**Student Name:**

**History of TSM**

**Further reading:**

<https://en.wikipedia.org/wiki/History_of_scientific_method>

<http://plato.stanford.edu/entries/scientific-method/>

The summary here serves to illustrate the main points for discussion and main points of this exercise.)

**Discussion points.**

-TSM taught to all students from the first science class.

-Important to realize that what we today think of as science, was part of philosophy; Science separated from philosophy and became its own field in the early part of the 20th century.

-History of TSM is long, including Greek, Arab and Persian philosophers. Started with a belief that observation is a good way to understand our world.

-One important figure is Francis Bacon (1561-1626). He emphasized the use of experimentation in natural philosophy.

-early 1900s- Science begins to separate from philosophy, mostly due to discoveries/ start of modern physics. Marie Curie, Rutherford, etc. Discovery of X-rays electrons. <https://en.wikipedia.org/wiki/History_of_physics> … With these discoveries, came wide acclaim and gaining dominance of scientific way of explaining the world in which we live.

-early 1900s also saw codification and formalization of our modern Scientific Method by a group of philosophers called the Vienna Circle. The Vienna Circle was interested in establishing a set of methods that will lend validity to social science and philosophy fields, including psychology, sociology etc; similar to that enjoyed by the new scientific fields. In order to do so, they adopted the strategy of trying to figure out the steps that characterized the practice of Science; and to then apply them to the social sciences and other fields.

**The Scientific Method.**

The Scientific Method is a set of steps that is meant to increase objective, factual knowledge of the world around us.

I am sure you have all heard of the Scientific Method. It might have been the first thing you learned in a science class. To many non-scientists AND scientists, the scientific method is what distinguishes science from non-science

Tomorrow, in class, we will have a discussion on the scientific method, identifying some philosophical and practical problems with these steps, and how the method can be abused in order to promote pseudoscience.

1. For tonight, please review wikipedia’s entry to scientific method.

What are the steps of the scientific method?

(Look in Faculty\_TSMVanHalenFlowChart) and go over the steps.

-Ask students “What were some of the characteristics of science that The Vienna School admired? What were they trying to replicate in TSM? What makes science different from other fields of human knowledge?”

Concepts of objectivity and universality. These are closely related terms.

-OBJECTIVITY: That Scientific facts are independent of observer opinions and preconceptions, biases and emotions. How does TSM codify objectivity? Because the experiment performed and data gathered can be shared and seen by all, and the conclusion based on those results are independent, that all reasonable people can see these results and conclude the same things about the hypothesis.

-UNIVERSALITY: That experimental results/scientific data produced in one place and time, can be then repeated at another time or place, and will yield the exact same results as long as the important variables are kept the same.

2. Image-search scientific method. On that first page, note the different ways the scientific-method is illustrated.

What is common, and what is different among these illustrations?

Make notes in your illustration of the steps of the scientific method above.

Many of these images will show different steps with feedback arrows at different points. This illustrates the idea that the scientific method is in many ways a living document, that it is used by different groups and scientists for their own purposes; to suit what they perceive science should be.

How do you think these differences change the nature of science?

Write a few sentences on your conjectures.

That there might not be one Nature of SCIENCE… that the different images reflect a difference in the fundamental understanding of what it means to DO SCIENCE. . What then does this mean about WHAT IS SCIENCE?

**Philosophical Criticisms and weaknesses of TSM.**

**Falsifiability.**

<http://platonicrealms.com/encyclopedia/Hempels-Ravens-Paradox>

One of the key early criticisms of TSM is that it *is impossible* with this method to ever prove that your scientific hypothesis is right. (Charles Hempel, 1965). Hempel showed this famously using The Raven Paradox.

Say you are interested in the color of ravens. You have observed a few ravens, they all seem to be black… so you follow TSM, and make the hypothesis that All Ravens are Black. How would you test this hypothesis?

Observe all ravens? No, that is practically impossible. Instead, let us observe a subset of ravens. All of them are black. Does this mean that your hypothesis is correct? Not necessarily, because there still might be a white raven out there (Albino-ism); or a raven that has not yet been born, or that has already died that was not black. Therefore, you can never prove that a hypothesis is correct. However, with a single observation of a white raven, your hypothesis is now wrong.

Which is why we have null hypothesis. (Expalin what is a null hypothesis) In some ways, a null hypothesis allows us to overcome this shortcoming of TSM. Experiments are designed to prove that the null hypothesis is wrong, but it does not actually prove that the alternative hypothesis is correct.

(Optional: There is also a logical contrapositive argument here too… All ravens are black, is equivalent to the hypothesis all non-black things are not ravens. Therefore, evidence of non-black things, which are then shown to be not ravens, should support the hypothesis. i.e. look, it’s a white bird, it’s a swan, not a raven, therefore, it supports our hypothesis that all ravens are black. But we don’t believe in the validity of contrapositive evidence in science).

**Science vs Non-Science.** [**http://www.skepticalraptor.com/skepticalraptorblog.php/pseudoscience-fool/**](http://www.skepticalraptor.com/skepticalraptorblog.php/pseudoscience-fool/)

Remember that one of the main goals of TSM is to be able to distinguish between Science and Non-Scientific fields of human knowledge. Does it actually succeed in doing that?

One of the key criticisms of non-science fields is that nothing is ever proven definitively, that because it does not rely on evidence and experimentation, there is therefore no testing of ideas against evidence. For example, literary theory, where our understanding of a piece of literature is not informed by any facts. (Note, this is not to belittle literary theory as a field of human knowledge, it is simply not science).

Yet, as we already criticized above, it is impossible in science to proven something is correct using TSM. Furthermore, if a hypothesis is wrong, one important step in TSM is the ability to change and modify the hypothesis in response to results… therefore, it is not a never-ending process; a hypothesis under TSM can be constantly modified and changed, and never definitively proven wrong… or right.

Note that even when a hypothesis is repeatedly tested and shown to be correct, it only becomes a theory…

In truth, TSM has been shown by different philosophers to be unable to distinguish between scientific fields and non-scientific fields in a clear manner. … funnily enough, no other theory has actually succeeded either.

**Pseudoscience.**

One major failure of TSM is the inability to distinguish between science and pseudoscience. One definition of pseudoscience is to go backwards on TSM. In TSM, one forms a hypothesis, then does experiments and collects data, and then reaches a conclusion. In pseudoscience, we start with the conclusion, then look at data from different experiments, cherry-picking the ones that support our conclusions, then forms hypothesis that chooses those experiments.

The problem is that it is impossible to distinguish between someone who is going backwards in TSM, from someone who is starting from hypothesis. TSM is structured around an individual experiment, and does not take into account all evidence available.

Common examples include creationists who argue that the complexity of ATPase is evidence of creationsim, or climate-change deniers who only focus on particular years of climate measurement. The problem with TSM is that the individual experiment carries too much weight compared to the predominance of evidence.

**USE.**

However, TSM is still powerful. Though it is a flawed philosophy, it remains an underlying structure in much of science. Scientists continue to use it in their day to day practice, forming a model of the work that they do. We can see this in things like the structure of a primary paper (Faculty\_TSMflowchart).