Kinetic Modelling of Mesenchymal Stem Cells

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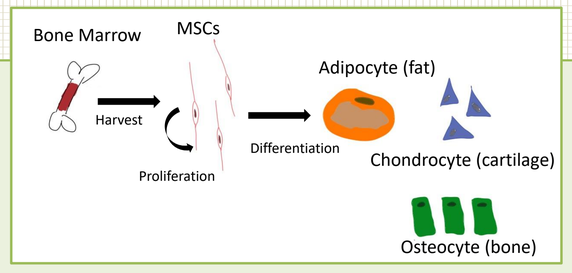
Background

Mesenchymal stem cells (MSCs) are adult stem cells, meaning they exist in grown humans, and can be harvested from many low-risk sources, like bone marrow and fat tissue.



Advantages
- Proliferation
- Differentiation
- No ethical issues
- Immunomodulatory

Leads to

Promising results with
- Alzheimer's Disease
- Liver Cirrhosis
- Graft vs. Host Disease

But

Challenges
Challenging and expensive to culture

Therefore

Approach
Modelling, to make growing MSCs more efficient

Method

- Cells were grown for 8 days in batch mode (day 8 not shown)
- First-order (1), Logistic (2), and Weibull (3) models selected from literature
- Models were trained on the first 5 days of viable cell count data
- Models predicted final two data points.

Basic exponential model

$$(1)\ \frac{dX_v}{dt} = X_v(\mu - k_d) \rightarrow X_v = X_0 e^{(\mu - k_d)t}$$

Like (1) but with a term for confluency

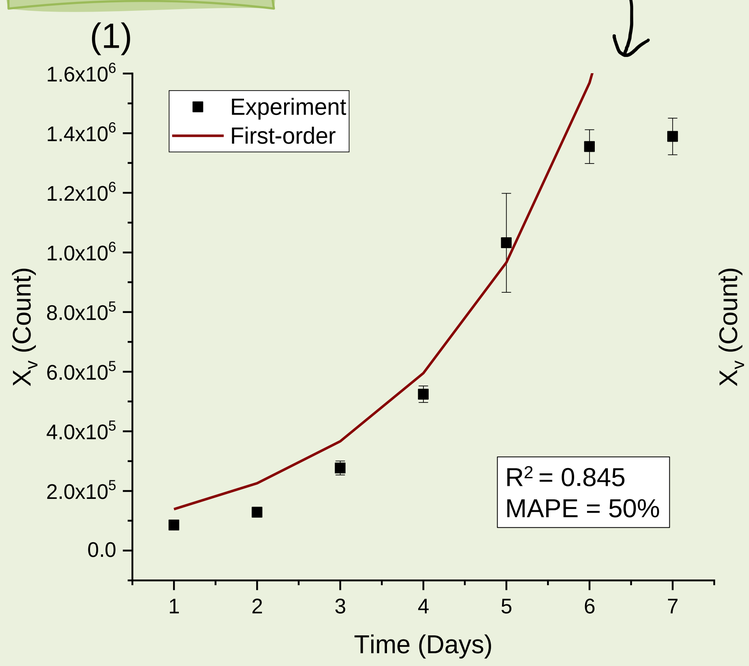
$$(2)\ \frac{dX_v}{dt} = \mu X_v \left(\frac{X_{max} - X_v}{X_{max}}\right) \rightarrow X_v = \frac{X_{max} X_0 e^{\mu t}}{X_{max} - X_0 + X_0 e^{\mu t}}$$

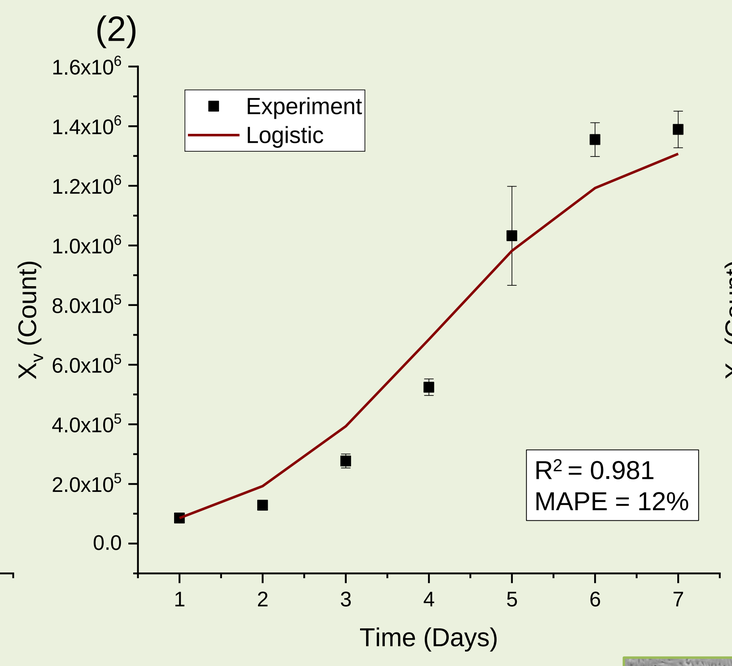
Cumulative distribution function with scale and shape parameters

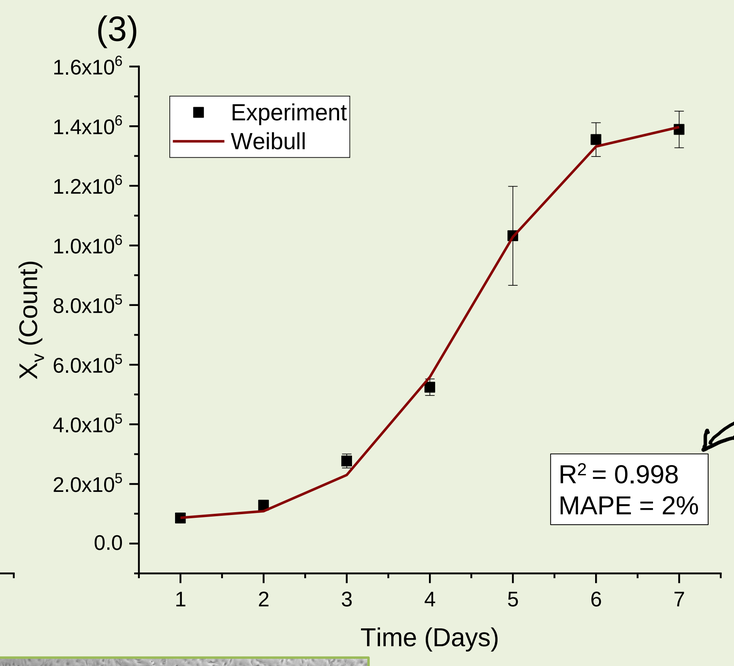
$$(3)\ X_v = X_{max} - (X_{max} - X_0)e^{(-\beta t^{\gamma})}$$

Results

Can not account for confluency

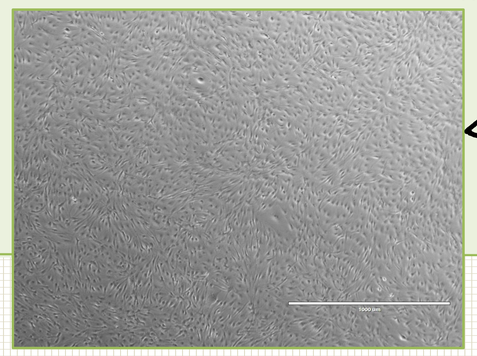






MAPE – measure of error for final two points

- First-order: predicts first 5 days well, but can not account for confluence
- Logistic: Good fit, but curve shape is a bit stiff
- Weibull: Adapts the shape of its curve, so exhibits best fit, but may be overfitted



Cells on day 7, with no more space to grow

Conclusion

- The models can be used to predict MSC growth under these conditions with success
- Using these models to predict growth parameter values must be done with caution
- To assess widespread applicability, more experimentation is needed.

References

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Most significant sources

Contact

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