Challenge Answers:

1. Since each parasite occupies 25% or more of the total area of the image and typically less than 50% or 60%, we can store the image as an array of tuples, where each tuple stores the index of microbes. This storage format where only the non-zero pixel values are stored would significantly reduce storage space.

We will store both the images generated by the dye sensor and the microscope in the same way.

Estimating storage size:

- Each image contains at least 25,000,000 black pixels (assuming 100,000x100,000 pixels and 25% occupancy).
- We just need 1 bits per pixel for grayscale images, the least storage size for the microscope image representation would be approximately 25,000,000 * 1 = 25,000,000 bits or 3.125 MB.

For representing images generated by the dye sensor, a similar sparse matrix structure could be used. Again, since the dye typically permeates the parasite's body with some leakage into surrounding areas, most of the pixels will be white (no dye). Hence, a sparse matrix representing the locations where dye is detected (non-zero pixels) would be efficient. The same format used to store images generated by microscope will be used.

The amount of dye detected inside the parasite's body would be significantly less than the total area occupied by the parasite(around 10%).

The least storage size for the dye sensor image representation would be approximately 0.1 * 3.125 MB = 0.3125MB

So, the minimum total storage size to store a microbe image generated by the dye sensor and the microscope is typically 3.4375MB.

In worst case, storage size will be (3.125*4 = 12.5MB) Microscopic Image 0.1*(3.125*4) = 1.25MB Dye sensor Image.

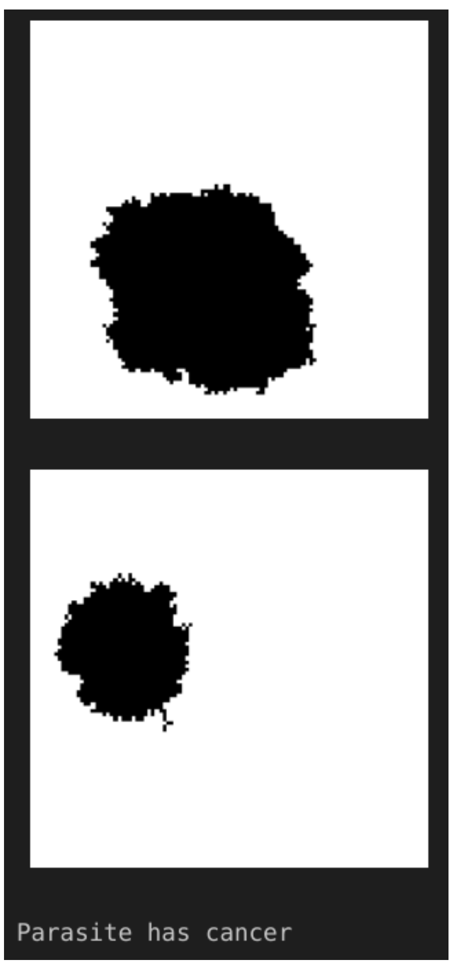
I.e a total storage of around 14MB.

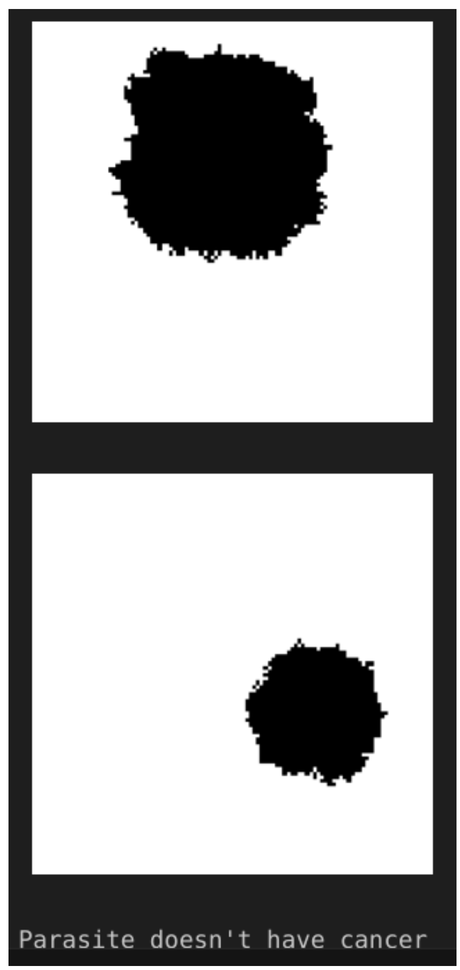
2. Coded in Jupyter Notebook. Generated 100x100 pixel images .

3. Coded in Jupyter Notebook.

Time Complexity is O(size of Microscope Image x size of Dye sensor image)

= $O(n^2)$





4. Coded in Jupyter Notebook.
Linear Algorithm using Two-Pointers.
Time Complexity O(size of Microscope Image) = O(n)

5. Similar to compressed sparse row (CSR) format, we can store only the list of column indexes of microbe pixels(A) and list of no.of microbe pixels in each row(B).
In this way Storage nearly reduces to hals. But to find the row index of a pixel we need to Do Binary search on list B which Takes O(log(n)) time.
So Time Complexity Changes from O(n) to O(nlog(n)).

I was unable to create a 1,000,000 x 1,000,000 size pixel image due to the memory limit of my laptop.

6.