Philosophy of Science Survey

Week 14

PHIL 2160. Ohio University. Spring 2021.

Chapter 29: Overview of the Theory of Evolution

Our plan

- DeWitt's chapter is organized backwards in terms of history of science. But we'll study the Darwinian worldview in a historical order:

1. Evolutionary thought before Darwin
   - This is not in DeWitt's book.
2. Darwin's evolutionary ideas
   - This overlaps with DeWitt's section on Darwin and Wallace.
3. Basics of modern evolutionary theory
   - This is DeWitt's first big section in the chapter.

Basics of Modern Evolutionary Theory

- In his section on "A brief overview of evolutionary theory since Darwin and Wallace," DeWitt presents what we call *the theory of population genetics.*
  - This theory is also called *evolutionary genetics*.
- This theory is a mathematical core of the modern evolutionary theory.
  - Notice the word "core": the modern evolutionary theory includes many other things than the theory of population genetics.
- We'll study basics of population genetics.

Basics of Modern Evolutionary Theory

- Population genetics studies *genetic* characteristics of a *population* of organisms.
  - This field emerged in the 1920s–1930s as a result of incorporating Mendelian genetics into Darwinian evolutionary theory.
- In population genetics, *evolutionary change* is understood as *a change in allele frequencies in a population over time*.
- Before we clarify this idea, we need to clarify the relevant genetic ideas.

Basics of Modern Evolutionary Theory

Basic genetic concepts

- A gene = a part of the hereditary material that is associated with a physiological function
  - E.g., If a certain part of DNA controls eye color, then we call that part the gene for eye color.
- An allele = a variant of a gene
  - E.g., consider our hypothetical gene for eye color. Imagine that in some people, this gene has the same DNA sequence (i.e., an order of ATGC) but in other people, it has a slightly different sequence. We then say that there are two alleles of the gene for eye color.
- An allele frequency = a frequency of a given allele in a population

Basics of Modern Evolutionary Theory

Example

- Imagine that we have a population of 5 organisms and that we are interested in a particular gene.
- Imagine also that there are two alleles A1 and A2 for the gene of interest.
- Imagine that an organism is diploid (has two copies of the same gene, one copy from each parent).
- Then, each organism has one of three *genotypes*: A1A1, A1A2, A2A2.

Basics of Modern Evolutionary Theory

- Suppose that 5 organisms have these genotypes:
  1. A1A1
  2. A1A2
  3. A2A2
  4. A1A2
  5. A1A1
- The frequency of A1 allele in this population is:

  Number of A1 alleles / 10 = 6/10

  - The denominator is 10 because there are 10 alleles in total (5 organisms carrying 2 copies each).

Basics of Modern Evolutionary Theory

- Suppose that we watch this population of organisms over many generations, and at some point, among the descendants of our original 5 organisms, the genotypes are distributed like this:
  1. A1A1
  2. A1A1
  3. A1A1
  4. A1A1
  5. A1A2
- The frequency of A1 allele is now 9/10.
- This sort of change in allele frequencies is what the theory of population genetics predicts and explains.

Basics of Modern Evolutionary Theory

- How does the theory of population genetics explain changes in allele frequency?
- It explains an allele frequency at a given time as a net result of various evolutionary factors, such as:
  - Natural selection
  - Genetic drift
  - Gene flow (migration)
  - Genetic mutation
- DeWitt describes each, but we'll focus on selection and drift and discuss them in more detail.

Basics of Modern Evolutionary Theory

Natural selection

- As we saw, Darwin argued that if ***certain conditions*** hold in nature, then natural selection will occur: organisms with particular variations will be more likely to survive and reproduce.
  - The relevant variations are those that are likely to help organisms in the struggle for life.
- These conditions, in the modern theory, are summarized as follows:

1. Heritable variation
2. Differential fitness

Basics of Modern Evolutionary Theory

1. Heritable variation
   - This corresponds to the following Darwinian conditions:
     - Organisms vary in their individual structures. (variation)
     - They transmit the variations to their offspring. (variations are heritable)
2. Differential fitness
   - This corresponds to the following Darwinian conditions:
     - There is struggle for existence.
     - Some individual variations are useful for their bearers to survive the struggle for existence.
   - *Fitness* is a quantity that describes an organism's tendency to survive and reproduce ***in a given environment***. (We can't talk about fitness of an organism in isolation.)

Basics of Modern Evolutionary Theory

- “In order to make it clear how, as I believe, natural selection acts, I must beg permission to give one or two imaginary illustrations. Let us take the case of a wolf, which preys on various animals, securing some by craft, some by strength, and some by fleetness; and let us suppose that the fleetest prey, a deer for instance, had from any change in the country increased in numbers, or that other prey had decreased in numbers, during that season of the year when the wolf is hardest pressed for food. I can under such circumstances see no reason to doubt that the swiftest and slimmest wolves would have the best chance of surviving, and so be preserved or selected . . .” (Darwin, *The Origin of Species*)

Basics of Modern Evolutionary Theory

- In Darwin's wolf example, we say that faster wolves have higher fitness than slower ones.
- But notice that fitness is a function of an organism's variation (e.g., speed) and the characteristics of the environment in which it lives.
  - The environment of an organism includes other organisms as well as physical characteristics.
- This is why Darwin specified: "Let us suppose that *the fleetest prey*, a deer for instance, had from any change in the country *increased in numbers*."
  - That is, now wolves live in an environment where their prey are comparably faster than before.

Basics of Modern Evolutionary Theory

- How much advantage faster wolves have over slower wolves can be measured and quantified in principle.
- That is, fitness difference can be measured and quantified.
  - E.g., it can be expressed as a percentage gain in the expected number of offspring by faster wolves.
- See example next.

Basics of Modern Evolutionary Theory

Example

- Consider three genotypes A1A1, A1A2, A2A2.
- Let's suppose that in a given environment, having one A1 allele confers small advantage but having two A1 alleles is not different from having one A1 allele.
- We can then assign relative fitness values as follows:

  A1A1 = 1, A1A2 = 1, A2A2 = 0.95

- These are *relative* values in the sense that we take the highest fitness as 1 and assign other values relative to it.
  - Here we are saying that A2A2 suffers 5% reduction in fitness relative to other genotypes.

Basics of Modern Evolutionary Theory

Genetic drift

- Imagine that all organisms in a population have the same fitness in its environment.
  - E.g., because resources are abundant.
- Since there is no differential fitness, natural selection does not occur.
- But suppose that the population size is finite.
  - This means that not all offspring can survive (if they could, the population size will be infinite).

Basics of Modern Evolutionary Theory

- In this condition, which organisms survive and reproduce in each generation is a matter of *chance*.
  - By chance, we don't mean "uncaused." By chance, we just mean that the reason of survival and reproduction has nothing to do with fitness difference.
- For example, with respect to ABO blood types, humans do not differ in fitness (as least as far as we know in a contemporary environment).
- So which blood type gets passed on to the next generation is a matter of chance.

Basics of Modern Evolutionary Theory

- In summary, the theory of population genetics explains changes in allele frequencies in a population as a result of the interaction among evolutionary factors, such as
  - Natural selection
  - Genetic drift
  - Gene flow (migration), and genetic mutation
- Drift represents effects of chance—events that have nothing to do with fitness—and selection represents effects of differential fitness.

Basics of Modern Evolutionary Theory

- https://www.radford.edu/~rsheehy/Gen_flash/popgen/
- Let's explore effects of selection and drift in computer simulations.
  - DeWitt's simulation in the book is just like this one.
- Try to vary:
  - Population size (N): what is the effect of large and small N?
  - Fitness (w): what is the effect of varying w?
- Consider:
  - Small N with different w's (i.e., with selection)
  - Small N with equal w's (i.e., no selection)
  - Large N with different w's
  - Large N with equal w's

Basics of Modern Evolutionary Theory

- In the modern evolutionary theory, evolutionary processes are ***mechanistic*** in the sense that they have no purpose.
- In this sense, the theory shares an aspect of the Newtonian worldview.

Darwinian Worldview

Common descent

- All organisms share a common ancestor.
  - This view rejects special creation.

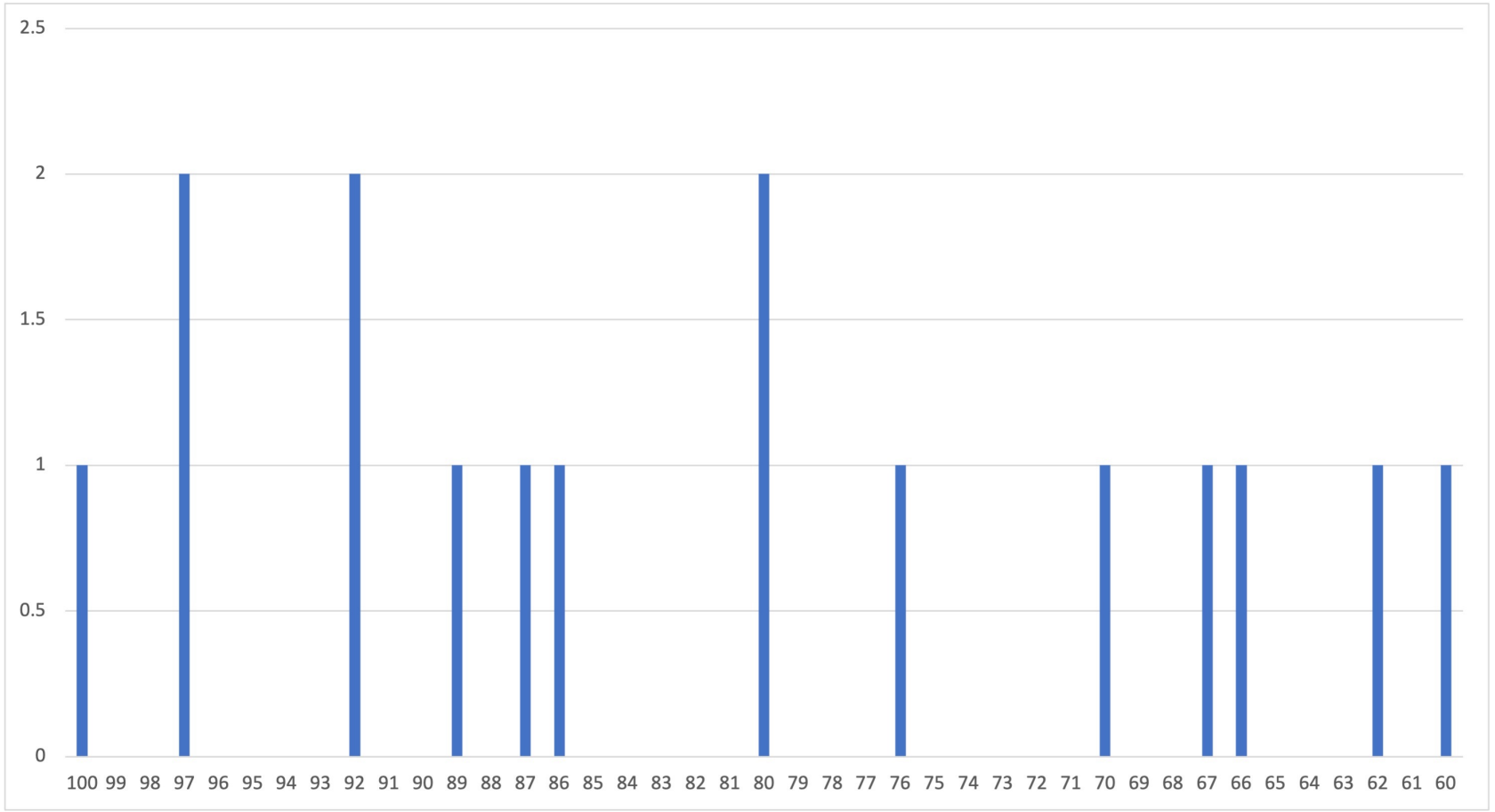
Species transformism ("descent with modification")

- Species change over time. Existing species are modifications of ancestral species.
  - This view rejects species essentialism and species permanence

Mechanistic view

- Evolutionary changes are caused by natural processes that do not have any ultimate purpose.
  - Natural selection and genetic drift are some examples of these processes.

Exam 3



Mean = 80
Median = 83

Chapter 30: Reflections on Evolution
Chapter 31: Worldviews – Concluding Thoughts

Chapter 30

- DeWitt's chapter has three topics:

1. Implications of Darwinian evolution on religion
2. Implications of Darwinian evolution on moral philosophy
3. Empirical studies of the evolution of human behaviors (cooperation, altruism, forgiveness, punishment, trust, etc.)

- In each topic, DeWitt focuses on recent debates and work.
- In this lecture, we'll see how Darwin and his contemporaries dealt with the implications of evolution on religion, and then we'll summarize the transitions of worldviews.

Evolutionary thought before Darwin (review)

The Christianized Aristotelian worldview before Darwin

Species essentialism

- A species has essential characteristics that distinguish it from other species, and the essential characteristics do not change over time.

Species permanence

- Species are fixed and do not change over time. Each species must have its own causal origin that is distinct from other species.

Special creation

- God separately created all species as they exist today.

Darwinian Worldview

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- All organisms share a common ancestor.
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Mechanistic view

- Evolutionary changes are caused by natural processes that do not have any ultimate purpose.
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Darwinian Worldview and Design

- In Week 6, we talked about how we common ascribe function (purpose) to features of biological organisms.
  - That is, we talk as if parts of an organism are designed to serve certain purposes. (e.g., The function of the heart is to pump blood.)
- Before Darwin, theologians working in the area called "natural theology" developed the so-called design argument, which gave a teleological explanation of function in nature.
- Darwin was greatly influenced by the design argument found in William Paley's *Natural Theology* (1802).

Darwinian Worldview and Design

- “In crossing a heath, suppose I pitched my foot against a *stone*, and were asked how the stone came to be there; I might possibly answer, that, for any thing I knew to the contrary, it had lain there for ever: nor would it perhaps be very easy to show the absurdity of this answer. But suppose I had found a *watch* upon the ground, and it should be inquired how the watch happened to be in that place; I should hardly think of the answer which I had before given, that, for any thing I knew, the watch might have always been there.” (Paley, *Natural Theology*)

Darwinian Worldview and Design

- “Yet why should not this answer serve for the watch as well as for the stone? why is it not as admissible in the second case, as in the first? For this reason, and for no other, viz. that, when we come to inspect the watch, we perceive (what we could not discover in the stone) that its several parts are framed and put together for a purpose [Paley describes the watch’s mechanism].” (Paley, *Natural Theology*)
  - Notice for Paley, a stone does not have any purpose. Paley is Newtonian rather than Aristotelian in this regard.
  - But a watch has a purpose, and Paley thinks that this is an important difference.

Darwinian Worldview and Design

- “This mechanism being observed [. . .], the inference, we think, is inevitable, that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use.” (Paley, *Natural Theology*)
- Paley’s argument goes like this:
  1. If an object is designed to perform a function, it must have been designed to do so by an artificer.
  2. The watch is designed for a function.
  3. So the watch must have been designed by an artificer.

Darwinian Worldview and Design

- “Or shall it, instead of this [conclusion], all at once turn us round to an opposite conclusion, viz. that no art or skill whatever has been concerned in the business, although all other evidences of art and skill remain as they were, and this last and supreme piece of art be now added to the rest? Can this be maintained without absurdity? Yet this is atheism.

  This is atheism: for every indication of contrivance, every manifestation of design, which existed in the watch, exists in the works of nature.” (Paley, *Natural Theology*)
  - In the last sentence, Paley means that biological entities have purposes or functions. e.g., the function of the eye is to see.

Darwinian Worldview and Design

- “I know no better method of introducing so large a subject, than that of comparing a single thing with a single thing; an eye, for example, with a telescope. As far as the examination of the instrument goes, there is precisely the same proof that the eye was made for vision, as there is that the telescope was made for assisting it. They are made upon the same principles; both being adjusted to the laws by which the transmission and refraction of rays of light are regulated. [. . .]” (Paley, *Natural Theology*)

Darwinian Worldview and Design

- “For instance; these laws require, in order to produce the same effect, that the rays of light, in passing from water into the eye, should be refracted by a more convex surface, than when it passes out of air into the eye. Accordingly we find that the eye of a fish, in that part of it called the crystalline lens, is much rounder than the eye of terrestrial animals. What plainer manifestation of design can there be than this difference?” (Paley, *Natural Theology*)
- Paley’s argument goes like this:
  1. If the eye of a fish is designed for vision under water, it was designed so by God.
  2. The eye of a fish is designed for vision under water.
  3. Therefore, it was designed so by God.

Darwinian Worldview and Design

- Consider Paley's key premise (generalized from the last argument):

  If parts of a biological organism perform specific functions in its environment, then they were designed to do so by God.

  Or

  Only God's design can explain the existence of design in nature.

- Paley's explanation of design in nature—the existence of functions in nature—is *teleological*.
  - E.g., The eye serves the function of seeing because that is what God intended when he designed the eye.

Darwinian Worldview and Design

- Darwin's innovation was to provide a *mechanistic* explanation of the existence of design in nature.
  - That is, Darwin showed Paley's key premise is not necessarily true, because natural selection over many generations can produce biological entities that appear to be designed for specific functions.
- Darwin's another innovation was to ***save*** the function talk in biology.
- How so? Isn't Darwinian worldview mechanistic (non-teleological)? (see next)

Darwinian Worldview and Design

Example: "The function of the eye is for vision."

- For Paley, this means that God intended the eye for vision. It's a claim about God's purpose.
- For Darwin, this means that in the past environment in which the bearer of the eye lived, there was natural selection in favor of variations that enhanced vision.
  - In other words, for Darwin, the sentence above is a claim about the history of organisms in question.

Darwinian Worldview and Design

- “To suppose that the eye [. . .] could have been formed by natural selection, seems, I freely confess, absurd in the highest possible degree. Yet reason tells me, that if numerous gradations from a perfect and complex eye to one very imperfect and simple, each grade being useful to its possessor, can be shown to exist; if further, the eye does vary ever so slightly, and the variations be inherited, which is certainly the case; and if any variation or modification in the organ be ever useful to an animal under changing conditions of life, then the difficulty of believing that a perfect and complex eye could be formed by natural selection, though insuperable by our imagination, can hardly be considered real.” (Darwin, *The Origin of Species*)

Darwinian Worldview and Design

- Darwin's argument follows his general argument for natural selection (review Week 13).

1. If the following conditions hold

a. Numerous gradations exist from a perfect and complex eye to one very imperfect and simple, each grade being useful to its possessor.
b. The eye varies ever so slightly, and the variations are inherited.
c. Any variation or modification in the organ be ever useful to an animal under changing conditions of life.

then a complex eye can be formed by natural selection over long time.

2. And these conditions *could* hold in nature.

- This was hypothetical because Darwin did not claim that there is evidence for (a).

3. Therefore, a complex eye can be formed by natural selection over long time.

Darwinian Worldview and Design

- Darwin's point was that there is a possible mechanistic explanation of design in nature.
  - For this purpose, he didn't have to show that the conditions of the evolution of a complex eye actually held in nature.
- Regarding the eye evolution, contemporary biologists have articulated Darwin's condition (a) in greater detail and found evidence that it held in nature. See, e.g.,:
- https://en.wikipedia.org/wiki/Evolution_of_the_eye
- https://woub.pbslearningmedia.org/resource/tdc02.sci.life.evo.nilssoneye/evolution-of-the-eye/
  - This PBS video is excellent and done by a leading researcher of the eye evolution.

Darwinian Worldview and Design

- “The old argument of design in nature, as given by Paley, which formerly seemed to me so conclusive, fails, now that the law of natural selection has been discovered. We can no longer argue that, for instance, the beautiful hinge of a bivalve shell must have been made by an intelligent being, like the hinge of a door by man. There seems to be no more design in the variability of organic beings and in the action of natural selection, than in the course which the wind blows. Everything in nature is the result of fixed laws.” (Darwin, *The Autobiography of Charles Darwin*)

Darwinian Worldview and Design

- As we saw, the Darwinian worldview became an alternative to the Christianized Aristotelian worldview that was still accepted among geologists and biologists in the early 19th century.
- Darwin's mechanistic explanation of design was another piece of the Darwinian worldview that was an alternative to the teleological and theological explanation of design.
- Darwin's contemporaries recognized the potential of Darwin's views to undermine the Christianized Aristotelian worldview.
- For example, Darwin's older contemporaries were strongly against Darwin's mechanistic explanation of design. (see next)

Darwinian Worldview and Design

- Adam Sedgwick (British geologist and priest, Darwin's teacher) wrote in a letter to his correspondent:
- Darwin's *Origin of Species* is "utterly false" because "it repudiates all reasoning from final causes [purposes]; and seems to shut the door on any view (however feeble) of the God of Nature as manifested in His works."
- What Sedgwick saw was that the traditional creator God of Christianity does not fit with Darwin's ideas.

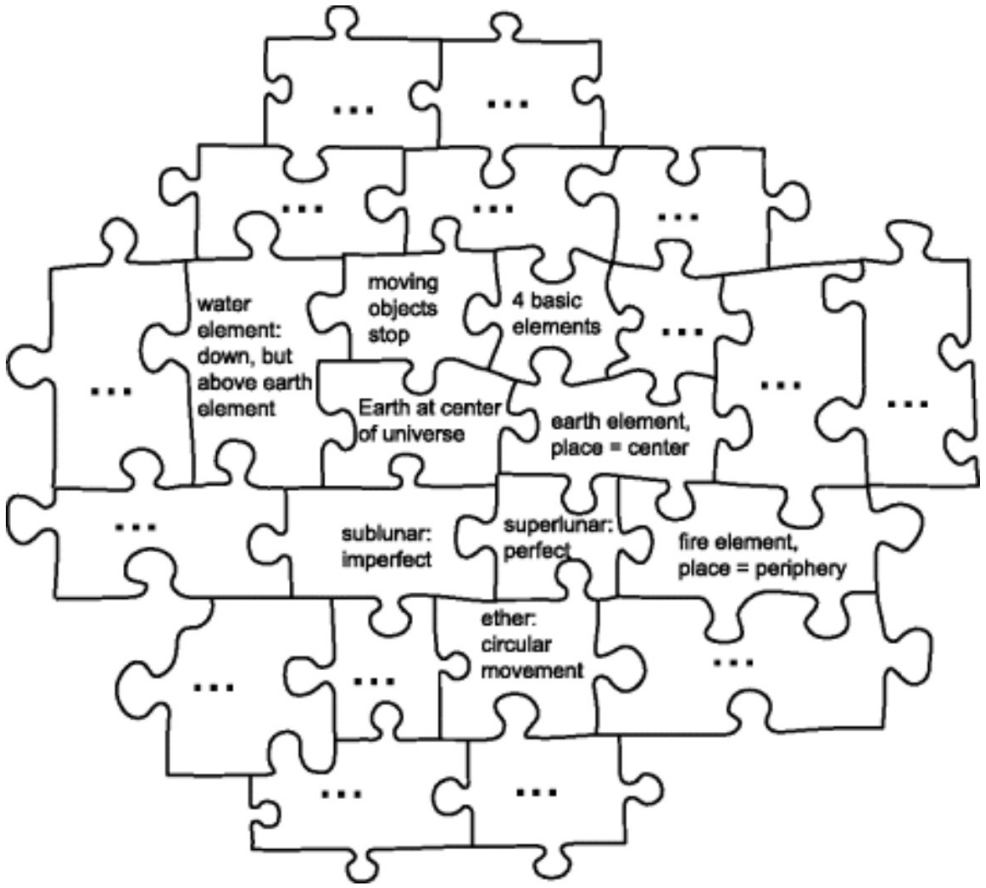
Darwinian Worldview and Design

- In DeWitt's chapter, he summarized views of recent scholars on the implication of the Darwinian worldview on religion.
- One view he summarized says:
- "In a scientifically informed and intellectually honest worldview there is no longer any room left for a belief in a God ***with the key characteristics typically associated with the western view of God***, nor any room for belief in a universe with any large-scale grand purpose."
- This view says that Sedgwick is right to see the conflict between the Darwinian worldview and the traditional notion of Christian God and that Sedgwick is wrong to reject the Darwinian worldview *for this reason*.

Darwinian Worldview and Design

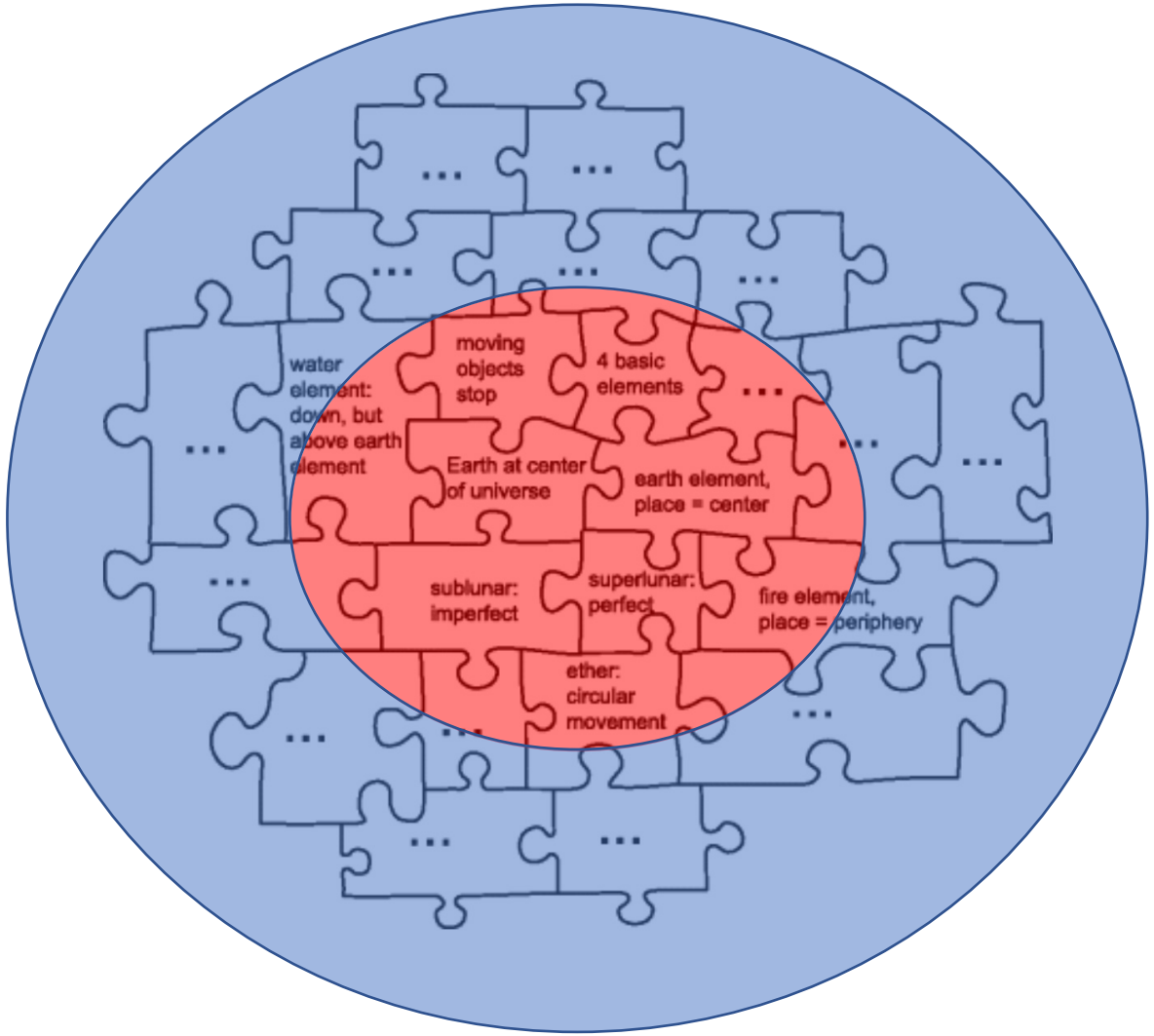
- But of course it's possible to modify the notion of God to accommodate the Darwinian worldview.
  - Just like the Newtonian worldview led to the notion of the watchmaker God.
- So DeWitt also presents the theologian John Haught's views.
- Haught agrees with the view quoted on the previous slide.
- And he argues that theologians should develop a different notion of God that is compatible with the Darwinian worldview.
  - DeWitt gives a brief summary of Haught's view.

Concluding Thoughts



A worldview = an interconnected system of beliefs

Concluding Thoughts



Core and peripheral beliefs

Concluding Thoughts

- The concept of a worldview, and the jigsaw puzzle metaphor, proved to be useful to understand the complex stories of scientific development.
- Focusing on astronomy, we first studied the development of the Aristotelian worldview, its transmission and elaboration by the Islamic scientists, and its Christianization in Europe starting the 12th century.

Peter Apian's representation of the universe from his *Cosmographia* (1524) (https://en.wikipedia.org/wiki/Petrus_Apianus)

Note the Christianization of the Aristotelian universe: the outermost part is the empire of God.

Concluding Thoughts

- In our discussions of the Newtonian worldview and the Darwinian worldview, one trend was to observe the impact of science on religion.
- This is partly because historically, the dominant worldview in Europe combined Aristotelianism and Christianity.
- So transitions from the Christianized Aristotelian worldview had impacts on religion (especially theology).

Concluding Thoughts

- Another trend in our discussions is a transition from a teleological worldview to a mechanistic one.
- Aristotelian (teleological) → Newtonian (mechanistic)
- Aristotelian (teleological) → Darwinian (mechanistic)
- DeWitt says that this transition can be seen as a change in our ***metaphorical*** conception of the sort of universe we live in:
- **Universe as organism → Universe as machine**
  - Organism has internal tendencies and has many parts performing specific functions related to the whole.
  - Machine is acted on by external forces and does not have any ultimate purpose of its own.

Concluding Thoughts

Universe as organism → Universe as machine → ?

Thank you!