Aristotle’s Philosophy of Science – *The Posterior Analytics*

- Science (epistêmê) is a deductive system distinguished by its
  - subject matter and
  - its indemonstrable first principles (indemonstrable primitive or not derivable from more basic principles)
- Derived principles of one science can be the indemonstrable principles of another.

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Aristotle’s Philosophy of Science – *The Posterior Analytics*

**First Principles:**
- First principles are propositions
- Indemonstrable first principles are also:
  - necessary
  - true
  - more knowable (than what we derive from them):
    - more knowable “without qualification” (i.e., have more explanatory power) rather than
    - more (perceptually) knowable “to us”
Aristotle’s Philosophy of Science – The Posterior Analytics

Demonstration, Explanation, and Understanding

• The relation between demonstration, explanation, and understanding can be summarized as follows:

  • Suppose I notice that \( p \) is always true, and I hypothesize that \( p \) is necessarily true. I then ask “Why is \( p \) necessarily true?”

  • I discover indemonstrable, necessarily true first principles \( q \) and \( r \) by means of dialectic.

  • I demonstrate that \( p \) is necessarily true by deducing \( p \) from \( q \) and \( r \), and in so doing, I explain why \( p \) is necessarily true (because \( q \) and \( r \) contain the cause of \( p \) being necessarily true).

  • Thus, by explaining why \( p \) is necessarily true, I come to understand \( p \).

A concrete example from APost. 1.13, 78a23-b34:

\[
p = \text{Why is it necessarily true that none of the planets twinkle?}
q = \text{Because it is necessarily true that none of the celestial bodies that are near the earth twinkle,}
\]
\[
r = \text{And it is necessarily true that all of the planets are near the earth.}
\]

• I demonstrate that \( p \) is necessarily true by deducing \( p \) from \( q \) and \( r \), and in so doing, I explain why \( p \) is necessarily true (because \( q \) and \( r \) contain the cause of \( p \) being necessarily true). Thus, by explaining why \( p \) is necessarily true, I come to understand \( p \).
Aristotle’s Philosophy of Science – *The Posterior Analytics*

**Demonstration, Explanation, and Understanding**

Or, where $A =$ non-twinklers, $B =$ celestial objects near earth, $C =$ planets:

\[ p \] = Why are all $C$s necessarily $A$s?
\[ q \] = Because all $B$s are necessarily $A$s,
\[ r \] = and all $C$s are necessarily $B$s.

- I **demonstrate** that all $C$s necessarily $A$s by deducing it from the facts that all $B$s are necessarily $A$s and all $C$s are necessarily $B$s, and in so doing, I **explain** why all $C$s necessarily $A$s. Thus, by **explaining** why all $C$s necessarily $A$s, I come to **understand** this fact.

- $B$ contains the cause of all $C$s necessarily being $A$s. In this case, it is the nearness of the planets that **explains** their not twinkling.

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Aristotle’s Philosophy of Science – *The Posterior Analytics*

**Demonstration, Explanation, and Understanding**

- Not every syllogism results in scientific understanding. A number of things could go wrong:
  - One or more of the propositions might not be necessary, e.g.,

    Why does Sara hate ($A$) cauliflower ($C$)? (contingent)
    Because Sara hates ($A$) vegetables ($B$), (contingent)
    And cauliflower ($C$) is necessarily a vegetable ($B$). (necessary)

    Why is cauliflower ($C$) necessarily a vegetable ($A$)? (necessary)
    Because only vegetables ($A$) are on sale today ($B$). (contingent)
    And cauliflower ($C$) is on sale today ($B$). (contingent)

*General principle:* If the premises are all necessary, so will the conclusion. (Deduction preserves necessity as well as truth.)
Aristotle’s Philosophy of Science – *The Posterior Analytics*

**Demonstration, Explanation, and Understanding**

- One of the explanatory premises might not be of the right level of generality, e.g., (a true story of Aristotelian explanation):

  A student in Cowell Dining Hall says: “I think sushi tastes just like rats. Of course, I’ve never tasted rats, but I’m sure that sushi tastes just like them.” By what demonstrative syllogism did this sage person reach this conclusion?

  Two possibilities come to mind:

  \[ p = \text{Why does sushi (C) (allegedly) taste like rats (A)?} \]

  \[ q = \text{Because all Japanese food (B) (allegedly) tastes like rats (A),} \]

  \[ r = \text{And sushi (C) is Japanese food (B).} \]

  \[ p = \text{Why does sushi (C) (allegedly) taste like rats (A)?} \]

  \[ s = \text{Because all food one isn’t familiar with (B) (allegedly) tastes like rats (A),} \]

  \[ t = \text{And sushi (C) is an unfamiliar food (B).} \]
Aristotle’s Philosophy of Science – The Posterior Analytics

Demonstration, Explanation, and Understanding

• Another pitfall: E.g., Where things are As if and only if they are Bs:

  *Explanatory:

  \[ p = \text{Why are all planets (C) necessarily non-twinklers (A)?} \]
  \[ q = \text{Because all celestial objects near earth (B) are necessarily non-twinklers (A),} \]
  \[ r = \text{and all planets (C) are necessarily celestial objects near earth (B).} \]

  *Not Explanatory:

  \[ r = \text{Why are all planets (C) necessarily celestial objects near earth (B)?} \]
  \[ s = \text{Because all non-twinklers (A) are necessarily celestial objects near earth (B),} \]
  \[ p = \text{and all planets (C) are necessarily non-twinklers (A).} \]

• The B term can explain the A term but not *vice versa*. Some propositions (e.g., \( r \)) are truly explanatory of others (e.g., \( p \)), while some are not.

Aristotle’s Philosophy of Science – The Posterior Analytics

An Answer to Meno’s Paradox

• 71a17: “We may also recognize that \( q \) by having previously recognized that \( p \) and acquiring recognition of \( q \) at the same time.”

• 71a25: “Before we perform the induction or the deduction, we should presumably be said to know in one way but not in another. ... But clearly we know it insofar as we know it universally, but we do not know it without qualification.”

• *We* make a distinction about the scope of “knows”:

  • True: Socrates knows that every sort of mammal is warm blooded.
  • False: Of every every sort of mammal, Socrates knows that it is warm-blooded.
  • But *Aristotle* wants to say that the second sentence is true “universally” and “potentially” (See *Metaphysics* M 10).
Aristotle’s Philosophy of Science – *The Physics*

Aristotle’s 4 Causes: A Typology of First Principles (*Phys.* 1.3)

- **The 4 Causes:**
  - **material cause**: e.g., the bronze in a statue
  - **formal cause**: the form or essence of a thing
  - **efficient cause**: the source of change or coming to be, e.g., the father causes the child, the cue causes the billiard ball to roll
  - **final cause**: the end, what it is for; health causes walking

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Aristotle’s Philosophy of Science – *The Physics*

Aristotle’s 4 Causes: A Typology of First Principles (*Phys.* 1.3)

- Material and efficient causes do not give us closure of explanation:

  Why can the axe chop wood?
  Because it is made of steel.
  Why is this axe made of steel?
  Because the axe-maker made it that way.
  Why did the axe-maker make it that way?
  Because steel was at hand to make it. Etc., etc. …

  … but final and formal causes do:

  Why can the axe chop wood?
  Because that is its function or purpose, and because its form is such and such.
Aristotle’s Philosophy of Science – *The Posterior Analytics*

The 4 Causes in Action: Examples in *APost.* Book 2, Chapter 11

- **Formal Cause:** In the following syllogism, the extinction of fire is a formal cause in the sense that it is the definition of thunder:

  Why must clouds (C) thunder (A)?
  Because thunder (A) is the extinction of fire (B),
  And clouds (C) must extinguish fire (B).

- **Material Cause:** In the following syllogism, being made of earth is a material cause of pottery’s falling when dropped.

  Why does pottery (C) fall when you drop it (A)?
  Because earthen things (B) fall when you drop them (A),
  And pottery (C) is made of earth (B).

- **Efficient Cause:** In the following syllogism, launching an attack is an efficient cause in the sense that it initiated the war:

  Why must the Athenians (C) go to war (A)?
  Because everyone who launches an attack (B) goes to war (A),
  And the Athenians (C) launched an attack (B).

- **Final Cause:** In the following syllogism, health is a final cause in the sense that it is the aim of walking after dinner:

  Why does walking after dinner (C) promote good digestion (A)?
  Because health (B) promotes good digestion (A),
  And walking after dinner (C) promotes health (B).
Aristotle’s Philosophy of Science – *The Posterior Analytics*

**The 4 Causes in Action: Examples in APost. Book 2, Chapter 11**

- **Final Cause cont’d**: But one could “transpose the accounts” as follows and make good digestion the aim of walking after dinner:

  Why is walking (C) after dinner always healthy (B)?  
  Because good digestion (A) promotes health (B),  
  And walking after dinner (C) promotes good digestion (A).

  Note that this works because it is assumed that one has good digestion (A) if and only if one is healthy (B), which allows us to say that good digestion (A) promotes health (B) and that health (B) promotes good digestion (A).)

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Aristotle’s Philosophy of Science – *The Physics*

**Contrariety, Persistence & Coming to Be (Phys. Book 1)**

- Methodology. (Chapter 1)
- The principles of physical things are opposites. (Chapter 5)
  - 2 types of argument for this claim:
    - Inductive survey of reputable opinions
    - Series of arguments based on certain abstract or formal considerations:
      - First principles can’t be derivable from other principles or from each other.
      - Things don’t come to be out of any chance thing.
      - Things change between opposites.
Aristotle's Philosophy of Science – *The Physics*

**Contrariety, Persistence & Coming to Be (Phys. Book 1)**

- There must be three principles of physical things. (Chapter 6)
  - Physical things can’t have just one first principle.
  - Physical things can’t have an infinite number of first principles.
  - Physical things can’t have just two principles.
  - Physical things can’t have more than 3 principles.

- The Principles of Physical Things: *Hypokeimenon*, Form, and Privation (Chapter 7)
  - The very same change can be described in three ways:
    i. The man becomes musical.
    ii. The unmusical thing becomes musical.
    iii. The unmusical man becomes the musical man.
Aristotle’s Philosophy of Science – *The Physics*

**Contrariety, Persistence & Coming to Be (Phys. Book 1)**

- The Principles of Physical Things: *Hypokeimenon*, Form, and Privation (Chapter 7)

- 3 principles of physical things:
  1. Form, e.g., the form of a man or of musicality
  2. the privation of form, e.g., formlessness and unmusicality, and
  3. the “subject” that underlies.

Aristotle’s Philosophy of Science – *The Physics*

**Contrariety, Persistence & Coming to Be (Phys. Book 1)**

- Aristotle’s Answer to the Eleatic Challenge (Chapter 8)

- Parmenides: Coming to be is impossible because coming to be is coming to be *ex nihilo*, and this is impossible.

- Aristotle: Only under certain descriptions does coming to be look like coming to be *ex nihilo*:
  
  i. The matter becomes formed.
  
  ii. The unformed thing becomes formed.
  
  iii. The unformed matter becomes the formed matter.
Aristotle’s Philosophy of Science – *The Physics*

- Puzzles About Identity:
  - The Ship of Theseus (Plutarch)
  - The Growing Argument (Epicharmus)

- Diachronic vs. Synchronic Identity:
  - Diachronic Identity = Persistence = Identity Across Time
  - Synchronic Identity = Individuation = Identity at a Time

- Necessary vs. Sufficient Conditions for Identity:
  - Sufficient Condition: If condition X holds, then \( a = b \).
  - Necessary Condition: If \( a = b \), then condition X holds.

Aristotle’s Philosophy of Science – *The Physics*

- Problem posed by the Ship of Theseus & the Growing Argument: How can an enduring entity gain and shed properties while still remaining numerically the same entity? That is, if the indiscernibility of identicals holds (\( \forall x \forall y (x = y \rightarrow \forall F (Fx \iff Fy)) \)), then how can something remain identical through a change?

- Two types of solution:
  - Deny the indiscernibility of identicals. Give a sufficient condition (criterion) of identity.
  - Accept the indiscernibility of identicals. Explain how what persists does not violate the principle. Give no criterion of identity because it is not necessary to address the puzzle. Aristotle’s solution falls into this category. He claims that the changing thing remains “one in substrate,” but not “one in form.”
Aristotle’s Philosophy of Science – *The Physics*

**Nature (Physics Book 2, Chapters 1-2)**

- Two classes of things in the world:
  1. natural substances (animals and their parts, plants and the simple bodies such as earth, fire, air, and water)
  2. artificial creations or artifacts
- Nature is “a principle of motion and stability in place, in growth and decay, or in alteration.”
- Conceptual Pluralism
- Problems

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Aristotle’s Philosophy of Science

**Nature (Metaphysics Book 5, Chapter 4)**

- 5 Senses of “Nature”:
  1. the genesis of growing things
  2. that immanent part of a growing thing, from which its growth first proceeds [e.g., a seed]
  3. the source from which the primary movement in each natural object is present in it in virtue of its own essence
  4. the primary material out of which any natural object is made
  5. the essence of natural objects
Aristotle’s Philosophy of Science – *The Parts of Animals*

- Three ways in which one might appeal to final causes (purposes) in biological explanations (*PA* 1.1, p. 532):
  
  A. The purpose of an animal part is to secure an organism’s existence, since without it, the organism couldn’t exist.

  B. The purpose of an animal part is to contribute to an organism’s well being but not to secure its existence.

  C. The purpose of a biological process is to produce an animal part of a certain sort, and the character and order of the process can be explained by reference to the part to be produced.

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Aristotle’s Philosophy of Science – *The Physics*

**Hypothetical Necessity** (*Phys.* Book 2, Ch. 8-9, *PA* Book 1, Ch. 1, 5)

- Absolute necessity: *p* is true in all possible circumstances.

- Hypothetical necessity: *p* is necessary on the hypothesis that *q*.

  - Usually *q* expresses a goal and *p* expresses a necessary condition of that goal being achieved. E.g., if the purpose of an axe is to chop wood, it is hypothetically necessary that it be made of a suitably hard material.

  - Can also have a “type C” application: If the goal of process is φ, then ψ must first be accomplished.