

Why discuss Science and Scientific Method in this course

- ▶ Our understanding of the process guiding scientific research in the empirical sciences helps us to understand the role of statistics in research projects
- ▶ This understanding clarifies the role of a statistician (consultant) in a research project

What is Science?

- ▶ “The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.”
(Oxford Living Dictionary)
- ▶ “a : knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method
b : such knowledge or such a system of knowledge concerned with the physical world and its phenomena : natural science ”
(Merriam-Webster online dictionary)

“Science”

- ▶ Scientific Method: process for developing *models* to predict the ways in the Universe
- ▶ Scientific body: the body of knowledge (models) about the universe that has been acquired through the scientific method

Science is self correcting through testing the accuracy of predictions based on scientific models.

Scientific Theory

- ▶ *model* that is developed to explain some phenomenon and is used as the basis for making predictions

Proof of Scientific Theories

- ▶ science **does not prove** theories (or hypotheses) to be correct
- ▶ experimental results consistent with predictions made by the theory **provide evidence to support** the theory

Proof of Scientific Theories – examples

- ▶ theory with little support: four cups of coffee per day increase life expectancy of humans (December 2017)
- ▶ theory well supported by a large amount of evidence and data: theory of evolution (Darwin (1809–1882))
- ▶ a theory is accepted as scientific knowledge (law) when it has been verified by rigorous scientific studies (e.g. $E = mc^2$)
- ▶ a theory remains a theory until it has been repeatedly proven or tested experimentally

- ▶ Also, if you want proof beyond all doubt become a mathematician

Disciplines of Science

- ▶ Natural sciences (biophysical sciences)
 - ▶ Physical sciences (physics, chemistry, geology, earth and atmospheric sciences)
 - ▶ Biological or Life sciences
 - ▶ Mathematics and logic – are these natural sciences?
- ▶ Social sciences
 - ▶ Sociology, Anthropology, Political Science, Psychology, Education, Economics

Note: The humanities (history, religion, philosophy, languages, fine arts, etc.) are not considered a science because knowledge of these cannot be investigated using the scientific method.

The Scientific Method

- ▶ systematic approach to scientific research that supports all natural and social sciences (empirical research)
- ▶ develops systematically from the beginning (a research question) to the end (a published manuscript/presentation)

Features of Scientific Research

- ▶ *logic*
- ▶ *systematic* (in methodology and organization of results)
- ▶ *objective* (not based on personal judgment or feelings)
- ▶ *rigorous* (thorough, following strict procedures, accurate)
- ▶ *consistent* (minimize effect of confounding factors)

Features of Scientific Research (contd.)

- ▶ *falsifiable*
- ▶ *precise and reliable*
- ▶ **based on empirical evidence**
- ▶ *probabilistic*
- ▶ *repeatable, reproducible and replicable*
 - repeatable – given data and statistical tools the same results can be recreated
 - reproducible – given a description of a study it can be conducted again producing consistent results
 - replicable – given a description of the aims of a study a new study can be conducted leading to consistent conclusions
- ▶ *shared*
- ▶ *generalizable*

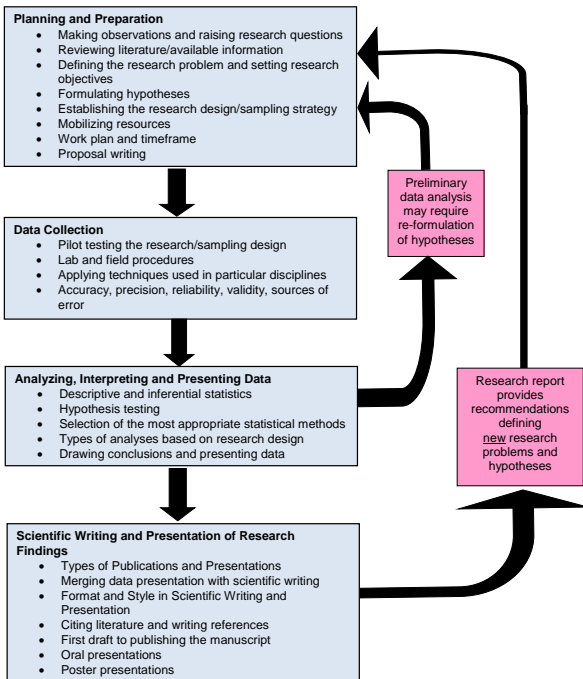
For the purpose of this discussion

Stages of the Scientific Process

- ▶ Planning and Preparation
- ▶ Data Collection
- ▶ Analyzing, Interpreting and Presenting Data
- ▶ Scientific Writing and Research Presentations (sharing with peers)

see diagram for discussion of these stages

Flow Chart of the Scientific Process



Why Science?

- ▶ crucial role in the advancement and progress of human civilization
- ▶ through science, man rises above nature and can control his environment
- ▶ discovers solutions to social problems
- ▶ invents new tools and technologies that makes work easier and save time
- ▶ facilitates development and economic advances
- ▶ provides basis for government policies

Why Science? (contd.)

- ▶ agent of diversification and evolution of society
- ▶ leads to evolution of life styles and society in general
- ▶ trains the mind in logic and understanding
- ▶ new look at the world and every day experiences in life in an objective and analytical way

A word of caution

- ▶ science is neither good nor bad.
- ▶ *use and application* of science must be controlled by moral and ethical values
- ▶ artificial intelligence (can be used to help, but also to destruct), super virus/weapons (could kill humanity, but help understand the world and prevent such events)), manipulate human behaviour to gain unethical advantages to nudge decision towards “better” actions

Society should aim for useful, productive, and positive uses of science and technology