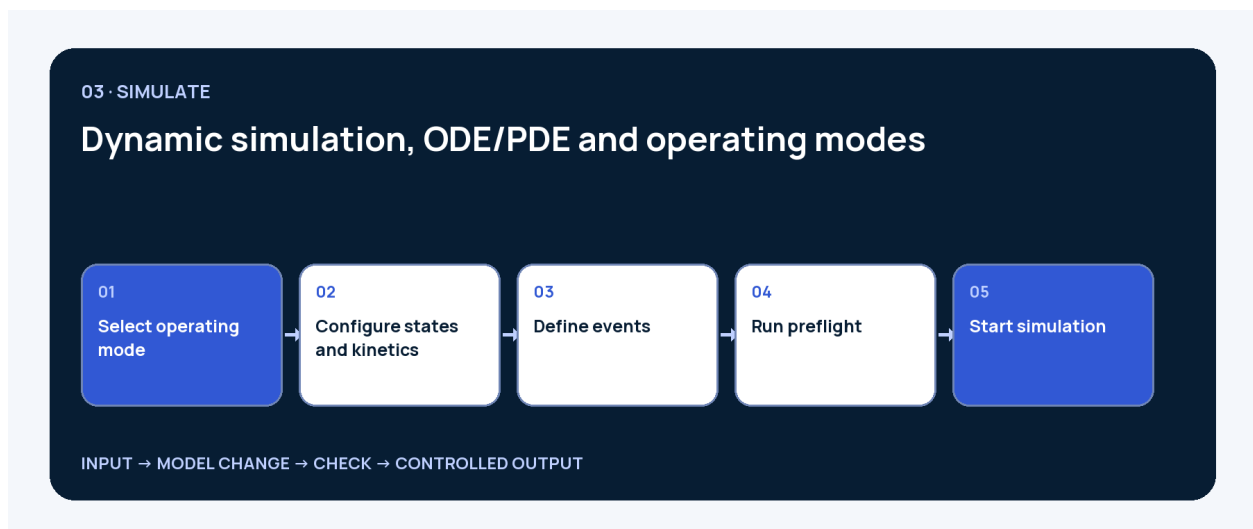




Axion

Dynamic simulation, ODE/PDE and operating modes

Calculate batch, fed-batch, perfusion and continuous processes reproducibly



EDITION 2.6 · 19 AUGUST 2026 · MODULE MANUAL · 03 · SIMULATE

Axion · Bioprocess engineering software



At a glance

Engineering decision	Path in Axion
How do process states evolve over time and within which operating envelope is the scenario plausible?	Simulate → Dynamic simulation / Advanced modelling

Primary users	Permitted maturity
Process Development, Modelling, Scale-up, MSAT	Screening without calibration; Calibrated after estimation; Validated only with an independent dataset

DECISION RULE

Axion couples component balances with time-dependent states. ODEs represent ideal mixed states; PDEs represent spatial gradients as discretised fields. The operating mode and events must match real operation.

The screenshot displays the Axion Process OS interface. On the left is a dark sidebar with a navigation menu. The main content area is light blue and shows the 'Plant Overview' for 'Cultured Meat - Perfusion'. It includes five summary cards: Annual product (4.88 t), Campaign duration (272 h), Direct cost (\$52,456/kg), Utilities (1,840.2 MWh), and Plant utilization (59%). Below these is a 'PROCESS ENGINEERING REVIEW' section for the 'Cultured Meat production model', with a description and an 'Open Process Builder' button. At the bottom, a 'CURRENT MODEL STATUS' section shows the 'Screening model' is 29% complete, with a progress bar indicating 0 design ready, 6 operations ready, 1 blocked, and 22 missing inputs.

Axion Process OS
BIOPROCESS ENGINEERING

MODEL

- Model Brief
- Project Space
- Plant Overview**

PROCESS MODEL

- Flowsheet Studio
- Equipment Register
- Stream Table
- Model Equations

ANALYZE

- Dynamic Simulation
- Advanced Modelling
- Reactor CFD
- Constraints + AI
- Standards Check

REVIEW + HANDOFF

Plant Overview

Export Reset model kbrenner

Annual product **4.88 t**

Campaign duration **272 h**

Direct cost **\$52,456/kg**

Utilities **1,840.2 MWh**

Plant utilization **59%**

PROCESS ENGINEERING REVIEW

Cultured Meat production model

Industrial screening workspace for the first serious design review: equipment architecture, material streams, metabolite and oxygen-transfer boundaries, scheduling pressure, source-backed assumptions, and economics are evaluated together before design freeze.

Open Process Builder

CURRENT MODEL STATUS

Screening model

The model is useful for screening and comparing scenarios, but it is not yet a validated design, investment, LCA, CFD or GMP basis.

29%
EVIDENCE COMPLETE

0 design ready 6 operations ready 1 blocked 22 missing inputs

Relevant Axion workspace for this module manual.



Prepare the model

Input	Why it is required	Ready when
Initial states	Start biomass, substrates, product, metabolites, volume and temperature.	Every state has value, unit and source.
Kinetics	Defines growth, uptake, formation and death.	Equation, parameter range and applicability are documented.
Operating profile	Distinguishes charge, feed, bleed, harvest and continuous flow.	Events, rates and control logic are defined.
Numerics	Controls stability, accuracy and runtime.	Solver, step size, tolerance and stop conditions are set.
Measured data	Supports calibration and independent validation.	Training and validation datasets are separated.

Preflight check

- Confirm the correct project, branch and controlled version
- Verify units, provenance and permissions
- Save a restore point before a decision-relevant change
- Keep blocking gaps visible

APPLICABILITY LIMIT

A stable numerical solution is not biological validity. Project calibration and independent validation remain required.



Workflow

1. Select operating mode

1. Choose batch, fed-batch, perfusion or continuous and verify working volume.

VISIBLE RESULT

Volume and transfer equations visibly change with mode.

2. Configure states and kinetics

2. Open ODE/PDE variables, parameters, bounds and sources.

VISIBLE RESULT

The state register is complete and dimensionally consistent.

3. Define events

3. Schedule feed, inoculation, harvest, bleed, samples and transfers.

VISIBLE RESULT

The event line is causal and chronological.

4. Run preflight

4. Check structure, units, initial values, bounds and numerics.

VISIBLE RESULT

No blocking finding remains.

5. Start simulation

5. Start the run and observe convergence, step size and residuals.

VISIBLE RESULT

Run ID, solver state and complete trajectory are produced.

6. Compare scenarios

6. Change only intended parameters and compare to branch baseline.

VISIBLE RESULT

Before/after exposes states, outputs and boundary violations.



Review the result

Review criterion	Pass condition	If it fails
Scope and structure	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Units and balances	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Evidence and uncertainty	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Reproducibility	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Review state	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.

DECISION RULE

A stable numerical solution is not biological validity. Project calibration and independent validation remain required.



Troubleshooting

Observation	Likely cause	Correction
The result looks plausible but cannot be explained	Inputs, units, model version or evidence are missing.	Open the relevant register, restore traceability and rerun.
A change affects unexpected outputs	Dependencies or imported mappings were not reviewed.	Inspect the change plan and before/after diff; undo if required.
The module appears complete but readiness is low	Required industrial evidence is still missing.	Assign the visible gaps and keep maturity at Screening or Not decision-ready.



Handover and next steps

Artifact	Recipient	Must contain
Module result package	Engineering reviewer	Inputs, calculations, results, units, intervals, maturity
Readiness register	Model owner	Gap, required work, owner, due date, intended use
Controlled version	Project team	Branch, version, change note, reviewer and restore point

Completion check

- The active project, branch, version and intended use are visible.
- All inputs have units, provenance, review state and uncertainty where relevant.
- Blocking model, physical, numerical and evidence gaps are closed or assigned.
- The result maturity matches the available evidence.
- A controlled output package opens correctly and includes limitations.

[Open Axion](#) [Book technical onboarding](#)