

```
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 = max(x)
    ymax = max(y)
    axs[i].plot(x/xmax, label = "Prey")
    axs[i].plot(y/ymax, label = "Predator")
    axs[i].set_title(f'r = {r}')
    axs[i].legend(loc='upper right')

plt.tight_layout(pad = 0.5)
```