

--- Day 11: Cosmic Expansion ---

You continue following signs for "Hot Springs" and eventually come across an **observatory**. The Elf within turns out to be a researcher studying cosmic expansion using the giant telescope here.

He doesn't know anything about the missing machine parts; he's only visiting for this research project. However, he confirms that the hot springs are the next-closest area likely to have people; he'll even take you straight there once he's done with today's observation analysis.

Maybe you can help him with the analysis to speed things up?

The researcher has collected a bunch of data and compiled the data into a single giant **image** (your puzzle input). The image includes **empty space** (.) and **galaxies** (#). For example:

```
...#.....
.....#..
#.....
.....
.....#...
.#.....
.....#
.....
.....#..
#...#.....
```

The researcher is trying to figure out the sum of the lengths of the **shortest path between every pair of galaxies**. However, there's a catch: the universe expanded in the time it took the light from those galaxies to reach the observatory.

Due to something involving gravitational effects, **only some space expands**. In fact, the result is that **any rows or columns that contain no galaxies** should all actually be twice as big.

In the above example, three columns and two rows contain no galaxies:

```
  v   v   v
...#.....
.....#..
#.....
>.....<
.....#...
.#.....
.....#
>.....<
.....#..
#...#.....
  ^   ^   ^
```

These rows and columns need to be **twice as big**; the result of cosmic expansion therefore looks like this:

```
...#.....
.....#...
#.....
.....
.....#....
.#.....
.....#
.....
.....#...
#...#.....
```

Equipped with this expanded universe, the shortest path between every pair of galaxies can be found. It can help to assign every galaxy a unique number:

```
...1.....
.....2...
3.....
.....
.....4....
.5.....
.....6
.....
.....7...
8....9.....
```

In these 9 galaxies, there are **36 pairs**. Only count each pair once; order within the pair doesn't matter. For each pair, find any shortest path between the two galaxies using only steps that move up, down, left, or right exactly one **.** or **#** at a time. (The shortest path between two galaxies is allowed to pass through another galaxy.)

For example, here is one of the shortest paths between galaxies **5** and **9**:

```
...1.....
.....2...
3.....
.....
.....4....
.5.....
.##.....6
..##.....
...##.....
....##...7...
8....9.....
```

This path has length **9** because it takes a minimum of **nine steps** to get from galaxy **5** to galaxy **9** (the eight locations marked **#** plus the step onto galaxy **9** itself). Here are some other example shortest path lengths:

- Between galaxy **1** and galaxy **7**: 15
- Between galaxy **3** and galaxy **6**: 17
- Between galaxy **8** and galaxy **9**: 5

In this example, after expanding the universe, the sum of the shortest path between all 36 pairs of galaxies is **374**.

Expand the universe, then find the length of the shortest path between every pair of galaxies. **What is the sum of these lengths?**

To begin, **get your puzzle input**.

Answer: [\[Submit\]](#)

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