Organizational Details

TAs (also markers) :

    Yuchen Ma   (yma@physics.utoronto.ca)
    Tae-Hyoun Park   (thpark@physics.utoronto.ca)
    Kenny Long Sang Yip (lskyip@physics.utoronto.ca)

Class Times : Tuesdays 17:00 – 19:00, MP 137

Look at "Course Homepage"

    hep.physics.utoronto.ca/~orr/wwwroot/JPH441

Proposed Marking Scheme

3 Essays Assigned – *you have three weeks to do each of them:*

15th January ⎞ I set the topic
5th February ⎠
5th March   -   You can chose from a list that I give you,
                  or you can make a proposal for a topic
                  and discuss with me.

Mid term 26th February – essay form

3 hour final written exam – essay form

JPH441   PHYSICAL SCIENCE IN CONTEMPORARY SOCIETY

WHAT IS SCIENCE ?

- HOW DOES IT CLAIM TO KNOW ABOUT THE WORLD ?

- WHAT IS THE SCIENTIFIC METHOD ?

- DOES SCIENCE REVEAL AN OBJECTIVE EXTERNAL REALITY ?

- ARE THERE AREAS OF REALITY THAT ARE NOT AMMENABLE TO THE SCIENTIFIC APPROACH ?

- HOW DOES SCIENCE INTERACT WITH SOCIETY ?

WILL STICK INITIALLY TO OUTLINE OF

WHAT SCIENCE KNOWS:~

NATURE OF EVIDENCE

"ENEMIES" OF SCIENCE

THE FURNITURE ← CONCEPTS CRUCIAL
TO SCIENCE

THE PHYSICAL SCIENCES

BIOLOGY & COGNITION

MATHEMATICS (& "ENEMIES" OF)

FORMAL SCIENCES

PROBABILITIES & RISKS

ARE THE SOCIAL SCIENCES SCIENCE ?

ACTUALLY EXISTING SCIENCE

COMPLEXITY AS AN OBSTACLE TO KNOWLEDGE

IS THAT ALL THERE IS ?

- SCIENCE AAS CERTAINLY CHANGED THE WAY HUMANS LIVE, AND THE WAY THEY VIEW THE WORLD AROUND THEM.

  → IT WILL CONTINUE TO DO SO

- I GUESS MOST OF US REGARD SCIENCE AS A "GOOD THING" → ELSE WE WOULD BE DOING SOMETHING ELSE.

  → DOES EVERY ONE?

"EMEMIES" OF SCIENCE   MAY   RESENT :

AIMS, METHODS & DISCOVERIES

↓ SCIENCE IS :
- SOCIALLY CONSTRUCTED
- DETERMINED BY VESTED INTEREST
- UNDETERMINED BY DATA
- "WESTERN"
- GODLESS
- PATRIARCHAL
- REDUCTIVE
- LINEAR
- DEPENDENT ON OBSERVER
- ALWAYS FALSIFIED IN THE LONGRUN

- LOGICALLY IMPOSSIBLE TO CONFIRM

IS THERE
ANY THING
IN ANY
OF THESE
?

SOMETIMES ONE HEARS THAT THE SCIENTIFIC
METHOD IS JUST FORMALIZED COMMON SENSE

THIS IS TRUE AT SOME LEVEL

BUT IT DOES NOT REALLY ADDRESS

— PHILOSOPHICAL CRITICISM THAT SCIENCE
IS SOCIALLY CONSTRUCTED AND DOES
NOT DEAL WITH OBJECTIVE REALITY.

— CAN WE REALLY MAKE SCIENTIFIC
STATEMENTS ABOUT THINGS THAT
WE MAY NOT BE ABLE TO OBSERVE

— SUPER STRINGS

— PARALLEL UNIVERSES.

SIMPLE STATEMENT OF SCIENTIFIC METHOD

- — THINK OF A THEORETICAL MODEL
- — DEDUCE SOME EXPERIMENTAL PREDICTION
- — TEST PREDICTION AGAINST REALITY
- — DECIDE WHETHER THEORY IS A "MODEL OF REALITY"

IN FACT MOST HUMAN KNOWLEDGE RESULTS FROM INDUCTION → THAT'S HOW YOU COME UP WITH THE THEORETICAL MODEL.

EVIDENCE

BEFORE TALKING ABOUT ∞ HILBERT SPACES
OR PARALLEL UNIVERSES
→ LOOK AT HOW WE KNOW
SIMPLE THINGS

FRANKLIN GIVES SEVERAL (AMUSING??)
EXAMPLES → THINK ABOUT WHETHER YOU
AGREE

POINT IS THAT WE USE LOW LEVEL
EMPIRICAL GENERALIZATIONS → GIVE
SHAPE TO OUR KNOWLEDGE OF THE WORLD

ALL RAVENS ARE BLACK → HOW DO WE KNOW?

WELL.... FRANKLIN IS A PHILOSOPHER — BUT LET'S
GO ALONG WITH THIS.

HUMAN OBSERVATION → FUNDAMENTAL FACTS
OF SCIENCE

↓

SUPPORT STRUCTURE
OF MORE THEORETICAL
SCIENCE

TO UNDERSTAND RATIONALITY
OF SCIENCE

}

GRASP HOW WE
KNOW STRAIGHTFORWARD
TRUTHS.

Some Possible Pitfalls

- Do we have classifications and concepts clear? Will we know definitely whether a new observation is   — a raven
   — is black

- Do we understand how we know by perception of a single instance

"All ravens are black"

These deal with scientific and logical underpinnings of common sense knowledge.

Come back to these → for now ↓

HOW DO WE MAKE LEAP OF INDUCTIVE INFERENCE

ALL OBSERVED RAVENS (A FINITE NUMBER) HAVE BEEN BLACK

↓

ALL RAVENS (UNOBSERVED, FUTURE) ARE BLACK

JUSTIFIED ?

DEGREE OF CONFIDENCE ?

⇒ PROBLEM OF INDUCTION

PROBLEM OF INDUCTION REGARDED (BY PHILOSOPHERS?) AS CLASSIC LOGICAL PROBLEM TO UNDERSTAND WHY SCIENCE IS RATIONAL

→ UNERSTAND WHY SEEING A BLACK RAVEN IS EVIDENCE FOR PROPOSITION THAT ALL RAVENS ARE BLACK

BAYESIAN APPROACH ← cf STATISTICAL TESTING OF HYPOTHESES.

OBJECTIVE BAYESIAN VIEW OF EVIDENCE

ALSO CALLED LOGICAL PROBABILISM

RELATION OF UNCERTAIN
EVIDENCE TO CONCLUSION } PURELY LOGICAL

SUPPORT OF BIG BANG BY EVIDENCE

SUPPORT OF RIEMANN HYPOTHESIS

↳ OBJECTIVE MATTERS

↳ SAME AS DEDUCTIBILITY OF PYTHAGORAS

FROM EUCLID'S AXIOMS

OBJECTIVE BAYESIANISM ≠ DEDUCTIVISM
(ALL LOGIC IS DEDUCTIVE)

OB → EXISTENCE OF NON-DEDUCTIVE LOGIC

— A LOGICAL PROBABILITY

— PARTIAL IMPLICATION

BETWEEN EVIDENCE AND HYPOTHESIS

SUPPORTS OR CONFIRMS
BUT DOES NOT DEDUCTIVELY IMPLY.

"PROBABILITY" MEANS DEGREE OF CONFIDENCE

ARGUMENTS FOR EXISTENCE OF NON-DEDUCTIVE LOGIC

- ARGUMENTS OVER WHETHER A GIVEN BODY OF EVIDENCE LEADS TO SOME GIVEN CONCLUSION

- INFERENCE SCHEME

PROPORTIONAL SYLLOGISM

STATISTICAL SYLLOGISM

DIRECT INFERENCE

LOOKS MUCH LIKE STANDARD ARGUMENT OF DEDUCTIVE LOGIC ⟶ SYLLOGISM.

(A)

ALL MEN ARE MORTAL

SOCRATES IS A MAN

SOCRATES IS MORTAL

IMPOSSIBLE FOR
PREMISE TO BE TRUE
& CONCLUSION FALSE

(B)

99.9% OF MEN ARE MORTAL

SOCRATES IS A MAN

SOCRATES IS MORTAL

STATISTICAL SYLLOGISM

POSSIBLE FOR
CONCLUSION TO BE
FALSE → NOT LIKELY

WHAT IS SO SPECIAL ABOUT 100% cf 99.9%
THAT (A) IS JUST LOGIC & (B) NOT ?

- ONE EXPRESSION OF BAYES' THEOREM

q is A CONSEQUENCE OF p

q is FOUND TO BE TRUE

p MORE LIKELY TO BE TRUE THAN BEFORE

→ FUNDAMENTAL INDUCTIVE PATTERN

- CONJECTURES IN PURE MATHEMATICS

USE NON DEDUCTIVE INFERENCE

MATHEMATICS TRUE IN ALL } RATIONALITY OF
POSSIBLE WORLDS   INFERENCE A
MATTER OF LOGIC

- INFERENCE OF THE BEST EXPLANATION
  ↳ WIDELY REGARDED AS NECESSARY TO INFER ATTRIBUTES OF PHYSICAL WORLD

→ LAST THREE BULLETS ARE SUBSTATIAL REASONS OF ACCEPTING LOGICAL PROBABILITY

OBJECTIVE BAYESIANISM } IT MAY NOT BE EASY TO RELATE EVIDENCE TO CONCLUSION

BUT THAT RELATION EXISTS.

WHY INDUCTION IS LOGICALLY JUSTIFIED

A UNIVERSAL GENERALIZATION

ALL RAVENS ARE BLACK

IS NOT LOGICALLY IMPLIED BY ANY NUMBER
OF FINITE OBSERVATIONS

→ AS IN OPINION POLLING IT IS ALWAYS
POSSIBLE THAT YOU HAVE AN UNREPRESENTIVE
SAMPLE

→ CAN WE RELY ON INDUCTIVE ARGUMENTS
WHICH HAVE TRUE PREMISES, TO HAVE
TRUE CONCLUSIONS MOST OF THE TIME?

INDUCTIVE INFERENCE $\rightarrow$ INFERENCE FROM SAMPLE TO POPULATION $\rightarrow$ PROPORTIONAL SYLLOGISM

- THE VAST MAJORITY OF LARGE SAMPLES RESEMBLE THE POPULATION
- THIS IS A LARGE SAMPLE
- THIS SAMPLE RESEMBLES THE POPULATION

- 99.9% OF WOMEN ARE MORTAL
- HYPATIA IS A WOMAN

- HYPATIA IS MORTAL

PREMISES GIVE GOOD, NOT CONCLUSIVE, REASON FOR BELIEVING CONCLUSION $\rightarrow$ AS A MATTER OF LOGIC

THE VAST MAJORITY OF LARGE SAMPLES
RESEMBLE THE POPULATION → MATHEMATICAL TRUTH

THIS EXPLAINS WHY INDUCTIVE INFERENCE IS USUALLY RELIABLE

INTERESTINGLY → NO NEED TO ~~UNDERSTAND~~ CAUSALITY

VAST, LARGE, RESEMBLE A BIT IMPRECISE
BUT IF YOU KNOW ABOUT STATISTICS
YOU CAN QUANTIFY THEM

WORKS EVEN FOR SMALLISH NUMBERS

100 BALLS → BLACK & WHITE IN UNKNOWN
PROPORTION

SAY THAT "RESEMBLES" MEANS WITHIN
4% OF POPULATION

SAY 60 WHITE / 40 BLACK → SAMPLE SIZE 50
"SHOULD" HAVE
30 WHITE

4%

IF IT HAS 28, 29, 30, 31 or 32   RESEMBLES
POPULATION

→ TRUE OF 68% OF SAMPLES

DAVID HUME WAS SKEPTICAL ABOUT INDUCTION

PAST EXPERIENCE ⟶ FUTURE OBSERVATION ?

" ALL ARGUMENTS CONCERNING EXISTENCE ARE FOUNDED ON THE RELATION OF CAUSE AND EFFECT; OUR KNOWLEDGE OF THAT RELATION IS DERIVED ENTIRELY FROM EXPERIENCE, AND ALL OUR EXPERIMENTAL CONCLUSIONS PROCEED FROM THE SUPPOSITION THAT THE FUTURE WILL BE CONFORMABLE TO THE PAST

CIRCULAR ARGUMENT.
ALWAYS TRUE OF INDUCTION ?

NO → NOT CIRCULAR ARGUMENT

- HUME'S MISTAKE (DO YOU AGREE?) IS TO ASSUME THAT ANY PROBABLE (NON-DEDUCTIVE) REASONING RELIES ON CAUSE & EFFECT

- NOT TRUE → PROPORTIONAL SYLLOGISM IS A PURELY LOGICAL CONNECTION

"ALL ARGUMENTS CONCERNING EXISTENCE ARE FOUNDED ON THE RELATION OF CAUSE & EFFECT..."

WOULD DENY THAT THERE COULD BE ANY PROBABILISTIC ARGUMENTS THAT ARE MATTER OF PURE LOGIC "EASY TO SUPPLY EXAMPLES"
⇒ CAN YOU ??

INDUCTION IS CENTRAL TO SCIENTIFIC
METHOD   SEE   SIDEBARS
    — EVILS OF INDUCTIVE SKEPTICISM
    — CONSTRUCT A NON-INDUCTIVE WORLD.
    — IS THE FAR SIDE OF THE MOON THE
      SAME AS THE NEAR SIDE?

BUT NOT THE ONLY TOOL IN THE BOX !
    — INFERENCE TO BEST EXPLANATION

    — CONTROLLED EXPERIMENT.

INFERENCE TO BEST EXPLANATION

EARTH AS A GLOBE EXPLAINS LUNAR ECLIPSE

MASS OF FACTS $\longrightarrow$ UNIFIED BY SINGLE THEORY

INFERENCE TO BEST EXPLATION
ABDUCTION

LIKE INDUCTION $\longrightarrow$ NON-DEDUCTIVE
INFERENCE

- DALTON'S ATOMIC
  THEORY
    $\downarrow$
  LAW OF MULTIPLE
  PROPORTIONS

$\longrightarrow$ NO LOGICAL GUARANTEE
THAT EXPLANANTION IS BEST
OR UNIQUE

- WHAT IS IT ABOUT A THEORY THAT MAKES IT EXPLANATORY?

- WHY DO WE THINK A SIMPLER EXPLANATION IS BETTER?

- ABILITY TO DESCRIBE MANY PHENOMENA NOT SUFFICIENT → EG PARANOIA

- NEED CHECKABLE PREDICTIONS

IF h INITIALLY UNLIKELY, GIVEN b THEN A CONSEQUENCE OF h WHICH IS UNLIKELY WITHOUT h INCREASES ITS PROBABILITY.

Controlled Experiment?

Science "Reveals Truth" Through

OBSERVATION
EXPERIMENT?

These are not the same thing

Science started as OBSERVATIONAL

Bacon / Galileo → EXPERIMENTAL

At present interpretion of an
experiment in terms of a theory almost
always involves other theories

Higgs ⊙ LHC → E&M, Quantum Mech
Special Relativity ------

Experiments are Fallible

However
- — Consistency
- — Repeatability
- — Repeat with different Calibrations
- — Statistical Tests
- — Intuition of Reasonableness

Increase Probability of Experimental Result

ARE FIELDS WHERE EXPERIMENT IS IMPOSSIBLE "SCIENCE"?

- COSMOLOGY
- SOCIAL ENGINEERING

INFER CAUSES FROM OBSERVATIONAL DATA

        ↳ SEE LATER

FOR NOW → LET'S TURN TO CRITICS OF SCIENCE.