CLAIMS

1. A method, comprising:

receiving cell growth data associated with a current cell culture of a cell growth system, the cell growth data comprising growth input parameter values indicative of a growth rate of the current cell culture, and process analytical technology (PAT) sensor data comprising indications of one or more of cell count, density, or target product formation;

providing the cell growth data to a mechanistic model as input;

obtaining, from the mechanistic model, mechanistic output comprising a prediction of future conditions of the current cell culture based on the cell growth data;

providing the cell growth data to a statistical model;

obtaining, from the statistical model, statistical output comprising relationships in the cell growth data and historical cell growth data based on the cell growth data;

identifying, using a first machine learning model, a prescriptive action to alter a yield of a target product of the current cell culture based on the mechanistic output and the statistical output , wherein the prescriptive action modifies a metabolism rate of the current cell culture, the prescriptive action comprising an adjustment to at least one of the feed flow rate, air flow rate, agitation rate, applied heat, applied pressure, or oxygen flow rate;

identifying, using the first machine learning model, a first level of confidence that the prescriptive action, when performed, alters the yield of the target product; and

causing the cell growth system to perform the identified prescriptive action in view of the first level of confidence.

2. The method of claim 1, further comprising:

using the cell growth data as input to the first machine learning model; and

obtaining one or more outputs of the machine learning model, the one or more outputs indicating (i) the prescriptive action, and (ii) the level of confidence that the prescriptive action, when performed, alters the yield of the target product; and

determining that the level of confidence for the prescriptive action satisfies a threshold condition.

3. The method of claim 1, further comprising:

applying a growth prediction model to the cell growth data to generate a predicted cell density of the current cell culture, wherein the growth prediction model is generated using one or more cell counts of one or more previous cell cultures in the cell growth system and one or more historical growth input parameter values indicative of a previous growth rate of each of the one or more previous cell cultures in the cell growth system; and

using the predicted cell density as input to the first machine learning model.

4. The method of claim 3, wherein the growth prediction model comprises the mechanistic model generated by performing at least an exponential regression using the one or more historical growth input parameter values.

5. The method of claim 1 further comprising:

receiving, from a first sensor, first sensor data indicative of an environmental condition of a growth environment of the current cell culture in the cell growth system; and

using the first sensor data as input to the first machine learning model.

6. The method of claim 5, further comprising processing the first sensor data using the statistical model by performing one of a process control analysis, univariate limit violation analysis, or a multivariate limit violation analysis on the first sensor data, wherein the first sensor comprises a process analytical technology (PAT) sensor.

7. The method of claim 5, further comprising:

receiving, from a second sensor, second sensor data indicative of the environmental condition of the growth environment of the current cell culture; and

using the first sensor data and the second sensor data as input to a second machine learning model;

obtaining one or more outputs of the second machine learning model, the one or more outputs indicating a second level of confidence that a first measurement accuracy of the first sensor data is greater than a second accuracy of the second sensor;

determining that the second level of confidence that the first measurement accuracy of the first sensor data is greater than the second accuracy of the second sensor satisfies a threshold condition; and

providing an indication of the second level of confidence to the first machine learning model, wherein at least one of identifying the prescriptive action or identifying the first level of confidence is based on the second level of confidence.

8. The method of claim 7, where the second machine learning model comprises a principal component analysis (PCA) model.

9. The method of claim 1, wherein the growth input parameter values comprises a value indicative of at least one of a feed flow rate, an airflow rate, or an oxygen flow rate to the current cell culture.

10. The method of claim 1, wherein the first machine learning model comprises at least one of a random forest decision tree model, a partial least squares regression (PLS) model, or a multivariate statistical process control (MVSPC) model.

11. A non-transitory machine-readable storage medium comprising instructions that, when executed by a processing device, cause the processing device to perform operations comprising:

receive cell growth data associated with a current cell culture of a cell growth system, the cell growth data comprising growth input parameter values indicative of a growth rate of the current cell culture, and processing analytical technology (PAT) sensor data comprising indications of one or more of cell count, density, or target product formation;

provide the cell growth data to a mechanistic model as input;

obtain, from the mechanistic model, mechanistic output comprising a prediction of future conditions of the current cell culture based on the cell growth data;

provide the cell growth data to a statistical model;

obtain, from the statistical model, statistical output comprising relationships in the cell growth data and historical cell growth data;

identify, using a first machine learning model, a prescriptive action to alter a yield of a target product of the current cell culture based on the mechanistic output and the statistical ouput, wherein the prescriptive action modifies a metabolism rate of the current cell culture based on the cell growth data, the prescriptive action comprising an adjustment to at least one of feed flow rate, air flow rate, agitation rate, applied heat, applied pressure, or oxygen flow rate;

identify, using the first machine learning model, a first level of confidence that the prescriptive action, when performed, alters the yield of the target product; and

cause the cell growth system to perform the identified prescriptive action in view of the first level of confidence.

12. The non-transitory machine-readable storage medium of claim 11, the operations further comprising:

use the cell growth data as input to the first machine learning model; and

obtain one or more outputs of the machine learning model, the one or more outputs indicating (i) the prescriptive action, and (ii) the level of confidence that the prescriptive action, when performed, alters the yield of the target product; and

determine that the level of confidence for the prescriptive action satisfies a threshold condition.

13. The non-transitory machine-readable storage medium of claim 11, the operations further comprising:

apply a growth prediction model to the cell growth data to generate a predicted viable cell density of the cell culture, wherein the growth prediction model is generated using one or more cell counts of one or more previous cell cultures in the cell growth system and one or more historical growth input parameter values indicative of a growth rate of each of the one or more previous cell cultures in the cell growth system; and

use the predicted viable cell density as input to the first machine learning model.

14. The non-transitory machine-readable storage medium of claim 11, the operations further comprising:

receive from a first sensor, first sensor data indicative of an environmental condition of a growth environment of the current cell culture in the cell growth system; and

use the first sensor data as input to the first machine learning model.

15. The non-transitory machine-readable storage medium of claim 14, the operations further comprising:

process the first sensor data by performing one of a process control analysis, univariate limit violation analysis, or a multivariate limit violation analysis on the first sensor data, wherein the first sensor comprises a process analytical technology (PAT) sensor.

16. The non-transitory machine-readable storage medium of claim 14, the operations further comprising:

receive, from a second sensor, second sensor data indicative of the environmental condition of the growth environment of the current cell culture;

use the first sensor data and the second sensor data as input to a second machine learning model;

obtain one or more outputs of the second machine learning model, the one or more outputs indicating a second level of confidence that a first measurement accuracy of the first sensor data is greater than a second accuracy of the second sensor;

determine that the second level of confidence that the first measurement accuracy of the first sensor data is greater than the second accuracy of the second sensor satisfies a threshold condition; and

provide an indication of the second level of confidence to the first machine learning model, wherein at least one of identifying the prescriptive action or identifying the first level of confidence is based on the second level of confidence.