

```

In[ ]:= h+[p_,  $\theta$ _, n_] := p^n / (p^n +  $\theta$ ^n)
h-[p_,  $\theta$ _, n_] := 1 - h+[p,  $\theta$ , n]

tmax = 200;

With[{ma = 1., mb = 1., mc = 1.,
      na = 2.2, nb = 2.2, nc = 2.2,
       $\theta$ a = 0.28,  $\theta$ b = 0.28,  $\theta$ c = 0.28,
      ka = 1., kb = 1., kc = 1.,
       $\gamma$ a = 1.,  $\gamma$ b = 1.,  $\gamma$ c = 1.,
       $\delta$ a = 1.,  $\delta$ b = 1.,  $\delta$ c = 1.},
  sol = NDSolve[{r_a'[t] == ma * (h-[p_c[t],  $\theta$ c, nc]) -  $\gamma$ a * r_a[t],

    r_b'[t] == mb * (h+[p_a[t],  $\theta$ a, na] + h+[p_c[t],  $\theta$ c, nc]) -  $\gamma$ b * r_b[t],
    r_c'[t] == mc * (h-[p_b[t],  $\theta$ b, nb]) -  $\gamma$ c * r_c[t],
    p_a'[t] == ka * r_a[t] -  $\delta$ a * p_a[t],
    p_b'[t] == kb * r_b[t] -  $\delta$ b * p_b[t],
    p_c'[t] == kc * r_c[t] -  $\delta$ c * p_c[t],
    r_a[0] == 0,
    r_b[0] == 0, r_c[0] == 0, p_a[0] == 0, p_b[0] == 0, p_c[0] == 0},
    {r_a, r_b, r_c, p_a, p_b, p_c}, {t, 0, tmax}]];

```

```

ParametricPlot[Evaluate[{p_a[t], p_b[t]} /. First[sol]], {t, 0, tmax},
  AxesLabel -> {p_a, p_b}, ColorFunction -> "Rainbow", PlotRange -> Full]

```

```

Plot[Evaluate[{p_a[t], p_b[t], p_c[t]} /. First[sol]],
  {t, 0, tmax}, PlotLegends -> {"p_a", "p_b", "p_c"}]

```



