I – 2. TERMS AND CONCEPTS OF SCIENCE

I – 2. 1. Introduction

Epidemiological research, and clinical research just the same, is science in the original and still principal meaning of the word, namely that for which the term used to be 'natural philosophy' or 'natural history' (Gr. *historia*, 'inquiry'). Now the term generally is *natural science* – or, simply, *science*. This is the meaning of 'science' here. ('Science' entered the English language in the 19th century.)

The concept of science still is, principally, one of process, the activities of scientific inquiry, scientific *research*; but an added meaning of the word is the *knowledge* derived from the research. (Plato's and Aristotle's word for scientific knowledge was *epistēmē*.)

Scientific research on, and knowledge about, Nature has as its *objects* various *truths* about Nature, generally truths that are *abstract* – meaning abstract-general (placeless and timeless) rather than particularistic (spatio-temporally specific) – even if paleogeography and cosmology, for example, are in some respects exceptions to the concern, in science, only for abstract truths about Nature. (The reason for these exceptions is that the Earth and the cosmos have evolved, over enormous spans of time.)

The prevalence of malaria in a given place at a given time is not a potential object of epidemiological research (different from epidemiological practice concerned with that place at that time). The corresponding objects of epidemiological research and its resulting scientific knowledge are the ways in which malaria's rates of occurrence are in general – without reference to any particular place and/or time – functions of characterizers of people's constitutions, behaviors, and/or environments. There generally are no proper names (of places) in the objects of science, nor are there any references to calendar time (apart from some exceptions, noted above).

By the same token, the people participating in a 'trial' (experiment) on prophylaxis against malaria are not being studied in such a trial. The true object of the study is, in the main, the intervention's effectiveness in people in general, in the abstract, within the domain of the study (presence of potential indication for the intervention and absence of contra-indications for this, making distinctions among suitably

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defined subdomains); and a secondary object is the intervention's safety, in equally 'universal' terms. The participating people are, simply, being exploited – upon their 'informed consent' – for the purpose of learning about something that in no way is specific to them.

Similarly, the 'study subjects' in an etiogenetic study are not being studied in the study: they contribute to a study of etiogenesis in an abstract domain.

Science (of Nature) is, already, differentiated into numerous separate, more-or-less independent *component sciences*, each with a relatively coherent overall *material object*, subject-matter. Thus, neuroscience – neurology in this meaning – is separate from, for example, cardiological science, from cardiology in this meaning (just as the corresponding disciplines of medicine are separate). The idea is that it is possible to study the neurological system – including illnesses of it – without broad and deep knowledge about the cardiovascular system, and vice versa.

Component sciences are not distinguished by their respective *formal objects,* nor by the methods they deploy. Thus, inquiry into the occurrence aspect of phenomena of health in humans does not constitute a science unto itself but is involved in many medical sciences (neuroscience, i.a.); nor does this epidemiological inquiry constitute or define a science even if it were to deploy (as has been commonplace to believe) 'the epidemiological method,' unique to this research.

Among particular sciences there are various shared methods of observation, methods of imaging between neurology and cardiology, for example. And there are, even, *shared methods of research*, *specific to shared types of formal object* of study, common across different sciences – shared methods for studying formal objects of the epidemiological and meta-epidemiological clinical types, for example. But, contrary to a common claim among philosophers, there is no general-purpose 'method of science' or 'scientific method,' applied in all of scientific research.

Instead of a common scientific method, by definition shared among all sciences is, for one, commitment to heed the imperatives of *logic* – and to deploy the faculty of *reason* more broadly – in the designs of the objects and methods of their studies, and in inferences (about the abstract objects of study) based on the results (particularistic) of the studies.

Also generally shared is the understanding that science is an intersubjective, *public* enterprise, and that this requires *objectivity* of communication about the objects, methods, and results of study. Statements about these should, as much as possible, have the same meaning for all concerned, in part by their sufficient *specificity* – and, apropos here, by the use of *appropriate terminology* to boot (cf. Introduction), now preferably in the lingua franca of modern science (English) first and foremost.

And as a science is about truths (about Nature, in natural science), the scientists' *truthfulness* about their work – and, equally, about the work of others, including about its perceived meaning for inference about the objects of study – is an overarching imperative in science. While science is central to the 'Baconian optimism' about progress in the human condition, Jacob Bronowski, in his venerable *The Ascent of Man* (1973), points out that those who have contributed to this ascent have been characterized by two qualities: "an immense integrity, and at least a little genius."

While "at least a little genius" characterizes the most consequential of scientists, "immense integrity" is expected of all of them.

I – 2. 2. Mini-dictionary

Where an asterisk (*) is here attached to a term, it indicates the term's inclusion in the I.E.A. dictionary of epidemiology [4].

Abstract (synonyms: general, abstract-general, universal; antonym: particularistic) – Concerning an object of inquiry and knowledge, the quality – generally definitional of science – of having a referent in neither place nor time; that is, being without a spatio-temporal referent; cf. sect. I – 2. 1 above.

*Accuracy** – See 'Precision and accuracy.'

Analysis – See 'Analysis and synthesis.'

Analysis and synthesis – These two concepts are interrelated: "At the most elementary level, analysis concerns separation of a whole into its component parts, whereas synthesis is the reverse process of combining parts to form a complex whole" [30]. (Gr. *analuein*, 'unloose'; Gr. *syntheinai*, 'place together.')

Note 1: Kant distinguished between analytic and synthetic judgments, calling them explicative and augmentative, respectively [31]. The former only analyze a conception as to its constituent conceptions, while the latter add to the conception a predicate which was not contained in it [31].

Note 2: In their efforts to understand "the logical structure and empirical content of physical theory," subsequent philosophers have used the Kantian distinction (Note 1 above) extensively [30]. (Cf. 'Etiologic study' in sect. II – 4.)

*Analytical** – See 'Analysis and synthesis.'

*Applied** (antonym: pure) – Concerning a science, the quality of being application-oriented; that is, being intended to produce (by its research, potentially at least) knowledge of practical consequence. (Cf. 'Pure' and 'Basic versus applied research.')

Note 1: The term and concept apply not only to segments of natural science and other empirical sciences but to parts of theoretical/formal sciences as well – statistics (as a branch of mathematics), for example.

Note 2: Distinctions can be made between/among the degrees to which sciences, or topics within sciences, are 'applied.' Broadly, research in a 'basic' medical sciences is intended to potentially lead to an innovation for use in practices; but knowledge from quintessentially 'applied' medical research inherently provides for advancement of the very knowledge-base of practice [16].

Note 3: All of medical science, 'basic' medical science included, actually is 'applied' – supposed to have at least the potential to advance (the practice of) medicine. Research that deserves to be termed medical inherently is 'applied' [16].

Note 4: 'Applied' as a synonym for 'application-oriented,' while deeply and widely ingrained, is less than apposite. 'Instrumental' or 'practical' or 'pragmatic' might be better.

Applied research – See 'Basic versus applied research.'

Assumption – In theoretical sciences (such as mathematical statistics), a predicate taken as a given, without regard for whether it is true, to address what logically follows from it. (Cf. 'Presumption.')

Note: Assumptions are ubiquitous in theoretical (formal) sciences but have no place in empirical sciences.

Basic research – See 'Basic versus applied research.'

Basic versus applied research – As Peter Medawar (the Nobel laureate) in his *Pluto's Republic* (1982) disapprovingly put it, in medical academia the distinction is taken to be "between polite and rude learning, between the laudably useless and the vulgarly applied, the poetic and the mundane." (Cf. 'Applied,' Notes 2 and 3.)

Category (synonym: class) – A defined division in a system of classification. (See 'Nosology' in sect. I – 1. 2.)

*Causality** – "The power or propensity that an object or event has to produce a change in itself or in another object or event" [32].

Note: "In the history of modern science, however, there has been no agreement about the concept, or even the existence, of causality" [32]. To Kant it was a "conception a priori," a "noumenon" in this meaning [31].

Concept – The abstract essence of a thing (entity, quality, relation), true of each instance of the thing and unique to it [1].

Note: A concept is specified by its *definition*, which, ideally at least, specifies the concept's proximate genus and its specific difference within this genus [1]. Examples: triangle is polygon (proximate genus) with three sides (specific difference); man is rational animal (Kant).

Conception – The formation of a concept; also: a concept.

Conclusion – The result of deductive reasoning.

Note 1: A conclusion is *formally correct* if the logic in the deduction is correct. It is also materially correct and hence *totally correct* only if, in addition, the two premises in the syllogism (the major and minor premise) are (materially) correct. (Cf. 'Proof.')

Note 2: In empirical science there is *no justifiable place* for inductive 'conclusions' such as are now commonly required (by journal editors) in the Abstract or Summary of each research report. (Cf. 'Induction' and 'Inference.')

Note 3: Useful *deductive* conclusions *are* possible in empirical science. Example: If it has been established that (a given type of) screening provides for earlier treatment of a cancer, and that earlier treatment of the cancer is more commonly life-saving than later treatment, it follows (as a matter of deductive logic) that (the particular type of) screening for the cancer provides for saving of lives (through earlier treatment).

Note 4: Remarkably, however, the prevailing governmental doctrines about 'outcomes research' in the U.S. (see sect. III – 2) are decidedly averse to such reasoning, insisting on the need for randomized trials to test the hypothesis about mortality-reduction (despite the enormous cost and other drawbacks of these trials; see 'RCTism' in sect. III – 4).

Corroboration – Successful reproduction of previous evidence. (Similar result from a similar study, apart from efficiency and/or size, perhaps.)

*Data** (plural of datum) – A body of recorded observations, directly empirical (and hence particularistic) facts or factoids. (See 'Observation.')

Datum – See 'Data.'

*Deduction** (synonym: deductive inference) – Reasoning from two givens (the major and minor premises) to a conclusion.

Note: The conclusion follows because the minor premise is a special case of the more general, major premise. (Cf. Note 3 under 'Conclusion'; in it, the major premise follows the minor one.)

Definition – See 'Concept.'

Derivative study – See 'Study' (Note 2).

*Design** – Concerning a study, the way it is structured; also: the way this structure, with empirical content, is brought about. (Examples: factorial design/structure; and bringing about the factorial structure by means of separate, independent randomizations, together with the way of making observations in this framework.) (See Notes under 'Analysis and synthesis.')

*Determinant** – When one quantity (a rate, say) depends on something else (causally or acausally), the latter is said to be a determinant of the former. (Example: The rate of incidence of a cancer generally depends on the population's distribution by age; that is, age generally is a determinant of the age-specific rate, its magnitude.) (Cf. 'Determinism.')

Note: A binary, 'all-or-none' outcome – the 'all' – is not a quantity, and it thus does not have determinants (while the probability/risk of this does have).

*Determinism** – The philosophical doctrine that every phenomenon of Nature, and every human action and cogitation likewise, is an inevitable consequence of its antecedents.

Note 1: As a story goes, a youngster had just been chided by a parent of his/hers about bad behavior; and (s)he, looking up to the parent, asked: do you think this is genetic, or perhaps only environmental?

Note 2: In these terms, even very serious wrongheadedness in science [33] is not something that the scientists themselves are accountable for.

*Dimension** – An aspect in which an object may be characterized; also: the non-numerical aspect of a dimension in this meaning. (Examples: concerning an illness, the incidence and prevalence dimensions of its occurrence; the inverse-time dimension of an incidence-density of its inceptions; and the dimensionlessness of a rate of its prevalence.)

Discovery – The attainment of a qualitatively new piece of knowledge about Nature, especially if based on a single study (which is exceptional). (Example: Jenner's epochal discovery – and demonstration – of the preventability of smallpox by means of vaccination with matter from blisters of cowpox.)

*Empirical** (antonyms: theoretical, formal) – Concerning a science, or a result of a study, or a belief, the quality of being based on experience – scientific, with its attendant reasoning – rather than on reasoning alone. (Cf. 'Empiricism.')

Empiricism – The epistemological doctrine of 'logical positivists/empiricists,' most notably in the Vienna Circle, who held that, as knowledge is justified only by experience, the truths of science are not necessary but only contingent, and that knowledge could not extend beyond experience [34]. (Cf. 'Nominalism,' 'Realism,' and 'Rationalism.')

*Epistemic** (synonym: epistemological) – See 'Epistemological.'

Epistemological (synonym: epistemic) – Concerning a topic in the theory of a science, the quality of having to do with methods of inquiry (about the abstract), the conceptual approaches in this (as distinct from, notably, instrumentation or other procedural aspects of research). (Cf. 'Ontological.')

Note: This is a proposed adaptation, to science, of the corresponding central concept in philosophy, in which epistemology is the study of knowledge (as to its nature, extent, and justification). (Gr. *epistēmē*, 'knowledge.')

*Epistemology** – See 'Epistemological' (Note).

*Evidence** – Concerning a study in empirical science, the product of it; that is, a study's reported result(s) together with the documented genesis of the result(s) – the genesis being the methodology of the study, as designed and, more importantly, as this design got to be implemented (incl. as a matter of deviations from the design).

Note 1: For more on evidence, see ‘Study’ and ‘Result.’

Note 2: The result’s genesis determines its qualities in respect to its degrees of *validity* and *precision*.

*Experiment** (antonym: non-experimental study) – See ‘Observation and experiment.’

Explanandum (plural: explananda) – Something explained (potentially at least, by an explanans).

Explanans (plural: explanantia) – Something offered, or serving, as an explanation of something else, of an explanandum, that is. (Examples: The occurrence of an illness has its etiogenesis as a partial explanans; and the correct diagnostic probability conditional on a particular diagnostic profile would have the corresponding probability function as an explanans [16].)

Explanation – Concerning something known or presumed to be true, something else, also known or presumed to be true, that serves to remove the mystery in this, partially at least – by bringing the explanandum, to some extent at least, into the realm of the otherwise known. (Example: The known effect of the use of aspirin in reducing the risk of myocardial infarction has an explanation, partial, in the known effect of aspirin in reducing the adhesiveness and, hence, the aggregation of blood platelets.)

*Explanatory** – The quality of serving to provide an explanation, partial at least.

Fact – An objective observation (which presumably would have been agreed upon by all potential, qualified observers; cf. ‘Objective’); also: a well-established piece of knowledge (possibly erroneous; cf. ‘Knowledge’).

Factoid – A semblance of a fact; that is, something that appears to be a fact, or is presented as a fact, but is nevertheless false.

*Factorial design** – Concerning two (or more) co-determinants in a study, design arrangement such that the distribution of one of them is the same at all levels, or in all categories, of the other(s), and conversely.

Finding – Coming, empirically, to an abstract ‘truth’ about Nature, presumptively at least, either ‘finding’ a hypothesis (or a theory’s implication) to be ‘true’ or coming upon an unheralded, more-or-less serendipitous discovery; also: such a ‘truth’ per se. (Examples: based on measurement values for the degree of the bending of the paths of light beams in the gravitational field of the Sun, ‘finding’ an implication of Einstein’s General Theory of Relativity to be ‘true’; and ‘finding’ – discovering – H. Pylori to be the critical agent in the etiogenesis of peptic ulcer; also: the results of these ‘findings.’)

Note 1: A study result per se, without that inferential impact, is not a finding (of something qualitatively new, about Nature, in the abstract). This accords with the concept of finding in medicine (sect. I – 1.2).

Note 2: On a given topic in science there cannot be mutually discrepant findings, only discordance of evidence.

General (synonyms: abstract, abstract-general, universal) – See 'Abstract.'

*Generalization** – Concerning scientific knowledge, its extrapolation: given that something is known for a particular domain (a given gender of humans or a particular species of rodents, say), by inductive inference from experience specifically with this domain, taking this to mean that it thereby is also known or knowable – to some extent at least – for another domain (the other gender of humans or another species, say).

Note: In science one does not generalize from a 'sample' to a 'target population,' nor really from the particularistic to the abstract: the particularistic provides for *inference* about rather than generalization to – much less a conclusion about – the abstract. And as for etiogenetic research in particular, causation in the study experience is not an available fact (for generalization beyond this experience); it, already, would be an object of inference, but the real issue is inference about the abstract in the face of the available evidence. (Cf. 'Inference' and 'Conclusion.')

Genus (plural: genera) – A taxonomic category. (Example: disease as a genus of illness; cf. sect. I – 1. 2.)

Note: Genus is a subcategory of a taxonomic *family*, and a subcategory of a genus is a *species* of it. Example: communicable disease as a species of the genus disease in the family of illness.

Hermeneutics – The art of interpretation (originally of Scripture). (See 'Interpretation.')

*Hypothesis** – An idea in the meaning of a tentative piece of new (abstract) knowledge.

Note 1: A hypothesis – hypo-*thesis* – is more than a mere possibility, while remaining short of the status of knowledge. There is some reason to cautiously entertain the idea (according to those who do).

Note 2: Denial of a hypothesis is not a hypothesis ('null hypothesis'). It is, instead the stance expected of a scientist so long as there is no good reason to believe the hypothesis.

*Induction** (synonym: inductive inference) – The process of reasoning from a given but limited to something more general. (Example: reasoning from evidence – particularistic – to a state of Nature – abstract-general.) (Cf. 'Study,' Notes 3 and 4.)

Note 1: Different from deduction, induction *does not allow conclusion*. Arguably at least, inductive logic is a contradiction-in-terms.

Note 2: Knowledge in an empirical science is inductive and, therefore, fallible/uncertain. It is particularly uncertain in respect to causality, as this is not a phenomenon (but only a noumenon; cf. 'Causality').

*Inference** – Induction and/or deduction. See also 'Generalization,' 'Induction,' 'Result,' and 'Study' (Notes 2 and 4).

*Information** – Fact(s) documented and/or communicated.

Instrumental (synonym: applied) – See 'Applied.'

Interpretation – Concerning an evidentiary report, deciphering the meaning of it – what the evidence actually is (as a basis for inference about the object of study); also: concerning information more generally, deciphering what the information actually is. (Cf. 'Induction' and 'Inference.')

Note: Interpretation has to do with reception of a message. While a research report is a message, scientific evidence in a research report is not a message – from Nature to scientists. For, Nature is secretive rather than communicative about its truths.

*Interval scale** – See 'Scale' (Note 2).

Knowledge – Experts' consensus belief (possibly wrong) as to what an abstract truth is. (Gr. *epistēmē* is knowledge in this abstract-general meaning; cf. 'Gnosis.')

Note 1: From the vantage of an individual, a distinction is to be made between knowing something abstract and knowing *of* something abstract. When knowing something, one can justify one's sharing of the consensus belief of experts; otherwise the belief is but a *received* one, a matter of knowing *of* the consensus belief of experts. (In medicine, doctors generally do not know, e.g., the effects of the medications they prescribe; they only know *of* these.)

Note 2: Scientific knowledge is not the product of research per se. See 'Evidence,' 'Induction,' and Note 3 under 'Study.'

Note 3: Subjective knowledge is a contradiction-in-terms; it is but a subjective belief, rather a generally shared and in this sense an objective belief (which knowledge is).

Law – A formally (mathematically) expressed and well-established pattern of interrelation between phenomena. (Examples: Newton's laws of motion; laws of thermodynamics; and Ohm's law concerning electricity.)

Note: The double-helix structure of the DNA molecule is not a law of Nature, nor is the magnitude of Planck's constant; and while an empirical risk function for an illness is of the form of a law of Nature, it really is but descriptive of experience rather than of Nature in the abstract. Genuine laws of Nature are largely based on theoretical insights, confirmed by evidence.

Lemma – In a proof, a relevant subsidiary statement, taken to be true. (Example: In Note 1 under 'Conclusion' above, the deduction involves two lemmas.)

Lingua franca – A language used (as a medium of communication) among persons of diverse native languages.

Note: The lingua franca of *scientists* used to be Latin; now it is English.

Logic – The "science and art of correct thinking" [1].

Note: A formal distinction is to be made between *formal* and *material* logic (as Aristotle – the father of formal logic [among many other lines of scholarship] – already did). Formal logic is about reasoning per se, with no reference to subject-matter, whereas material logic (as in science) has both elements. *Theory of epidemiological research* – as for its terms and concepts and, especially, its principles – is a genre of material logic. Terms are included in this, as reason ultimately is the judge of what the admissible, tenable terms for the admissible, relevant concepts are.

*Measurement** – Concerning a presumed constant of Nature (the normal core temperature of the human body, say) or some particularistic quantity (a particular person's core temperature at a particular moment, say), a process producing an empirical value serving as an information input to quantification (inferential) of it, to assessment/estimation of the magnitude.

Note 1: In a study, measurement is production of an observation on a quantitative (interval or ratio) scale.

Note 2: Whereas observation on a purely qualitative (nominal) or ordinal (semi-quantitative) scale is not a result of measurement, errors of observation on such scales are not ones of wanting *precision* or wanting *accuracy*. They are, instead, matters of *misclassification*. (Cf. 'Precision and accuracy.')

*Misclassification** – Concerning an observation on a nominal or ordinal scale, classification of it in a category in which it does not belong. (Cf. Note 2 under 'Measurement.')

*Natural experiment** – A study in which the setting (for observations) is similar (or identical) in comparison with what in principle might be experimentally arranged, but this setting is a naturally occurring one rather than the result of selective assembly (as in a quasi-experiment) or artificial arrangement (as in an experiment).

Note 1: The term 'natural experiment' implies that an experiment can occur naturally, that the setting for experimental observations need not be artificial. But that is a contradiction-in-terms. Thus, 'natural experiment' is a self-contradictory term, a misnomer. The corresponding apposite term would be *natural quasi-experiment*.

Note 2: An example of a quasi-experiment in which the setting for observations is *not* naturally occurring is a non-experimental intervention study in medical research, one in which the study subjects with the contrasted interventions are assembled from some source population-time and the interventions are 'natural' in the meaning of not having been artificially arranged for the purpose(s) of the study.

*Natural history** – An archaic term for natural science. (Cf. sect. I – 1. 2.)

Natural quasi-experiment – See Notes under 'Natural experiment' (Note 1).

Natural science (synonym: science) – See 'Science.'

*Negative** – See Note 4 under 'Result.'

Nominalism – The philosophical doctrine that concepts (abstract) and judgments based on these have no objective referent but exist only in names (i.e., in terms and their purported interrelations). (Cf. 'Realism.')

Note: In a discussion with me, very long ago, D.L. Sackett declared himself a nominalist and, thereby, unconcerned with what I view as malformed concepts in medicine. (At issue were a diagnostic test's 'sensitivity' and 'specificity.')

*Nominal scale** – See 'Scale' (Note 1).

*Non-experimental** (synonym: observational; antonym: experimental) – See 'Observation and experiment.' (Notes 1 and 2).

Noumenon – A thing (entity, quality/quantity, relation) that is not subject to sensory perception/observation but is, instead, a 'conception a priori' of the mind (Kant [31]). (Prime example: causation.) (Gr. *noumenon*, 'concept, thought.')

*Objective** – Concerning a purported fact (denotation of a term, or a datum's relation to the corresponding fact/truth, say), the quality of being agreeable by all potential, qualified judges.

Observation – The acquisition of a datum (empirical). See 'Observation and experiment.'

Note: The 'observation' to which a research datum refers need not have been actually observed by the investigators. Thus, in an epidemiological study, a given number of deaths may have been 'observed' without any of the investigators actually having witnessed any of them to take place.

*Observational** (synonym: non-experimental; antonym: experimental) – Concerning a study (empirical), the quality of documenting what occurs naturally – in natural conditions, as distinct from artificial conditions arranged for the purposes of the study. (Cf. 'Observation and experiment.')

Note 1: All experiments (with their artificial arrangements) also are observational in the meaning of involving observations (as does all empirical research). Thus, actually meant by 'observational study' is study that is *purely* observational (i.e., devoid of experimental arrangements/artifacts for the phenomena to take place and to be observed); meant is *non-experimental* study.

Note 2: the observations in a scientific study generally do not take place naturally; artificial arrangements generally need to be made for these (Cf. 'Observation.')

*Observation and experiment** – The two foundations of knowledge in empirical sciences [35].

Note 1: That pair of terms for the conceptual duality, while traditional and still well-established, is less than apposite. The duality really is that constituted by *non-experimental* and experimental studies, both of these being 'observational' in the meaning of accruing observational facts – particularistic, directly or indirectly sensory – for the purpose of learning about something non-particularistic, something general in the meaning of abstract-general. (Cf. Note under 'Observational.')

Note 2: In non-experimental research, phenomena are observed in naturally occurring settings, though selectively and with forethought, and commonly with artificial arrangements for the observations themselves. The first corroboration of the General Theory of Relativity, concerning the bending of the paths of rays of light in a gravitational field, was *non-experimental*, as the light was issued by stars (during the solar eclipse of 1919). By contrast, the epoch-making Michelson-Morley study (in 1881, to study whether all-pervasive, stationary 'ether' actually exists), was *experimental* because the investigators themselves issued the light beams for the purposes of the study (to learn whether their speeds depend on their directions relative to the direction of the Earth's movement in space).

Note 3: Research on a diagnostic probability function is not experimental on the basis that artificial arrangements need to be made to observe – determine – the fact about the presence/absence of the illness at issue (cf. Note 1 above). But it is experimental if some of the diagnostic indicators are based on artificial arrangements for the study – experimental (rather than practice-based) radiography, for example.

*Occam's razor** – See 'Ockham's razor.'

Ockham's razor (synonyms: Occam's razor, principle of parsimony) – The ontological principle (ascribed to William of Ockham, not Occam) that the adopted set of concepts should be kept to the minimum necessary.

Note: Analogously, the *terms* denoting an adopted concept should be kept to the minimum necessary (commonly only one in any given language).

Ontal/ontic (synonym: ontological) – See 'Ontological.'

Ontological – Concerning a topic in the theory of science, the quality of having to do with the nature of the objects of inquiry and of the corresponding knowledge (about the abstract), especially as to their admissibility into the status of being legitimate objects of scientific inquiry and knowledge. (Example: The broadest and most fundamental ontic question for the development of the knowledge-base for scientific clinical medicine is about the generic nature – the form – of this knowledge; and the answer is: gnostic probability functions [16].) (Cf. 'Epistemological.')

Note: This is an adaptation, to science, of the corresponding central concept in philosophy, in which ontology is the study of the nature of being.

*Ontology** – See 'Ontological' (Note).

*Ordinal scale** – See ‘Scale’ (Note 1).

Original study – See ‘Study’ (Note 2).

Parsimony – In ontology, admitting only the minimum necessary set of concepts. (Cf. ‘Ockham’s razor.’) (L. *parsus*, ‘to spare.’)

Note: Parsimony as a general virtue in science is distinct from a related other virtue: *simplicity* – giving preference to the simplest formulation or explanation among otherwise interchangeable ones. (Prime example: preference for the Keplerian astronomy over Ptolemy’s.)

Phenomenon – A thing (entity, quality, relation) subject to sensory perception/observation (indirectly at least). (Examples: a genotype, an illness, a tumor’s doubling time, and the prevalence of a state of health.) (Cf. ‘Noumenon.’)

Positive – See ‘Positive study’ in section II – 4.

Precision and accuracy** – Concerning measurement (for assessment of the magnitude of a parameter of Nature), the respective referent concepts of these terms are [36]:

Precision (synonym: reproducibility) – The degree of agreement among a set of observations – results of measurement of a parameter of Nature – after all known sources of error are accounted for.

Accuracy – The degree of agreement between the precise measure and the corresponding true magnitude (unknown).

Note 1: These definitions emerged following the publication of the method of least squares by C.F. Gauss in 1809 and 1823, and they’ve remained rather stable ever since [36].

Note 2: ‘The precise measure’ can be the one from an infinite number of hypothetical replications of a study. Accuracy in this meaning is freedom from *bias*.

Note 3: The prevailing terminology in epidemiology is at variance with this; see ‘Accuracy,’ ‘Precision,’ and ‘Validity’ in section II – 4.

Presumption – A predicate judged to be true. (Cf. ‘Assumption.’)

Note: In statistical science, statistical models represent presumptions, not assumptions.

Principle – Concerning a line of research (epidemiological or meta-epidemiological clinical, say), a dictate of logic (about correct thinking, especially in the designs of the objects and methods of study, but in the inferences also).

Principle of parsimony (synonym: Occam’s/Ockham’s razor) – See ‘Ockham’s razor.’

Proof – Concerning a proposition or a thesis, incontrovertible demonstration of its correctness.

Note: It has become quite generally agreed that proofs are unattainable in empirical sciences [37]. Their justified place is only in theoretical/formal sciences, in which ideas generally are subject proof as to truth/untruth, on the basis of reasoning alone. (Cf. 'Conclusion' and 'Lemma.')

Proposition – A statement expressing a tentative judgment, put forward for critical consideration by others.

Pure (antonym: applied) – Concerning a science, or a region within a science, the quality of the inquiries in it not being intended to be of any practical consequence. (Cf. 'Applied.')

*Quasi-experiment** – A study (scientific, empirical) in which the setting for observations is similar or identical in comparison with what might be experimentally arranged, but the setting actually is a non-experimental one – naturally occurring (cf. 'Natural experiment') or the result of selective assembly of the observables. As the term implies, quasi-experiment is like an experiment without actually being one (as for the genesis of the setting for the observations).

*Ratio scale** – See 'Scale' (Note 2).

Rationalism – The epistemological doctrine according to which at least some knowledge about Nature is justifiable without reference to experience [34]. (Cf. 'Empiricism.')

Note: To a rationalist, genuine knowledge (abstract) about Nature is not necessarily 'evidence-based.' (Cf. 'Thought experiment.')

Realism – The philosophical doctrine (opposite of nominalism) that the abstract – its concepts and the relations of these – is more real than the phenomenal (sensory) counterpart(s) of the abstract. (Cf. 'Nominalism.')

Note: Plato and Aristotle were realists; and realism is, implicitly, the philosophical basis for a dictionary (such as this one) on terms and *concepts* of a line of research.

Received knowledge – See Note 1 under 'Knowledge.'

*Replication** – Concerning a study, its repetition in the same way (apart from place and time, and study efficiency and size, perhaps) on the same object (scientific, inherently unchanging from a study to its repetition).

Note: Replication need not – and commonly does not – reproduce the previous result(s). It is the (at least potential) irreproducibility of a result that justifies – and commonly calls for – replication of an initial study on the object of study.

*Reproducibility** (synonym: precision) – See 'Precision and accuracy.'

*Research** – In natural science, inquiry into an abstract truth about Nature, specifically the studies on a given object of inquiry in the aggregate, as a whole. (Cf. 'Study.')

Note: Given the abstract nature of the objects of scientific inquiries (with some exceptions; see sect. I – 2. 1), any given object of scientific inquiry can be – and commonly needs to be – studied repeatedly (and as a practical matter, in different places at different times) – as *re*-search, *replicating* previous studies on it. (See 'Replication.')

Result – Concerning a piece of research, an/the essential datum – empirical counterpart of something theoretical that is descriptive of Nature – produced by it. (Example: the results on – the empirical values for – for the speed of light obtained in the epochal Michelson-Morley experiment.)

Note 1: Result of a piece of research in this meaning is analogous to any result produced by a diagnostic test/'study' (inquiry into the health of a patient): it is the *object-descriptive datum*, however imprecise and/or biased. A measure of imprecision (the datum's standard error, say) is not descriptive of the object of study (but, instead, of the study on the object of study).

Note 2: There are *no results on causality/effects*, as causation is not a phenomenon (subject to documentation in data). In research on causality the aim is to produce a result – inherently descriptive – for use in inference about causality.

*Scale** – Concerning a particular dimension of an object per se or of observations on it (temperature or gender, say), the terms of specifying its possible realizations (e.g., the Celcius scale, or the Kelvin scale, for temperature; and the male-female duality for gender).

Note 1: Among non-quantitative scales, a distinction is made between *nominal** and *ordinal** scales. The categories of a (strictly) nominal scale (that of gender, say) have no intrinsic ordering, different from the categories of an ordinal scale (that constituted by the successive stages in the pathogenesis, or progression, of a cancer, or the categories of severity for cases of a congenital heart-defect, say). An ordinal scale can be thought of as being semi-quantitative.

Note 2: Among quantitative scales, a distinction is made between *interval** and *ratio** scales. An interval scale has an arbitrary point for zero units (as has, e.g., the Celsius scale for temperature), whereas a ratio scale is one in which zero units coincides with nothingness as the magnitude of the object of the quantification (as is the case with the Kelvin scale for temperature: 0 °K is the temperature in which all molecules are completely motionless). An interval scale admits statements about differences between values (e.g., that 27 °C is 27 °C higher than 0 °C) but not about ratios of values (e.g., that 27 °C is an infinite multiple of 0 °C). By contrast, a ratio scale does admit ratio statements as well (e.g., that 300 °K [27 °C] is 10% higher than 273 °K [0 °C]).

*Science** (synonym here: natural science) – Inquiry (by research and induction based on its results) into abstract truths about Nature; also: the knowledge (abstract) about Nature derived by the inquiry.

Note: More on the essence of science sect. I – 2. 1, in Part II and Part III, and here under ‘Study,’ ‘Result,’ and ‘Induction.’

*Serendipitous** – Concerning a discovery, the quality of having been achieved without a designed, methodical inquiry; that is, achieved by the application of acute intellection to an incidental observation. (Examples: discoveries of X-rays and penicillin.)

Simplicity – See Note under ‘Parsimony.’

Study – A piece of research; that is, a project to produce evidence (for inductive judgments) about the abstract truth (unknown) at issue. (See ‘Evidence,’ ‘Result,’ and ‘Induction.’)

Note 1: Inductive inference from the evidence produced by any given study may not be a proper concern in the context of the very first study on a given object of study. In this context the need may be for replication of the study before any inference (inductive) about the state of Nature.

Note 2: Once the first study on a given object of research has been replicated by at least one other *original* study, the aggregate of available evidence – in statistical science, notably – generally is to be subjected to a *derivative* study, in which the evidence from all of the original studies is synthesized (critically).

Note 3: In the face of the available entirety of evidence (commonly from derivative research), the need is for the translation of the evidence – through induction – into (updated) belief about the object of study. This is a task for members of the relevant *scientific community*, not for the researchers involved in the production of the evidence. (Those investigators are biased on the topic at issue, having a vested interest.)

Note 4: While science translates evidence into knowledge (Note 3 above), science does not translate knowledge into (knowledge-based) choice of *action*. “Science never tells a man how he should act; it merely shows how a man must act if he wants to attain definite ends” [38]. “The role of a scientist is not to determine which risks are worth taking, or deciding what choices we should take, but . . . to determine what the possibilities are” [39].

Syllogism – Statement of a deduction (of a conclusion from its premises).

Synthesis – See ‘Analysis and synthesis.’

*Taxonomy** – A system of classification. (Gr. *taxis*, ‘arrangement, order.’) (See ‘Genus,’ and also ‘Nosology’ in sect. I – 1.2.)

Test – Concerning a hypothesis, a study intended to provide evidence that either supports or takes away from the hypothesis; that is, either increases (by being positive) or decreases (by being negative) the credibility/plausibility of the hypothesis. (Cf. ‘Positive’ and ‘Negative.’)

Note: When the hypothesis implies the entire range of non-null values of the parameter being studied ('semi-infinite' in one direction, as is common in epidemiological research on etiogenesis of illness), a test result that is quite imprecise may be neither positive nor negative; the study may be quite uninformative, a failure except as a small contribution to a later derivative study.

Theorem – An idea that is demonstrably correct; that is, a proposition proven to be true. (Examples: Bayes' theorem and Central Limit Theorem, in probability theory and statistics, respectively.)

Note: There are no theorems in empirical science, only in theoretical/formal science. (Cf. 'Proof.')

Theoretical (antonym: empirical) – Concerning a science, the quality of its knowledge inherently being solely reasoning-based (as is true, most notably, of mathematics); also: concerning the magnitude of a quantity of Nature, its true but unknown value (as distinct from any empirical counterpart of this).

Theory – A grand and quite well supported thesis (no longer a mere hypothesis on its grand scale, but not yet knowledge either). (Examples: Darwin's idea about the evolution of species, and Einstein's general relativity, were theories rather than established truths before their general acceptances by the respective scientific communities.)

Thesis – A relatively forceful proposition, one that is advanced with considerable seriousness (as to belief in its correctness).

Thought experiment (synonym: Kantian experiment) – Imaginary experiment, to support/justify (or refute) an idea.

Note: Thought experiments were eminent in Einstein's physics.

Truth – In empirical science, the actual (hidden) way Nature is in a particular respect (this 'state of Nature' constituting an object of scientific inquiry).

Universal (synonyms: abstract, general, abstract-general) – See 'Abstract.'