03. Aristotle (384-322 B.C.)

I. Matter and Form

• All being is in the world.
• Forms exist in sensible objects; not in a separate Platonic realm.

_Doctrine of Hylomorphism_

• A sensible object consists of both _matter_ and _form_.
• _Form_ determines properties of the object.
  - properties cannot exist without a subject in which they adhere.
• _Matter_ provides substratum in which properties adhere.
  - by itself has no properties (neutral substratum).
  - does not exist without form.

_Aristotle's objection to Plato_
There can be no _matter_ without _form_, and no _form_ without _matter_ (with one important exception).

• _Goal of natural inquiry_ = To identify the forms of things.
  - This must start in the sensible world (and not in the realm of reason).

_Example_
- Gold is yellow, cold, malleable, heavy, smooth, _etc_; determined by its _form_.
- If all these properties could be stripped away, what would remain would be _matter_.

II. Change

• **Problem of change**: How can the world exhibit both permanence and change?

Consider the transformation of an acorn into a sapling.

- How can we identify the sapling with the acorn?
- How is this identity transferred during the transformation?

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*Aristotle's Account of Change*

• Permanence through change is provided by *matter*.
  - When a sensible object changes, *its form changes and its matter remains the same*.

• *So*: Change is fundamentally real.
  - *Not an illusion; not restricted to a lesser realm*.

• *But*: What about Parmenides' Objection: Change requires the emergence of something from nothing.
• Aristotle's Response:
  - *Change is not a transition from non-being to being, but from potential being (potential form) to actual being (actual form).*

  \[\text{Example:}\]
  - An acorn has both an *actual form* of being an acorn, and a *potential form* of being a sapling and an oak tree.
  - A sapling has both an *actual form* of being a sapling, and a *potential form* of being an oak tree.
  - When an acorn changes into a sapling, its *potential* form transitions into the *actual* form of a sapling.

• Two distinctions underlie Aristotle's concept of change:
  - *matter/form distinction* (static)
  - *potential/actual distinction* (dynamic)

  - *Pure potency* = "Prime Matter" (but this doesn't exist: actuality is prior to potency).
  - *Pure actuality* = "Prime Mover" (Aristotle's concept of god).

• This explains *how* change is possible. But it doesn't explain *why* change occurs: What is the *cause* of change?
• **Aristotle says**: Things undergo change due to their *natures* ("things are what they do").

- The *nature* of a thing is its tendency to actualize its potential.
- *nature* = an internal goal-directed cause of change.

- The *nature* of an acorn is to become an oak tree.
- The *nature* of a planet is to follow a perfect circular path in the heavens.
- The *nature* of a rock is to fall to the center of the cosmos.
- A rock has the actual form of heaviness and the potential form of being-at-the-center-of-the-cosmos.

**How is this different from contemporary accounts?**

• Consider Newton's 1st Law of Motion:
  - *Left unimpeded, a body will continue in a state of rest or in uniform motion along a straight line.*

• Why does a body do this?
  - *Inertia* = tendency of a body to obey the 1st Law of Motion.
  - The more inertia a body has, the greater its tendency to continue at rest or in uniform motion in a straight line.

• Why do bodies have inertia?
  - *No explanation within contemporary physics.*
• For Aristotle, knowledge consists in knowledge of *natures* (in general, of understanding the causes of change): "If we are ignorant of change, then we are ignorant of Nature."

**Three Points to Remember about Aristotelian natures:**

1. Not all things follow their natures and achieve their potentials.
   - *Most things are impeded by interactions with other things.*
   - *Left unimpeded, all things would follow their natures.*

2. Only *natural* things have natures, and hence are sources of change.
   - *Artificial things do not have natures.*

3. To determine *natures*, observation is sufficient.
   - *No need for intervention* (*i.e.* , controlled experimentation, repeatability, etc.)
III. The Four Causes

1. **Material:** What is it made of? (That *in which* change occurs.)
2. **Formal:** What kind of thing is it? (The form *into which* a thing changes.)
3. **Efficient:** How was it made? (That *by which* change is brought about.)
4. **Final:** What is it for? (That *for the sake of which* change occurs.)

- Four ways of explaining what makes a thing what it is.
- Operative in both Art (*techne*) and Nature (*physis*).

<table>
<thead>
<tr>
<th>marble statue of Zeus</th>
<th>acorn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. marble</td>
<td>1. material of acorn</td>
</tr>
<tr>
<td>2. shape of Zeus</td>
<td>2. oak tree</td>
</tr>
<tr>
<td>3. chisel and hammer</td>
<td>3. rain, sun, soil, nutrients</td>
</tr>
<tr>
<td>4. intent of sculptor</td>
<td>4. nature of acorn</td>
</tr>
</tbody>
</table>

- **Note overlaps:** The nature of an acorn is also associated with its form.
  - *In Art,* final causes are external/transcendent.
  - *In Nature,* final causes are internal/immanent.
- Is Aristotle deifying Nature with concept of final cause?
- **No**: Nature does not have an overall purpose.
- **Rather**: Natural processes are internally goal-directed.

**Example**: Functional explanations in contemporary biology.
- Why are grasshoppers green?
- **Typical answer**: Camouflage is a valuable adaptive trait for grasshoppers.

- But no explanations of this sort in contemporary physics:
  - Why does Saturn have rings?
  - **Typical answer**: The rings are the remnant of a moon that broke up in the distant past.

- No appeal to any possible value of having rings for planets.
- Explanations in contemporary physics tend to be framed in terms of *efficient* causes and not *final* causes.
- **Why?**
IV. Aristotle's Cosmology

1. The Four Elements

<table>
<thead>
<tr>
<th>element</th>
<th>form</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>earth</td>
<td>cold/dry</td>
<td>heaviest</td>
</tr>
<tr>
<td>water</td>
<td>cold/wet</td>
<td>lighter₁</td>
</tr>
<tr>
<td>air</td>
<td>hot/wet</td>
<td>lighter₂</td>
</tr>
<tr>
<td>fire</td>
<td>hot/dry</td>
<td>lightest</td>
</tr>
</tbody>
</table>

Transformations between elements:

- Contrary forms = two forms that cannot both be present in the same thing.
- Forms change via transitions between contraries.
2. The Cosmos

- A series of concentric spheres divided into two realms:

  The **Celestial Realm**
  (between the sphere of the moon and the sphere of the fixed stars).
  Composed of aether.

  The **Terrestrial Realm**
  (inside the sphere of the moon). Composed of the 4 elements.

- Each dotted circle really represents a set of nested spheres...

  The spheres of the sun and planets. In order:
  Moon
  Sun
  Venus
  Mercury
  Mars
  Jupiter
  Saturn
  fixed stars

  fire, air, water, earth
planet

Earth
Earth
- Explains retrograde motion.

- Aristotle requires additional spheres to counteract some of the motions of the planetary spheres. (These additional spheres are placed between the outermost sphere of a given planet and the innermost sphere of the next planet and are one less than the number of spheres of the latter.)

<table>
<thead>
<tr>
<th></th>
<th>Eudoxus</th>
<th>Callippus</th>
<th>Aristotle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Sun</td>
<td>3</td>
<td>5</td>
<td>5 + 4</td>
</tr>
<tr>
<td>Venus</td>
<td>4</td>
<td>5</td>
<td>5 + 4</td>
</tr>
<tr>
<td>Mercury</td>
<td>4</td>
<td>5</td>
<td>5 + 4</td>
</tr>
<tr>
<td>Mars</td>
<td>4</td>
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<td>5 + 4</td>
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<tr>
<td>Jupiter</td>
<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>Saturn</td>
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<td>4</td>
<td>4 + 3</td>
</tr>
<tr>
<td>fixed stars</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>34</td>
<td>56</td>
</tr>
</tbody>
</table>
3. Motion

- Two basic principles:

  I. No motion without a mover in contact with moving body.
  
  II. Distinction between:
      
      (a) Natural motion: mover is *internal* to moving body
      
      (b) Forced motion: mover is *external* to moving body

3 Types of Natural Motion and Corresponding Elements (Natural Bodies)

(1) In *straight line* towards center of the cosmos: earth, water

(2) In *straight line* away from center of the cosmos: fire, air

(3) In *circle* about center of the cosmos: aether ("fifth element")

- Cause of celestial motion = Unmoved Mover ("Prime Mover").
  - Acts as final cause ("object of desire")

- Cause of terestrial motion = celestial realm as final cause.
  - Cyclic transformation between elements emulates circular motion of heavens.
4. Doctrine of the Plenum

- **Claim:** There is no void (*contra* the atomists).
- **Assume:**
  
  (i) Speed is inversely proportional to resistance. \((V \propto 1/R)\)
  
  (ii) Infinite speed is physically impossible.

- **Conclusion:** Zero resistance is physically impossible.
- **Hence:** There can be no body through which motion can occur that has zero resistance (*i.e.*, zero density; *i.e.*, a void).

- **But:** Could also conclude that Assumption (i) is incorrect.
  
  - Zero resistance doesn't necessarily entail infinite speed.

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**Aristotle’s Physics: A Physicist’s Look**

*Abstract:* I show that Aristotelian physics is a correct and nonintuitive approximation of Newtonian physics in the suitable domain (motion in fluids) in the same technical sense in which Newton’s theory is an approximation of Einstein’s theory. Aristotelian physics lasted long not because it became dogma, but because it is a very good, empirically grounded theory. This observation suggests some general considerations on intertheoretical relationships.

*Keywords:* history of philosophy, ancient philosophy, Aristotle, philosophy of science, philosophy of physics