Theories as social constructs

Readings for today

- De Regt, H. W., & Dieks, D. (2005). A contextual approach to scientific understanding. Synthese, 144(1), 137-170.

Topics

1. Returning to understanding

2. Contextualized scientific understanding

3. Intelligibility and understanding

Returning to understanding

Empirical risk minimization

$$h_{best} \rightarrow h_{true}$$

<u>Generalization:</u> Given a fixed training data set, find the model that *best* predicts future unseen (test) data set as close to the best possible (h_{true})

$$E_{\text{risk}}\left(h, n, P\right) = \underbrace{\int_{(\mathbf{X},\mathbf{Y})}}_{\text{test}} \underbrace{\int_{(\mathbf{X},\mathbf{Y})}}_{\text{training}} \underbrace{R(h)}_{\text{risk}} \underbrace{dP_{X,Y}}_{\text{distribution}} \underbrace{dP_{(X,Y)}}_{\text{distribution}}$$

$$R(h) = \ell(h(X), Y)$$

(Vlastelica 2019; Vapnik 1991)

What is knowable

Statistical Learning:

A signal Y carries the information that X is F if $Y = f(X)$ is *learnable*.

- Phenomenological description.
- $f(X)$ conveys the mutual information between X and Y.
- Determining “X is F” is an inference goal, not a learning goal.
- “Knowledge” is then restricted to *iid* contexts.

Information → Knowledge → Understanding

Information

$$E_{\text{risk}}\left(h, n, P\right) = \underbrace{\int_{(\mathbf{X},\mathbf{Y})}}_{\text{train}} \underbrace{R(h)}_{\text{risk}} \underbrace{dP_{X,Y}}_{\text{distribution}}$$

Knowledge

$$E_{\text{risk}}\left(h, n, P\right) = \underbrace{\int_{(\mathbf{X},\mathbf{Y})}}_{\text{test}} \underbrace{\int_{(\mathbf{X},\mathbf{Y})}}_{\text{train}} \underbrace{R(h)}_{\text{risk}} \underbrace{dP_{X,Y}}_{\text{distribution}} \underbrace{dP_{(X,Y)}}_{\text{distribution}}$$

Understanding

$$E_{\text{risk}}\left(h, n, P\right) = \underbrace{\int_{(\mathbf{X},\mathbf{Y})_n}}_{\text{new}} \underbrace{\int_{(\mathbf{X},\mathbf{Y})}}_{\text{train}} \underbrace{R(h)}_{\text{risk}} \underbrace{dP_{X,Y}}_{\text{distribution}} \underbrace{dP_{(X,Y)_n}}_{\text{distribution}}$$

Goal of science

Contextualized scientific understanding

What is scientific understanding?

Explanations

A mechanistic or phenomenological description for how factors or observations relate to each other.

Understanding

"[S]ome deeper theory that explained what it was about each of these apparently diverse forms of explanation that makes them explanatory." - Newton-Smith (2000)

What is this?

How is it achieved?

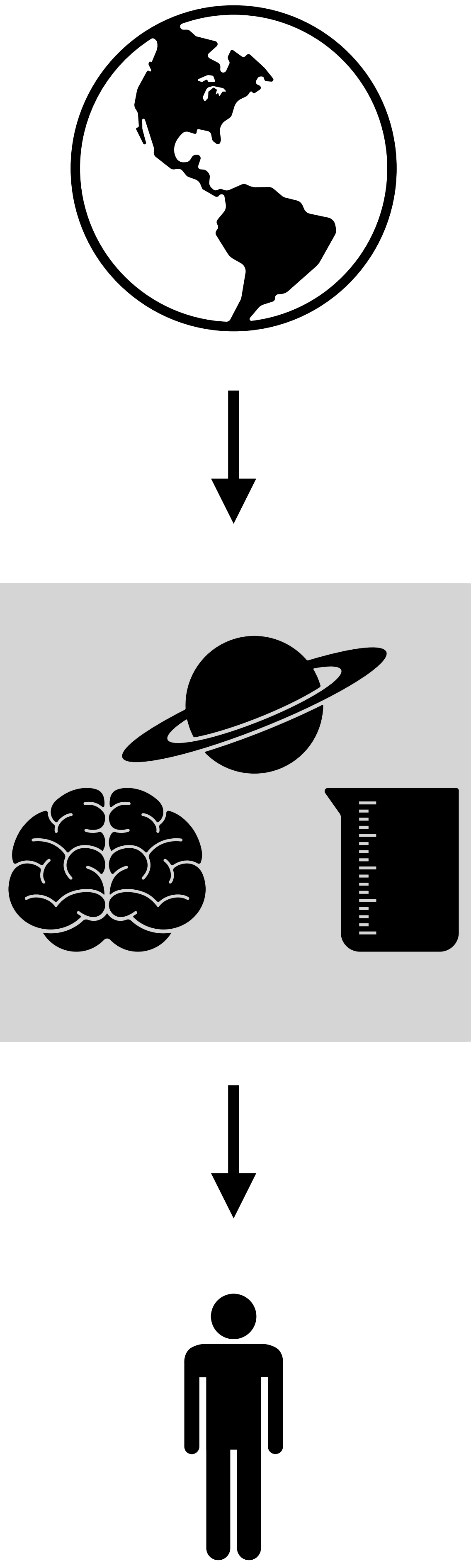
(De Regt & Dieks 2005)

Levels of explanation

Macro-level: Science as a whole

Meso-level: Scientific communities

Micro-level: Individual scientists



(De Regt & Dieks 2005)

Reasons for scientific understanding

Pragmatic

Explanation & understanding are simply subjective means of meeting human needs and drives, “a function of our interests and pleasures.”

Epistemic

Explanation and understanding are the fundamental goals of science.

“[U]nderstanding is an essential ingredient of the epistemic aims of science; without understanding these aims will remain out of reach”

(De Regt & Dieks 2005)

Conceptions of scientific understanding

Causal-mechanical model

Scientific understanding only progresses via causal theories of the world, explaining causal interactions & processes (Salmon 1984)

Unificationist model

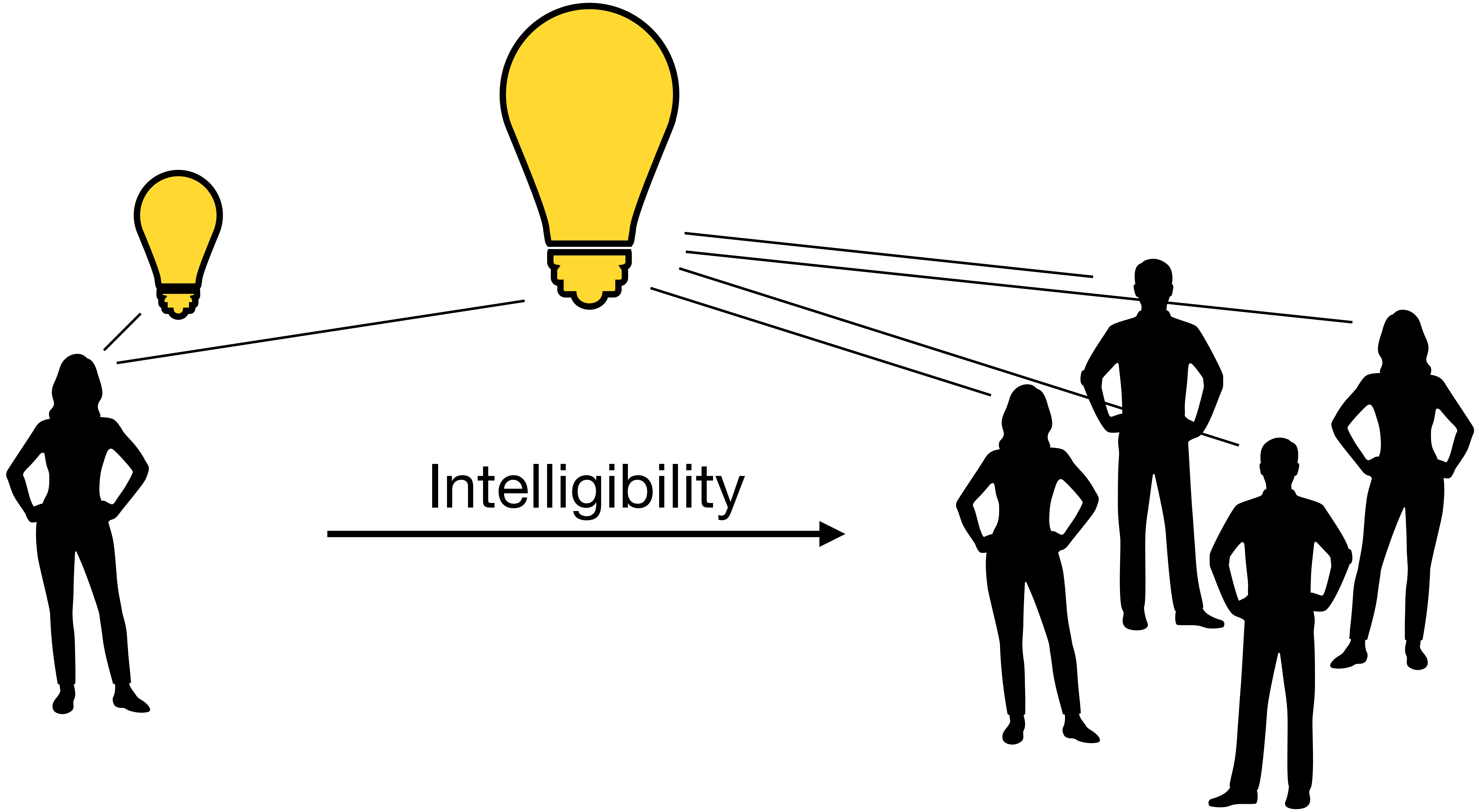
Scientific understanding reflects a unified picture of the world. “A world with fewer independent phenomena is, other things equal, more comprehensible than one with more.” (Friedman 1974)

Contextual model

Scientific understanding is a contextual process, influenced by meso- and micro-level differences and should be seen as a socially driven phenomenon (De Regt & Dieks 2005).

(De Regt & Dieks 2005)

Scientific understanding as a social phenomenon



"[A] scientific theory should be intelligible: we want to be able to grasp how the predictions are generated, and to develop a feeling for the consequences the theory has in concrete situations."

(De Regt & Dieks 2005)

Intelligibility and understanding

Understanding

Criterion for Understanding Phenomenon (CUP)

A phenomenon P can be understood if a theory T of P exists that is intelligible (and meets the usual logical, methodological and empirical requirements).

A couple of points

- CUP reflects a generally accepted theoretical framework that determines whether a phenomenon is understandable *in principle* (context dependent and meso-level).
- To provide scientific understanding, any proposed theory must conform to the “usual logical, methodological and empirical requirements” of a field.

(De Regt & Dieks 2005)

Intelligibility

Criterion for the Intelligibility of Theories (CIT)

A scientific theory T is intelligible for scientists (in context C) if they can recognise qualitatively characteristic consequences of T without performing exact calculations.

A couple of points

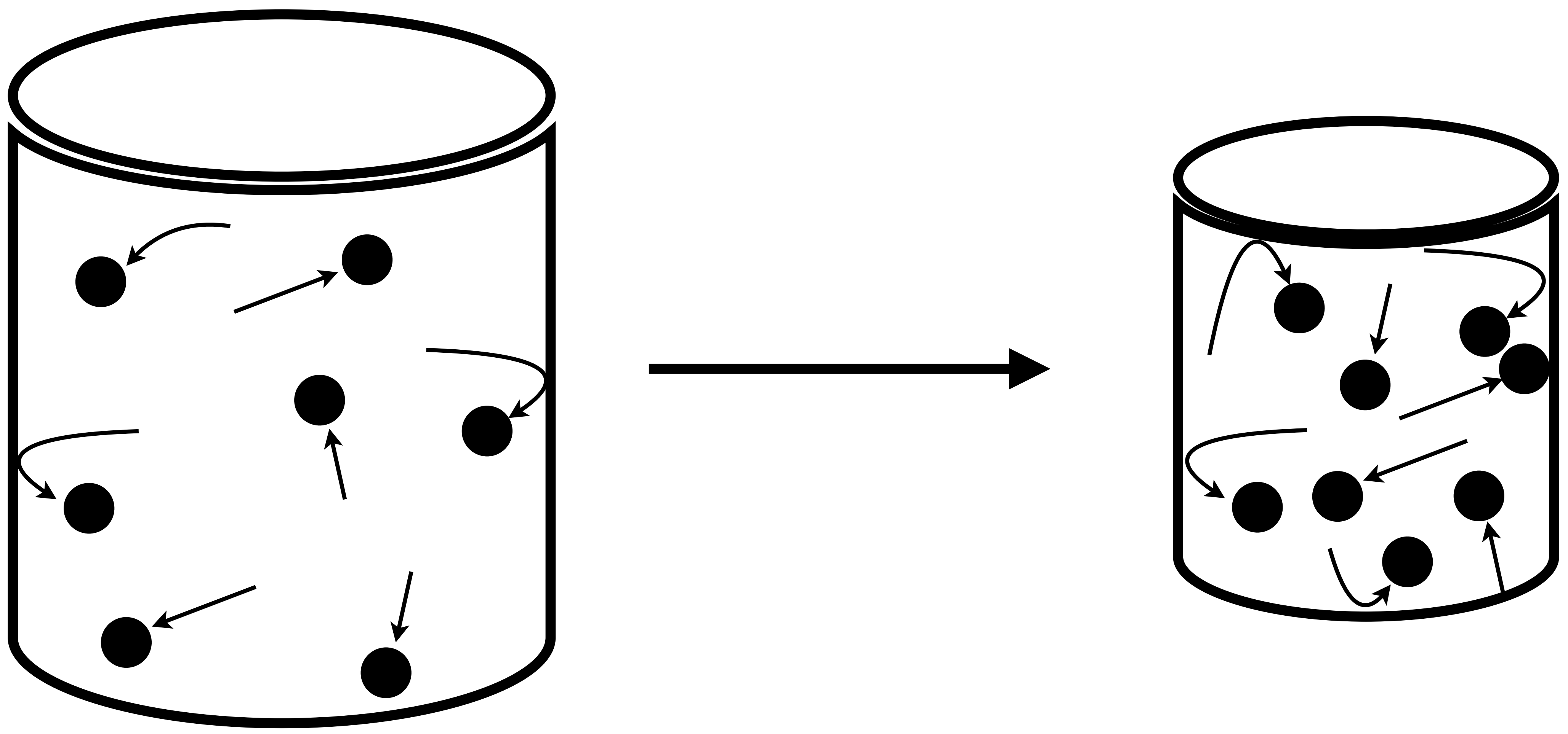
- CIT captures the pragmatic and contextual nature of intelligibility (and accordingly of understanding)
- It allows for the possibility that a scientific theory considered unintelligible by some (in one scientific community, at one time) will be regarded as intelligible by others

(De Regt & Dieks 2005)

Example: Boyle's law

Boyle's law: $P \sim \frac{1}{V}$, pressure is inversely proportional to volume.

Boltzmann's explanation:



Provides a qualitative understanding of relations between pressure, volume, and temperature without performing calculations.

(De Regt & Dieks 2005)

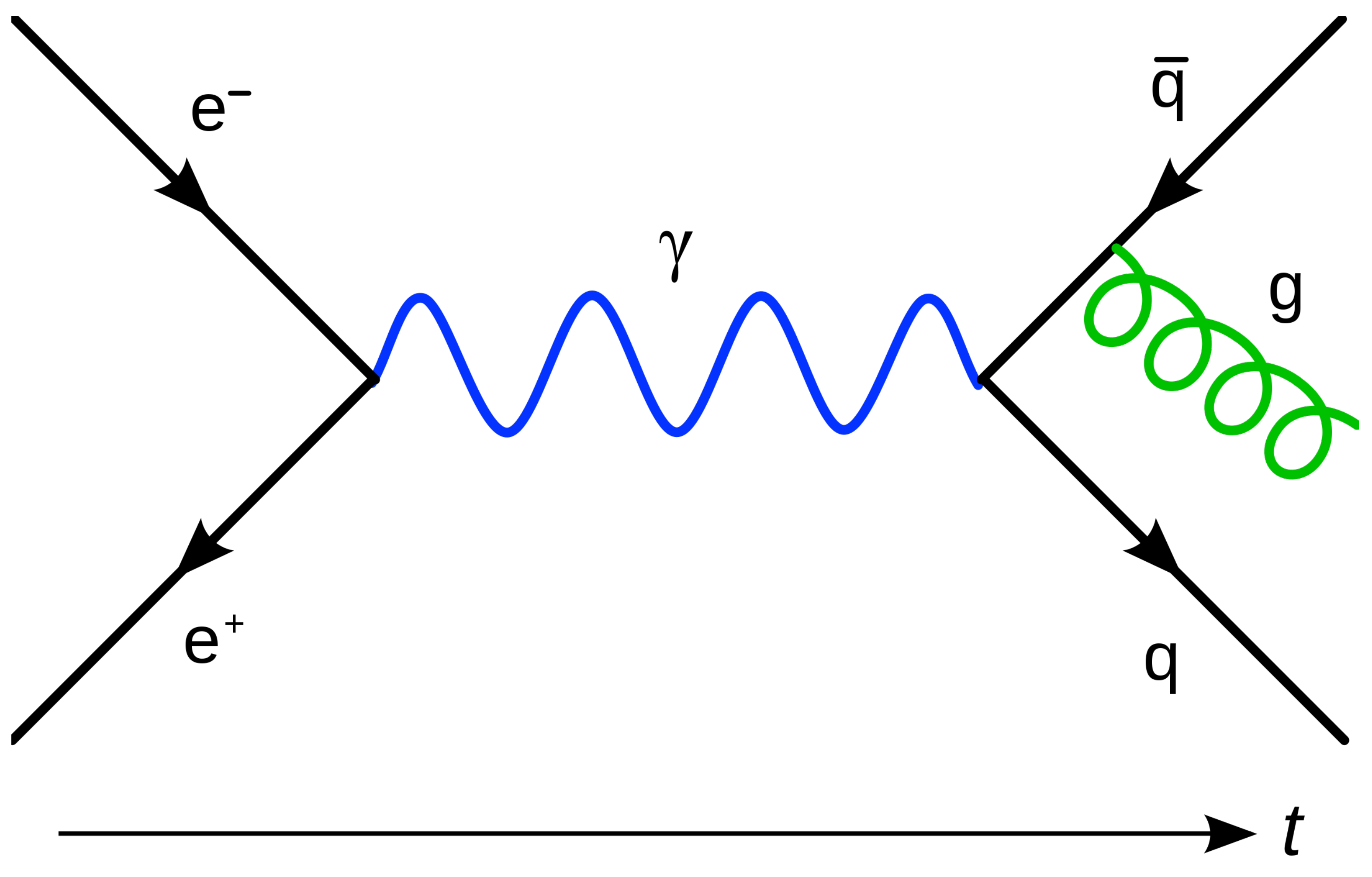
Conceptual toolkits

The CIT and CUP define the requirements of the *skills* and *tools* needed for achieving scientific understanding.

Skills & Tools

- Visualization standards
- Consensus definitions of terms
- Common analogies
- Inference standards
- Communication mediums
- Vetting procedures (e.g., peer review)

Example: Feynman Diagrams



Source: https://en.wikipedia.org/wiki/Feynman_diagram

(De Regt & Dieks 2005)

Take home message

- Scientific understanding is a contextual process, that relies on a community of researchers coming together to build generalizable theories.
- Thus communication efficiency (intelligibility) is critical in this collective process.