# Chosen Algorithm: Genetic Algorithm

Genetic Algorithms (GAs) are adaptive search techniques inspired by natural selection and genetics. They belong to the broader category of evolutionary algorithms and are used to find near-optimal solutions for complex optimization and search problems. GA is used to approximately generate new solutions within complex problems by constantly evolving a population of candidate solutions, which act as chromosomes in biological terms, over several generations. This often recognized as the natural selection and genetics. Through generations, GAs explore and exploit by applying selection, crossover, and mutation to evolve the population, guiding the search towards better solutions based on historical data. This process allows GAs to efficiently explore the solution space and adaptively improve performance over time.

# Implementation Details

Throughout the implementation process of the GA, the steps can be summarized as:

1. Initialize Population:

Generate a random initial population of solutions. Each solution representing a set of vehicle routes, which is ensured each customer is visited exactly once. The population size 𝑠 is tunable to increase or decrease the size.

1. Define Fitness:

Evaluate the fitness of each solution by calculating the total route cost, typically based on distance and cost per km. Penalize solutions that had violated constraints (e.g., route demand exceeding vehicle capacity) with a high bias value (e.g. + RM10000) to higher their fitness (higher cost).

1. Set Generations:

Define the number of generations g the GA will run, which controls the iteration count for evolving the population towards better solutions.

1. Selection:

Select the top 10% of solutions based on lowest fitness score to the next generation (new generation). This remains the best solutions for further evolution.

1. Mating (Crossover and Mutation):

Generate the remaining 90% of the new population by mating pairs of solutions from the top 50% and applying crossover and mutation. Crossover combines genes (e.g. route sequence and split ratio) from two parents, while mutation introduces small random changes of the route sequence to maintain diversity.

1. Replace and Iterate:

Replace the old population with the new one and repeat the selection, crossover, and mutation steps for g generations. This iterative process improves solution quality.

1. Find Best Solution:

After g generations, identify the best solution in the final population. This solution provides the most efficient set of routes, minimizing total cost while meeting all constraints.

# Result/ Performance

The initial and evolved solutions for the problem indicate significant improvements after applying the GA. The evolved solution reduced the total travel distance from 127.47 KM to 99.24 KM (a 22.15% reduction) and decreased the total cost from RM167.73 to RM132.04 (a 21.27% reduction). Vehicle A optimized its route, reducing travel distance by 4.38 KM and increasing demand utilization. Vehicle B, despite a slight increase in distance, it managed to keep costs balanced, while Vehicle C achieved a 26.67 KM reduction in travel distance by reaching nearby customers more effectively. Overall, GA refined the route allocation, leading to better load balancing and significant cost savings, demonstrating its effectiveness in optimizing logistics problems.