What is Science?

1. Science and Not-Science

It is important for both students and educators of any discipline or area X to know what that X is and what it covers — whether it is physics, philosophy, biology, science, technology, 'social sciences', 'humanities', or art. And if we pursue the question "What is X?" in each of these areas, we will soon find that they are all interconnected, and that one inevitably leads to the others. So, it is important for science students as well as science educators to ask themselves, "What is science?" and pursue that question, individually and collectively, in the context of other academic domains.

When discussing the question "What is a theory?" (Handout: "Introduction to Trans-Disciplinary Courses on Rational Inquiry," section 5), we suggested that the best way to look for an answer is to begin by scrutinizing examples of theories, and comparing them with examples of not-theories. Let us follow the same strategy in asking, "What is science?" beginning with a list of the pursuits that we judge to be science, and those that we judge to be not-science.

Science: astronomy, physics, chemistry, materials science, earth sciences, biology, neuroscience, forensic science, paleontology, …

Not-science: philosophy, literature, singing, dancing, interior decoration…

If we try to expand the list, we encounter a number of unclear cases that we may not be sure whether to group under science or not-science. Take these examples:

Unclear: mathematics, logic, computer science, neuropsychology, psychology, bio-linguistics, neuro-linguistics, linguistics, economics, educational neuroscience, medicine, engineering, technology, social science, …

In such situations, a good strategy is to begin by constructing an answer on the basis of clear cases, and examine the consequences of the answer to the unclear cases. We are then likely to find cases where the consequences of our definition are inconsistent with our preconceptions. For instance, we might view mathematics as a science, but it may logically follow from our definition that it is not a science. Likewise, we might view psychology as a not-science, but it may follow from our definition that it is indeed a science. In such cases, our commitment to rationality requires that we either revise our definition or abandon our preconception.

So let us begin with the clear cases to come up with a definition.

Before you proceed to the next section, think carefully about the following question and come up with an answer.

> What is science such that astronomy, physics, chemistry, and biology are sciences while philosophy, literature, and dancing are not sciences?

Discuss your answer with your friends and try to come up with a joint answer.

The handout called "Introduction to Trans-Disciplinary Courses on Rational Inquiry" began with the observation that the concepts of theories, definitions, calculations, and so on cut across the disciplinary divides of mathematics, physics, chemistry and biology. For students of math and of science, the *ability to come up with, to test, and to critically evaluate definitions* is as important as the ability to make calculations. By first trying to come up with a definition on your own individually, and then jointly, before looking at the definition in section 2 on the next page, you will get practice in constructing definitions, and a chance to develop that ability. *So if you want to do really well whether in math, physics, chemistry, or biology, it would be in your best interests not to proceed to the next page before you have struggled with the definition yourself.*

2. Towards a Definition of Science

For today, I will take the following as my preferred definition of science:

(1) Science is the intellectual activity of seeking to understand the general patterns in the world we live in on the basis of systematic observation and rigorous reasoning.

This definition has five parts:

(2) a. Science is an *intellectual* activity.
b. Science seeks to understand *the world we live in*.
c. Science seeks to understand *general patterns*.
d. Scientific knowledge is based on *systematic observation*.
e. Scientific knowledge is based on *rigorous reasoning*.

Given (2a), it follows that singing, dancing, and interior decoration come under the not-science category. Given (2b), mathematics, computer science, and singing come under the not-science category. Given (2c), activities that restrict themselves to the understanding of the particular (as in the literary analysis of a particular poem) without attempting to shed light on the general, are not-science. Given (2d), mathematics, computer science, and philosophy are not-science. Given (2e), singing and dancing are not-science. And given the combination of (2a-e), it follows that astronomy, physics, chemistry, materials science, earth sciences, biology, neuroscience, forensic science, paleontology, neuropsychology, psychology, bio-linguistics, neuro-linguistics, linguistics, economics, educational neuroscience, medicine, engineering, and technology are sciences. If we accept the definition in (1), we also have to accept these consequences of the definition.

Now, some of these consequences of our definition are logically inconsistent with the terminology used in the institutional categorizations of human knowledge: *sciences, natural sciences, physical sciences, biological sciences, life sciences, social sciences, human sciences, behavioural sciences, humanities,* and *arts*. Some of these terms are synonymous (e.g. life sciences and biological sciences), others are involve subset relations (natural sciences include physical and biological sciences) and yet others appear to be mutually exclusive (e.g. sciences seem to exclude social sciences.) Problems arise if we examine the categories which are mutually exclusive. Thus, in the conventional classification, mathematics is a science while psychology is not. Our definition treats mathematics as a not-science and psychology as a science. Should we revise our definition to make it consistent with the traditional typology, or should we restructure the typology to be consistent with the definition?

Let us first try to find a typology that is consistent with our definition. Astronomy, physics, chemistry, and materials science are about the ***physical world*** (that of *non-living entities*), and are treated as ***physical sciences***. Biology is about the ***biological world*** (that of *living entities*): molecular biology, genetics, cellular biology, developmental biology, and evolutionary biology are treated ***biological sciences***. Together, the physical and biological sciences are called ***natural sciences***. Psychology, linguistics, economics, and sociology are about the ***human world***. We might therefore treat these subjects as ***human sciences***.

The traditional grouping of astronomy, physics, chemistry, materials science, and biology as sciences and psychology, sociology, and economics as "social sciences", is roughly based on subject matter. In this grouping, natural sciences are sciences, but human sciences are not. But given what we have just said above, the physical sciences, the biological sciences, and the human sciences are all instances of science. Hence, there is no justification for treating psychology, economics, and sociology as not-science. Nor is there any justification for treating mathematics as a science. In contrast, the view that social sciences are sciences while mathematics is not a science is perfectly consistent with our definition in (1).

The traditional classification has other problems. Take the term ***social sciences***, which includes psychology, linguistics, sociology, and economics. While sociology and economics are about human social organization, psychology is the study of the human mind, not of human society. So it makes no sense to group psychology as a social science. Similarly, it makes no sense not to group as social sciences the study of the social organization of non-human creatures such as bacteria, ants, termites, bees, chimpanzees, and orangutans, traditionally grouped under biological sciences.

Likewise, if biological sciences are about the study of living beings, and human beings are living beings, why doesn't the study of human beings come under biological sciences? If social sciences are the study of social organization, why doesn't the study of non-human societies come under social sciences, as mentioned above? If the studies of the human body and the human brain, and disorders of the human mind (psychiatry) on the one hand, and the chimpanzee body, the chimpanzee brain, and chimpanzee consciousness on the other, are all sciences, why isn't the study of human consciousness, and the normal functioning of the human mind (psychology) a science?

Take the terminology of ***behavioural sciences***. On 4 January 2012, there was a write on recent discoveries in behaviour research in the journal *The Scientist*. (http://the-scientist.com/2012/01/04/behavior-brief-14/) The title of the journal indicates that what it covers comes under science. Behavioural science should then be one of the domains of science, along with the physical and biological sciences. The article provides information on recent research on the social awareness of chimps, numeracy among birds, and collective decision making among fish. If these come under "behavioural sciences" which in turn come under life sciences which come under sciences, then there is no reason why social awareness, numeracy and collective decision making among humans do not come under behavioural sciences, and hence under sciences. Granted that it is perfectly legitimate to distinguish between human behaviour and (non-human) animal behaviour, if behavioural science is a science then the scientific study of human behaviour is also a science. And if we concede this simple point, the scope of the term "science" (= scientific knowledge) would include the results of scientific inquiry in psychology, sociology, anthropology, linguistics, political science and economics.

Given these kinds of problems, it is imperative that educational institutions rethink their typology. It would be meaningful, for instance, to consider a typology such as in (3):

(3) *Science:* the study of ourselves and of the world we live in on the basis of systematic observation and rigorous reasoning.

a. *Physical sciences:* the study of non-living entities

b. *Biological sciences:* the study of living entities
   i. the study of human and non-human social organization (social sciences)
   ii. the study of the other aspects of humans and non-humans.

The term "human sciences" refers to the study of the various aspects of humans as part of (i) and (ii).

An alternative would be the typology in (4):

(4) *Science:* the study of ourselves and of the world we live in on the basis of systematic observation and rigorous reasoning.

a. *Physical sciences:* the study of non-living entities

b. *Biological sciences:* the study of living entities other than humans

c. *Human sciences*: (the study of humans)
   i. the study of human social organization
   ii. the study of the other aspects of humans

The term "social sciences" refers to the study of the social organization of living entities as part of (b) and (c).

Methodologically, the classificatory scheme in (4) has an appealing feature that makes it better than that in (3): it treats human sciences as a special category. It is only in the human sciences that we can have verbal evidence as possible grounds for knowledge. Methodologies such as interviews, surveys, textual evidence, and data from experiments in which the subject responds to linguistic stimuli or provides a linguistic response (as in psychology or human neuroscience experiments) are possible only in the human sciences, not in the physical or biological sciences. We will therefore adopt the definition in (1) together with the classification in (4).

3. Stereotypes of Science: Laboratories, Numbers, and Instruments

The term "scientist" in popular discourse conjures up the image of a person wearing a white coat, standing in front of an expensive instrument in a laboratory, jotting down numbers, and making calculations. If we were to go by this stereotype, we would revise the definition in (1) as (5):

(5) Science is the intellectual activity that seeks to understand the general patterns in the world we live in on the basis of systematic experiments in a laboratory, specialized equipment/instruments, numerical data, and mathematical modeling.

This definition is problematic in many ways. First, experimental research in science is not restricted to ***laboratory experiments*** or the laboratory setting. Many scientists rely on ***field experiments*** done outside laboratories. Second, leading theoretical scientists, including Einstein and Feynman, and Darwin didn't do laboratory experiments. Furthermore, experimentation is not feasible in some domains, like astronomy, or in case studies in medical research. A scientist can't move planets around, or change the direction of their spin, to test a theory of the solar system. Nor can a medical researcher cut out pieces of the human brain to study brain function, as we do with chimpanzees. Even if we removed the reference to laboratories in the definition, it would still disqualify many theoretical scientists from being scientists, and astronomy from being a science. So we must go back to "systematic observation" in definition in (1), leaving experiments and laboratories as an optional aspect of science.

Specialized instruments are useful in many areas of science; but they are neither essential nor useful in many other areas, for instance, the scientific research on therapeutic drugs, or in many types of clinical case studies. Darwin based his theory of evolution on systematic observation, not specialized instruments. Nor did he appeal to quantitative data or mathematical calculations in his theory. This is true of many types of work in science, for instance, what neuroscientists do.

Put together, the objections to (5) require that we reject it in favor of (1).

We should note, however, that laboratories, experiments, specialized instruments, numerical data, and mathematical modeling are found only in science disciplines. We might incorporate this insight into (1) and revise it as follows:

(6) Science is the intellectual activity that seeks to understand the general patterns in the world we live in on the basis of systematic observation and rigorous reasoning, *prototypically (not necessarily) using laboratories, experiments, specialized instruments, numerical data, and mathematical modeling*.

The definition in (6) retains the consequences of (1), and has the following additional features:

(7) Observational strategies: Observations are

a.	prototypically:	laboratory experimental
	less prototypically:	field experimental
	non-prototypically:	non-experimental
b.	prototypically:	instrumental
	less prototypically:	non-instrumental
c.	prototypical:	quantitative
	less prototypical:	non-quantitative

(8) Mathematical modeling: Propositions are expressed in:

prototypically:	the language of mathematics
non-prototypically:	ordinary language

Given (7) and (8), the theories of relativity and of particle physics are most prototypical of science, in contrast to evolutionary theory, which though science is not prototypical science. Sciences like economics, psychology, and linguistics arrange themselves at different locations between the two extremes.

Notice that the first part of our definition in (6) refers to the *subject matter* of science (understanding ourselves and the world we live in), and the rest of it refers to its *modes of inquiry* (the strategies of gathering and making sense of data). The classification in (4) adds further details to the subject matter, while (7) and (8) add further details to the modes of inquiry.

The combination of (6)-(8) and (4) constitutes an answer to the question "What is science?" As you can see for yourself, this view of science is principled and coherent, not arbitrary or logically inconsistent. Given what we have outlined above, human sociology and chimpanzee sociology are both sciences of social organization, and human sociology is, in addition, a human science (unlike chimpanzee sociology). Likewise, the study of human consciousness, chimpanzee consciousness, and drosophila consciousness are all sciences; among these, only the study of human consciousness is a human science.

4. Historical Sciences

In (4), we distinguished between the physical sciences, the biological sciences, and the human sciences. It would be useful to add a fourth category to this list, namely, historical sciences, which are part of the physical, biological, and human sciences.

We may define a ***historical science*** as a science (consistent with (6)) that investigates the past. An example of historical science would be the Big Bang theory (which deals with the origin of the physical universe) as a part of the history of the universe. The history of the solar system and the history of the earth would also be part of physical history, as a branch of the physical sciences.

Evolutionary theory, which is about the history of life forms on the earth, is an example of historical science as a branch of biological sciences. The origin and history of the human species would also be a part of biological history. The origin and history of human languages would be a branch of human sciences. So would the history of Hindi.

The history of science, the history of philosophy, the history of mathematics, and so on would be instances of intellectual histories within the human sciences. The history of different traditions of music, of literatures, of religions, of cuisines, of architectures, of educational systems, of political systems, of social systems, and of economic systems, would form yet another group within historical sciences.

If we recognize history as a dimension in investigating physical, biological and human systems, we get an interesting distinction between ***historical explanations*** and ***a-historical explanations***. If we asked, "Why do the planets revolve around the sun in an elliptical orbit?" the response would appeal to the theory of gravity and motion (non-historical), and would be an a-historical explanation for elliptical orbits. But if we asked, "Why are the orbits of planets in the solar system on the same plane?" the response would appeal to the history of the solar system, and hence would constitute a historical explanation. If we asked, "Why don't humans have tails like other mammals?" the response can appeal either to the genotype of humans (a-historical explanation), or to random mutation and selection in the history of the human species (historical explanation).

Some scholars have referred to this view of history — as the study of all aspects of the physical, biological and human past — as 'Big History'. The kind of history that is presented in high school history textbooks is largely the history of nations and their rulers, which is just one part of human political history. This view of history would be 'small history' in contrast to 'big history'.

Most examples of big history come under the rubric of science. This prompts us to ask if we should classify small history also as 'science'. Historians in history departments may not agree on this issue. Some may view small history as part of the human social sciences, and hence as a science; others may view it as part of the humanities, and not a science. To understand this difference of opinion, we need to understand the distinction between the sciences and the humanities; we will talk a bit more about that distinction in section 6.

5. Is Mathematics a Science?

Our earlier statement that mathematics is not a science may have surprised students of mathematics (and mathematicians too). There are two reasons for taking this position:

(9) a. Scientific claims are shown to be true (justified, defended, substantiated, validated, …) on the basis of observation and reasoning (definition (6)). Mathematical claims (called conjectures) are shown to be true (proved as theorems) on the basis of other theorems (already proved), axioms, definitions, and reasoning. Thus, the ultimate grounds for science are *observations*, while those for mathematics are *axioms and definitions*.

b. Scientific knowledge is a body of propositions that happen to be true about *the particular world that we live in:* philosophers call them *contingent truths*. Mathematics, on the other hand, is a body of propositions that are true about *any possible world* (subject to the conditions of rationality): philosophers call them *necessary truths*.

Let us explore (9a) first. Suppose we want to prove that no human being can be 500 years old. If we adopt the scientific mode of inquiry, the following grounds and reasoning would support our position.

(10) I have examined a randomly selected representative sample of ten million human beings. Not a single human being in my sample is more than 200 years old. Furthermore, a very large number of human beings are attested as dying before they are 200 years old. In the absence of evidence to show that there exist humans who are more than 200 years old, therefore, it is reasonable to conclude that no human being can be 500 years old.

This is a perfectly valid scientific proof. However, it is not a valid mathematical proof. This is because we have not ruled out the possibility of a few 510-year old humans, who, unknown to us, live in a cave in some far away mountain in complete isolation from civilization. The grounds in (10) are not sufficient to rule out possible error, hence it is not admissible as a mathematical proof. There is no way to defend our claim using a valid mathematical proof.

Let us take another example. Suppose we wish to prove that no human being can be five years old when his/her maternal grandmother is born. If we adopt the scientific mode of inquiry, we can establish the truth of our claim as follows:

(11) I have examined a randomly selected representative sample of ten million human beings. Not a single human being in my sample was born before his/her maternal grandmother. Furthermore, there is a very large number of attested cases of human beings being born many years after their maternal grandmother was born. In the absence of evidence to show that there exist or existed humans who are/were five years old when their maternal grandmother was born, therefore, it is reasonable to conclude that no human being can be five years old when his/her maternal grandmother is born.

This too is a perfectly valid scientific proof, but as in the previous example, it does not rule out the possibility of human beings who, unknown to us, were born before their maternal grandmother, hence it is not a valid mathematical proof. But the following proof is indeed valid within the mathematical mode of inquiry.

(12) a. Definition 1: The *mother* of a human x is the female human who gave birth to x.

b. Definition 2: The *maternal grandmother* of a human x is the mother of the mother of x.

c. Definition 3: The process of y giving birth to x is one of bringing x into existence, such that x does not exist before y gives it birth, and exists from the time y gives it birth until it dies.

d. Definition 4: The age of any entity at time t is the duration of time from the point of its birth to time t.

e. Definition 5: x is older than y = the age of x is greater than that of y.

f. Axiom: For every human being x, x has one and only one birth mother.

g. Proof: i. Given (12a) and (12c-f), it follows that for any human being x, there exists one and only one birth-mother y, and that y existed before x was born.

ii. From (12b) and (12gi), it follows that for any human being x, there exists one and only one maternal grandmother z, and that z existed before y was born.

iii. From (12gi-ii), it follows that for any human being x, it is not true that x was five years old when x's maternal grandmother was born.

The logic used in the proof in (12) is that of classical deductive logic. In contrast, the logic in the proofs in (10) and (11) is that of inductive logic. Depending on the type of claim, the justification of a claim in science would use classical deductive logic, defeasible deductive logic, probabilistic deductive logic, inductive logic, speculative deductive logic, or abductive logic. In contrast, only classical deductive logic is permitted in the justification of a claim in mathematics.

You don't need to know at this point what the terms deductive, defeasible, abductive, and so on mean. You will learn about different types of logics at a later point in TDC 201. What I expect from you at this stage is an intuitive recognition that the logic used in (12) has almost total certainty, such that if the axioms and definitions are true, it cannot be the case that the conclusion is false. In contrast, the logics used in science typically do not guarantee certainty.

Let us take a real life example to illustrate the above difference. Consider the following facts:

(13) The sum of 4, 5, and 6 is 15; 15 is divisible by 3.
The sum of 5, 6, and 7 is 18; 18 is divisible by 3.
The sum of 12, 13, and 14 is 39; 39 is divisible by 3.
The sum of 51, 52, and 53 is 156; 156 is divisible by 3.

On the basis of such facts, we may propose the following conjecture:

(14) Conjecture: The sum of any three consecutive numbers is divisible by three.

How do we prove this conjecture? If we use inductive logic, we might provide the following justification in defense of (14):

(15) I have examined a randomly selected representative sample of one million triplets of consecutive numbers. The sum of every triplet is divisible by three. I have not been able to find a triplet of consecutive numbers whose sum is not divisible by three. In the absence of evidence to the contrary, therefore, it is reasonable to conclude that the sum of any three consecutive numbers is divisible by three.

While the type of logic used in (15) is acceptable for scientific conjectures like: "The period of a simple pendulum is directly proportional to its length", it does not rule out the possibility that there is some triplet of consecutive numbers that we have not looked at which is not divisible by three, and hence the proof does not guarantee total certainty. In mathematical inquiry, therefore, (15) is inadmissible. A valid proof for (14) in mathematics would be along the following lines:

(16) Let n be any number. The number that follows it then is $n+1$ and the next number is $n+2$. The sum of these three numbers is $3n+3$, which is divisible by 3. Hence, we conclude that the sum of any three consecutive numbers is divisible by three.

We began our exploration of the distinction between science and mathematics by saying that these two subjects differ in the way they justify their conclusions ((9a)) and in what their knowledge content is about ((9b)). Now, what does it mean to say that scientific knowledge is about what is true about the particular world that we live in, while mathematical knowledge is about what must necessarily be true in any world that is subject to the conditions of rationality?

Let us take an example. What is the sum of the angles in a triangle? The answer that many of us learn in school is that it is two right angles. As it happens, however, this is correct only in Euclidean geometry, which has the axiom that for any point *p* outside a line *l*, there exists one and only line through *p* that is parallel to *l*. Riemannian geometry subscribes to the axiom that for any point *p* outside a line *l*, there exist more than one line through *p* that are parallel to *l*. And given this axiom, the sum of angles in a triangle is more than two right angles. If we accept Einstein's theory of relativity, the universe we live in is Riemannian. If we ask a mathematician what the sum of the angles in a triangle is, the answer would be:

> In any world where it is true that for any point *p* outside a line *l*, there exists one and only line through *p* that is parallel to *l*, the sum of the angles in a triangle is two right angles.
>
> In any world where it is true that for any point *p* outside a line *l*, there exist more than one line through *p* that are parallel to *l*, the sum of the angles in a triangle is more than two right angles.

To put it differently, mathematical truths are logical truths of the form, "In any logically possible world, if X is true, then Y is also true." This is the fundamental difference between science and math. Scientific truths are of the form "X is true in the world we live in."

Logic, mathematics, and (theoretical) computer science share the property of being necessary truths. We may refer to these subjects as ***logico-mathematical studies***, to distinguish them from the sciences.

6. The Human Sciences and the Humanities

In conventional terminology, "humanities" typically refers to philosophy, the study of the arts (literature, painting, music, sculpture, etc.) and (human) history. Intuitively, we would agree that philosophy and literary studies are not sciences, and hence the distinction between the human sciences and the humanities is legitimate. But it is possible that our "intuition" has taken shape because of what we have learnt as part of our education. To figure out if this distinction is based on an actual difference, we need to unearth and clarify the general characteristics of the humanities that distinguish them from the sciences.

Let us begin with philosophy. There was a time when the distinction was not made between science and philosophy, or even between mathematics and philosophy. The term *philosophy* comes from Greek, where *philo-* refers to love (as in *audiophile*, *anglophile*), and *-sophy* refers to knowledge (as in *theosophy*), so a philosopher is one who loves knowledge. Euclid, a mathematician, Plato, a philosopher in the modern sense of the term, and Aristotle, who studied biological systems among other things, were all philosophers. If we use the term ***academic*** to refer to *one who devotes one's life to the pursuit of knowledge*, we would call Euclid, Plato, and Aristotle academics.

The distinction between philosophy and science as we now know it began to emerge in the sixteenth and seventeenth centuries, with the concept of *natural philosophy* as the pursuit of knowledge of nature. Newton, for instance, regarded himself as a natural philosopher. If we coined the terms *conceptual philosophy* and *formal philosophy* to distinguish natural philosophy from what we now call philosophy and mathematics, we might refer to Plato as a conceptual philosopher, and Euclid as a formal philosopher.

How are natural philosophy and conceptual philosophy distinct? When investigating questions of, say, consciousness and freewill, conceptual philosophers investigate them concepts on the basis of *introspection* (looking inwards), their prior experience (including prior knowledge), and intuitions. While the conceptual philosopher looks inwards, the natural philosopher looks outwards at the world around to investigate human behavior and human brain, relying on *observation* (both experimental as well as non-experimental). Similarly, in philosophy of language, researchers explore meaning on the basis of intuitions of meaning; in linguistics, they explore meaning on the basis of experimental and non-experimental data.

It must have become clear by now that the scientific mode of inquiry allows us to study not only human consciousness and human language but also the consciousness of chimpanzees and drosophila, and the language of dolphins and bees. The conceptual mode of inquiry used in philosophy is restricted to human consciousness and human language, and does not lend itself to the observational strategies needed for the study of non-human consciousness and non-human language.

Another important difference between philosophical and scientific inquiries becomes clear when we study moral systems. When we observe the moral judgments of individuals or groups of humans, and the moral systems that underlie these judgments, we find considerable variation. In some cultures, "honor killing" is judged as morally virtuous, and in others as morally loathsome. In some cultures, premarital sex is a sin, and female virginity is a virtue, while in others, pre-marital sex is part of normal life and virginity (whether male or female) is an embarrassment in adulthood. Suppose we investigate the moral systems of different communities on the basis of experimental data (e.g., by giving various scenarios to experimental subjects and eliciting their moral judgments on the scenarios), and construct theories to account for the patterns in the data. We will then see that some principles that are part of these theories are shared across communities. If, on the basis of such cross-cultural patterns, we construct a descriptive universal theory of human morality that addresses the question, "What is the moral system of the human species?" we would be constructing a scientific theory of human morality. This would be a pursuit within the human sciences.

Suppose, instead, we ask, "What moral system *should* we adopt as members of the human species?" Given that some cultures look down on pre-marital sex while others allow it, which of these moral codes would be conform to the moral values we ought to adopt? To respond to this question, we would have to use the philosophical mode of inquiry, relying on introspection and shared intuitions rather than on data. And such a pursuit would result in a philosophical theory of morality. As in the case of consciousness and language, the philosophical mode is useful only for investigating human morality. The scientific mode, on the other hand, lends itself to investigation of the moral systems of humans as well as other creatures.

Given the reliance on introspection and prior knowledge in philosophy (as opposed to systematic observation in science), and its potential to investigate not only questions of truth but also of values (as opposed to questions of truth alone in science), it follows from our definition in (6) that philosophy is not a science. What about literature, painting, music, and other arts?

To answer this question, it would be useful to distinguish between the ***subjective*** and the ***objective*** worlds. If I tell you that in a dream last night I saw an elephant climbing a tree in the park next to my house, I am making a statement about my subjective world, the *internal world of my consciousness*. But if I tell you that last night an elephant was climbing a tree in the park next to my house, I am making a statement about the objective world, the *external* world outside my consciousness. Science, as we said in our definition, is concerned with the external world. Philosophy, as we have seen, can investigate the subjective world.

Anyone who studies literature, dance, music, or art as an academic subject has to be able to analyze and interpret, and in many cases, give a judgment on the quality of a literary work (a poem, a novel, etc.), a dance performance, a music concert, or a painting. Each of these instances of analysis, interpretation, and critical evaluation is concerned with particular entities (a particular poem, a particular dance recital, a particular painting). This is unlike science, which, as definition (6) says, is concerned with the general patterns that cut across the particulars.

Another aspect of subjects like literature, painting, music, and other arts, which makes it not-science, is that the conclusions in these domains are typically based on semi-subjective perceptions that are often specific to particular cultural groups. This is unlike conclusions in scientific inquiry, which, according to our definition, are based on observation and reasoning.

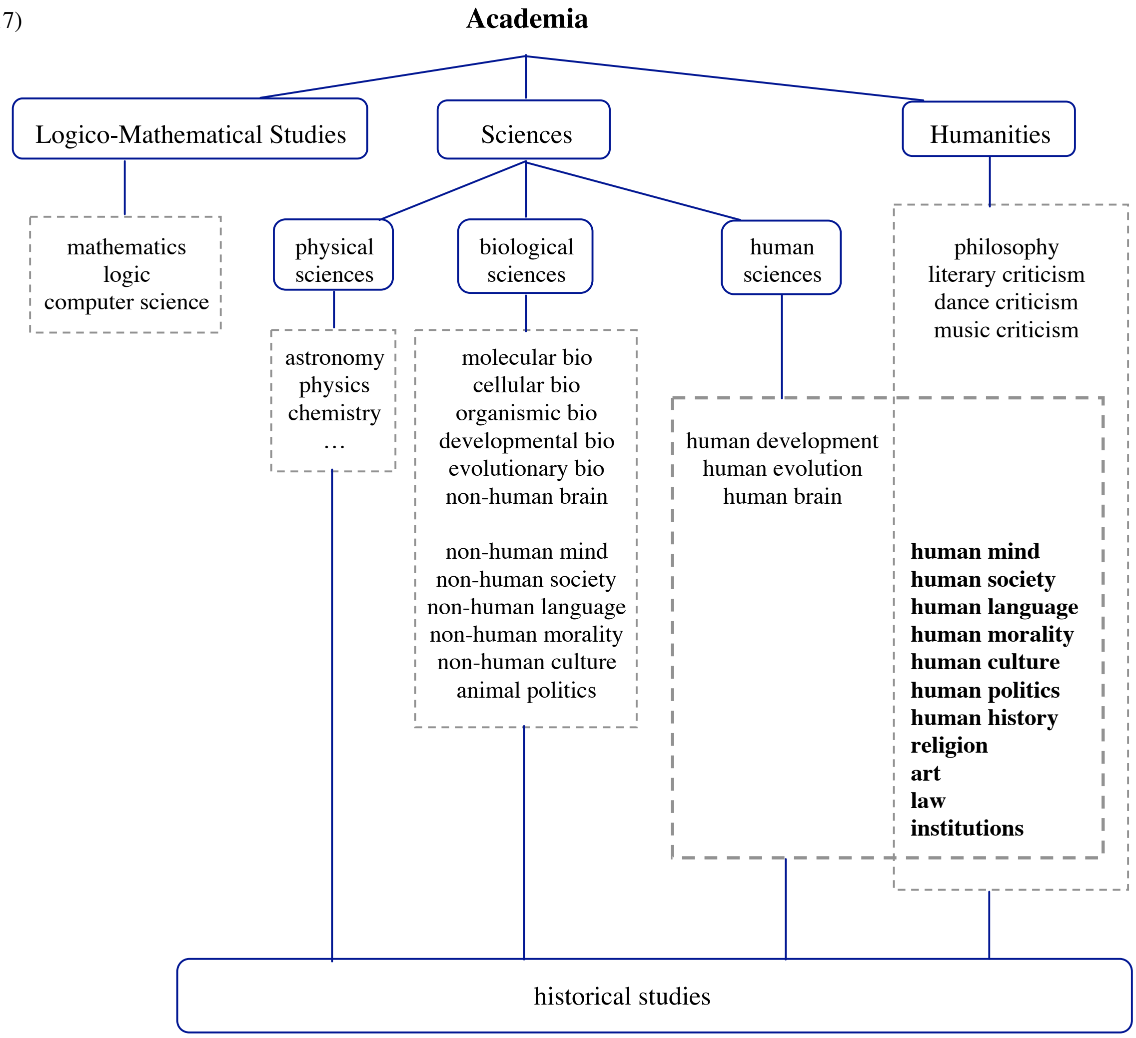
7. What makes us human?

Suppose we use the term ***human studies*** to include not only the human sciences but also subjects like philosophy, law, and literary criticism. An important question that human studies need to grapple with it is: *what makes us human?* What is it that distinguishes the human species from the other species that inhabit the planet? This is an age old fundamental question that leading thinkers in the past have been fascinated with. The answers range from the human genome, and our flexible thumb to the human language, religion, reasoning, art, culture, consciousness, and free will. Plato, for instance, regarded rationality as the quality that distinguishes us from other animals, while Descartes regarded it as the soul. The early twentieth century anthropologists pointed to our tool use (biologically made possible by our flexible thumb) and a whole range of other cultural characteristics such as religion, death rituals, cuisines, language, and so on as other possible candidates.

In the second half of the twentieth century, MIT linguist Noam Chomsky proposed that the architecture of the human language faculty lies at the very core of what makes us human, and established the a research program in theoretical linguistics that draws upon the foundations of mathematics, computer science, and formal logic. Others followed. Melvin Connor's *Tangled Wings: The Biological Foundations of the Human Spirit,* Brian Butterworth's *What Counts: How Every Brain is Hardwired for Math*, Frans de Waal's *Good Natured: the Origins of Right and Wrong in Humans and Other Animals*, Philip Ball's *Music Instinct,* and Dennis Dutton's *Art Instinct* would be just a few examples of the recent scientific interest in what makes us human, resulting in the emergence of recent fields such as bio-linguistics, neuro-ethics, neuro-aesthetics, and educational neuroscience, along with more established pursuits like neuro-linguistics.

With the emergence of these new disciplines, one can no longer accept the traditional classification of academic subjects built into school and university programs. What emerges from our reflections, instead, is the following picture of academic pursuits:

(17)


Academia
Logico-Mathematical Studies
Sciences
Humanities
mathematics
logic
computer science
physical sciences
biological sciences
human sciences
philosophy
literary criticism
dance criticism
music criticism
astronomy
physics
chemistry
…
molecular bio
cellular bio
organismic bio
developmental bio
evolutionary bio
non-human brain
non-human mind
non-human society
non-human language
non-human morality
non-human culture
animal politics
human development
human evolution
human brain
human mind
human society
human language
human morality
human culture
human politics
human history
religion
art
law
institutions
historical studies