Philosophy 1103: Introduction to Philosophy of Science

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(Partial) Answers to the Practice Final

Section A: *Answer **two** of the following short questions.*

[Each question is worth 20 marks, and should require about 200 words for a good answer.]

1. Jake, a first-year philosophy student, is explaining to a friend the difference between empiricists and rationalists in science. Jake says:

> Empiricist scientists don't theorise at all, they just stick to the data. Like ants, they just collect observations and use them. Rationalist scientists on the other hand aren't interested in the data at all, but just theorise based on their own intuitions and philosophical assumptions. Francis Bacon put it very nicely, describing them as "spiders spinning webs out of their own substance".

(i) Are Jake's definitions of 'empiricism' and 'rationalism' in science accurate? For example, can you think of examples of scientists who fit these definitions? Explain your answer, correcting the definitions if necessary. [8]

His definitions are exaggerated and extreme. Empiricist scientists *do* theorise; they just try to judge which theory is true using the data, without paying attention to any intuitions or prejudices about how nature should be. And rationalists do pay attention to data as well as their intuitions.

(ii) Give one or more examples of rationalistic arguments in science (e.g. in 17th century astronomy) used in support of theories that turned out to be incorrect. [6]

The classic one is probably Kepler's theory from *the Mysterium Cosmographicum*, where he explains the radii of the 6 known planetary orbits using a model with the 5 Platonic solids stacked inside each other, separated by spheres.

(iii) Give one or more examples of rationalistic arguments in science (e.g. in 17th century astronomy) used in support of theories that were (at least approximately) correct. [6]

(E.g.) Kepler again, his theory of elliptical orbits of the planets, with the sun at one focus, was based on a desire for mathematical simplicity, and avoidance of *ad hoc* features like equants, eccentrics, etc.

2. (i) Explain the difference between induction and falsification, as accounts of the logic of science. Your answer should specify the logical structure of each type of argument, using 'H' for the hypothesis and 'E' the data/observation statement. [6]

Look it up

(ii) Briefly state Popper's reasons for rejecting induction in science. [6]

Look it up. (Briefly, he was an empiricist, and followed Hume's reasoning.)

(iii) Briefly summarise the "Duhem problem" that Popper's falsificationist view faces, illustrating it using an example from the history of science. [8]

Look it up. One good example (among many) is Copernicus's response to the stellar parallax problem.

3.

(i) Summarise the ancient argument for a stationary earth, based on the absence of an annual stellar parallax. [6]

(ii) Briefly state Copernicus's response to the stellar parallax problem, including (for a good answer) his argument that this response was not merely *ad hoc*. [7]

(iii) The parallax argument for a stationary earth was strengthened by the observation that a star appears as a small disc (roughly 2 arc minutes in diameter as seen with the naked eye, or 5 arc-seconds when viewed through a telescope). Explain why this observation made Copernicus's response to the parallax problem more difficult to uphold, and briefly state the Copernican response to this additional problem. [7]

This is all in the lecture notes. Part (iii) refers to how the Copernican abyss led to the problem of star sizes.

4. "The evidence shows that people who habitually stay up late have higher IQs than those who typically go to bed early. So much for the saying, *Early to bed and early to rise, makes a man healthy, wealthy and wise*. The 'wise' part is the opposite of the truth!"

(i) Describe the *data* in the statement above, using the terms "correlation", and either "positive" or "negative". (N.B. there is more than one correct way to do this.) [3]

Staying up late is positively correlated with having high IQ. (Or going to bed early is negatively correlated with high IQ, etc.)

(ii) Write down any *theoretical* (causal) claim in the statement above. [3]

In writing "The 'wise' part is the opposite of the truth!", the author seems to suggest that going to bed early causes people to become stupid.

(iii) Write down two alternative causal theories that might be proposed to explain the same data given above. [6]

Perhaps being intelligent might cause people to stay up late.

Or some third factor X might cause high IQ and staying up late

(iv) For each of these three possible causal relations (the one in the statement, plus your two alternatives) propose a specific mechanism for how it might operate, and assess how plausible that mechanism is. [8]

It seems unlikely that early bedtimes could reduce IQ. Sleep is apparently good for the brain. But perhaps long sleepers miss out on intellectual stimulation?

High IQ could cause staying up late, as being intelligent might cause people to have jobs (lawyer, doctor, professor, etc.) that force them to work long hours.

IQ is raised by good nutrition. Perhaps Western countries, where the nutrition is good, also have artificial lighting, which causes late nights?

5. The diagram below shows the 'family tree' of the tetrapods (four-legged animals). As shown on the diagram, the Reptiles (*Reptilia*) are an animal class that includes Tuatara, Lizards, Snakes, Turtles, and Crocodilians.

(i) Reptiles all occur naturally, i.e. they aren't made by humans. Does this show that the class *Reptilia* is a natural kind? Briefly explain your answer, including a definition of 'natural kind'. [8]

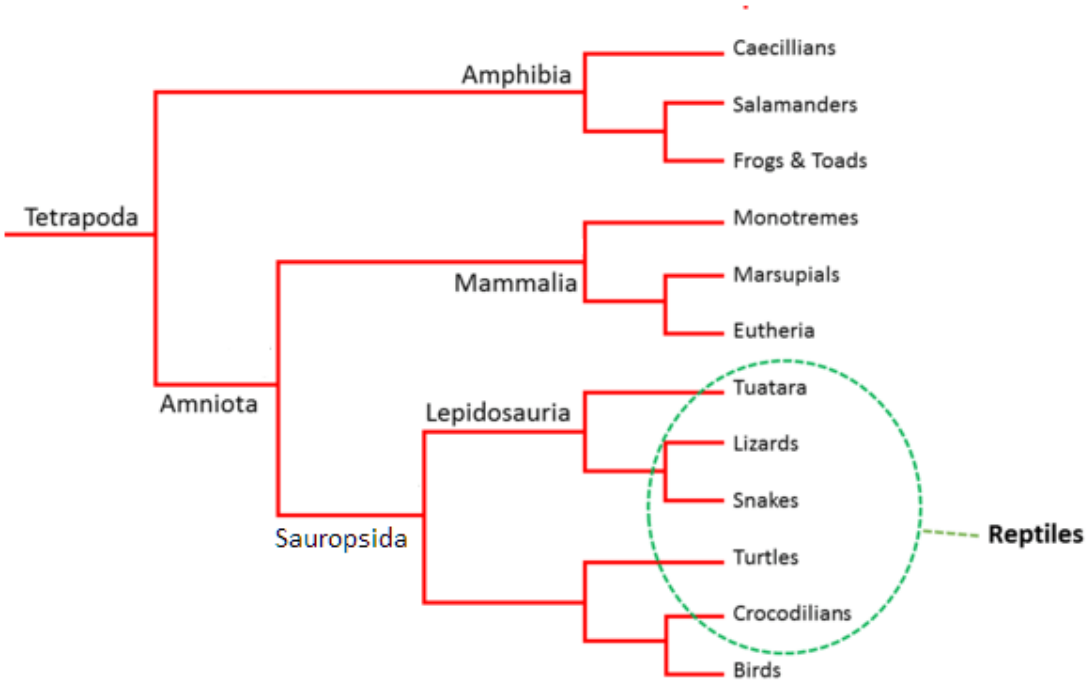
No. The members of a natural kind must be relatively similar to one another, not just naturally occurring. E.g. let's define a 'frant' as anything that is either a frog or an ant. Frants are then all naturally occurring, but frant isn't a natural kind, because frogs and ants aren't very similar to one another.

(ii) The class *Reptilia* includes a variety of different orders, such as snakes, turtles, etc. that are rather different from each other. Does this fact show that reptiles aren't a natural kind? Briefly explain your answer. [4]

No. Some natural kinds are quite diverse. The important thing is that differences between two things within the natural kind are much smaller than differences between something inside and something outside. E.g. mammals are also diverse, as bats are different from whales in many ways, but those differences are generally smaller than the differences between a mammal and a non-mammal.

(iii) Is there any information in the diagram below that suggests that reptiles are not a natural kind? Explain your answer. [8]

Yes, the exclusion of birds (and other kinds of dinosaur) from the 'reptile' group suggests that reptile isn't a natural kind, but rather a superficial category. Crocodiles (reptiles), for example, are more closely related to chickens (non-reptiles) than to lizards (reptiles). This breaks the rule mentioned in part (ii) above. Crocodiles and lizards are grouped together just because they *look* similar (4 legs, cold blooded, etc.)


Caecillians
Amphibia
Salamanders
Frogs & Toads
Tetrapoda
Monotremes
Mammalia
Marsupials
Eutheria
Tuatara
Amniota
Lepidosauria
Lizards
Snakes
Reptiles
Sauropsida
Turtles
Crocodilians
Birds

Section B *Answer **two** of the following longer questions.*

[Each question is worth 30 marks, and should require about 400 words for a good answer]

6. Read the following passage and answer the questions below.

Prior to around 1650, most scientists believed in a universal flood that covered the whole earth (described in the Bible) for perhaps a year, a few thousand years ago. The earth was believed to be less than 10,000 years old. The flood was responsible for most geological formations, including the layers of sedimentary rock seen all around the world. ('Sedimentary' rock is formed from tiny grains, compressed together in layers. It forms at the bottom of lakes and oceans as sediment settles to the bottom.) The flood theory was supported by some evidence, such as the discovery of fish fossils at the tops of mountains, indicating that those areas were once under water. Also, many tribes from various continents (the Arabs, Chinese, Mexicans, Peruvians, and Brahmins) had a legend of a massive flood long ago.

During the 18th century, however, new evidence caused most scientists to think that Noah's flood was less significant in geology. Here are some of the relevant findings and the problems they caused.

James Hutton (1726-1797) discovered features called 'angular unconformities', where relatively horizontal strata lie on top of the evidently eroded edges of steeply tilted layers. Hutton argued that such phenomena were evidence for important revolutions in earth history. The older layers had been hardened, tilted on edge, uplifted above the ocean surface, eroded, then submerged again beneath the sea and buried under newly deposited marine sediments. In other words, the rock sediments were not all laid down at the same time, during a single flood.

Lehmann, Fuchsel, and Pallas discovered that rock strata occurred in orderly sequences, commonly thousands of feet thick, and that in many instances individual layers could be traced horizontally for tens or hundreds of miles. The thickness, extent, and orderliness of the stacks of layers were increasingly difficult to account for in terms of a single, brief, chaotic, turbulent flood. Charles Lyell, in his *Principles of Geology* (1830) argued that the fragile ash cones of the Auvergne volcanoes in central France were very old, and could not have survived a massive flood, so no geologically recent flood like Noah's could have covered the whole earth.

Hutton's theory of the earth's history was called "Plutonism", after the Greek god of the underworld, since it stressed the importance to geology of enormous heat, and lakes of molten rock, deep under the ground. Hutton saw that the continents were slowly being ground into dust, which was carried by rivers to the oceans and deposited there. The layers of ocean sediment would, over millions of years, get very thick, and slowly harden into rock. If this process were continued indefinitely, the continents would eventually disappear altogether, and all would be ocean. But according to Hutton, powerful forces (due somehow to the fiery underworld) sometimes force the ocean bed upward, forming new continents. And then the whole process repeats itself. In fact, the existing continents were originally formed from the ground-up remains of earlier continents, deposited on ocean beds, and then uplifted. No one took Hutton's ideas too seriously, until they were later refined and popularised by Lyell.

(i) Summarise the relevant data (geological or otherwise) mentioned in the passage above, in point form. [8]

- Fish fossils on mountain tops
- Many flood legends
- Angular unconformities
- Deep, extensive, orderly rock layers
- Fragile ash cones in central France

(ii) Briefly describe the two hypotheses, mentioned in the text, that were used to explain these data. [6]

Flood geology vs. Hutton and Lyell's Plutonism (summarise them)

(iii) How plausible was each theory? (Point out any aspects that seem inherently plausible/implausible to you, or which would have seemed plausible/implausible in the 18th and 19th centuries.) [6]

Noah's flood seems rather implausible, as it would take a lot of rain to cover the whole earth. On the other hand, the idea of the world being as old as Hutton said might have seemed crazy too.

(iv) How well did each theory predict the data, overall? Explain your answers. [10]

Overall Plutonism seems to do better, as it explains everything except the flood legends. Flood geology only explains the first 2. (Plutonism might even explain the flood legends, since floods happen in many places, and stories can get exaggerated.)

7. Jerry Coyne has argued that some supernatural theories, such as ESP and telekinesis, are empirically testable in principle. However, in saying this he seems to be referring only to the *kinematic* component of such theories. If ESP were ever empirically confirmed, for example, his response would be, "some people can read the thoughts of others at a distance, though I don't know how that is done."

(i) Explain the difference between a kinematic theory and a mechanical theory in science, giving one or two examples from astronomy or elsewhere. [10]

[See lecture notes]

(ii) Are there any examples from the history of science where a kinematic theory could be tested empirically, even in the absence of an underlying mechanical theory? If so, then give two such examples. [10]

Yes. E.g. Kepler's ellipse theory was just kinematic, but it led to good predictions of planetary movements.

(iii) Discuss and evaluate Coyne's view that theories such as ESP could, in principle, be proposed *by scientists* to explain observed phenomena. For example, would a mechanism for understanding ESP eventually be needed? [10]

Science cannot give a mechanism for everything, as explanations must end somewhere. (E.g. we cannot explain what negative charge is, or why it attracts positive charge.) I think that if ESP were empirically verified, scientists would continue to *try* to find a natural mechanism for it, but acceptance of ESP as real wouldn't require finding a mechanism.

8. (i) Explain the difference between the theory of evolution, or 'transmutation', and the theory of natural selection. As part of your answer, you might mention scientists who believed in evolution but rejected the theory of natural selection. [10]

(ii) Summarise some of the theoretical arguments and empirical data that led Darwin to his theory of natural selection. (N.B. you should say something about Paley and the design argument here.) [20]

[This is similar to the last question of problem set 4.]

9. Read the passage below and discuss whether it is a fair and accurate description of Galileo's life and work, and of opposition to heliocentrism in the first half of the 17th century. [30 marks]

In the 17th century Galileo laid the very foundations of science itself in his battle against the dark forces of superstition and tradition. Using the scientific method of observation and reasoning he demonstrated that the earth orbited the sun, but this made little impression on his geocentrist opponents (who followed religious authority and tradition rather than science). The Cardinals were utterly opposed to scientific research, and stuck doggedly to the established cosmology of Aristotle and Ptolemy. In the end of course they banned Galileo's book to avoid having to face the facts, and even threw poor Galileo into a dungeon for the rest of his life. Thanks in part to Galileo's courage, however, scientists today have total freedom to research and publish whatever the evidence shows them.

Lots of nonsense here. All discussed in the textbook, and the lecture notes.

10. The 'germ theory of disease' is the view that most diseases are caused by tiny living organisms that invade the patient's body and multiply, and then attack the body from within. The 'nutrient theory' of disease, by contrast, regards disease to result from a lack of essential nutrients – later called 'vital amines' – in one's diet.

(i) Philosophers of science often refer to these 'theories' of disease as scientific *paradigms*, rather than theories as such. Explain the difference between a theory and a paradigm, and say why the germ and nutrient theories of disease are more paradigm-like. [6]

A paradigm is a kind of general framework, or set of assumptions, that specific theories can be based on. For example, there were many late Medieval world maps, but they were all based on the assumption of a spherical earth. The specific maps are theories, the spherical earth idea is a paradigm.

In the late 19th century Christiaan Eijkman, a proponent of the germ theory, discovered that chickens got the nerve disease beriberi when fed a diet of old rice left over from soldiers' meals. When fed fresh rice, the chickens recovered.

(ii) How might Eijkman explain this observation, in the light of the germ theory? [6]

Eijkman could say that the leftover rice was contaminated with germs (from the soldiers maybe) which caused the disease.

Eijkman's assistant Gerrit Grijns later continued this research, but was a proponent of the nutrient theory of disease. Grijns noted that the soldiers' rice was expensive 'polished' rice. (Polishing makes rice white, by removing the bran coating.) The rice that cured the chickens was unpolished.

(iii) How might Grijns explain this observation, guided by the nutrient theory? [6]

The bran coating on the rice might contain vitamins that the chickens need. A deficiency in some vitamin might cause beriberi.

Grijns then did his own experiment, in which leftover polished rice from the soldiers' mess hall was fed to chickens along with the 'polishings' (bran coating) of other rice. The chickens remained healthy.

(iv) Explain why Grijns' experiment did not *refute* Eijkman's theory about the cause of beriberi, by showing that Eijkman can explain the observation within his paradigm. Suggest some approaches to resolving this dispute between Eijkman and Grijns, such as further experiments that could be carried out. [12]

At first sight, this does refute Eijkman's theory, as the chickens are (supposedly) getting the germs from leftover rice, and so should get sick according to Eijkman. (But we know from Duhem that it is always possible to wriggle out of such falsifying data.)

Here, perhaps the bran coating is killing or supressing the germs that were causing the disease?

Another experiment that might help resolve the issue would be to feed the chickens just the leftover polished rice, but thoroughly cooked to kill any germs in it. If the chickens still got sick, then this would support Grijns. (But maybe the germs are heat resistant?)