

## What is a theory? The Received View of Theories

### How do we use theories in science? The Deductive Nomological Model

## What is a Scientific Theory?

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3. **The Theoretical Language.** Sentences that contain ONLY theoretical terms (introduced by the theory) and logical connectives.
4. **Mixed Sentences.** Sentences that contain BOTH observational and theoretical terms as well as logical connectives.

The theory itself has two parts:

1. **THE THEORETICAL POSTULATES:** These sentences can connect together terms in the theoretical language, explaining the relations between the various entities, properties and processes that the theory postulates.
  - E.g. An **allele A** must exist in one of three relations to any other **allele B**:
    - a) Be **dominant** with respect to B
    - b) Be **recessive** with respect to B
    - c) **Interact** with B

We also need....

2. THE CORRESPONDENCE RULES: The sentences which connect up the theoretical terms to that which we can observe, i.e. the observable terms.

We are trying to understand the terms "Allele A", "Allele B", "dominant", "recessive", and "interact".

So we would need the following rules....

Rules that explain the terms "dominant", "recessive", and "interact".

9. If A is **dominant** with respect to A\*, then the organism is heterozygous, and has the genotype AA\*, and the **phenotype A**.
10. If A is **recessive** with respect to A\*, then the organism is heterozygous and has the genotype AA\* and the **phenotype A\***.
11. If A **interacts** with A\*, then then the organism is heterozygous, and has the genotype AA\*, but will have neither the **phenotype A** or the **phenotype A\***, but some **new phenotype** that results from their interaction.

**While any phenotype is some observable characteristic or other, “Phenotype A” doesn’t refer to any particular observable property. You therefore need bridge laws, that tell you to which observable properties the terms “phenotype A” “phenotype A\*” and “some other phenotype” refer.**

e.g.

“Flower colour in peas is determined by a gene that has alleles R, W and P which produce Red, White, and Purple flowers respectively in the homozygous plant. In heterozygous plants, R interacts with W, to produce pink flowers; P is dominant with respect to W, and produces Purple flowers and; R is dominant with respect to P and produces red flowers.”

If this is what a scientific theory IS, then how does a scientific theory work? What does it get you?

First Answer:

If this is what a scientific theory IS, then how does a scientific theory work? What do scientific theories explain and how do they do so?

A First Answer: **PREDICTION**

If this is what a scientific theory IS, then how does a scientific theory work? What does it get you?

A First Answer: **PREDICTION**

A scientific theory allows you to predict what will occur, by using natural laws, regularities or set of inter-connected regularities in nature.

## The Deductive-Nomological Model of Explanation

Deductive = To follow by reasoning

Nomological = Having to do with laws (of nature).

The D-N Model: Science provides explanations of observed phenomena by the *deducing* statements about the phenomenon to be explained from the *laws* proposed by the theory plus and the *antecedent* (or experimental) *conditions*.

The D-N Model was formally proposed by Carl Hempel and Paul Oppenheimer in a now famous article "Studies in the Logic of Explanation".

"A mercury thermometer is rapidly immersed in hot water; there occurs a temporary drop in the mercury column, which is then followed by a swift rise. How is this phenomenon explained? The increase in temperature affects at first only the glass tube of the thermometer; it expands and thus provides a larger space for the mercury inside, whose surface therefore drops. As soon as the heat conduction reaches the mercury, however, the latter expands, and as its coefficient of expansion is considerably larger than that of the glass, a rise of the mercury level results. This account consists in statements of two kinds. Those of the first kind indicate certain conditions which are realized prior to, or at the same time as, the phenomenon to be explained; we shall refer to them briefly as antecedent conditions. In our illustration, antecedent conditions include, among others, the fact that the thermometer consists of a glass tube which is partly filled with mercury and that it is immersed in hot water. The statements of the second kind express certain general laws; in our case, these laws include the laws of thermal expansion of mercury and glass, and a statement about the small thermal conductivity of glass....."

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phenomenon to be explained

the scientific explanation

analysis of the parts of the explanation

Hempel and Oppenheimer cont'd...

"....The two sets of statements, if adequately and completely formulated, explain the phenomenon under consideration; they entail the consequences that the mercury will first drop, then rise. Thus, the event under discussion is explained by subsuming it under general laws, i.e. by showing that it occurred in accordance with those laws, by virtue of the realization of certain specified antecedent conditions."

- how the explanation works

How is this D-N model supposed to work?

Some terminology...

**The Explanandum** (“what is to be explained”): the phenomenon or phenomena that you want to have explained.

e.g. “There occurs a temporary drop in the mercury column, which is then followed by a swift rise.”

**The Explanans** (“what does the explaining”).

The explanans (explanation) consists of two types of sentences:

1. **The Antecedent Conditions.** What happened prior to the unexplained phenomenon—in the case of science experiments, the experimental set-up.

E.g.

C<sub>.1</sub> There is a thermometer made of a glass tube containing mercury.

C<sub>2</sub> The thermometer is lowered into hot water.

2. **General Laws of the theory.** Generalizations that the theory states as true.

L<sub>1</sub> Glass is a moderate conductor of heat.

L<sub>2</sub> The volume expansion of glass is about  $10^{-5}$  ( $^{\circ}\text{C}$ ).

L<sub>3</sub> The volume expansion of mercury is about  $10^{-4}$  ( $^{\circ}\text{C}$ ).

L<sub>4</sub> When heated, the volume of a material will continue until it reaches thermal equilibrium.

The logic of the explanation...

1. C<sub>1</sub> There is a thermometer made of a glass tube containing mercury.

2. C<sub>2</sub> The thermometer is lowered into hot water.

PLUS

3. L<sub>1</sub> Glass is a reasonably low conductor of heat.

4. L<sub>2</sub> The volume expansion of glass is about  $10^{-5}$  ( $^{\circ}\text{C}$ ).

5. L<sub>3</sub> The volume expansion of mercury is about  $10^{-4}$  ( $^{\circ}\text{C}$ ), ten times greater than that of glass.

6. L<sub>4</sub> When heated, the volume of a material will continue until it reaches thermal equilibrium.

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Conclusion: There occurs a temporary drop in the mercury column, which is then followed by a swift rise

Filling in the premises..

1. C<sub>1</sub> There is a thermometer made of a glass tube containing mercury.
2. C<sub>2</sub> The thermometer is lowered into hot water.

PLUS

3. L<sub>1</sub> Glass is a reasonably low conductor of heat.
4. L<sub>2</sub> The volume expansion of glass is about  $10^{-5}$  ( $^{\circ}/C$ ).
5. As the glass is heated, it will begin to expand.
6. At first the mercury will not be heated.
7. The mercury will fall in the glass tube because it is larger.
8. L<sub>3</sub> The volume expansion of mercury is about  $10^{-4}$  ( $^{\circ}/C$ ), ten times greater than that of glass.
9. The mercury will begin to heat slowly as the glass conducts energy.
10. The mercury will expand to greater degree than the glass
11. L<sub>4</sub> When heated, the volume of a material will continue until it reaches thermal equilibrium.

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Conclusion: There occurs a temporary drop in the mercury column, which is then followed by a swift rise in the mercury column.

How is this D-N model supposed to work?

### Another example...Mendel's Genetics

**The Explanandum** ("what is to be explained"): the phenomenon or phenomena that you want to have explained.

e.g. The fact the off-spring of a purple true-breeding pea plant and a white true-breeding pea plant are all purple flowering pea plants.

**The Explanans** (“what does the explaining”).

The explanans (explanation) consists of two types of sentences:

1. **The Antecedent Conditions.** What happened prior to the unexplained phenomenon—in the case of science experiments, the experimental set-up.

E.g.

C<sub>1</sub> Two true-breeding pea plants, one purple and one white, were cross-bred.

1. **General Laws of the theory.** Generalizations that the theory states as true.

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L<sub>2</sub> A homozygous Purple flowering plant is homozygous if and only if it has the genotype PP.

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L<sub>3</sub> A homozygous White flowering plant is homozygous if and only if it has the genotype WW.

L<sub>4</sub> The genotype W is recessive with respect to the genotype P.

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L<sub>3</sub> A homozygous White flowering plant is homozygous if and only if it has the genotype WW.

L<sub>4</sub> The genotype W is recessive with respect to the genotype P.

If you now take the antecedent condition,  $C_1$

**AND** the laws  $L_1, L_2, L_3, \& L_4$

**AND** the rest of the Laws of Mendelian Genetics (which include the law about what it is for an allele to be recessive)

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**THEN** it follows that **the off-spring of a purple true-breeding pea plant and a white true-breeding pea plant must all be purple flowering pea plants.**

According to Hempel, D-N explanation is sound if and only if:

- I. The Logical Conditions of Adequacy.
  - a) The Explanandum must be a logical consequence of the Explanans.
  - b) The Explanans must contain general laws.
- II. The Empirical Condition of Adequacy.

The sentences of the Explanans must be true.

Remember, for any argument, if you can deduce the conclusion from true premises your argument is SOUND.



So on the D-N model, your scientific theory EXPLAINS the phenomenon just because:

Your Explanandum (what is to be explained) follows from the Explanandum (your theory and the antecedent conditions)

And the Explanandum is TRUE.