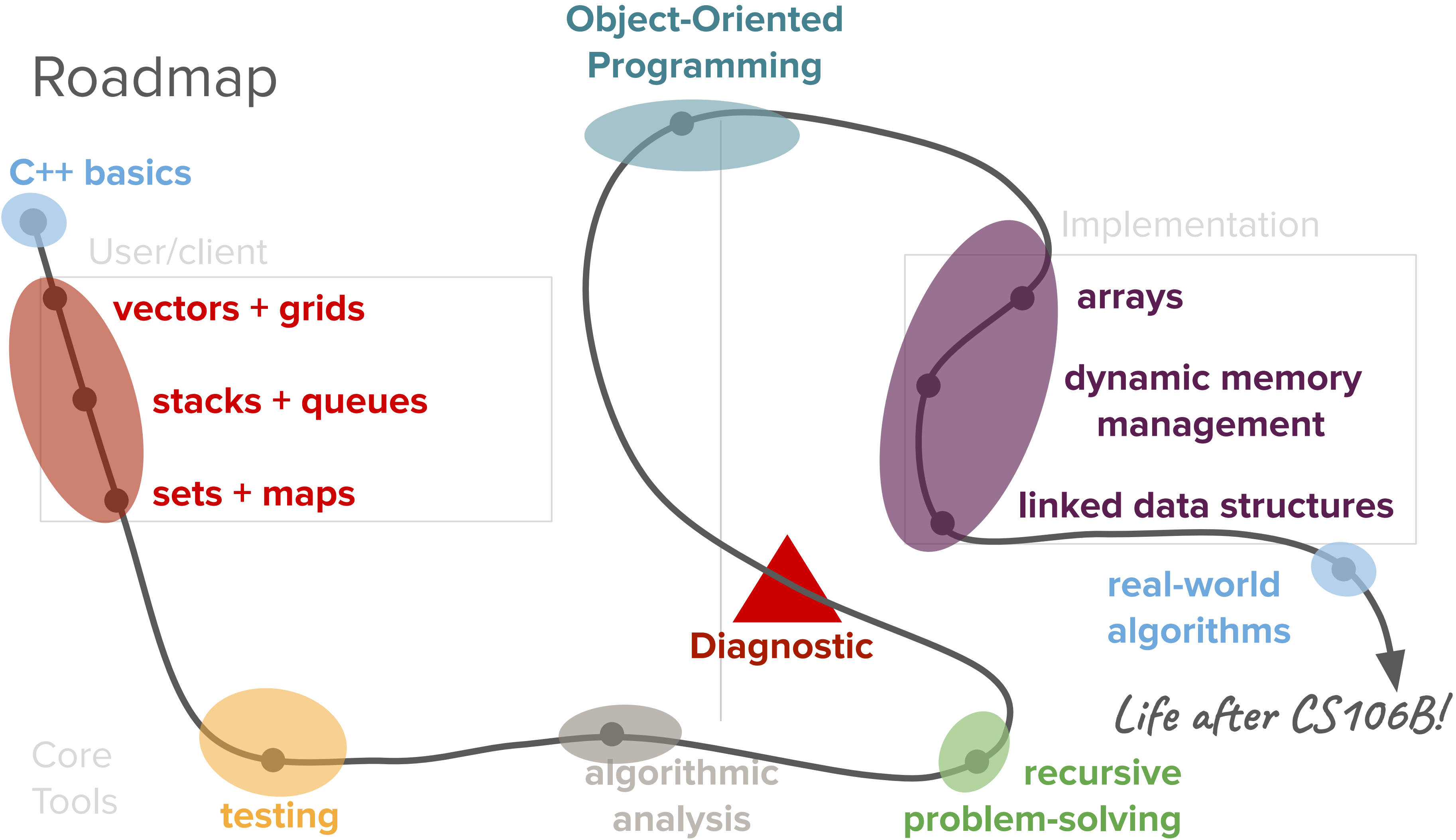
Strings and Testing

What's something that's *become more difficult* for you during online learning?

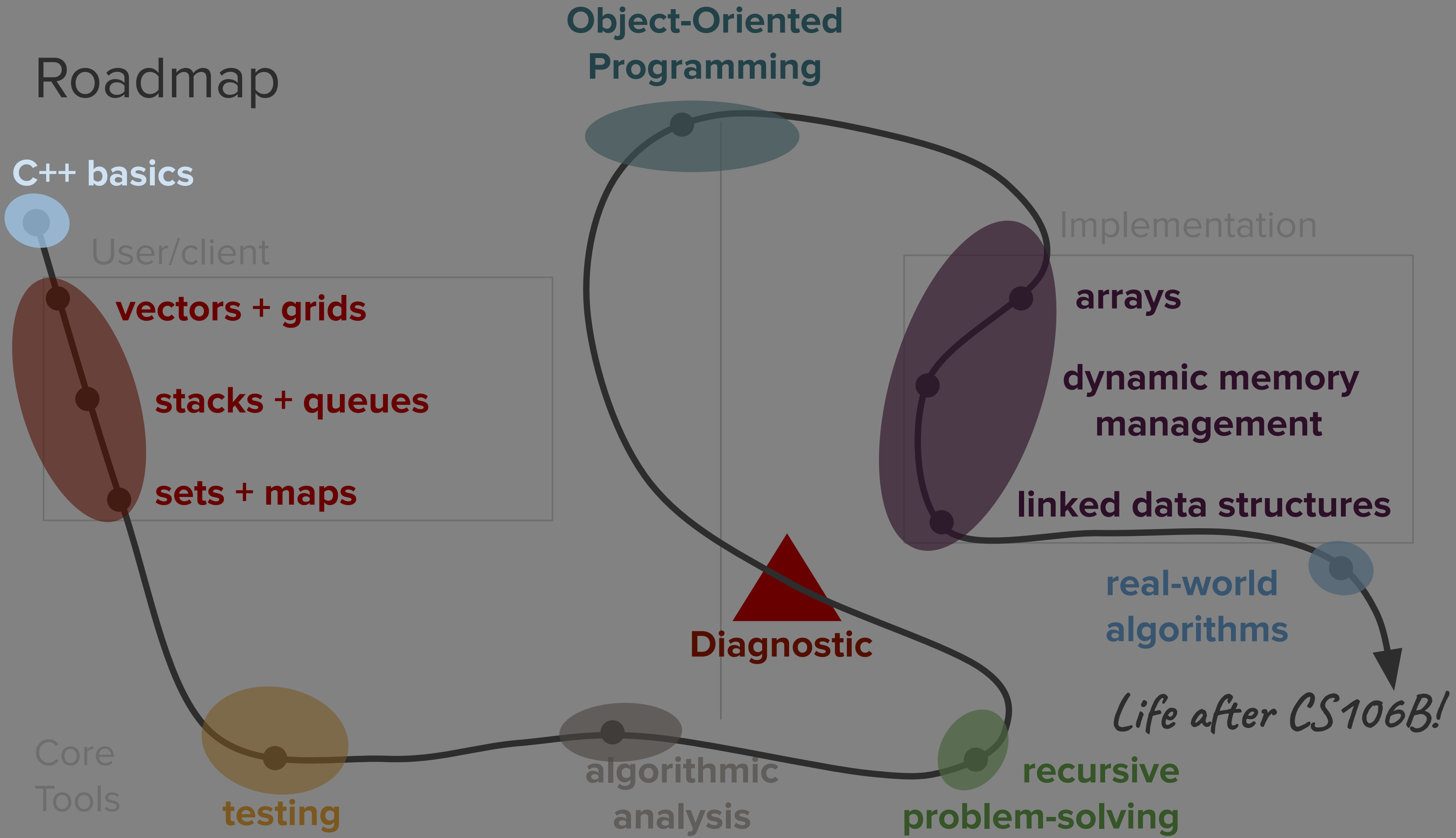
(put your answers the chat)

Roadmap



Object-Oriented Programming
C++ basics
User/client
vectors + grids
stacks + queues
sets + maps
Implementation
arrays
dynamic memory management
linked data structures
real-world algorithms
Diagnostic
Life after CS106B!
Core Tools
testing
algorithmic analysis
recursive problem-solving

Roadmap



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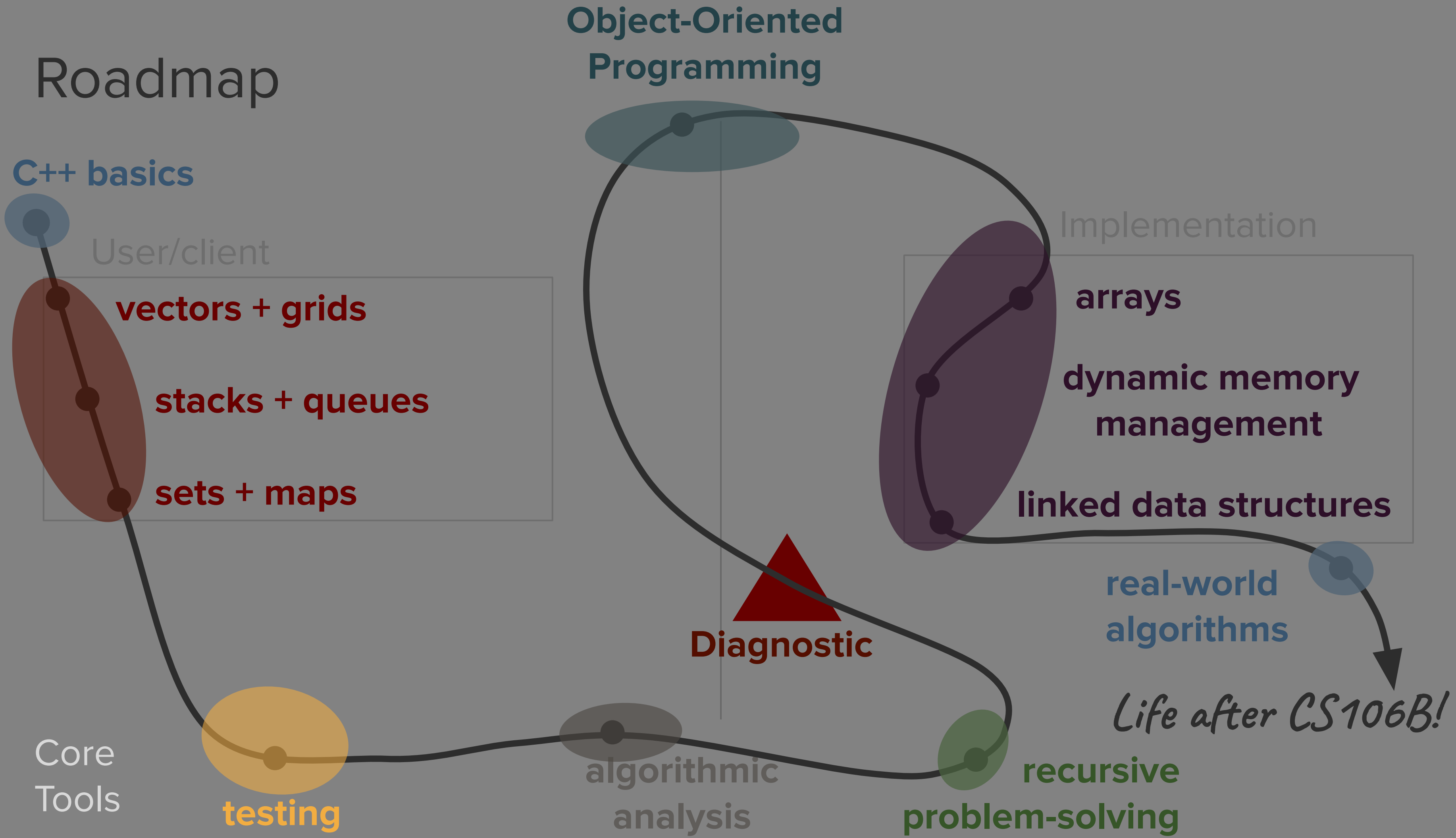

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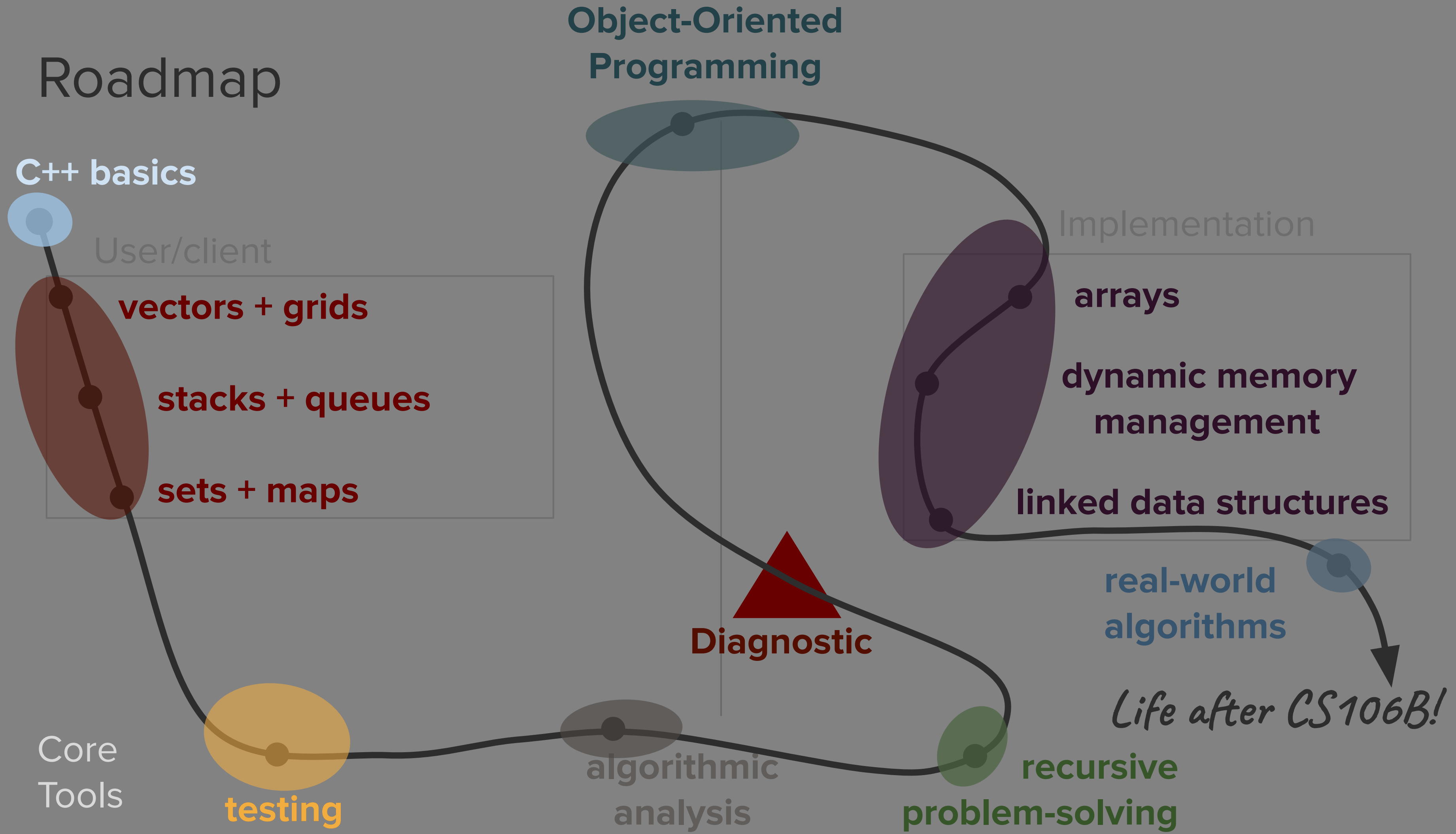

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Today's questions

How can we improve the online learning environment?

[Review with **`spaceship.cpp`**]

What's special about strings in C++?

How do we test code in CS106B?

What's next?

How can we improve the online learning environment?

Zoom chat is distracting.

The enthusiasm and curiosity is inspiring!

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New norm: Anyone can ask questions, but only course staff will answer questions in the chat. (We'll try this, and we can always adjust later if this isn't working.)

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Thank you for the early feedback!

We can better center questions around learning.

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There are two (vastly oversimplified) types of questions:

1. Questions that will enable you to understand the rest of the topic/lecture.
2. Questions will expand your depth of knowledge but that your immediate understanding does not depend upon.

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There are two (vastly oversimplified) types of questions:

1. Questions that will enable you to understand the rest of the topic/lecture.

Strategy: Ask immediately by raising your hand (or putting it in the chat if you're more comfortable with that). If you found something confusing, someone else probably did, too. And remember, celebrate struggle!

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There are two (vastly oversimplified) types of questions:

2. Questions will expand your depth of knowledge but that your immediate understanding does not depend upon.

Strategy: Write down your question and ask when it’s clear we’re transitioning to a new topic. We’ll also often stop for questions then.

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Strategy: If you can answer the question yourself by writing a small piece of code to test your question, we encourage you to do that, too!

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There are two (vastly oversimplified) types of questions:

1. Questions that will enable you to understand the rest of the topic/lecture.
2. Questions will expand your depth of knowledge but that your immediate understanding does not depend upon.

Think about how to use questions to maximize your concentration and learning!

We can better center questions around inclusivity.

There is also a third type of question:

Some students ask questions that are not really questions so much as opportunities to demonstrate knowledge of jargon or facts that are beyond the scope of the topic at hand. This can have a discouraging effect on other students. If you find yourself wanting to make such a question or comment in lecture, I encourage you to consider office hours as a better venue for exploring that topic with me.

- Cynthia Lee, Stanford Senior Lecturer in CS

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One of the most difficult things about teaching CS is catering to an audience of diverse backgrounds and prior programming experience.

Curiosity is wonderful, and we're happy to talk about advanced CS topics with you during office hours.

But we also don't want to send the message that you need to know about these things when entering CS106B.

- In particular, we don't expect students in this class to have prior C++ knowledge or knowledge of the topics that we explicitly introduce from scratch. So please keep this mind when you're asking questions!

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One of the most difficult things about teaching CS is catering to an audience of diverse backgrounds and prior programming experience.

Curiosity is wonderful, and we're happy to talk about advanced CS topics with you during office hours.

But we also don't want to send the message that you need to know about these things when entering CS106B.

If you do have prior experience in C++ or in the topics we'll be covering, that's great! It also benefits your learning to approach these concepts with a beginner's mindset – you might notice and learn things that you didn't before.

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It also benefits your learning to approach these concepts with a beginner's mindset – you might notice and learn things that you didn't before.

Consider if lecture or individual office hours is the right venue for your question.

Review

(using `spaceship.cpp`!)

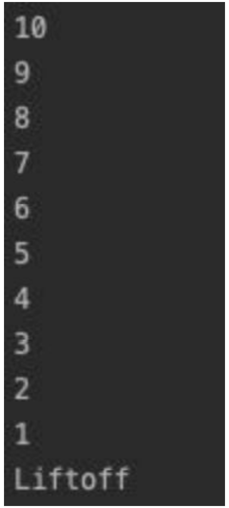
Functions, variables, for loops, console programs

I wanted to follow up on a couple of the questions asked during class yesterday...

- *Can you declare two variables with the same name but within different scopes of the same function (e.g. one inside a for loop and one before the loop)?*
  ➜ Yes, but this gets confusing quickly so avoid variables with the same names!

- *Can you create two functions with the same name but different return types?*
  ➜ No, not if the return type is the only aspect that differs between the function prototypes. But you are allowed to create two functions that have the same name if they take different parameters (number or type). In this case, the return types don't matter. Again, this gets confusing quickly so try to avoid it!

Write a program that prints out the calls for a spaceship that is about to launch.
Countdown the numbers from 10 to 1 and then print “Liftoff.”



```
10
9
8
7
6
5
4
3
2
1
Liftoff
```

```python
def main():
    for i in range(10, 0, -1):
        print(i)
    print("Liftoff")

if __name__ == "__main__":
    main()
```

Python

```cpp
#include <iostream>
using namespace std;

int main() {
    /* TODO: Your code goes here! */

    return 0;
}
```

C++

Ed Example

(workspace)

Notes about Ed workspaces

- To immediately preserve work done during lecture, we’re going to set the “Breakout Room X” workspaces to view-only right after lecture.

- We’ll be reusing the same breakout room workspaces every lecture, which means we’ll also wipe the contents before the next day’s class (likely in the morning before lecture).

- Feel free to download or fork the workspace after class to continue working on the code independently or with others.

What’s special about **strings** in C++?

Definition

string

A data type that represents a sequence of characters

Characters can be letters, digits, symbols (&, !, ~), etc.

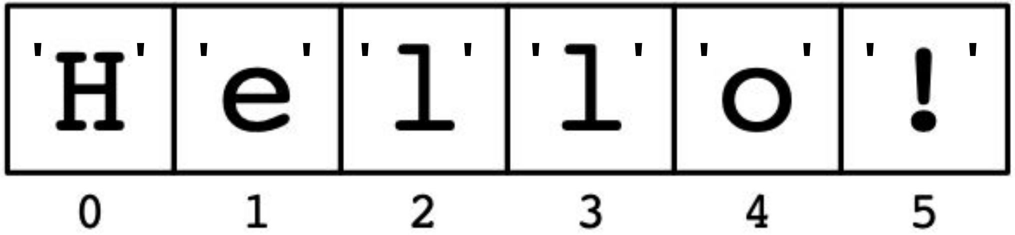
Definition

string

A data type that represents a sequence of characters

Strings review

Strings are made up of characters of type char, and the characters of a string can be accessed by the index in the string (this should be familiar):



string activity

[demo + poll]

What are the key characteristics of strings in C++?

- Strings are mutable in C++
  - ○ Unlike in Python and Java
  - ○ But you must assign string indices to a character:

YES: `word[1] = ‘a’;`

NO: `word[1] = “a”;`

What are the key characteristics of strings in C++?

- Strings are mutable in C++

- You can add characters to strings and strings to strings using += and +
  - Strings must use double quotes (“”) while characters use single (‘’).
  - There is a caveat you’ll see shortly

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- You can use logical operators to compare strings (and characters)

string and char conventions

[demo]

string utility functions

Three categories of functions

- Built-in C++ char functions (<cctype> library)

- Built-in C++ string methods

- Stanford string library functions

<cctype> library

- **`#include <cctype>`**
- This library provides functions that check a single **`char`** for a property (e..g, if it is a digit), or return a **`char`** converted in some way (e.g., to uppercase)
  - **`isalnum`**: checks if a character is alphanumeric
  - **`isalpha`**: checks if a character is alphabetic
  - **`islower`**: checks if a character is lowercase
  - **`isupper`**: checks if a character is an uppercase character
  - **`isdigit`**: checks if a character is a digit
  - **`isxdigit`**: checks if a character is a hexadecimal character
  - **`iscntrl`**: checks if a character is a control character
  - **`isgraph`**: checks if a character is a graphical character
  - **`isspace`**: checks if a character is a space character
  - **`isblank`**: checks if a character is a blank character
  - **`isprint`**: checks if a character is a printing character
  - **`ispunct`**: checks if a character is a punctuation character
  - **`tolower`**: converts a character to lowercase
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```
char letter = 'L';
islower(letter);
//returns false
```

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string methods

`#include <string>`

- **`s.append(str)`**: add text **`str`** to the end of a string
- **`s.compare(str)`**: return **`-1`**, **`0`**, or **`1`** depending on relative ordering
- **`s.erase(index, length)`**: delete text from a string starting at given **`index`**
- **`s.find(str)`**: return first index where the start of **`str`** appears in this string (returns **`string::npos`** if not found)
- **`s.rfind(str)`**: return last index where the start of **`str`** appears in this string (returns **`string::npos`** if not found)
- **`s.insert(index, str)`**: add text **`str`** into a string at a given **`index`**
- **`s.length()`** or **`s.size()`**: number of characters in this string
- **`s.replace(index, len, str)`**: replaces **`len`** chars at **`index`** with text **`str`**
- **`s.substr(start, length)`** or **`s.substr(start)`**: the next length characters beginning at **`start`** (inclusive); if length omitted, grabs till end of string

string methods

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#include <string>
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Stanford string library functions

`#include “strlib.h”`

- **`endsWith(str, suffix)`**
  `startsWith(str, prefix)`: returns **`true`** if the given string begins or ends with the given **`suffix`**/**`prefix`** text
- **`integerToString(int)`**
  `realToString(double)`
  `stringToInteger(str)`
  `stringToReal(str)`: returns a conversion between numbers and strings
- **`equalsIgnoreCase(s1, s2)`**: **`true`** if **`s1`** and **`s2`** have same **`chars`**, ignoring casing
- **`toLowerCase(str)`**: returns a lowercase version of a string
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- **`trim(str)`**: returns string with surrounding whitespace removed

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Two types of C++ strings

[poll]

Poll: What will happen with the following line of code?

```
string hiThere = "hi" + "there";
```

You would get...

- An error
- The string “hithere” stored in `hiThere`
- A garbage value stored in `hiThere`

Poll: What will happen with the following line of code?

```
string hiThere = "hi" + '?'
```

You would get...

- An error
- The string “hi?” stored in `hiThere`
- A garbage value stored in `hiThere`

C strings vs. C++ strings summary

- C strings have no methods
  - This is why you can't do something like `"hi".length()` in C++

- Conversion fixes
  - Store the C string in a variable first to convert it to a C++ string
  - Use a conversion function
    - `string("text");` converts the C string literal into a C++ string
    - `string.c_str()` returns a C string from a C++ string

- **Takeaway**: Beware the C string!

Announcements

Announcements

- Sections start today! Check cs198.stanford.edu to see your time.

- Assignment 0 is due today at midnight.

- Assignment 1 is out and is due next Tuesday at 11:59pm in your local timezone.
  - YEAH hours are at 6pm PDT tonight; no minors but they will be recorded.

- As a reminder, Nick and I have group and individual office hours (OH) every week. Nick's individual OH are tomorrow from 9-11am PDT!

How do we **test** code in CS106B?

Testing

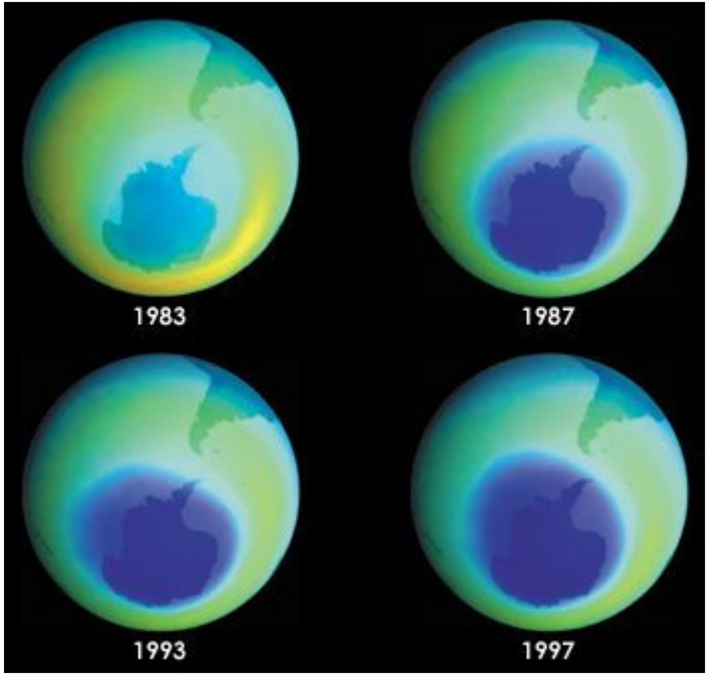
Software and cathedrals are much the same – first we build them, then we pray.
– Sam Redwine

Why is testing important?

Discuss in breakout rooms!

Why is testing important?

The hole in the ozone layer over Antarctica remained undetected for a long period of time because the data analysis software used by NASA in its project to map the ozone layer had been **designed to ignore values that deviated greatly from expected measurements.**



Source

Why is testing important?

In 1996, a European Ariane 5 rocket was set to deliver a payload of satellites into Earth orbit, but problems with the software caused the launch rocket to veer off its path a mere 37 seconds after launch. The problem was the result of **code reuse from the launch system's predecessor, Ariane 4, which had very different flight conditions from Ariane 5.**

Source

Why is testing important?

A 2002 study commissioned by the National Institute of Standards and Technology (referred to here) **found that software bugs cost the U.S. economy $59.5 billion every year** (imagine the global costs…). The study estimated that more than a third of that amount, $22.2 billion, **could be eliminated by improved testing.**

Source

Why is testing important?

- Testing can save money

Why is testing important?

- Testing can save money

- Testing can save lives

Why is testing important?

- Testing can save money
- Testing can save lives
- Testing can prevent disasters

Why is testing important?

- Testing can save money
- Testing can save lives
- Testing can prevent disasters
- **Testing is a programmer's responsibility.**
  - You must think about ethical considerations when you develop code that impacts people.

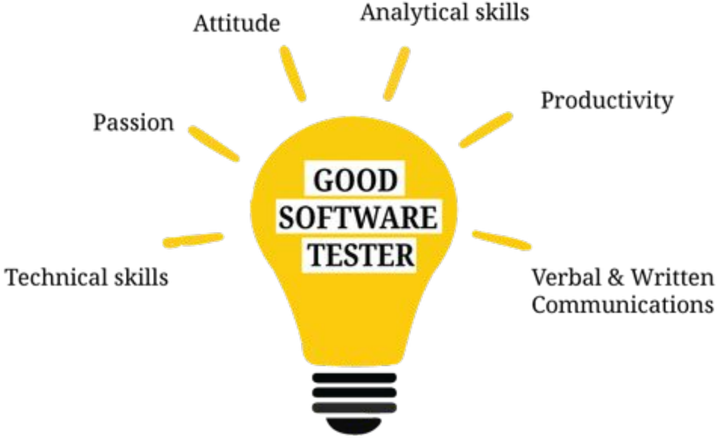
What are good testing strategies?

What are good testing strategies?

- Write tests that cover a wide variety of use cases for your function!

What are good testing strategies?

- Write tests that cover a wide variety of use cases for your function!
  - Use your critical thinking and analysis skills to identify a diverse range of possible ways in which your code might be used.



What are good testing strategies?

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- Consider:
  - Basic use cases
  - Edge cases

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Definition

edge case

Uses of your function/program that represent extreme situations

What are good testing strategies?

- Write tests that cover a wide variety of use cases for your function!
- Consider:
  - Basic use cases
  - Edge cases

For example, if your function takes in an integer parameter, test what happens if the value that is passed in negative, zero, a large positive number, etc!

Definition

edge case

Uses of your function/program that represent extreme situations

SimpleTest

What is SimpleTest?

- SimpleTest is a C++ library developed by some of the lecturers here at Stanford that allows standalone, C++ unit testing

- For those of you coming from CS106A in Python, this is similar in functionality to the **doctest** infrastructure that you learned

- We will see SimpleTest a lot this quarter! You will learn how to write good, comprehensive suites of tests using this library, starting from the very first assignment.

How does SimpleTest work?

CS106B Testing Guide

– make sure to read it!

How does SimpleTest work?

main.cpp

```
#include "testing/SimpleTest.h"
#include "testing-examples.h"

int main()
{
    if (runSimpleTests(SELECTED_TESTS)) {
        return 0;
    }

    return 0;
}
```

```
NO_TESTS
SELECTED_TESTS
ALL_TESTS
```

How does SimpleTest work?

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}
```

testing-examples.cpp

```
#include "testing/SimpleTest.h"

int factorial (int num);

int factorial (int num) {
    /* Implementation here */
}

PROVIDED_TEST("Some provided tests.") {
    EXPECT_EQUAL(factorial(1), 1);
    EXPECT_EQUAL(factorial(2), 2);
    EXPECT_EQUAL(factorial(3), 6);
    EXPECT_EQUAL(factorial(4), 24);
}

STUDENT_TEST("student wrote this test") {
    // student tests go here!
}
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How does SimpleTest work?

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#include "testing-examp

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    return 0;
}
```

testing-examples.cpp

```
                   ng/SimpleTest.h"

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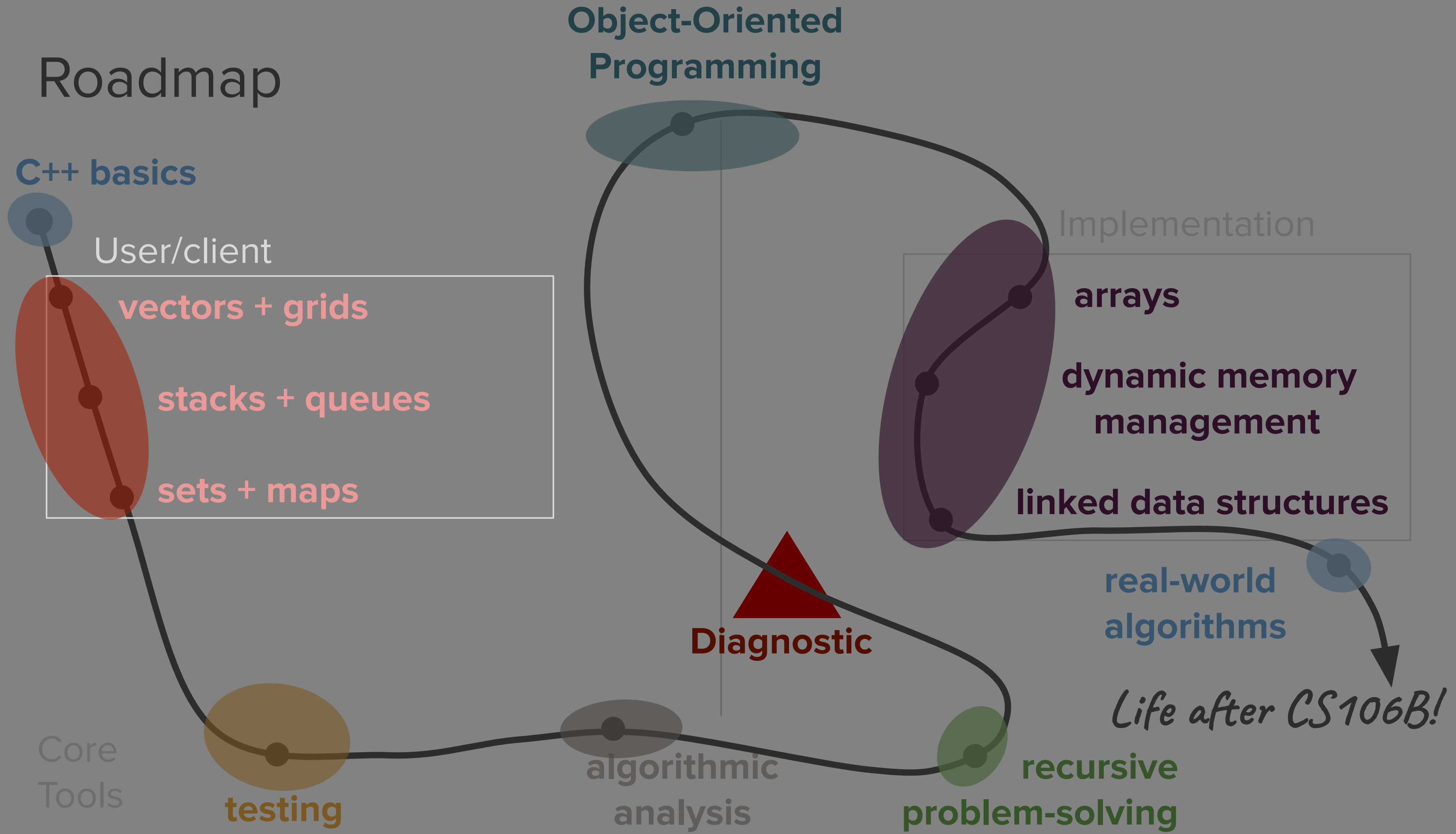
What’s next?

Roadmap



Object-Oriented Programming

C++ basics

User/client

vectors + grids

stacks + queues

sets + maps

Implementation

arrays

dynamic memory management

linked data structures

real-world algorithms

Diagnostic

Life after CS106B!

Core Tools

testing

algorithmic analysis

recursive problem-solving

Vectors and Grids