Testing

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October 2011

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Motivation

You already know how to debug

- `traceback()` tells you where the problem is
- `browser()` starts an interactive debugger where it's called
- `options(error = recover)` starts interactive debugger automatically on error
- `options(warn = 2)` turns warnings into errors so you can find them more easily

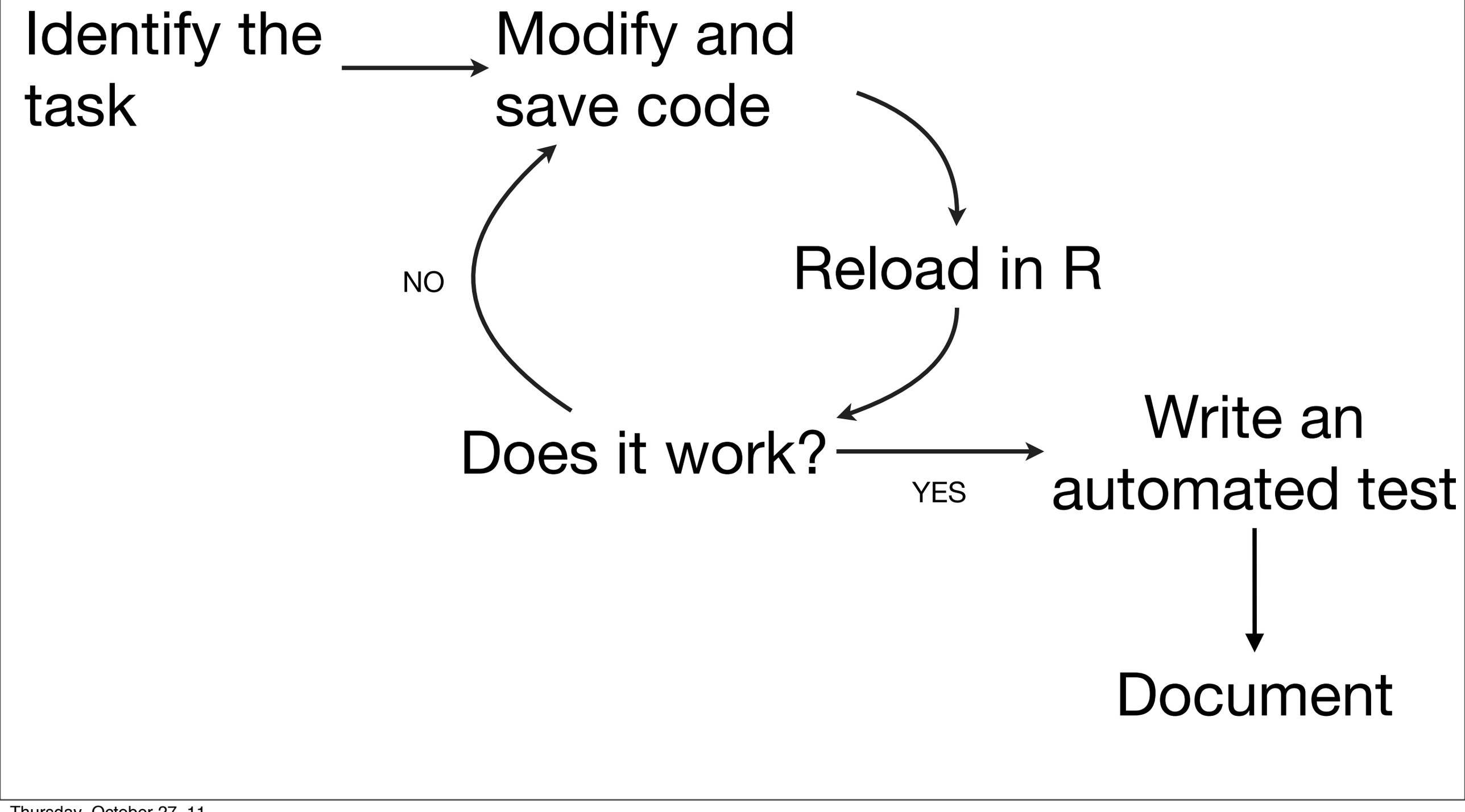
Automated tests

How do you keep bugs from coming back?

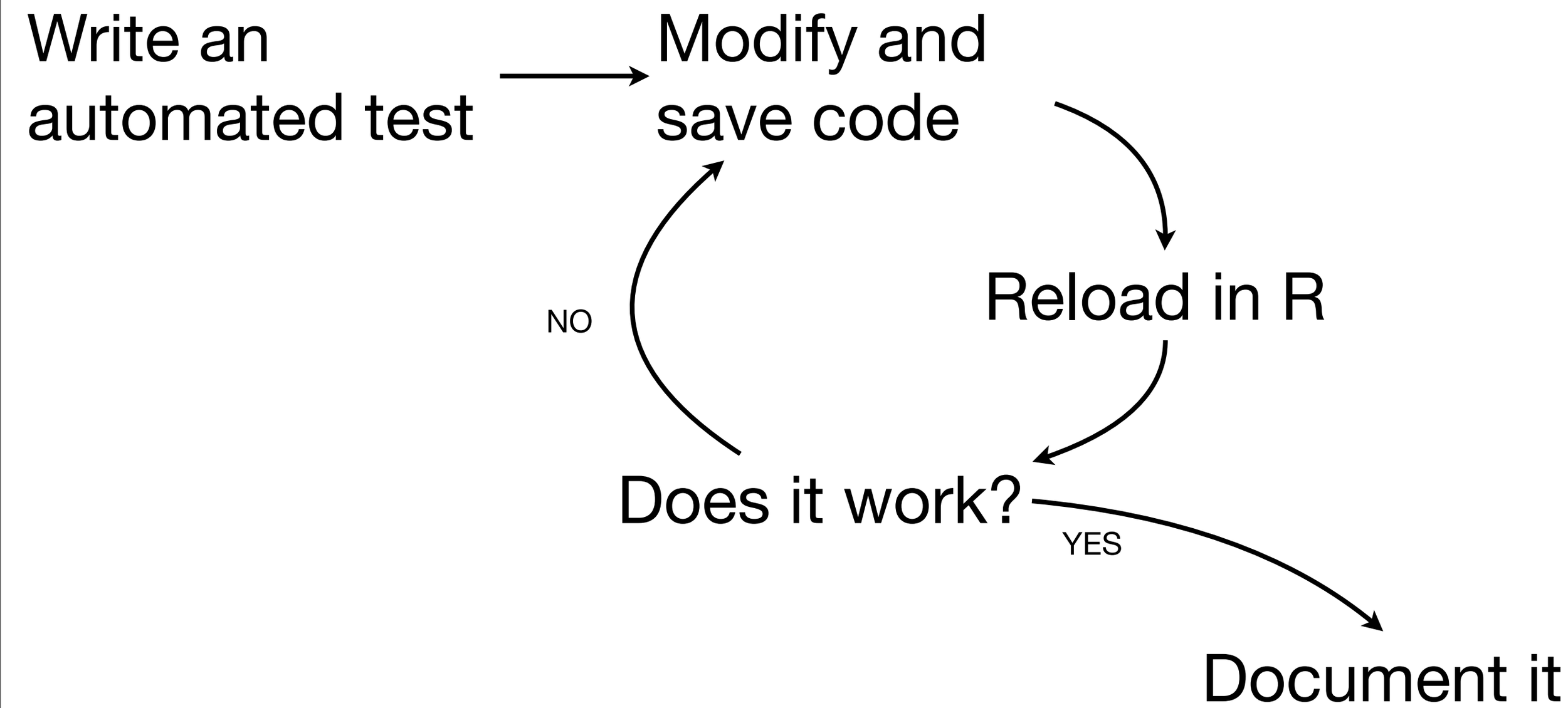
You can’t manually check every function every time you make a change – it takes too long

Solution: automate your testing so you can quickly run tests after every change

Exploratory programming



Confirmatory programming



aka test driven development (**TDD**)

Other benefits

- Code that can be tested easily, often has a better, more modular, design
- When you stop working, leave a test failing. You'll know what to work on when you come back
- Make big changes without fear of accidentally breaking anything

Testing packages

- `RUnit`
- `svUnit`
- `testthat`

Why test that?

- Easy transition from informal to formal tests. Can be used in wide variety of situations
- Wide range of expectations/assertions
- Fun, colourful output that keeps you motivated

https://github.com/hadley/devtools/wiki/Testing

Overview

Key components

- **Expectations**: what do you expect a function to do?
- **Tests**: a group of expectations that tests a small piece
- **Contexts**: a group of tests that tests behaviour of a large piece of functionality (function, class, etc)

```
context("String length")

test_that("str_length is number of characters", {
  expect_that(str_length("a"), equals(1))
  expect_that(str_length("ab"), equals(2))
  expect_that(str_length("abc"), equals(3))
})

test_that("str_length of missing string is missing", {
  expect_that(str_length(NA), equals(NA_integer_))
  expect_that(str_length(c(NA, 1)), equals(c(NA, 1)))
  expect_that(str_length("NA"), equals(2))
})

test_that("str_length of factor is length of level", {
  expect_that(str_length(factor("a")), equals(1))
  expect_that(str_length(factor("ab")), equals(2))
  expect_that(str_length(factor("abc")), equals(3))
})
```

Test structure

- **Informal**: just use expectations casually
- **Structured**: organised tests in files and directories
- **Package**: in inst/tests with test/run-all.r

Running tests

- `testthat::test_file(path)`
  Run all tests in a single file.
- `testthat::test_dir(path)`
  Run all files starting with `test-` in a directory
- `testthat::test_package(installed_package)`
  Run all tests in an installed package. Tests run in package namespace
- `devtools::test(package)`
  Run all tests in a development package.

Example packages

- `testthat`, `stringr`, `plyr`, `lubridate`

- `MSnbase`

- Reverse suggests from:
  `http://cran.r-project.org/web/packages/testthat/`

Your turn

Download the source for these packages.

Where are the tests? How are they structured?

Expectations

Expectation	Test	Abbreviation
`equals`	`all.equals`	`expect_equal`
`is_identical_to`	`identical`	`expect_identical`
`is_equivalent_to`	`all.equals, check.attributes = FALSE`	`expect_equivalent`
`is_a`	`inherits`	`expect_is`
`is_true / is_false`	`identical`	`expect_true / expect_false`

Your turn

Write down your expectations of output from `nchar()`. Try using character vectors, factors, missing values, escaped strings.

```
expect_that(nchar("a"), equals(1))
expect_equal(nchar("a"), 1)
expect_equal(nchar("abc"), 3)
expect_equal(nchar("\"\"\""), 3)

# But remember we want to avoid repetition!
check_length <- function(string, n) {
  expect_equal(nchar(string), n)
}
check_length("a", 1)
check_length("abc", 3)
check_length("\"\"\"", 3)
```

```
# However errors aren't very informative
check_length(NA, NA)

# But all expect functions take extra arguments for
# just this reason (or you could use substitute +
# eval)
check_length <- function(string, n) {
  expect_equal(nchar(string), n,
    label = paste("nchar(", string, ")", sep = ""),
    expected.label = n)
}
check_length(NA, NA)
check_length(factor("a"), 1)
check_length(factor("abc"), 3)
```

Expectation	Test	Abbreviation
`matches`	`grepl + any`	`expect_matches`
`prints_text`	`matches applied to output`	`expect_output`
`shows_message`	`matches applied to messages`	`expect_message`
`gives_warning`	`matches applied to warnings`	`expect_warning`
`throws_error`	`matches on errors`	`expect_error`

Tests

```
# Tests collect related expectations and name them
test_that("str_length of missing string is missing", {
  expect_that(str_length(NA), equals(NA_integer_))
  expect_that(str_length(c(NA, 1)), equals(c(NA, 1)))
  expect_that(str_length("NA"), equals(2))
})
```

```
test_that("nchar of missing string is missing", {
  expect_that(nchar(NA), equals(NA_integer_))
  expect_that(nchar(c(NA, 1)), equals(c(NA, 1)))
  expect_that(nchar("NA"), equals(2))
})
```

```
# But real advantage is when you put them in
# a file, and run all at once.

library(testthat)
test_file("nchar-test.r")
```

```
# Green . = passing test
# Red number = failing test (or error)
# Numbers index list of all failed expectation
#  giving message and test name.
```

Your turn

Create a file that tests `tapply`. Test:

What happens when `X` and `index` vectors are different lengths (or require recycling).

What happens with length 1 or length 0 inputs?

If `INDEX = seq_along(X)`, does `output = input`?

```
# As far as I can tell, there's only one test for
# tapply in the R source:
tapply(character(0), factor(letters)[FALSE], length)

# And in my opinion this output is incorrect. It
# should be a vector of 0s.
pieces <- split(character(), factor(letters)[FALSE])
vapply(pieces, length, integer(1))

# Not quite as worrying as it might seem, because
# R-core tends to rely on output tests...
```

Output tests

For each `.R` in `tests/`, a `.Rout` file is created. If a `.Rout.save` file exists, then the two are compared, and any differences cause an error

Useful for testing large scale behaviour. But very sensitive to output format.

Contexts

```
context("My context")

# Used to label a file
# Up to you how to arrange tests in files
# But keep related tests together.
```

Running tests

Running tests

- `testthat::test_file(path)`
  Run all tests in a single file.
- `testthat::test_dir(path)`
  Sources `helper-*.R` then runs all tests in `test-*.R`
- `testthat::test_package(installed_package)`
  Run all tests in an installed package. Tests run in package namespace
- `devtools::test(package)`
  Run all tests in a development package.

```
# Casually, during development
# (automatically reloads all code)
test("stringr")

# More formally
install("stringr")
test_package("stringr")

# Even more formally (and the next topic)
check("stringr")
```

Package tests

Store all tests in `inst/tests` so they are installed with the package. Then users can run to check their installation/OS is ok.

Include the following code in `tests/test-all.R` (note capital `R`). This ensures `R CMD check` will not pass unless all tests pass

```
library(testthat)
# This loads the version being tested
library(stringr)

test_package("stringr")
```