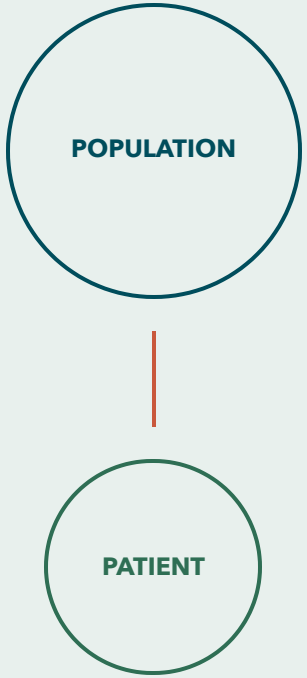
CLINICAL INQUIRY I · 2026

Causal Models

Representing population knowledge and reasoning about an individual patient

From what we know to what we think is happening



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OPENING PROBLEM

Same outcome. Same cause?

PATIENT A

Reduced six-minute walk distance

Marked quadriceps weakness. Stable cardiovascular response. Preserved balance.

SAME MEASURED RESULT

6MWD ↓

PATIENT B

Reduced six-minute walk distance

Adequate isolated strength. Early dyspnea. Abnormal exertional response.

> **Would you expect the same explanation or the same intervention?**

Review of the reading

CLAIMS	CONDITIONS	REALITY	MODELS
An association is not, by itself, evidence of causation.	Causes operate through mechanisms and within contexts.	What we observe does not exhaust what occurs or what can generate events.	Every analysis presupposes some account of the causal structure.

Back to the opening problem: the same 6MWD invites different counterfactuals.

PATIENT A	PATIENT B	SAME INTERVENTION?
Had quadriceps weakness been absent, would the 6MWD still have been reduced?	Had exertional dyspnea been absent, would the 6MWD still have been reduced?	Had each patient received strengthening, would each patient have improved?

> A counterfactual evaluates a specified causal contrast. The observed outcome alone does not tell us which contrast is clinically relevant.

THE POPULATION-TO-PATIENT PROBLEM

Which causes matter?

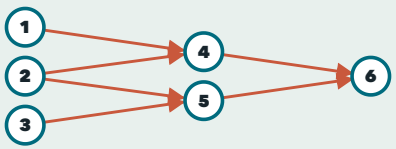
SAMPLE → POPULATION

Research builds the model

Accumulating studies slowly expand and revise how well it represents population knowledge.

BUILDS →

revises



Empirical	observed events
Actual	operative mechanisms
Real	generative mechanisms

Representative causal model of current knowledge

USES →

findings may revise ←

POPULATION → PATIENT

Clinical reasoning uses the model

Patient evidence constrains which represented mechanisms could be operative now.

Still unknown: which causal configuration is operative in this patient?

Both sides can modify the same model. Research primarily builds it; clinical reasoning primarily uses it.

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TODAY'S NEXT STEP

From observations to causal diagrams to patient-specific explanation

Population knowledge

Models4PT

Represents causal claims together with mechanisms, evidence, context, provenance, uncertainty, and disagreement.

→

Patient reasoning

Clinical instantiation

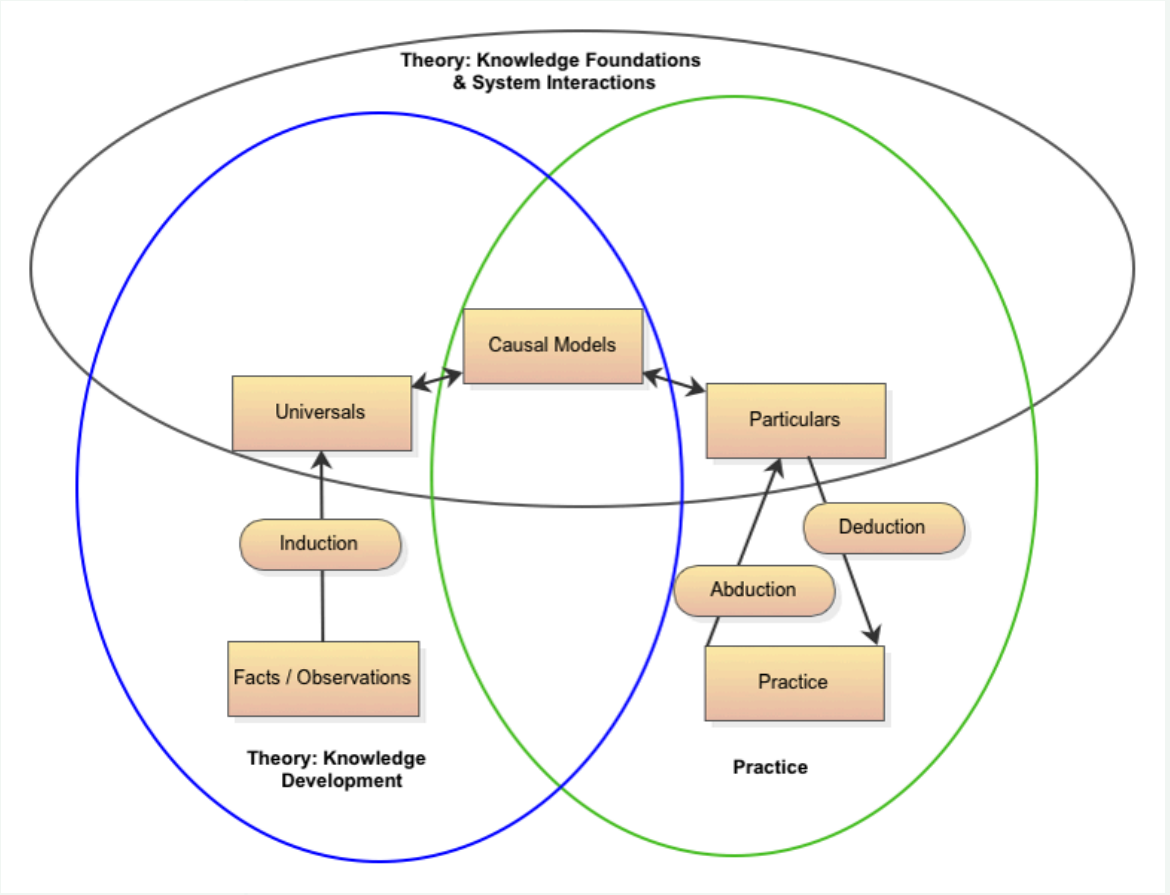
Uses generic causal knowledge and current patient evidence to construct a provisional patient-specific explanation.

The causal model represents population knowledge that constrains patient reasoning. It does not determine the answer.

HISTORICAL FOUNDATION

Clinical inquiry diagram

How should knowledge move between research and practice?



Plymouth State DPT clinical inquiry curriculum materials, 2015. Image provided by the course author.

READING THE 2015 LOGIC

Clinical inquiry moves between particulars and universals

Induction
particular observations → general claims

Deduction
general knowledge → expected findings

Abduction
findings → best current explanation

PRACTICE TO RESEARCH clinical experience → patterns + anomalies → candidate claims + questions → structured research → population knowledge

A clinical encounter may be structured for patient care. Clinical experience as a whole is not structured to support population inference.

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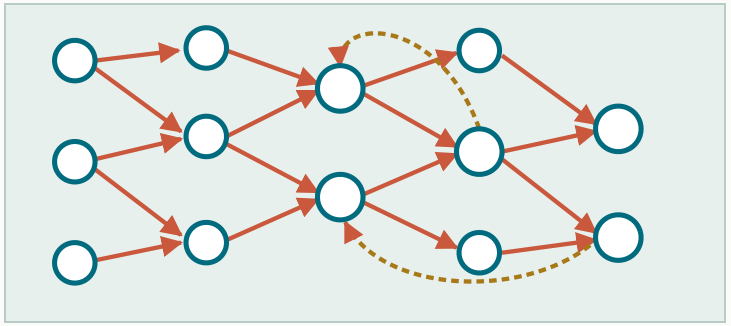
GENERIC CAUSAL MODEL

A model is a structured set of claims

> An epistemological representation of the causal structure believed to characterize a class of systems or patients.

Adapted from Collins, 2026 preprint

NODES	variables or concepts selected for the purpose
ARROWS	candidate claims about causal direction or influence
PATHS	possible mechanisms and competing explanations
GRAPH FORM	cyclic models retain feedback paths; acyclic models prohibit return paths for a defined, often time-ordered analysis
BOUNDARY	what the representation includes and omits



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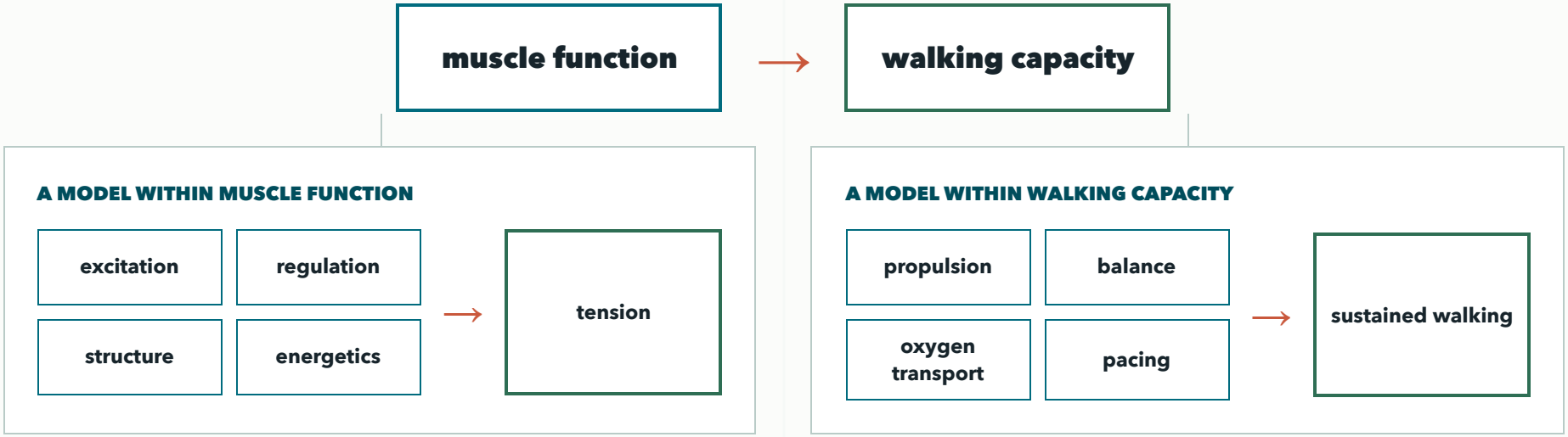
CRITICAL REALIST STRATIFICATION

Causal models represent knowledge across scales



A node at one scale can open into another causal model. At every scale, the model is a fallible representation of what we know, not the generative system itself.

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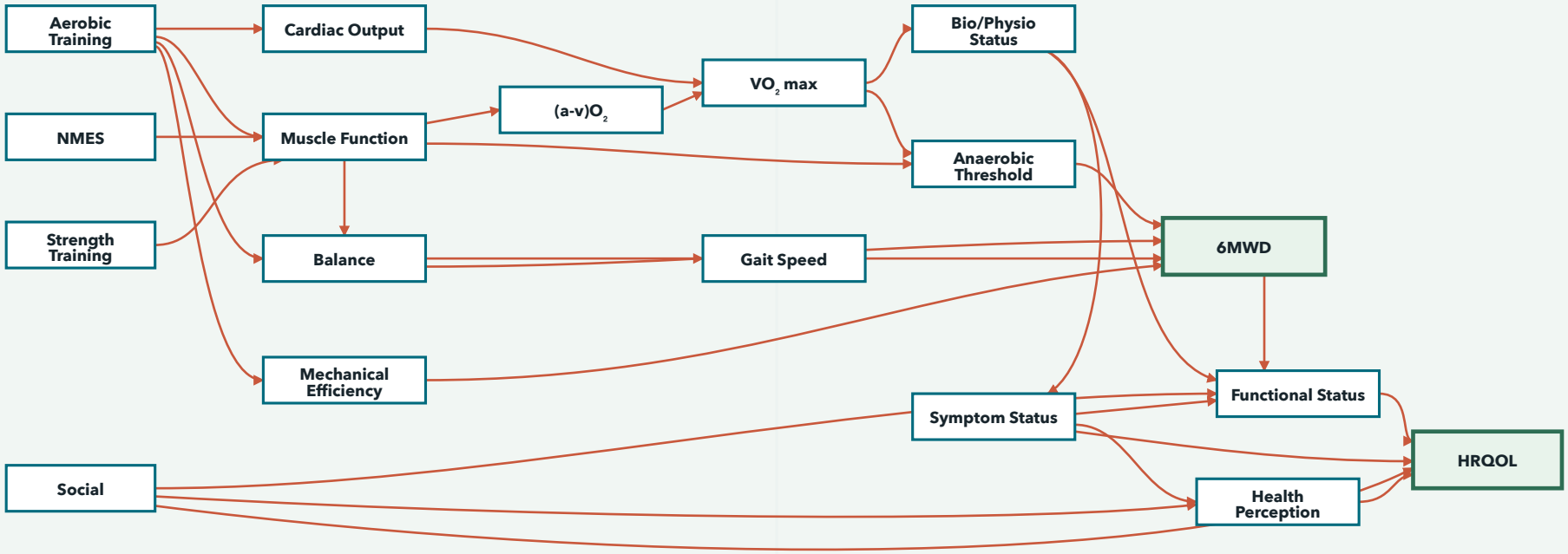
DEVELOPMENTAL TEACHING MODEL

Several pathways can limit walking

DRAFT



MODEL 4D, REVISED · 18 VARIABLES · 29 PROPOSED CAUSAL CLAIMS

Back to Patients A and B: Their findings direct attention to different regions of the same population causal model. They do not yet identify the operative pathway.

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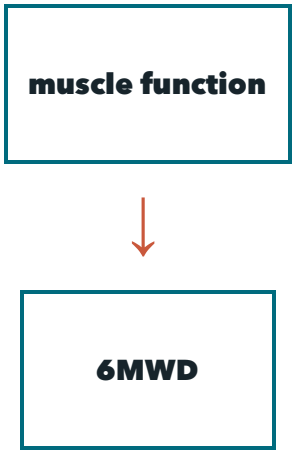
POPULATION KNOWLEDGE REPRESENTATION

The graph shows the claim, not why we should trust it



MEANING What precisely does each variable represent?	**MECHANISM** What lower-scale pathways does this arrow collapse?
EVIDENCE What observations or studies support the arrow?	**SCOPE** For whom, when, and under what conditions?
PROVENANCE Where did the claim come from, and who revised it?	**UNCERTAINTY** How strong, disputed, or incomplete is the claim?

Models4PT connects causal structure to meaning, mechanisms, evidence, provenance, context, and uncertainty.

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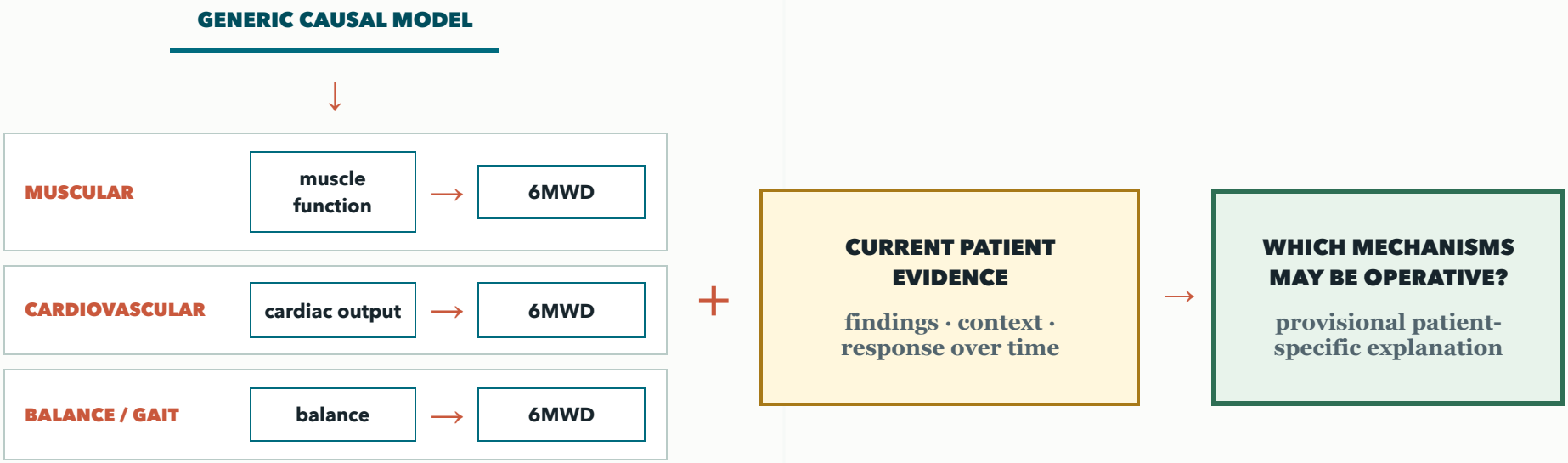
THE TRANSITION TO PATIENT REASONING

The population model informs but does not identify a patient's causal configuration



> Population knowledge defines scientifically plausible possibilities. Patient evidence constrains which may explain this patient, here and now.

PATIENT-SPECIFIC REPRESENTATION

Clinical instantiation

Generic causal knowledge and current patient evidence jointly constrain a **provisional model of what may be happening in this patient now.**

generic model + **evidence now** → $\mathcal{I}(M, E_t) = M_{p,t}$

In words: Applying clinical instantiation to generic causal knowledge and the evidence currently available for a patient produces a provisional patient-specific causal representation.

We must understand this process because it's what we're trying to teach future clinicians!

$\mathcal{I}$

constructs a patient-specific representation

do(X)

represents an intervention within a specified causal model

Clinical instantiation is a potentially composite process, not a settled mathematical operator or automated answer.

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SMALL GROUP ACTIVITY

Build two provisional models

FICTIONAL CASES

> Use the population causal model from slide 10 to construct a provisional explanation for each patient.

PATIENT A · DIFFICULTY ATTAINING

- Marked quadriceps weakness
- Stable cardiovascular response
- Preserved balance
- Cannot generate enough force to rise and initiate walking

PATIENT B · DIFFICULTY SUSTAINING

- Adequate isolated strength
- Early dyspnea
- Abnormal exertional response
- Preserved gait mechanics

1. Which path is currently foregrounded?

2. What competing explanation remains plausible?

3. What one observation would discriminate between them?

4. Would strength training or NMES target the represented limitation?

DEBRIEF • NEW EVIDENCE

A useful model remains provisional and revisable

PATIENT A

New finding: repeated contractions fatigue rapidly despite improved initial force.

Revision: add a sustain/endurance hypothesis; do not discard the strength finding.

PATIENT B

New finding: exertional dyspnea coincides with new pulmonary crackles and an S3.

Revision: increase concern for a disease-specific limitation and reconsider intervention priorities.

Return to the opening problem: The same reduced 6MWD supports different provisional explanations. For Patient A, muscle function appears most relevant, with new evidence that endurance may also limit performance. For Patient B, the findings increase concern for a disease-specific exertional limitation. The model guides different next questions and intervention priorities; it does not provide a certain final answer.

Educational cases only. The findings illustrate model revision, not patient-specific recommendations.

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A LONG JOURNEY TOWARD GREATER CLARITY

Represent population knowledge. Reason about the particular.

SCIENTIFIC INQUIRY
stats4PT + Physiolog

→

GENERIC CAUSAL MODEL
Models4PT

+

CURRENT PATIENT EVIDENCE
findings · context · response

→

CLINICAL INSTANTIATION
$\mathcal{I}(M, E_t)$

→

PROVISIONAL PATIENT MODEL
$M_{p,t}$

→

CLINICAL REASONING
supported by CIE

CLINICAL INQUIRY questions · observations · action · new evidence · revision

Causal models organize population knowledge; they remain fallible and revisable.

Clinical instantiation uses current evidence to construct a provisional patient-specific explanation.

Clinical inquiry continually tests and revises that explanation through questions, observations, and action.

2018 causal models synthesis · 2026 clinical instantiation preprint · Heart failure clinical practice guideline · Models4PT · stats4PT DAG lesson

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