- Assignment 3 will be released Thursday! Due after Thanksgiving Break

Namespaces

Scope Resolution

There was a lot of `std::` and `StringVector::` in our code

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```
//using namespace std;

using std::cout;              using std::endl;
using std::string;            using std::vector;
using std::priority_queue;    using std::ostream;
using std::unordered_set;
```

Scope Resolution

There was a lot of `std::` and `StringVector::` in our code

```
#include "stringvector.h"

// default constructor
StringVector::StringVector() :
    logicalSize(0), allocatedSize(kInitialSize) { //
    elems = new std::string[allocatedSize];
}

// fill constructor
StringVector::StringVector(size_type n, const std::string &val) :
    logicalSize(n), allocatedSize(2*n) {
    elems = new std::string[allocatedSize];
    std::fill(begin(), end(), val);
}

// destructor
StringVector::~StringVector() {
    delete[] elems;
}
```

Scope Resolution

There was a lot of `std::` and `StringVector::` in our code

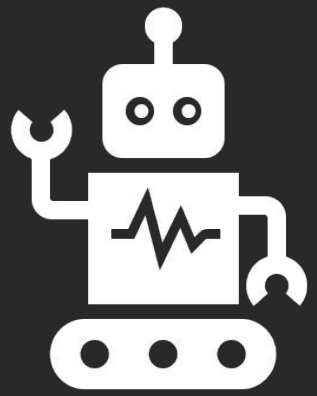
Why?

Namespaces

The standard library uses common names

- string
- max
- count

It is easy for libraries to conflict in their names



Example

Namespace Clash

Namespaces

Most modern languages use namespaces to fix this

Namespaces (Python)

Most modern languages use namespaces to fix this

```
# Generate a random number in Python
import random

print random.random()
```

Namespaces (JavaScript)

Most modern languages use namespaces to fix this

```
# Read file in JavaScript
const fs = require('fs');

const data = fs.readFileSync('file.txt')
```

Namespaces (C++)

Most modern languages use namespaces to fix this

```
# Count how many times value appears in C++
#include <algorithm>

std::count(v.begin(), v.end(), 1);
```

Aside: Scope Resolution

stringvector.cpp

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➔ So that the compiler knows which class you're defining a function for!

Aside: Scope Resolution

definitelynotastringvector.cpp

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Inheritance

Warning: This is a quick overview of inheritance.

We'll cover C++-specific details of inheritance, but won't be spending time on when to actually use it.

Take CS 108 to learn more!

Inheritance

Motivation:

```
ifstream& ifstream::operator<<(int i) {
  // Implementation
}
istringstream& istringstream::operator<<(int i) {
  // Implementation
}
```

Inheritance

Motivation:

```
void print(ifstream &stream, int i) {
   // do some stuff
   stream << i;
}
void print(istringstream &stream, int i) {
   // do some stuff
   stream << i;
}
```

Inheritance

Motivation:

```
void print(ifstream &stream, int i) {
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void print(istringstream &stream, int i) {
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```

Would much rather have just one!

Inheritance

Try #1:

```
template <typename StreamType>
void print(StreamType& stream, int i) {
   // do some stuff
   stream << i;
}
```

This works because templates use the concept of implicit interface.

Note that there isn't a list of what operators/functions are required.

Inheritance

Try #1:

```
template <typename StreamType>
void print(StreamType& stream, int i) {
   // do some stuff
   stream << i;
}
```

This works because templates use the concept of implicit interface.

~~Note that there isn't a list of what operators/functions are required.~~

Next lecture: Concepts (C++20)!

Explicit Interface

If there’s an implicit interface, there must be an explicit one

Usually just called an interface, the simplest form of inheritance

Interface

In Java:

```
interface Drink {
   public void make();
}


class Tea implements Drink {
   public void make() {
      // implementation
   }
}
```

Interface

In Java:

```java
interface Drink {
   public void make();
}


class Tea implements Drink {
   public void make() {
      // implementation
   }
}
```

In C++:

```cpp
class Drink {
public:
   virtual void make() = 0;
};


class Tea : public Drink {
public:
   void make() {
      // implementation
   }
};
```

Interface

In Java:

```
interface Drink {
   public void make();
}


class Tea implements Drink {
   public void make() {
      // implementation
   }
}
```

In C++:

```
class Drink {
public:
   virtual void make() = 0;
};
```

Called a pure virtual function, denoted by the = 0.

Means that the inheriting class must define that function.

Interfaces

There is no interface keyword in C++!

- To be an interface, a class must consist only of pure virtual functions

- To implement an interface, a class must define all of those virtual functions

Interfaces

There is no interface keyword in C++!

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  ➜ What if we do want to define some functions in our class?

- To implement an interface, a class must define all of those virtual functions

Abstract Classes

If a class has at least one pure virtual function, then it's called an abstract class. (Interfaces are a subset of abstract classes.)

Abstract classes cannot be instantiated.

```
class Base {
public:
   virtual void foo() = 0; // pure virtual function
   virtual void foo2();    // non-pure virtual function
   void bar() = { return 42; }; // regular function
};
```

Inheritance

Try #2:

```
void print(istream &stream, int i) {
   // do some stuff
   stream << i;
}
```

As long as istream implements print (as a non-virtual function), and all types of streams inherit from istream, you only need to write one function!

Aside: Inherited Members

No “virtual” members - instead, if a member has the same name as an inherited member, it hides it

```
struct A {
   int a;
};
struct B : public A {
   double a; // Hides A::a
};
```

Terminology

Base class: the class inherited from

- aka a superclass or parent class

Derived class: the class that inherits from the base class

- aka a subclass or child class

Constructors

Always call the superclass constructor.

```
class Derived : public Base {

  Derived() : Base(args), /*others*/ {
    // rest of constructor
  }

};
```

Destructors

Only inherit from a class that has a virtual destructor!

(And if you want your class to be inheritable, make sure you make the destructor virtual!)

```
virtual ~Base() {}
```

Otherwise will almost definitely have memory leaks.

Non-Virtual Destructors

```
class Base {
   ~Base() {}
};

class Derived : public Base {
   ~Derived() {}
}

Base *b = new Derived();
delete b; // Never calls the destructor for Derived!
```

Terminology: Access Specifiers

Fancy name for three words you've seen a lot:

- `private`
- `protected`
- `public`

Terminology: Access Specifiers

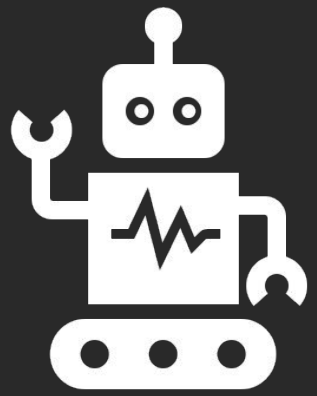
Fancy name for three words you've seen a lot:

- `private`
  - Can only be accessed by this class
- `protected`
  - Can only be accessed by this class or derived classes
- `public`
  - Can be accessed by anyone

Terminology: Access Specifiers

```
class Base {
public:
   void foo();
protected:
   void bar();
private:
   void baz();
};
```

Derived classes can access `foo` and `bar`. Unrelated classes can only access `foo`.

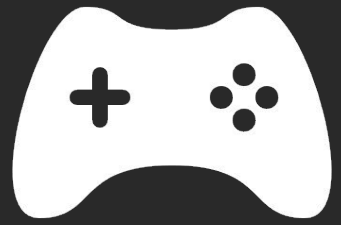


Example

Simple Inheritance (if we have time)

What We Didn’t Cover

- Polymorphism
- All the tricky details of using references and pointers with inheritance
  - These are details with inheritance generally, not C++, so we don’t cover them - we encourage you to read up on inheritance if you plan to write your own class though!
- Next time: brief look at casting



Next time

Template Classes and Concepts