Homework 1

SIMBAS and Modeling Exponential Growth

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ABE 58000
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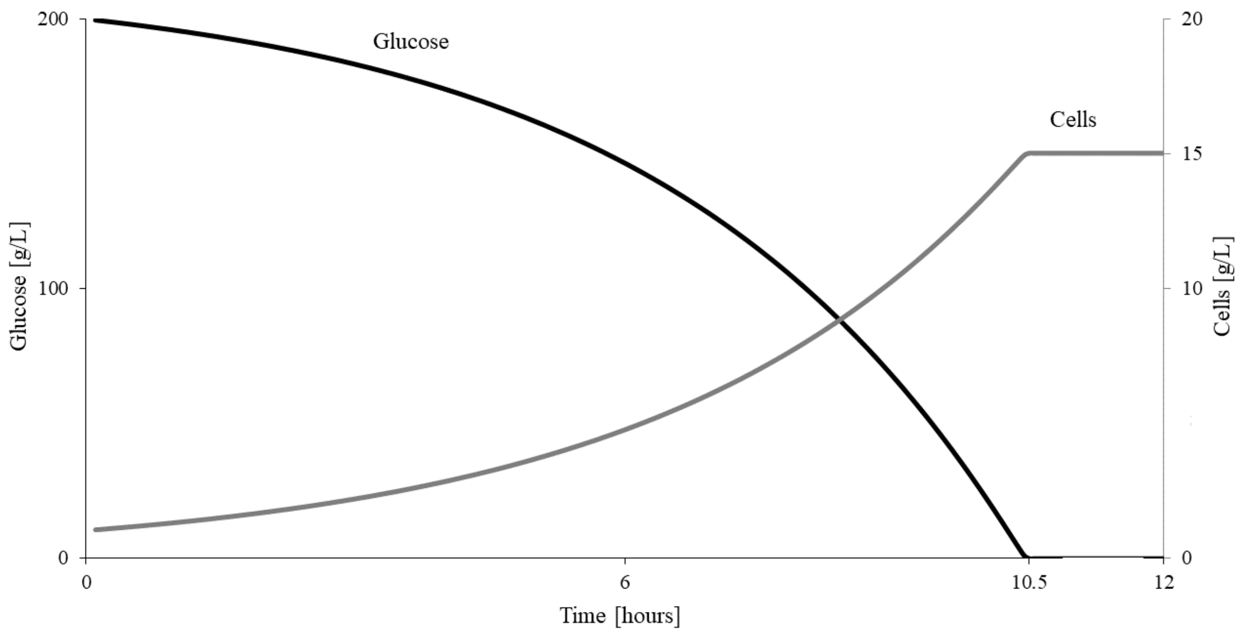

Figure 1: Glucose Concentration and Cell Concentration vs. Time

To produce the graph shown in Figure 1, two ordinary differential equations were used:

$$\frac{dX}{dt} = \frac{\mu_{max} S}{K_m + S} X \quad [1]$$

$$\frac{dS}{dt} = -Y_{S/X} \frac{dX}{dt} \quad [2]$$

In these equations, X and S are variables, representing the concentration of cells and glucose in grams per liter, respectively. The given initial conditions state that there is one gram of cells per liter and 200 grams of glucose per liter initially in the reactor. The constant μ_{max} represents the maximum growth rate of the cells, with units of inverse time, hours^{-1} in this case. K_m is the Monod constant, which represents the concentration of glucose where the growth rate is half of the maximum growth rate with units of grams of glucose per liter. $Y_{S/X}$ is the yield coefficient, which represents the utilized substrate per yield of cells with units of grams of glucose per grams of cells. As seen in Figure 1, the cells take 10.5 hours to utilize all of the glucose with the given constants and initial conditions.

The time to use all of the glucose is inversely proportional to the constant μ_{max}. That is, if μ_{max} is doubled, the time to consume all of the initial glucose is halved (Figure 2), and if μ_{max} is halved, the time to consume all of the initial glucose is doubled (Figures 3). Adjusting the K_m value does not have a significant effect on the time to use all of the glucose, but the effect it does have is proportional to the change in K_m. As such, if K_m is decreased, the time to use all glucose is decreased and vice-versa (Figures 4 and 5). Finally, adjustments to the $Y_{S/X}$ value not only have an inveresly proportonal effect on the time to consume all of the initial glucose, but also an inversely proportional effect on the yield of cells given the same amount of initial glucose. When $Y_{S/X}$ is doubled, the time to use all of the glucose is decreased by about 25% and the final concentration of cells is reduced by nearly half (Figure 6), and when it is halved the time to use the glucose increases by about 25% and the final concentration of cells nearly doubles (Figure 7).

The code used to create all of the graphs in this report can be found in Figure 8.

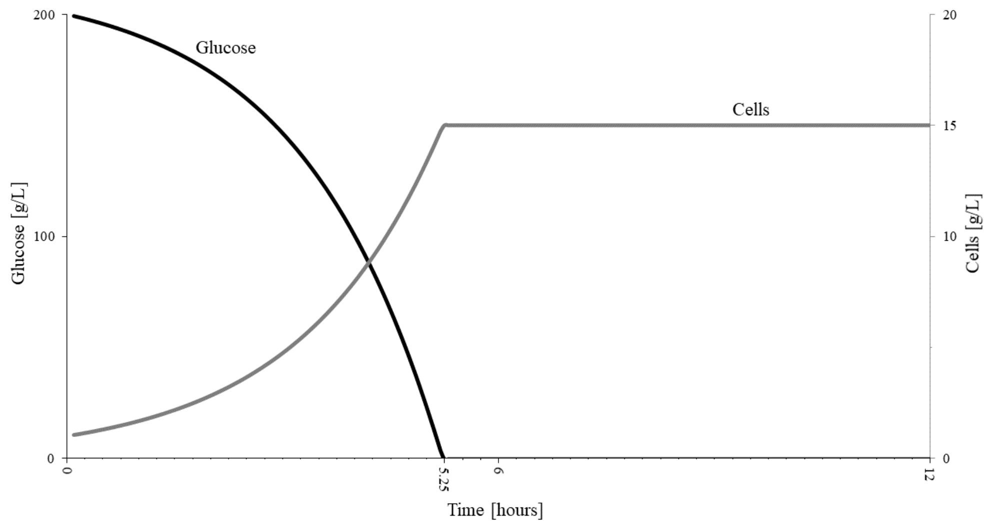

Figure 2: Glucose and Cell Concentration vs. Time when μ_{max} has been doubled from its initial value

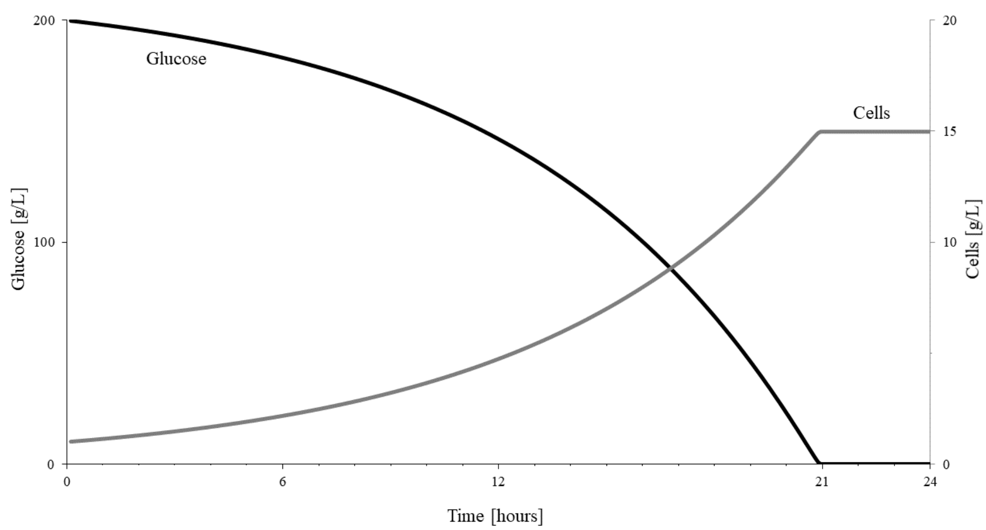

Figure 3: Glucose and Cell Concentration vs. Time when μ_{max} has been halved from its initial value

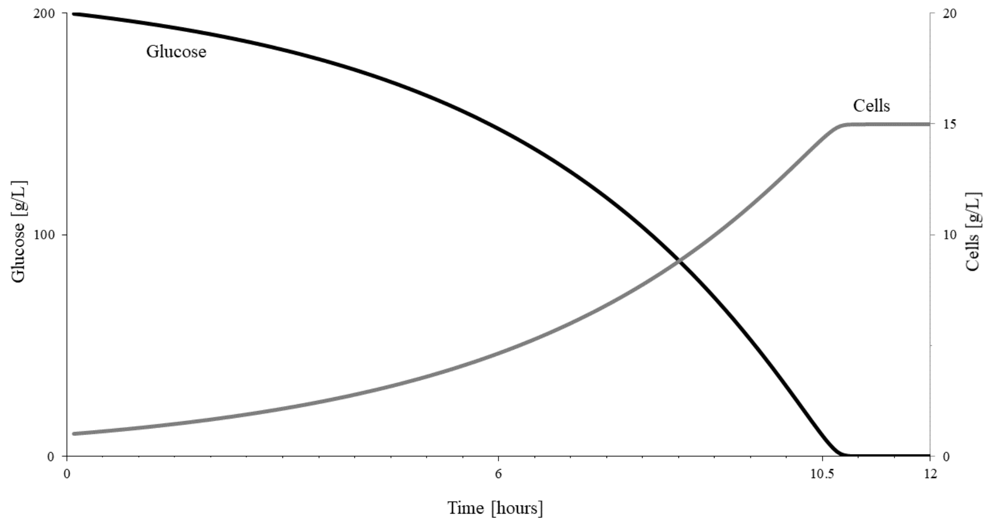

Figure 4: Glucose and Cell Concentration vs. Time when K_m is eight times its initial value

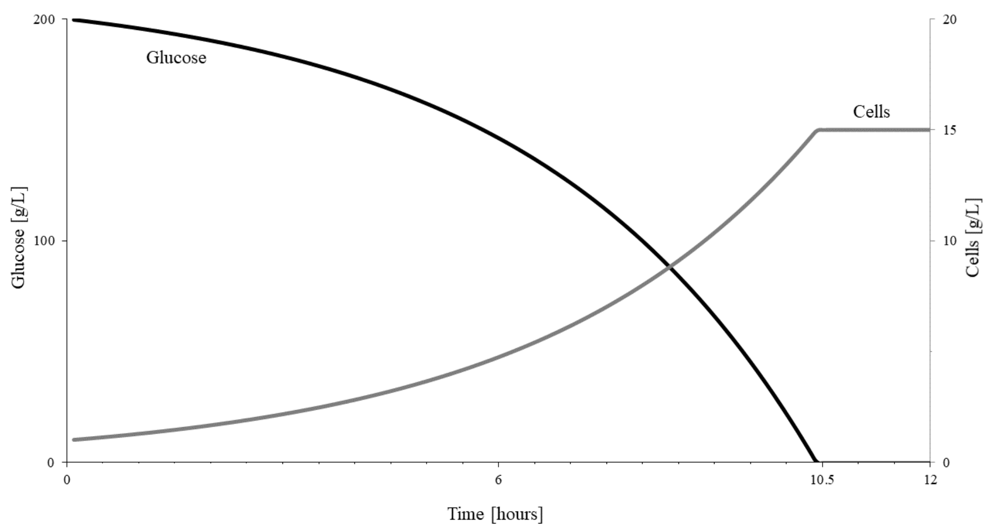

Figure 5: Glucose and Cell Concentration vs. Time when K_m is an eighth of its initial value

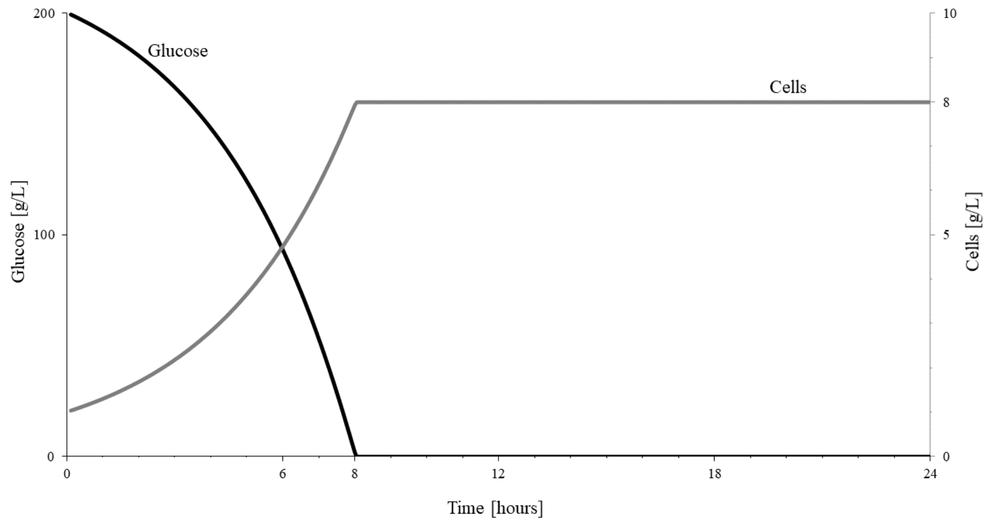

Figure 6: Glucose and Cell Concentration vs. Time when $Y_{S/X}$ has been doubled from its initial value

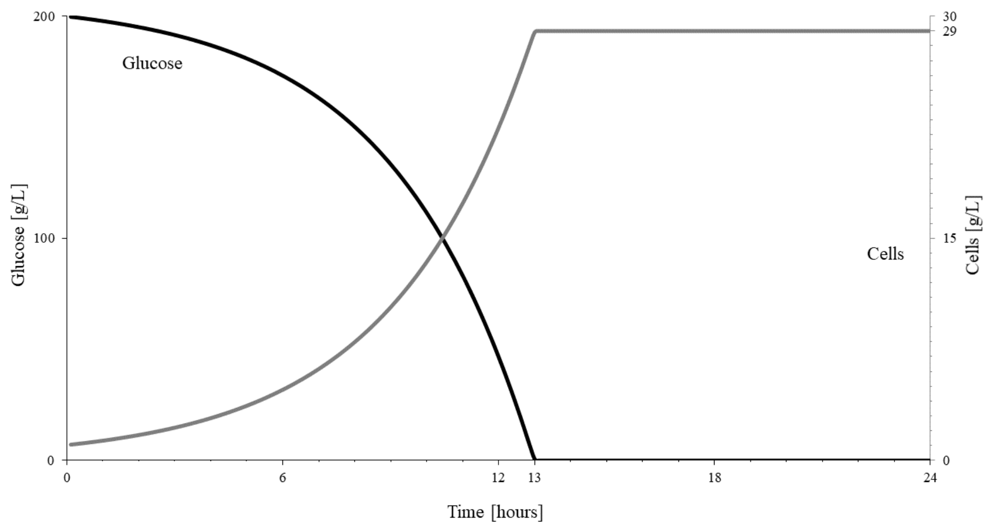

Figure 7: Glucose and Cell Concentration vs. Time when $Y_{S/X}$ is half of its initial value

```
Sub constants()
    'Enter the values for the step size and the number of equations here.
    stepSize = 0.05
    numEq = 2

    '*******************************************
    ReDim I(numEq), O(numEq)        ' Just leave this line alone.  It dimensions the
                                    ' input and output arrays
    '*******************************************

    ' Enter the initial conditions
    startTime = 0                   'Time value at which the intial conditions are known
    O(1) = 1                        'X [g cells / L]
    O(2) = 200                      'S [g substrate / L]

    'Enter the time at which you would like the simulation to end
    stopTime = 24

End Sub

Function inputs(eqnNumber As Integer, timeValue As Variant, outputs() As Variant)
    '*******************************************
    Dim j As Integer                'Just leave this code alone.
                                    '
    For j = 1 To numEq              '
        O(j) = outputs(j)           '
    Next j                          '

    t = timeValue                   't is the time
    '*******************************************

    'Enter the constants here
    Pi = 3.14
    mumax = 0.26
    Km = 0.315
    Ysx = 14.3

    'Constraints
    If O(1) <= 0 Then O(1) = 0
    If O(2) <= 0 Then O(2) = 0


    'Enter the input equations here
    I(1) = (mumax * O(2)) / (Km + O(2)) * O(1)
    I(2) = -Ysx * I(1)

    '*******************************************
    inputs = I(eqnNumber)

End Function
```

Figure 8: SIMBAS code to produce graph shown in Figure 1