Reinforcement Learning Technique to Overcome Antibiotic Resistance Bacteria

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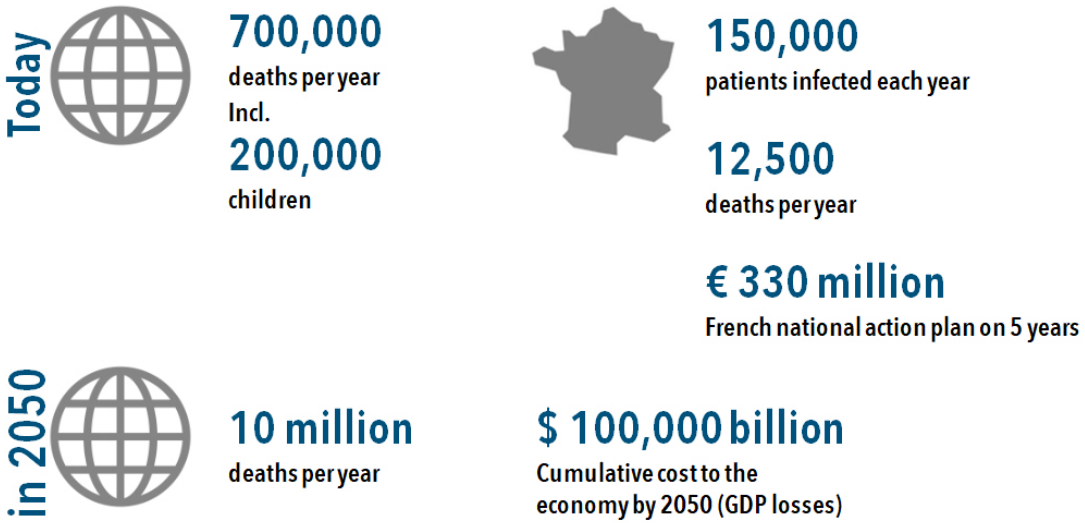
Motivation I



- Over millions of people get infections resistant to antibiotics every year.
- The traditional antibiotic designing approaches are slow and require huge investment.

Motivation II

- pharmaceutical companies are losing interest to invest in antibiotic research.
- We propose a reinforcement learning approach to overcome this problem.

Bacteria and Antibiotics I

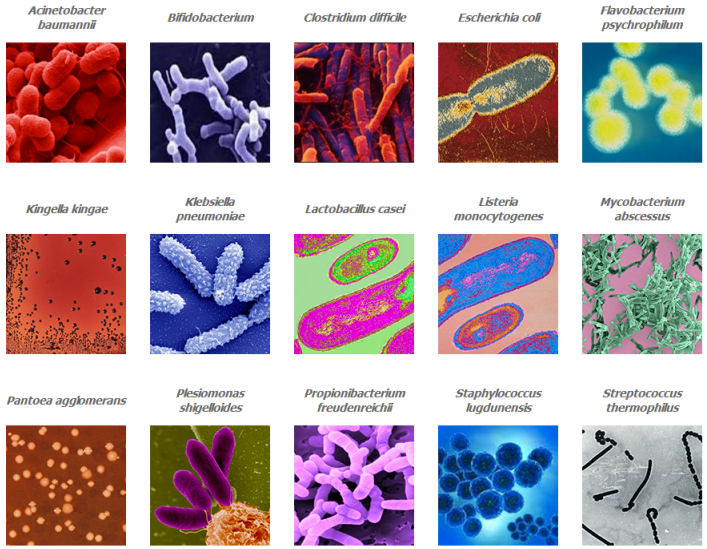


Figure: Different types of bacteria

- Bacteria is a form of biological cells that comprise large domain of microorganisms.

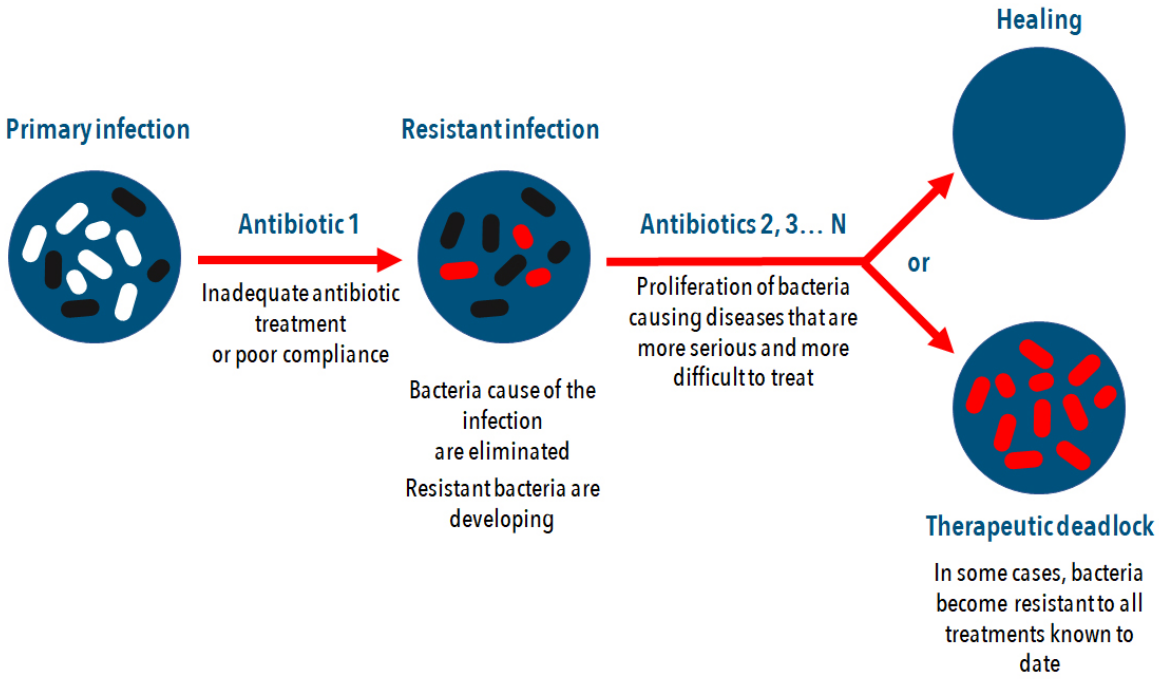
Bacteria and Antibiotics II

- Their total biomass is greater than that of all animal and plant cells combined.
- They live everywhere; on the ground, in the water, inner and outer part of our body
- There are harmless bacteria and bad bacteria that might cause harmful infections.
- Antibiotics are amazing medicines that we use to fight the bacteria that is affecting our health.

Bacteria and Antibiotics III

- They are made of synthesized chemicals or naturally occurring things (like fold).
- The antibiotics kill or neutralize the bacteria by interfering bacteria's protein synthesis or interrupting it is cell wall without harming human cells.

How bacteria resist to antibiotics I



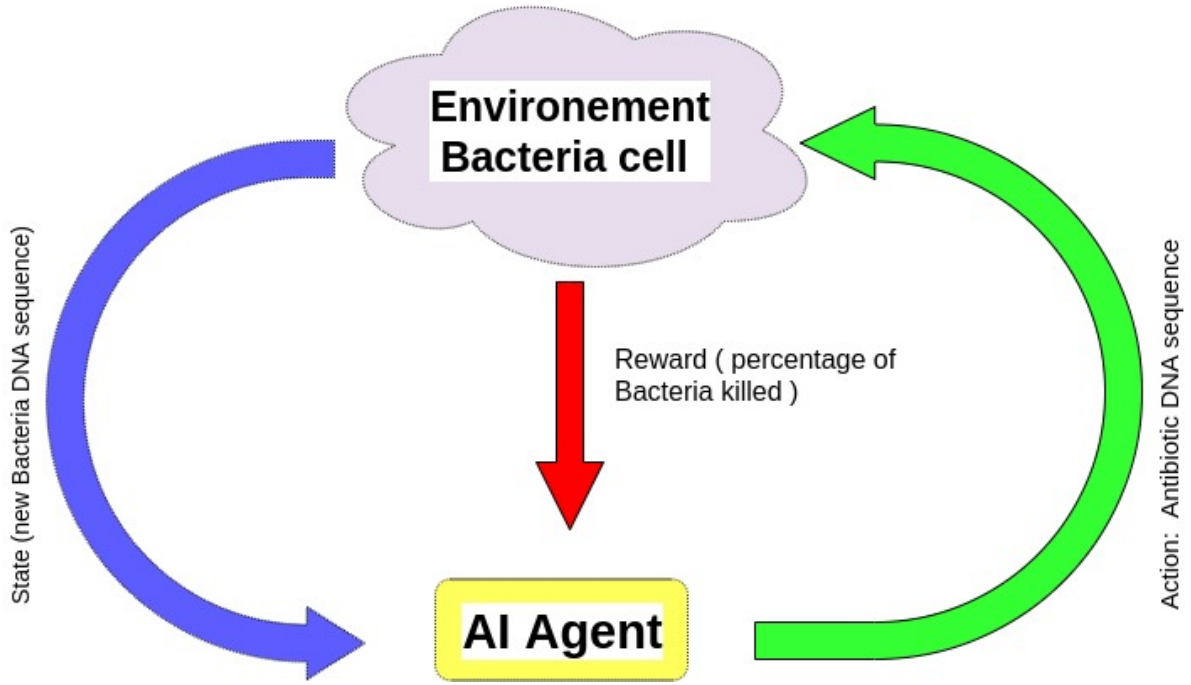
- Bacteria becomes resistant to antibiotics by random Mutation - a method that is often called random selection.

How bacteria resist to antibiotics II

- A mutation occurs when a DNA gene is damaged or changed in such a way as to alter the genetic message carried by that gene.
- The mutation leads to a variation in genes.
- The microorganisms (bacteria) to protect themselves from antibiotics they develop enzymes that disrupts the antibiotic structure.

Problem Formulation

Q: How can RL can address this problem.



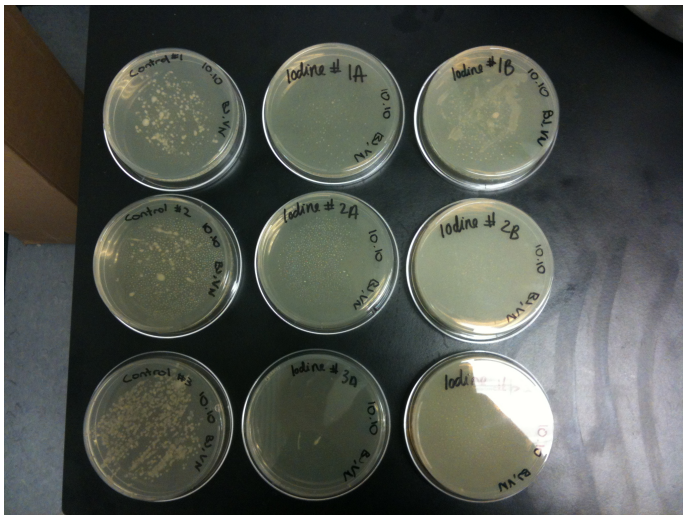
Policy optimization & validation I

- Policy $\pi(a|s;w)$ is defined as the probability of giving antibiotic DNA sequence given a specific bacteria DNA sequence.
- The state-action is too big and cannot be represented in a table.
- Policy will be learned directly from neural network (NN). The Policy will be optimized by turning the weights parameters.
- Input to $\pi(a|s;w)$ will be DNA sequence of remaining bacteria cell, the percentage of bacteria that have been killed and the time steps taken for the antibiotic to kill.
- start with exploring since the neural network parameters are initialized randomly.

Policy optimization & validation II

- Policy validation our target is to check and validate the optimal policy function.
- The agent will be used to predict the new DNA sequence of the antibiotic (a) and the possible state (i.e. bacteria DNA sequence).
- Experiments and comparing to our results from policy.
- This is Human free experiment validating which makes it easy to validate.
- bacteria will be allowed to mutate to a new state and a new antibiotic will be introduced, this action will continue until we finish all the number of states in that episode

Data collection I



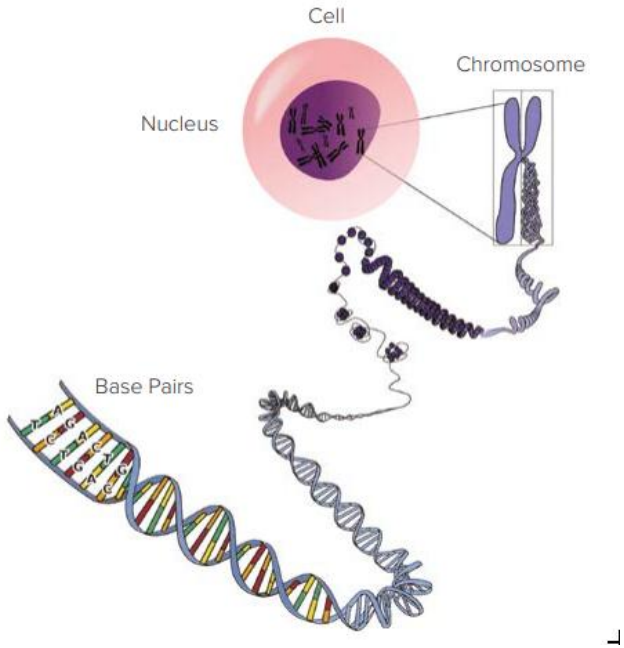


Figure: Culture of Bacteria and DNA sequence

- Most widely used methods of multiplying bacteria under controlled environment conditions.

Data collection II

- Important factors: temperature, pH, Concentration of atmospheric gases (particularly oxygen)
- Definitive identification and characterization of the bacteria.
- Can also induce chemicals that will give strength to the bacteria to mutate.
- The changed DNA sequence will be recorded by performing lab checking.
- Antibiotic will be also generated based on the new state of the bacteria.
- The model : learn how the DNA sequence of the bacteria changes to generate the new sequence of the antibiotics.

Discussion (Feasibility and Limitations)

- We have discussed here a project that has a global impact.
- The study is feasible since we have full control of the environment.
- Upon successful completion, this will save a lot of human lives and improve significantly the production of antibiotics.
- Time taken to train could be a possible limitation
- Another limitation could be the antibiotic production.

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THANK YOU
Q&A