In [122…

```
import numpy as np
import matplotlib.pyplot as plt
import scipy.integrate as integrate
from ipywidgets import interact
```

In [152…

```
#Make paraters global
global c
global mu
global nu
global alpha
global beta
global gamma
global delta

c = 0.19
mu = 0.03
nu = 0.003
alpha = 800
beta = 1.5
gamma = 0.004
delta = 2.2
```

In [144…

```
def xdot(state: tuple , t : np.ndarray, r: float):
    x, y = state


    cross = (alpha*x*y) * (1/(beta + x))

    dxdt = x*(r - c*x)*(x - mu)* (1/(nu + x)) - cross
    dydt = gamma * cross - delta * y
    return [dxdt, dydt]
```

In [ ]:

```
num_r = 5
rspan = np.linspace(1.4, 2.65, num_r)
timespan = np.linspace(0, 100, 1000)
x0, y0 = 3, 0.010
init = [x0, y0]
fig, axs = plt.subplots(num_r, figsize = (12, 12))
for i, r in enumerate(rspan):
    sol = integrate.odeint(xdot, init, timespan, args=(r, ))
    x, y = sol.T
    xmax = x / max(x)
    ymax = y / max(y)


    #finding period ->Taking derivative and plotting zeros

    x_max_pts = []
    y_max_pts = []

    prev_diff = 0
    for j, diff in enumerate(np.diff(xmax)):
        if prev_diff >= 0 and diff <= 0:
            x_max_pts.append((j, xmax[j]))
        prev_diff = diff

    prev_diff = 0
    for j, diff in enumerate(np.diff(ymax)):
        if prev_diff >= 0 and diff <= 0:
            y_max_pts.append((j, ymax[j]))
        prev_diff = diff


    axs[i].plot(np.diff(np.array(x_max_pts)[:, 0]), label = "Prey")
    axs[i].plot(np.diff(np.array(y_max_pts)[:, 0]), label = "Predator")
    axs[i].set_title(f'r = {r}, T = {np.diff(np.array(x_max_pts)[:, 0])[-1]}')
    axs[i].set_ylabel("Timestep")
    axs[i].set_xlabel("Period iteration")

    axs[i].legend(loc='upper right')

plt.tight_layout(pad = 0.7)
```