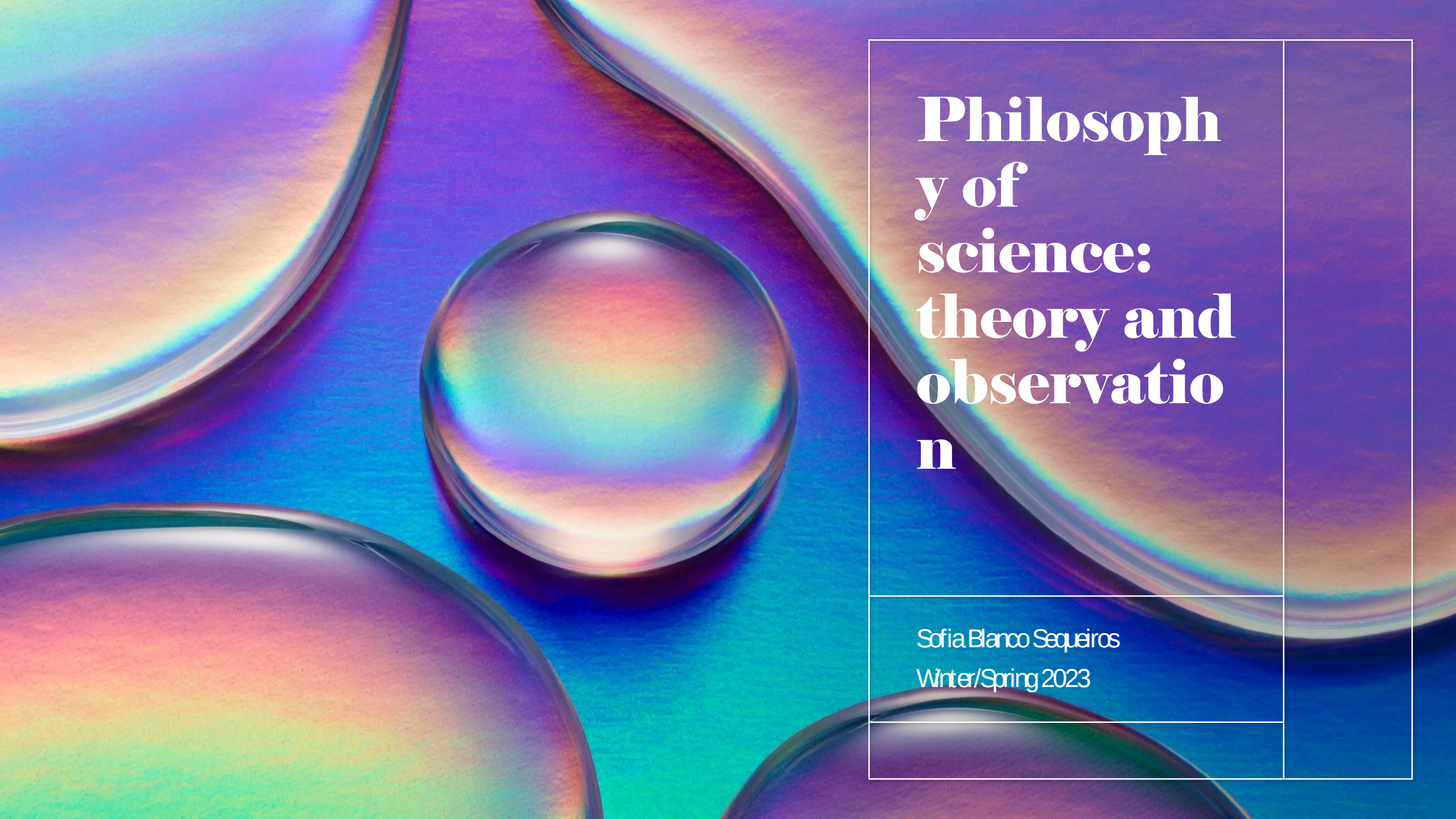

Philosophy of science: theory and observation

Sofia Blanco Sequeiros

Winter/Spring 2023

Building blocks of science

- Theory and observation: two central building blocks of science
  - Also: experiments, models
- Long history in philosophy of science of thinking about theories, observations and their relationship
- Understanding what theory and observation mean and do in science is central to understanding how science produces knowledge, how that knowledge can be evaluated, and why and how science proceeds

Theory

- What does it mean for something to be a theory?
- What distinguishes scientific theories from other theories, e.g. conspiracy theories, or someone's subjective "theory"? What do these have in common?
- What do scientific theories and theories of art have in common?
  - Quantum field theory, general relativity, evolutionary theory…

A note on the context

- This presentation draws mostly from “analytic” philosophy of science
- Philosophy of science developed from the 1920’s, with a focus on the logical structure of science
  - The role of logic, “metamathematics” i.e. the formal apparatus such as set theory needed to build and make sense of mathematics, mathematics
- The context explains why the focal point is often on formal modelling, measurement, and theories as they were first developed in the natural sciences
- Other important perspectives to philosophy of science: critical theory, poststructuralism, postmodernism
  - Often notably critical of science as a human enterprise; science as indoctrination, illegitimate social authority

Why think about science in this (narrow and boring?) context?

- Science (broadly understood) massively influences the society and our daily lives
- Any critique of science and its authority will be much stronger if the content of the enterprise/field of science is understood
  - An outsider's perspective is extremely useful for formulating criticisms
  - For the critiques to truly "hit their target" it is crucial to understand how and why modern science works the way it does – this includes sciences like physics, biology, economics and sociology
- It's actually very interesting!!! The history of 20th century philosophy of science is a story about war, desperate love, depression, and miracles!!

FOLLOW THE ANTS IN A SPIRIT OF WONDER!

The concept of theory in philosophy of science

- What is the structure of scientific theories?
- Theory as consisting of language, but according to some views, abstracting away from natural language – a set of *something* that describes *something*

"The *syntactic* view that a theory is an axiomatized collection of sentences has been challenged by the *semantic* view that a theory is a collection of nonlinguistic models, and both are challenged by the [pragmatic] view that a theory is an amorphous entity consisting perhaps of sentences and models, but just as importantly of exemplars, problems, standards, skills, practices and tendencies." (Savage 1990, vii–viii)

“Theory” in philosophy of science

- In short, philosophers have disagreed over what it means for a scientific theory to be a theory
- These discussions are significant, because what a theories about the structure of scientific theories are both descriptive and prescriptive: this is what science *is*, and what it *should* be
- Scientific theories also contain descriptive and normative content – an ideal theory may be only descriptive regarding the phenomenon it describes (e.g. the theory of gravity, evolutionary theory, broken windows theory of crime), but it always contains some prescriptive content
    - “This phenomena should be investigated in this way”, “Crime is doing wrong against an individual or society”
- Thus, a concept of “theory” is essential for understanding 1) How scientific theories develop and how scientific progress is made, 2) How theories can be evaluated and criticized and 3) What kind of “knowledge” and “understanding” scientific knowledge and understanding are

The concept of theory in philosophy of science

- What are theories (scientific, artistic) used for? What do you use theories for in your own research? What kinds of research practices rely on theory?

The uses of scientific theory

- A theory formulates the principles of (the behavior or functioning) of a given phenomenon: gravity, evolution, psychiatric development, crime
- Theories may have ”epistemic virtues”: scope, simplicity, explanatory power; unification, novel prediction, precision
  - A theory enables **explanation** and **prediction**
- Heather Douglas: internal consistency, empirical adequacy
- Not all theories are equal; there are good and bad theories, and ideally, science makes progress when scientists distinguish good theories from bad ones
  - Scientific realism: scientific theories are true; they describe reality, things like “atoms” and “inflation” exist
  - Scientific antirealism: Scientific theories are not true; they are useful instruments used to categorize observations
  - Scientific arealism: We cannot know whether scientific theories are true or not; knowledge about this is not possible
- BUT WHAT IS “TRUTH”?

The concept of observation in philosophy of science

- What is ”an observation”? What does it mean to “observe”?
- What does it mean for something to be unobservable?
- What is the difference between someone to observe something with their bare eyes vs. through a microscope? Is there a difference?
- What does the concept of “observation” presuppose or entail? Are these presuppositions warranted?

A Brief History of Observation in Philosophy of Science

- “Reasoning from observations has been important to scientific practice at least since the time of Aristotle, who mentions a number of sources of observational evidence including animal dissection (Aristotle(a), 763a/30–b/15; Aristotle(b), 511b/20–25). Francis Bacon argued long ago that the best way to discover things about nature is to use experiences (his term for observations as well as experimental results) to develop and improve scientific theories (Bacon 1620, 49ff). The role of observational evidence in scientific discovery was an important topic for Whewell (1858) and Mill (1872) among others in the 19th century. But philosophers didn’t talk about observation as extensively, in as much detail, or in the way we have become accustomed to, until the 20th century when logical empiricists transformed philosophical thinking about it.”

Empiricist models of science

- Sensory observation (empirical observation) is the main source of (scientific) knowledge – history of science, massive breakthroughs in scientific observation in 1500-1600
  - E.g. Francis Bacon
  - David Hume
- In contrast to **rationalism**, where *reason* is the ultimate source of knowledge
  - David Hume and Immanuel Kant: “Woke me up from my dogmatic slumber”
- According to inductivist views of science, science proceeds by 1) Gathering observations, 2) Generalizing those observations into theories and 3) Testing those theories with new observations
  - A highly idealized view of science that misrepresents many aspects of it!

Hume

- “If we take in our hand any volume of divinity or school metaphysics, for instance, let us ask, Does it contain any abstract reasoning concerning quantity or number? No. Does it contain any experimental reasoning concerning matter of fact and existence? No. Commit it then to the flames: for it can contain nothing but sophistry and illusion.”

Theories, observations and inductive reasoning

- Scientific knowledge is produced by systematically gathering observations and making generalizations
  - “2/3 of the employees of the organizations are happy.”
  - ”Two nations with a McDonalds have never gone to war, so this will also be the case in the future”
- The goal is to produce theories that explain the observations: the goal of theory formulation is to unify and generalize the observations into theories. If new observations do not fit the theory, the theory has to be changed.
- Problems: observations have to be constrained (there is a potentially infinite number of observations to be made, underdetermination of theory by observation/data)

Theory-ladenness of observation

- Pure, unmediated observation does not exist
  - If it does, it is often not useful in science – how do we gain “pure observation” of atoms or planets?
- Observations include conceptual content both in the natural and social sciences
  - We observe things as something – atoms, computers, criminals – and this is colored by our conceptual background, beliefs and experiences and abilities

Examples

- A computer scientist will observe the insides of a computer very differently than a philosopher
  - The observations that both make will be colored by their theoretical and conceptual background
  - An exaggerated example: a computer scientist might observe the different computer parts, their functions and conditions of operation; computer parts make sense in a completely different way to a computer scientist than someone else

Theory-ladenness of observation

- Scientific observations contain theoretical elements, they are theory-laden: an observation of temperature is meaningful when we have a concept and a theory of measuring temperature
    - Previously, philosophers of science considered this an issue – but does theory-ladenness matter, if the theoretical presuppositions are correct?
    - Is theory-ladenness a threat to the objectivity of science?
- Theoretical assumptions affect how research questions and hypotheses are formulated
    - How, where and why observations/data are gathered from
    - How this data is interpreted
- Ian Hacking (b. 1936)

Alternatives to simple inductivism

- Popper's falsificationism – has its own problems
- The picture of scientific practice in philosophy of science now is much more nuanced
  - In general, observations have a part in confirming or disconfirming theories
  - Theories are needed to guide observations – theory tells us what observations are meaningful and why, how these observations can and should be interpreted, and what those observations act as evidence for

Observing art

- How is art observed?
- How does the theory-ladenness of observation manifest when art is the object of research?
- How do theory and observation play a part in creating intersubjective or shareable and evaluable knowledge about art?