# Reinforcement & Applications

Andey Robins & Dr Borowczak

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# Outline

- Monty Hall Simulations
- Giant Rat Breeding
- Fermi Paradox
- The Next Steps

# Today's Plan

We'll be exploring applications and uses of python!

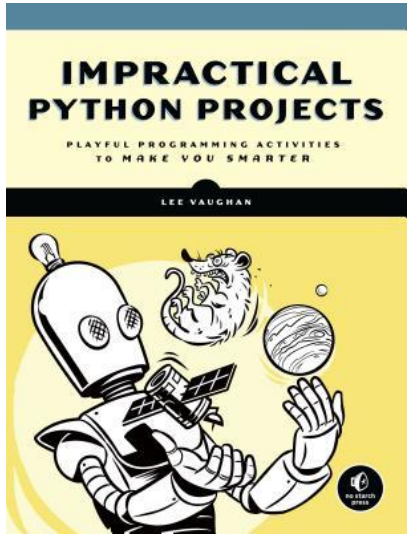



Figure 1: Impractical Python Projects

# Projects

1. Monty Hall Problem
2. Breed Bulldog sized Rats
3. Model the Fermi Paradox

# Monty Hall Problem

# Monty Hall Problem

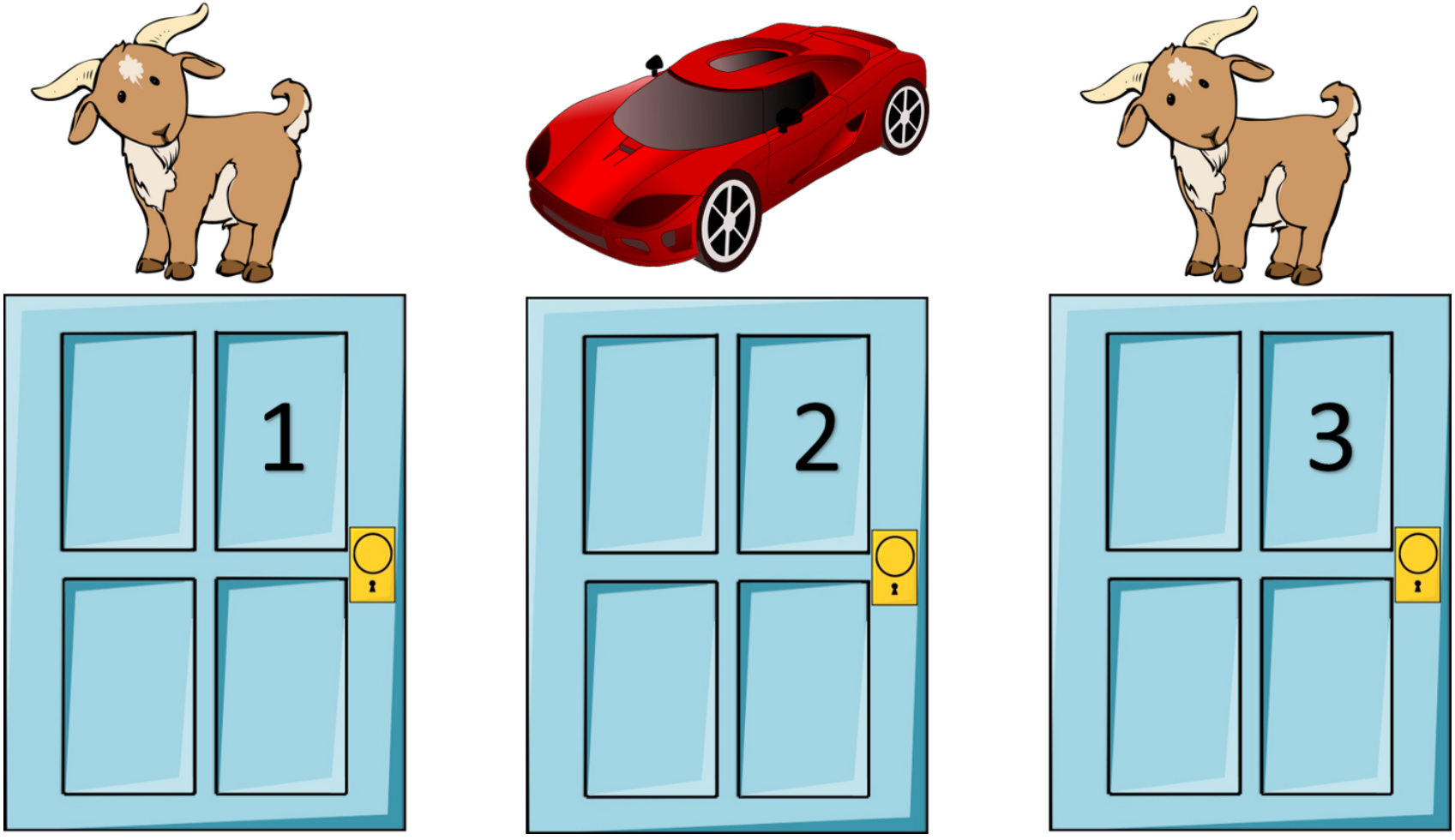



Figure 2: A showcase of the Monty Hall problem

1. Contestants are shown three doors
2. The contestant chooses a door
3. One of the unselected doors is opened to reveal a goat
4. The contestant can switch doors or keep their selection
5. If they end up opening the door with the car, they win!

# Optimal Strategy

1. Choose a door
2. After a door is revealed, switch your door
3. Win 2/3 of the time.

# The Controversy

A popular "Ask column" provided the correct solution (i.e. switch) as an answer in 1990, but was met with major push back from the general public.

We'll experimentally prove the answer by simulating many many instances of the problem.

# Simulation

```
for i in range(1000):
  doors = setup_doors()
  choice = choose_door()
  revealed_door = reveal_door(doors, choice)

  if switch_wins(doors, revealed_door, choice):
    switch_win_count += 1

  if stay_wins(doors, revealed_door, choice):
    stay_win_count += 1
```

```
def setup_doors():
  car_idx = random.randint(0, 2)
  doors = ["goat", "goat", "goat"]
  doors[car_idx] = "car"
  return doors
```

```
def choose_door():
  return random.randint(0, 2)
```

Why did we put this in a function?

```
def reveal_door(doors, choice):
  if choice == 0:
    if doors[1] == "car":
      return 2
    else:
      return 1
  elif choice == 1:
    if doors[0] == "car":
      return 2
    else:
      return 0
  else: # choice == 2
    if doors[0] == "car":
      return 1
    else:
      return 0
```

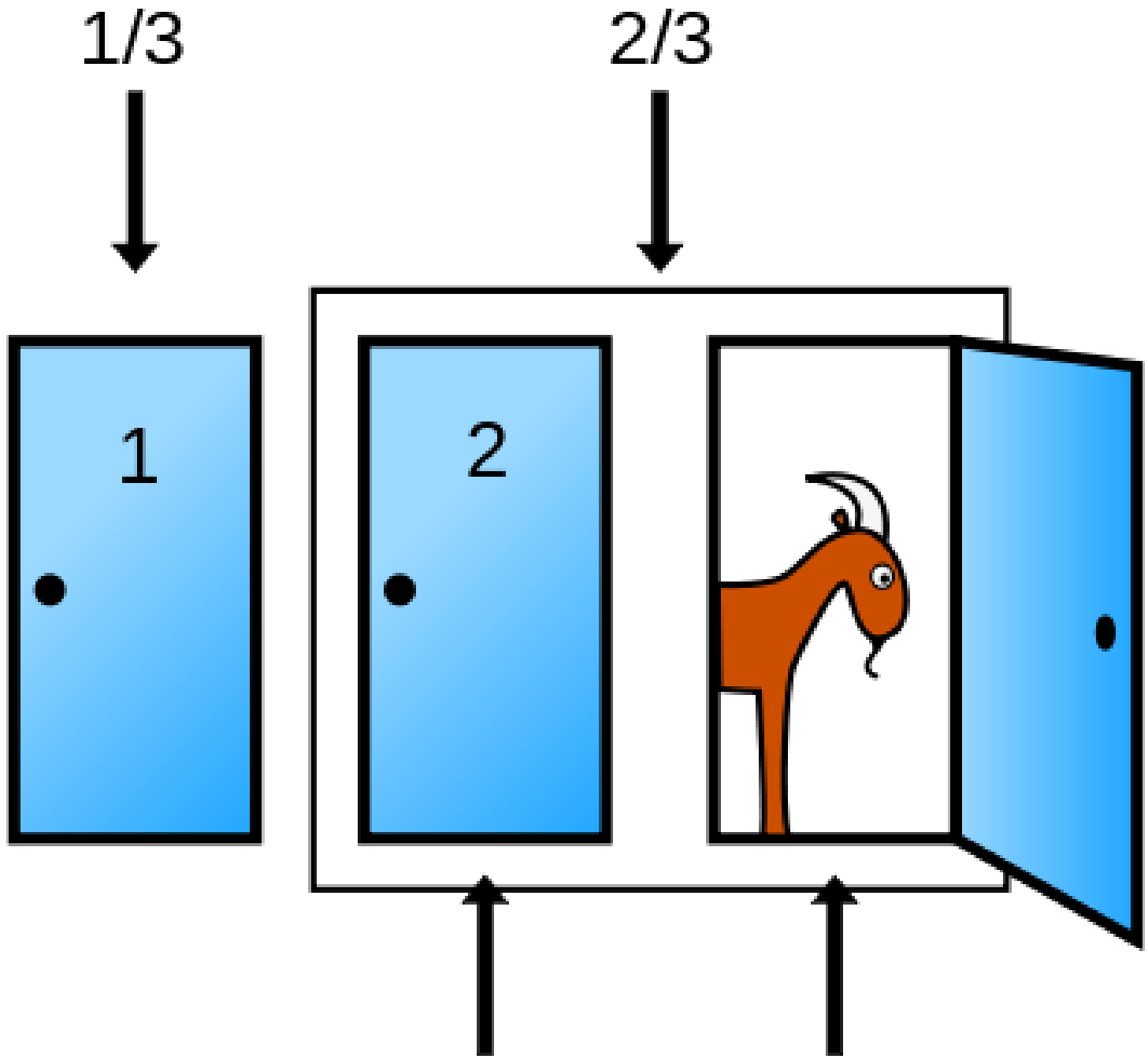
```
def switch_wins(doors, revealed, choice):
  doors_idxs = [0, 1, 2]
  if revealed > choice:
    doors_idxs.pop(revealed)
    doors_idxs.pop(choice)
  else:
    doors_idxs.pop(choice)
    doors_idxs.pop(revealed)
  return doors[doors_idxs[0]] == "car"
```

```
def stay_wins(doors, revealed, choice):
  return doors[choice] == "car"
```

# Simulation Results

```
$ python3 monte.py
Welcome to the Monty Hall Solution Simulator
The game will be run 1000 times for staying and switching.
Beginning simulation...
Finished simulation. Results to follow.
The win rate of staying is 0.334
The win rate of switching is 0.666
```

# Monty Hall Math

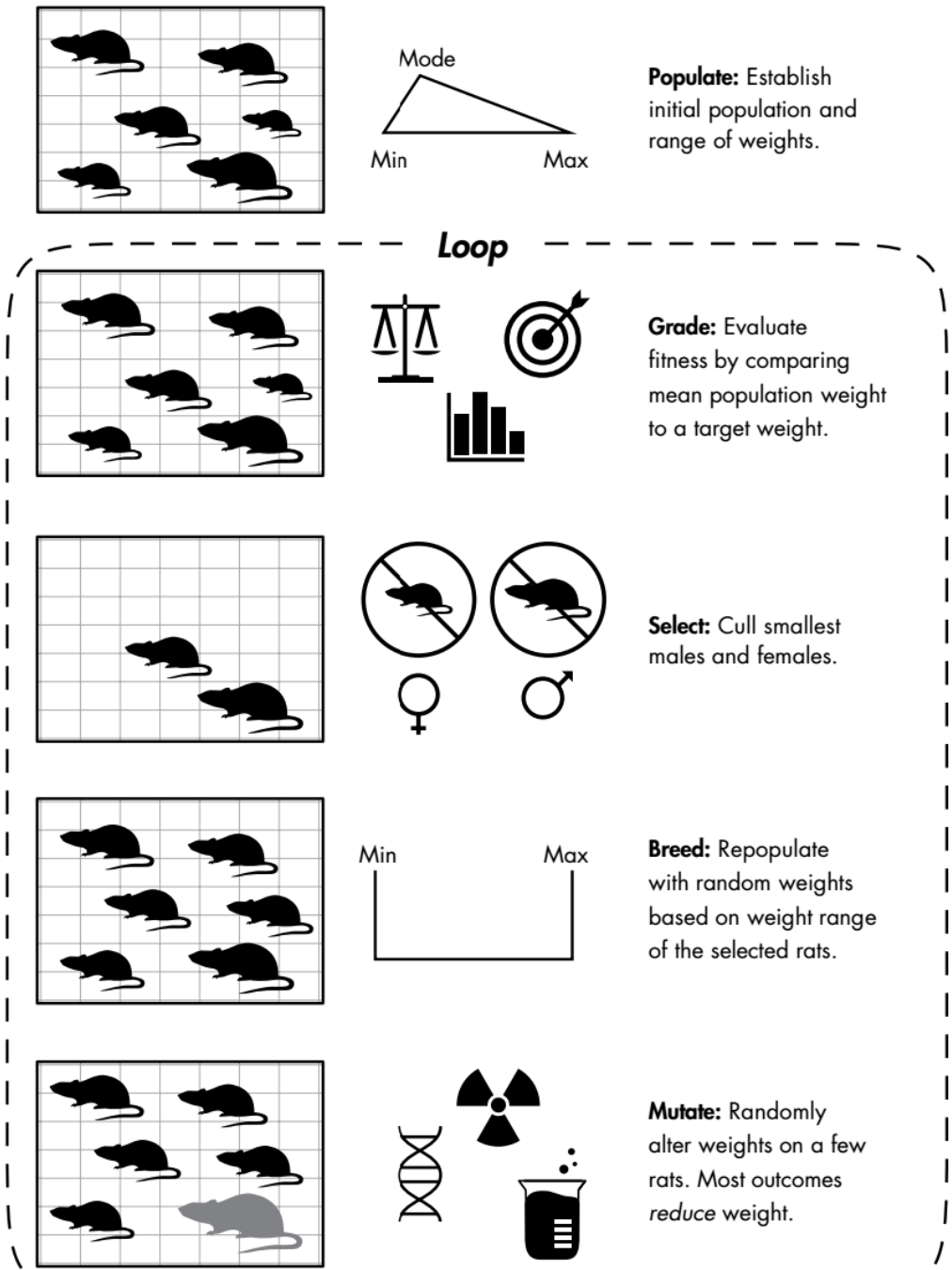


# Giant Rats

# Genetically Breeding Giant Rats

I feel like a mad scientist today, and I've decided that I'd like to create a race of super-mutant, giant rats. To see if it's even feasible, I'd first like to mode the outcomes in python to determine if we can actually do this (because that's the only challenge we need to overcome in this scenario).

# Strategy




**Populate:** Establish initial population and range of weights.

**Grade:** Evaluate fitness by comparing mean population weight to a target weight.

**Select:** Cull smallest males and females.

**Breed:** Repopulate with random weights based on weight range of the selected rats.

**Mutate:** Randomly alter weights on a few rats. Most outcomes *reduce* weight.

**Table 7-1:** Brown Rat Weight and Breeding Statistics

| Parameter | Published values |
|---|---|
| Minimum weight | 200 grams |
| Average weight (female) | 250 grams |
| Average weight (male) | 300–350 grams |
| Maximum weight | 600 grams* |
| Number of pups per litter | 8–12 |
| Litters per year | 4–13 |
| Life span (wild, captivity) | 1–3 years, 4–6 years |

*Exceptional individuals may reach 1,000 grams in captivity.

Figure 5: Information about the brown rat

**Table 7-2:** Input Assumptions for the Super-Rats Genetic Algorithm

| Variable and value | Comments |
|---|---|
| `GOAL = 50000` | Target weight in grams (female bullmastiff) |
| `NUM_RATS = 20` | Total number of *adult* rats your lab can support |
| `INITIAL_MIN_WT = 200` | Minimum weight of adult rat, in grams, in initial population |
| `INITIAL_MAX_WT = 600` | Maximum weight of adult rat, in grams, in initial population |
| `INITIAL_MODE_WT = 300` | Most common adult rat weight, in grams, in initial population |
| `MUTATE_ODDS = 0.01` | Probability of a mutation occurring in a rat |
| `MUTATE_MIN = 0.5` | Scalar on rat weight of least beneficial mutation |
| `MUTATE_MAX = 1.2` | Scalar on rat weight of most beneficial mutation |
| `LITTER_SIZE = 8` | Number of pups per pair of mating rats |
| `LITTERS_PER_YEAR = 10` | Number of litters per year per pair of mating rats |
| `GENERATION_LIMIT = 500` | Generational cutoff to stop breeding program |

Figure 6: Parameters for our program

# Simulation

```
def main():
  # create initial population
  generations = 0
  parents = populate(NUM_RATS, INITIAL_MIN_WT,
            INITIAL_MAX_WT, INITIAL_MODE_WT)
  pop_fitness = fitness(parents, GOAL)

  # create new generations
  while pop_fitness < 1 and generations < GENERATION_LIMIT:
    selected_rats = select(parents, NUM_RATS)
    children = breed(selected_rats, LITTER_SIZE)
    children = mutate(children, MUTATE_ODDS,
                      MUTATE_MIN, MUTATE_MAX)
    parents = selected_rats + children
    pop_fitness = fitness(parents, GOAL)
    generations += 1
```

```
def populate(num_rats, min_wt, max_wt, mode_wt):
  rats = []
  while num_rats > 0:
    rats.append(random.triangular(min_wt, max_wt, mode_wt))
    num_rats -= 1
  return rats
```

```
def fitness(population, goal):
  avg = statistics.mean(population)
  return avg / goal
```

```
def select(population, num_to_retain):
  sorted_population = sorted(population)
  return sorted_population[-num_to_retain:]
```

```
def breed(rats, litter_size):
  small_pop = rats[int(len(rats)/2):]
  random.shuffle(small_pop)
  large_pop = rats[:int(len(rats)/2)]
  random.shuffle(large_pop)

  children = []
  for rat1, rat2 in zip(small_pop, large_pop):
    for child in range(litter_size):
      if rat1 < rat2:
        child = random.randint(int(rat1), int(rat2))
      else:
        child = random.randint(int(rat2), int(rat1))
      children.append(child)

  return children
```

```
def mutate(children, mutate_odds, mutate_min, mutate_max):
  for idx, rat in enumerate(children):
    if mutate_odds >= random.random():
      children[idx] = round(rat *
                  random.uniform(mutate_min, mutate_max))
  return children
```

# Simulation Results

```
...
Generation 355 fitness = 0.8798
Generation 356 fitness = 0.8829
Generation 357 fitness = 0.8878
Generation 358 fitness = 0.9170
Generation 359 fitness = 0.9730
Generation 360 fitness = 1.0119

number of generations = 361
number of years = 36
```

# Fermi Paradox

# Fermi Paradox

Since the Universe is ~13 billion years old, and even a modestly space faring civilization could explore the entire milky way galaxy in ~10 million years. The radio bubbles of these groups would likely be larger than their explored space, so: *where are all the aliens?*

Figure 7: A spiral galaxy similar to the Milky Way

# Drake Equation

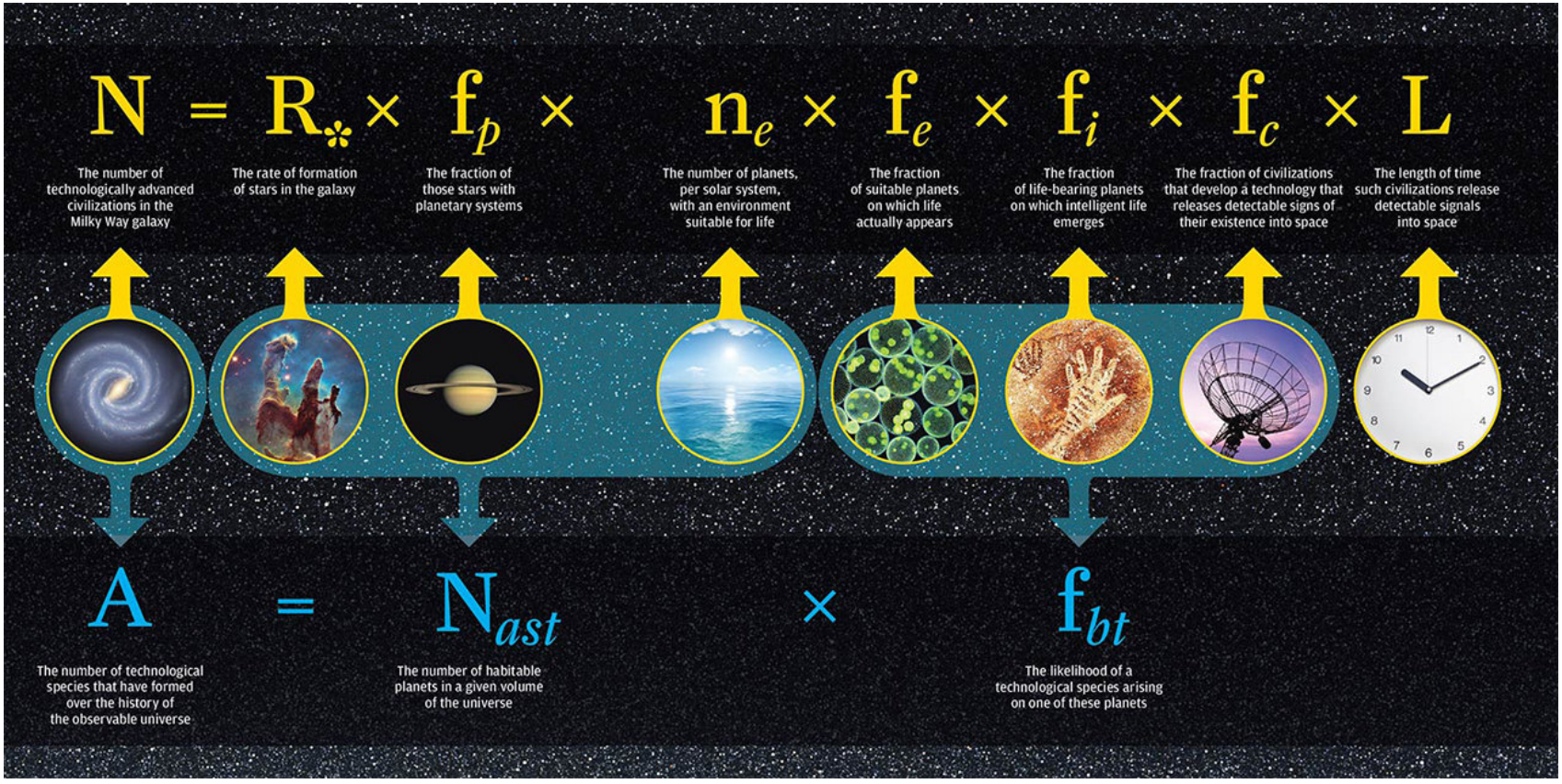



Figure 8: A modeling of the drake equation

# Constant Values

**Table 10-1:** Some Drake Equation Inputs and Results

| Parameter | Drake 1961** | Drake 2017 | Your choices |
|---|---|---|---|
| $R^*$ | 1 | 3 | |
| $f_p$ | 0.35 | 1 | |
| $n_e$ | 3 | 0.2 | |
| $f_l$ | 1 | 0.13 | |
| $f_i$ | 1 | 1 | |
| $f_c$ | 0.15 | 0.2 | |
| $L$ | $50 \times 10^6$ | $1 \times 10^9$ | |
| $N$ | $7.9 \times 10^6$ | $15.6 \times 10^6$ | |

**midpoint of ranges shown

Figure 9: Fermi Constant Estimates

# Calculating the Drake Equation

```
R_STAR = 3
F_P = 1
N_E = 0.2
F_L = 0.13
F_I = 1
F_C = 0.2
L = 10 ** 9

def drake_estimation():
  return R_STAR * F_P * N_E * F_L * F_I * F_C * L

print(int(drake_estimation()))
```

15,600,000

Using these estimates, they place an approximate estimation for the number of detectable civilizations at ~15.6 million.

Note: detectable in this context means that they could be detected in the MWG not they could be detected from Earth

# Radio Bubbles

Assuming that an alien civilization would only be leaking incidental radio waves (i.e. not broadcasting their existence into the universe), their presence would be defined by a "radio bubble."

This is a "bubble" approximately 200 LY across centered around the civilization's home planet.

We will model the galaxy as a collection of radio cubes, a very loose estimate of a radio bubble.

# Simulation

```
def main():
  cube_count = radio_cubes_in_galaxy(RADIO_BUBBLE_RADIUS)
  civilization_count = drake_estimation()
  locations = []

  # simulation to follow
```

```
def drake_estimation():
  return int(R_STAR * F_P * N_E * F_E * F_I * F_C * L)
```

```
def radio_cubes_in_galaxy(radio_bubble_radius):
  galaxy_volume = 3.14 * 50_000 * 50_000 * 1_000
  bubble_volume = 3.14 * (4/3) * radio_bubble_radius
  return galaxy_volume / bubble_volume
```

```
for i in tqdm(range(civilization_count)):
  locations.append(random.randint(1, cube_count))

counts = {}
for val in tqdm(locations):
  if val in counts:
    counts[val] += 1
  else:
    counts[val] = 1

detected_civs = 0
for val in tqdm(counts.values()):
  if val > 1:
    detected_civs += val
```

# Simulation Results

```
Populating galaxy
100%|============================| 15600000/15600000
Counting civs per cube
100%|============================| 15600000/15600000
Counting overlapping civs
100%|============================| 15593457/15593457
The number of civs who could have
  detected each other = 13084
This is a rate of 0.0839%
```

In other words, the chance of a civilization being in a position to detect another is 1 in 1750.

# Questions

# The Next Steps

This has been a great start to your computer science journey, but how do you move forward from here?

- Studying/Practice
- Courses
- Learning new Languages

# How to Practice

We've mentioned before, but just writing code is often the best way to practice! Fortunately, there are a lot of great places you can go to practice programming problems at various levels!


Figure 10: kattis.com

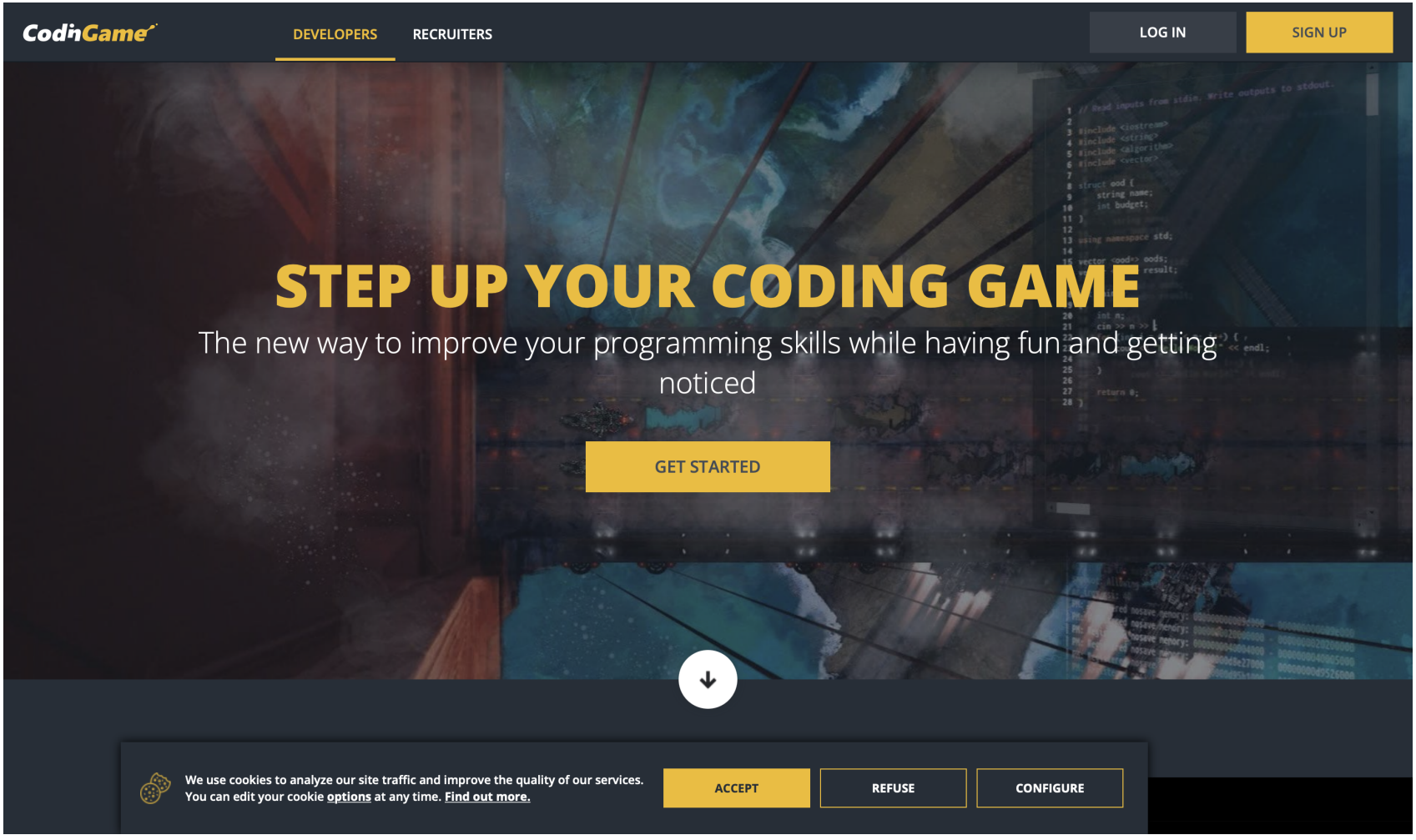



Figure 11: codingame.com

Project Euler.net

About | Archives | Recent | N

## About Project Euler

### What is Project Euler?

Project Euler is a series of challenging mathematical/computer programming problems that will require more than just mathematical insights to solve. Although mathematics will help you arrive at elegant and efficient methods, the use of a computer and programming skills will be required to solve most problems.

The motivation for starting Project Euler, and its continuation, is to provide a platform for the inquiring mind to delve into unfamiliar areas and learn new concepts in a fun and recreational context.

### Who are the problems aimed at?

The intended audience include students for whom the basic curriculum is not feeding their hunger to learn, adults whose background was not primarily mathematics but had an interest in things mathematical, and professionals who want to keep their problem solving and mathematics on the cutting edge.

Figure 12: projecteuler.net

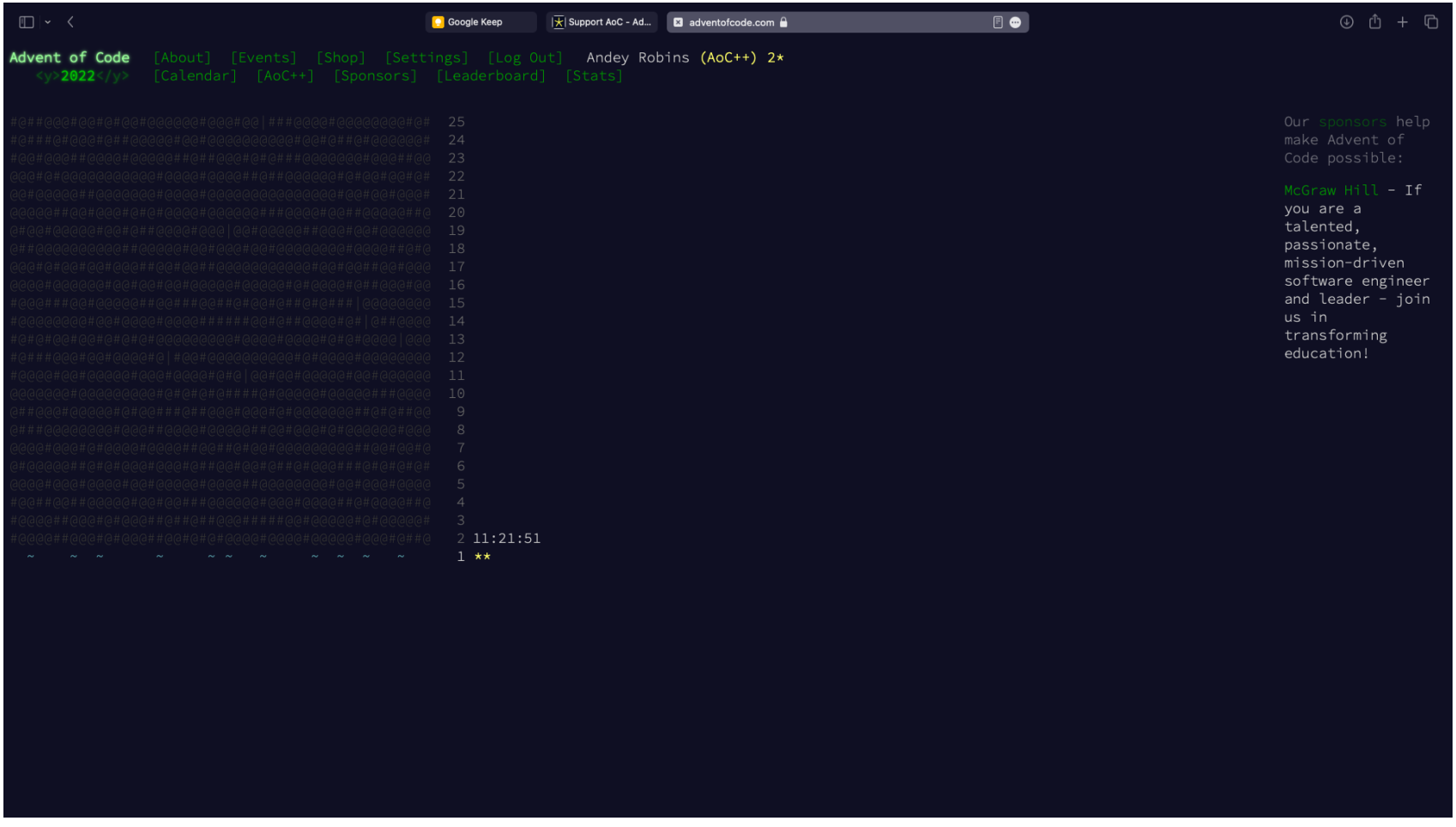



Figure 13: adventofcode.com

# Courses

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **FRESHMAN YEAR** | | | | | | | | | |
| COSC 1010 | Intro to Comp Science | | 3 | C | | COSC 1030 | Computer Science I | 4 | C |
| | | | | | | *Prerequisite:* | *C in COSC 1010* | | |
| MATH 2200 | Calculus I | Q | 4 | C | | MATH 2205 | Calculus II | Q | 4 | C |
| *Prerequisite:* | *C in Math 1405 or 1450, MPE 5, Math ACT 27, Math SAT 640* | | | | | *Prerequisite:* | *C in Math 2200* | | |
| | Science Elective- *see list* | PN | 4 | D | | | Science Elective- *see list* | PN | 4 | D |
| | USP: First Year Seminar | FYS | 3 | C | | | USP: Communications I | C1 | 3 | C |
| | Total | | 14 | | | | Total | | 15 | |
| **SOPHOMORE YEAR** | | | | | | | | | |
| COSC 2150 | Computer Organization | | 3 | C | | COSC 3011 | Intro to Software Design | | 3 | C |
| *Prerequisite:* | *C in COSC 1030* | | | | | *Prerequisite:* | *C in COSC 2030* | | | |
| COSC 2030 | Computer Science II | | 4 | C | | COSC 3020 | Alg & Data Structures | | 4 | C |
| *Prerequisite:* | *C in COSC 1030* | | | | | *Prerequisite:* | *C in COSC 2030 and COSC 2300* | | | |
| COSC 2300 | Discrete Structures | | 3 | C | | MATH 2250 | Elementary Linear Algebra | | 3 | C |
| *Prerequisite:* | *C in COSC 1030 and MATH 2200* | | | | | *Prerequisite:* | *C in Math 2200 or Math 2350* | | | |
| | USP: Human Culture | H | 3 | D | | | USP: Human Culture | H | 3 | D |
| | USP: Communications II | C2 | 3 | C | | | General Elective | | 3 | D |
| *Prerequisite:* | *C in C1* | | | | | | | | | |
| | Total | | 16 | | | | Total | | 16 | |
| **JUNIOR YEAR** | | | | | | | | | |
| COSC 3015 | Functional Programming | | 3 | C | | COSC 3050 | Ethics for Computer Prof | | 1 | C |
| *Prerequisite:* | *C in COSC 2030 and COSC 2300* | | | | | *Prerequisite:* | *Junior Standing, COSC Major* | | | |
| COSC | Systems Course (4760 or 4820) | | 3 | C | | COSC | Theory Course (4100 or 4200) | | 3 | C |
| *Prerequisite:* | *Varies* | | | | | *Prerequisite:* | *Varies* | | | |
| COSC 3765 | Computer Security | | 3 | C | | COSC | COSC Elective I | | 3 | C |
| *Prerequisite:* | *COSC 2030* | | | | | *Prerequisite:* | *Varies* | | | |
| | Math/Science Elective - *see list* | | 4 | C | | | General Elective | | 3 | D |
| | USP: US & Wyo Const. | V | 3 | D | | | General Elective | | 3 | D |
| | Total | | 16 | | | | Total | | 13 | |

Figure 14: UWyo COSC Courses

# How to Learn a New Language

1. Learn the basic, atomic pieces
2. Solve some basic problems
3. Learn the tools
4. Build a medium project and “release” it
5. Read about and implement best practices

```cpp
#include <iostream>
int main() {
  int max = 0;
  bool show_text = false;
  int my_nums = { 0, 2, 3, 50, 1};

  if (show_text)
    std::cout << "The array: ";

  // ....
```

```
  // ....
  for (auto num: my_nums) {
    if (num > max)
      max = num;
    if (show_text)
      std::cout << num << " ";
  }
  if (show_text) {
    std::cout << std::endl << "Max number: "
              << max << std::endl;
  }
}
```

# Tools

Instead of the interpreter `python3` we use the compiler `gcc`.

Instead of pip, we use "header files."

Instead of `import` we say `include`.

# Releasing Something

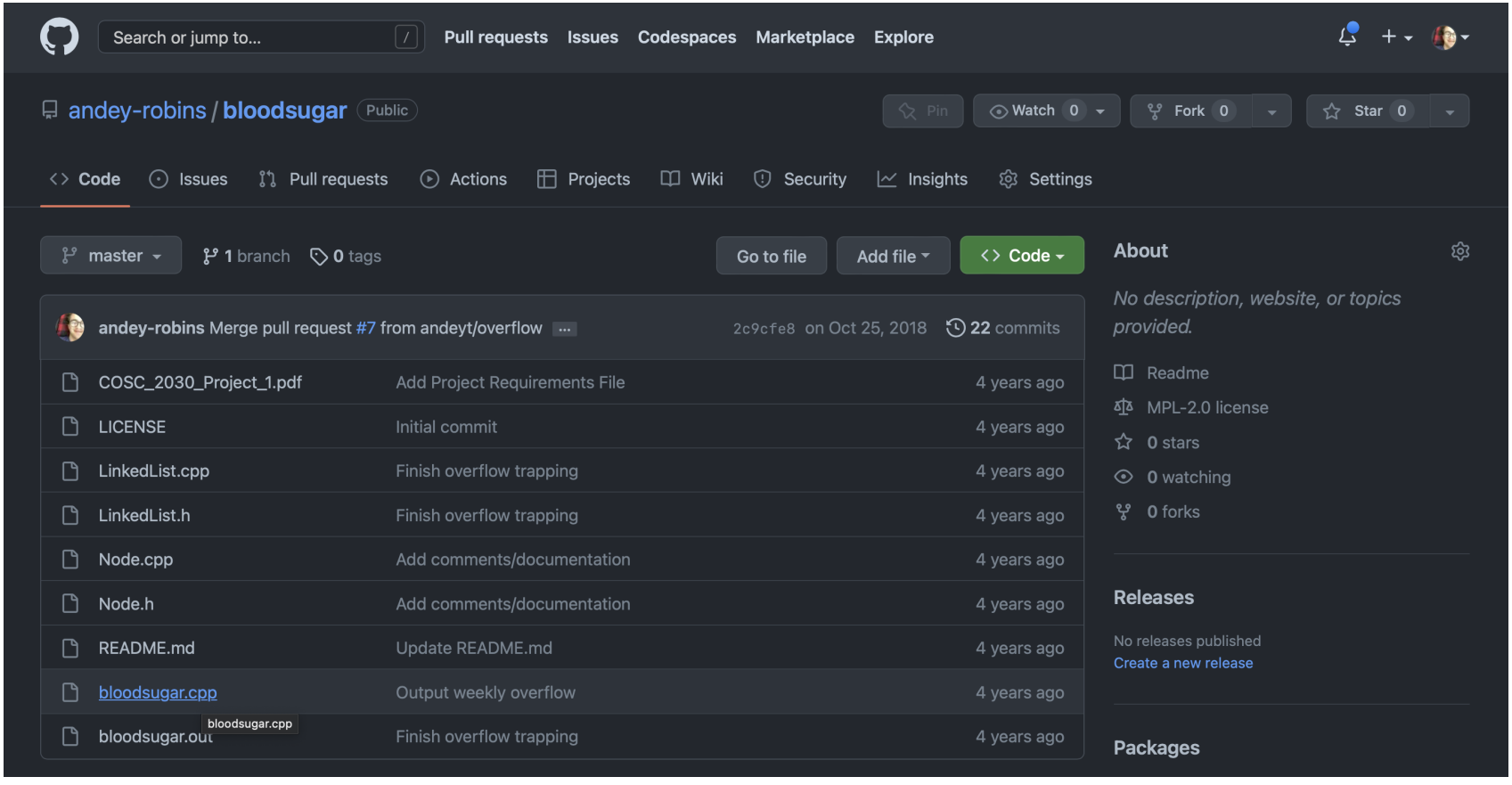
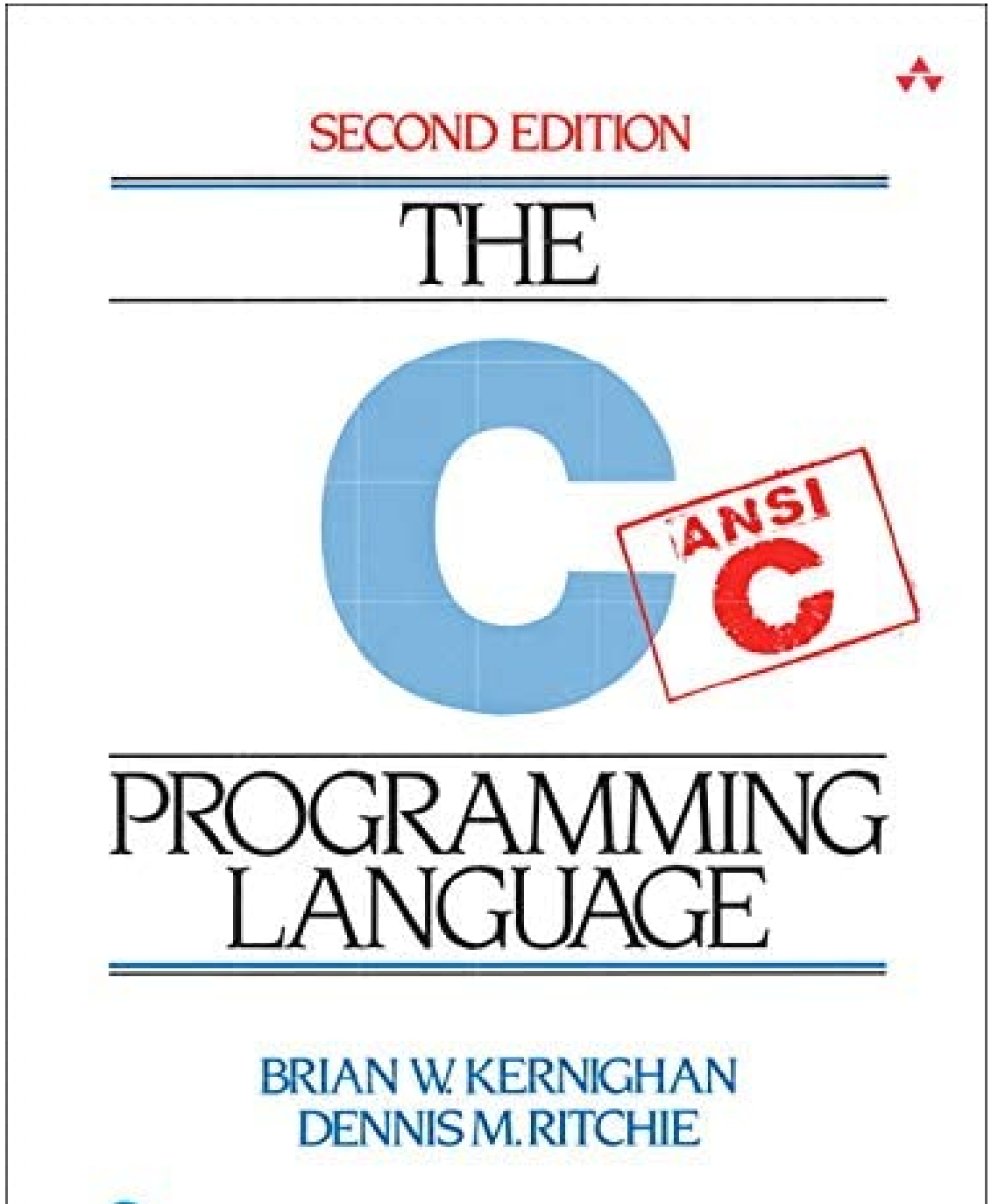



Figure 15: 2030 Bloodsugar project

# Best Practices



# Questions