UCC Law Journal. Volume 2 Issue 2 Dec. 2022, pp. 13-40
DOI: 10.47963/ucclj.v2i2.1117

THE BEARING OF SCIENTIFIC DATA ON LEGAL REASONING

Kwadwo Addo Tuffour[1]

ABSTRACT

Legal reasoning and its associated dialectical features generally provide the dimensions and contours for the jurisprudence that govern international, municipal as well as verdicts reached by the courts. Policy makers, international organisations together with the legal systems of various countries take a number of decisions on both the drafting and the conclusion of agreements based on multiple factors. One of these important factors to be taken into consideration is the impact of these agreements, conventions and decisions on humanity in general. Will it affect the security of mankind, will it have effect on the ecosystem-both flora and fauna, biodiversity, climate change and a host of others. With modern advancements in science and technology, scientific assessments have also become one of the biggest considerations on agreements as well as verdicts reached by courts. Studies abounds that reinforce the evidence that "scientific data has a huge bearing on legal reasoning." The first section of the paper looks at the parameters between the law and science. The next examines the theoretical conceptions of the scientific process followed by the explanation of key concepts. Philosophical analysis of the concept of reasoning together with its foundational principles are also discussed. Finally, the paper highlights the synergy between scientific data and legal reasoning. The socio-legal methodology is used to undertake a contextual analysis of some international agreements and their implications, as well as the jurisprudence reached by some courts with the aid of scientific knowledge. Conclusion is then drawn based on the discussion.

Keywords: Scientific data, Legal reasoning, International agreements, Courts, Jurisprudence

INTRODUCTION

In general, law is seen as 'a method of regulating social action, and the science of law has a content over and above that met in the knowledge of actual conditions.'[2] The parameters of 'legal and scientific reasoning' was developed and deliberately elevated by, a former Harvard Law School dean, Christopher Columbus Langdell from 1870 to

[1] Department of Peace Studies, University of Cape Coast, kaddotuffour@ucc.edu.gh
[2] S Brewer, *Scientific Models of Legal Reasoning: Economics, Artificial Intelligence, and the Physical Sciences* (Routledge 2011).

1895.[3] Langdell in his efforts to posit 'law as a profession rather than a trade,' stressed the idea that the study of law 'is a science and that the law faculty, like the faculties of the sciences, is a body of permanent scholars devoted to legal research.'[4] Wigmore[5] has also opined that, there is "a science of proof underlying legal reasoning." The author further emphasised that, the science of proof was one that was inductive.[6] He again intimated that, 'the science of proof underlying **legal reasoning** is manifestly different from that of deductive logic.'[7]

Kantorowicz[8] in addition distinguished between 'empirical science and normative science.' Smits[9] has also noted as follows:

> 'If legal science were an empirical science, its chief method would be explanation through cause and effect. If it were a rational and normative science, its chief category would be justification through reason and consequence.

A legal practitioner or academic is permitted to use "extralegal" materials to resolve legal issues that crop up if only some valid processes are adhered to.[10] Cottorrell[11] has described 'law's nature as follows:

> When law borrows from scientific disciplines or practices it appears to do so as it sees fit, taking what it deems useful, on its own conditions, for its own purposes. Concepts borrowed are often transformed, turned into 'hybrid artefacts' and tailored to legal use.

Sidharta[12]in his book "Hukum Penalaran dan Penalaran Hukum" has stated that, there is a distinction between the "concept of law of reason and legal reasoning." Here he

---

[3] MR Cohen, Law and scientific method. Address delivered at the twenty fifth Annual Meeting of the Association of American law schools (December 29 1927).
[4] Ibid.
[5] JH Wigmore, Jottings on comparative legal ideas and institutions, 6 1 *Tulane Law Review* (1931-1932*)* 48-82.
[6] Ibid.
[7] G Sartor, *Legal reasoning*: *A treatise of legal philosophy and general jurisprudence* (Springer 2005).
[8] H Kantorowicz, Some rationalism about realism *The Yale Law Journal*, *43* 8 (1934) 1248-1249.
[9] Smits, Legal reasoning and argumentation (2014) 81.
[10] D Canter, In the Kingdom of the blind, in D Canter and R Žukauskienė (eds.) *Psychology and Law: Bridging the Gap* (2008) 1-4.
[11] R Cottorell, Why must legal ideas be interpreted sociologically?' *Journal of Law and Society* (1998).
[12] BA Sidharta, *Refleksi tentang struktur ilmu hukum: sebuah penelitian tentang fundasi kefilsafatan dan sifat keilmuan ilmu*, Mandar Maju (2009).

places legal reasoning in the work of science groups that have scientific characteristics so that it is identified as science. In the view of Brewer:[13]

> … judges 'begins where the scientist ends, with a specific situation in which the outcome must be decided - not predicted and tested but decided by examining the similarities and differences between this new case and the previous cases and choosing an outcome that corresponds to the holdings of the cases it most resembles.

Aminudin et al.[14]have emphasised that, 'judicial theory and theories in the philosophy of science' has made it possible to develop a structure that manifests the synergy between law and science in the judicial process, and the significant role of science in complementing the objectives and functions of law. The use of scientific evidence in the judicial process highlights the nexus between the law and the sciences.[15] Scientific evidence assists greatly to enable a researcher either disclaim or affirm a hypothesis.[16] In the legal sense, scientific evidence is one that is presented in court which flows directly from scientific tests or studies. Scientific evidence could be a fact or opinion evidence that is generally drawn from 'specialised knowledge of science or relies on scientific principles in its evolution.'[17] Scientific evidence here, aids the court to either understand the evidence or determine the facts of a legal problem disputed by the parties.[18]

The scientific method encapsulate norms and practices that are involved in experiments to test a concept, results observation to which inferences could be made and then testing those inferences with further experimentation.[19] Consequently, for purposes of establishing the truth relative to the legal process, the law always go behind science sluggishly, since results from scientific experiments have to be firmly grounded (even if not universally accepted) before they can be accepted within the judicial process.[20] This stems from concerns of 'due process and fundamental fairness.' The standards set by the scientific community provides the threshold for integrity and reliability which

---

[13] Brewer (n 2).
[14] Aminudin C, Fakhriah EL, Nurlinda I and Ikhwansyah I, Role of scientific evidence in the adjudication of dispute for restoration of burned forest and land, In *E3S Web of Conferences* (2020).
[15] Ibid.
[16] Ibid.
[17] BA Garner, Black's law dictionary (St. Paul MN: West Group 1999) 1276.
[18] Ibid.
[19] HBM McCormack, Scientific evidence *Science Bench Book for Judges 13* 14 (2019) 1-118.
[20] Ibid.

becomes the basis for determining the admissibility of materials as evidence before the court.[21]I will now proceed to explain some key concepts that will be of importance in the paper.

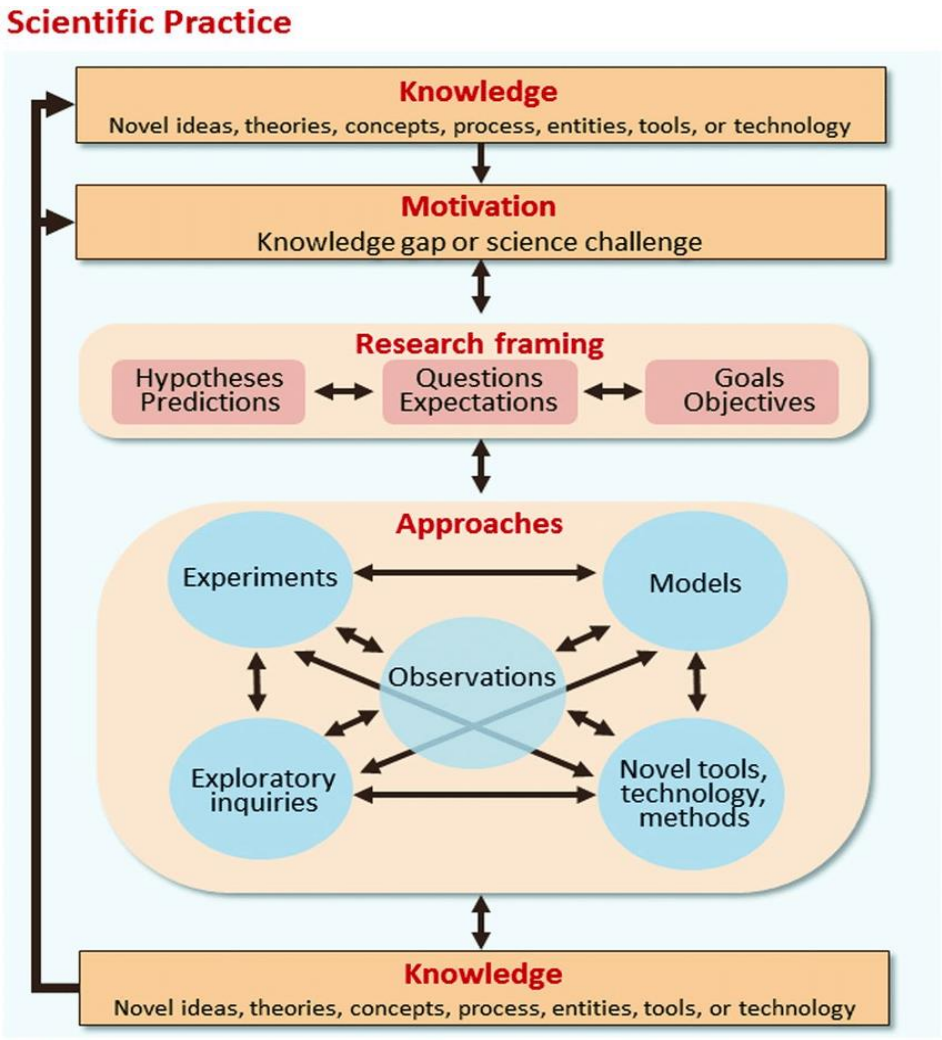
THEORETICAL CONCEPTIONS OF THE SCIENTIFIC PROCESS

Scientific is anything based on or characterised by the methods and principles of science.[22]It is technical, research-based, knowledge – based and empirical. The Black's Law Dictionary,[23] define "scientific method" as 'the process of generating hypotheses and testing them through experimentation, publication and replication.' In the decided case of *Daubert v Merrell Dow Pharm*[24] the US Supreme Court defined scientific as "Grounded in the methods and procedures of science." Overall, Scientists agree that:

> '…knowledge is produced through a series of steps during which data are accumulated methodologically, strengths and weaknesses of information are assessed and knowledge about causal relationship are inferred, hypotheses developed and measured against data and either supported or refuted.'[25]

[21] Ibid.
[22] Oxford Paperback Thesaurus Dictionary (OUP 2006).
[23] B Garner, *Black's Law Dictionary* (Thomas Reuters USA 10th Edition 2014)
[24] 509 US 579, 590 (1993).
[25] Garner (n 22).

Figure 1: Depicts the conceptions of 'Good Science'.



Source: KC Elliott, Kendra SC, Georgina MM and Soranno PA.[26]

MEANING OF DATA

What also constitute data? Data is facts and statistics collected together for reference or analysis.[27]The Oxford Thesaurus Dictionary,[28] also sees data as:

[26] Conceptions of the scientific process (ResearchGate 2016) Accessed on 12/06/22 at 8am.
[27] Oxford Languages (2022).
[28] Oxford Paperback Thesaurus (n 21).

> facts, figures, statistics, details, particulars, specifics, information, intelligence, material and input. Data are individual facts, statistics, or items of information, often numeric. In a more technical sense, data are a set of values of qualitative or quantitative variables about one or more persons or objects, while a datum is a single value of a single variable.

According to Hicks as quoted by Holwell (1998),[29] data is "a representation of facts, concepts or instructions in a formalised manner suitable for communication, interpretation or processing by humans or by automatic means." Nobel Price laureate, Joshua Lederberg[30] during a testimony before a US congressional committee that was deliberating on the promulgation of a new legislation on a database security bill stated as follows:

> Data are the building blocks of knowledge and the seeds of discovery. They challenge us to develop new concepts, theories, and models to make sense of the patterns we see in them. They provide the quantitative basis for testing and confirming theories and for translating new discoveries into useful applications for the benefit of society. They are also the foundation of sensible public policy in our democracy. The assembled record of scientific data and resulting information is both a history of events in the natural world and a record of human accomplishment.

This piece by Lederberg depicts the worth and significance of scientific data in our contemporary world. What then is scientific data?

EXPLAINING WHAT CONSTITUTES SCIENTIFIC DATA

Scientific data is information that is based on research undertaken by scientific scholars which are published in a peer-reviewed journal.[31]Scientific data also means:

> earth system science products, with accompanying metadata and quality assessments, made available through production or services provided by the project. Some examples of scientific data include geophysical parameters, such as sea surface temperature, sea surface height, atmospheric

[29] Hicks as quoted by Holwell (1998).
[30] Joshua Lederberg, Collections of Information on Antipiracy Act (March 18 1999).
[31] Law Insider Dictionary (2022).

> pressure/temperature levels, precipitation, atmospheric chemical species and aerosols ice sheet mass balance, and various terrestrial surface measurements.[32]

Moreover, scientific data include materials collected by scientists or scientific instruments in the cause of conducting experiments or during observations. Typical examples include 'astronomical information captured by telescopes, data from patients in healthcare centres as well as laboratory data collected by lab technicians and technologists.[33] Scientific Data develop from a rigorous 'peer-review processes' that conducts assessments and evaluate the quality of experiments conducted to develop the data and its completeness.[34] According to the National Research Council,[35] data are "facts, numbers, letters and symbols that describe an object, idea, condition, situation, or other factors." Scientific data is again seen 'as material artifacts that are collected and used as empirical evidence for the plausibility of claims about the nature of reality.'[36]

Defining the Concept Legal

The Black's Law Dictionary[37] define legal as 'relating to law or involving law generally, falling within the province of law, established or permitted by law.'The Oxford Thesaurus Dictionary [38]explain legal as:

> lawful, legitimate, licit, within the law, legalised, valid, permissible, permitted, allowable, allowed, above board, admissible, acceptable, authorised, sanctioned, licensed as well as being constitutional.

Knowing what is legal, will serve as the 'litmus test' to help us understand whether the use of scientific assessments as well as other relevant matters that are taken into consideration in the promulgation of agreements or drawing conclusions before the law courts are valid or permissible.

---

[32] Law Insider Dictionary (n 30).
[33] Chen et al., Inflammatory responses and inflammation associated diseases in organs (Oncotarget 2018).
[34]Nguyen et al.,Vindr-cxr: An open dataset of chest x-rays with radiologists annotations (Springer Nature 2022).
[35] National Research Council, A question of balance: Private rights and the public interest in scientific and technical databases (1999). Also see Yin et al. on rights and belief.
[36] S Leonelli, Why the current insistence on open access to scientific data? Big data, knowledge production and the political economy of contemporary biology *Bulletin of Science, Technology & Society* 33 1 2 (Sage 2013) 6–11.
[37] The Black's law dictionary (n 22).
[38] Oxford Paperback Thesaurus (n 21).

PHILOSOPHICAL ANALYSIS OF THE CONCEPT OF REASONING

Reasoning is the process where inferences or conclusions are drawn through a 'logical' process according to the Black's Law Dictionary.[39] Reasoning again, is seen as ideas and opinions that are based on logical thinking. Moreover, reasoning also connotes thinking, reason, thought, thought processes, logic, analysis, interpretation, explanation, rationalisation and rationale arguments. Gilbert Harman,[40] who belongs to the "internalists' school see 'reasoning as a mental, psychological or internal process," "a procedure for changing one's view." On the other hand, 'externalists' like Jim Mackenzie[41] also see reasoning as processes involved in the semantic dialogue that appears to be more sociological than psychological.

According to Walton,[42] reasoning connotes the myriad of processes that are involved from the beginning where 'reasoners' attend to important information (linguistic or perceptual) to draw one or more inferences contingent on the information available**.** In the view of Khemlani,[43] 'reasoning is a mental process that draws conclusions from the information available in a set of observations or premises.' In the Dictionary of Philosophy, Peter Angeles[44] defines reasoning in three ways. The first is about the process of making inferences from conclusions from statements. The second involves the application of logic and/or abstract thought patterns in the solution of problems or the act of planning, while the third connotes the ability to know certain things without 'recourse directly to sense perceptions' or what is being experienced immediately.

Aristotle gave recognition to two distinct kinds of inferences, that is deduction, which is derived through 'syllogistic reasoning' and induction, based on an inference "from the particular to the universal."[45]Khemlani[46] has again intimated that reasoning 'concerns the cognitive processes' which enable one to make inferences from vital, intelligible pieces of information that they understand. Consistent with logical patterns of reasoning, as compared to the psychological viewpoint, 'reasoning may be defined as a series of steps of inference in which some propositions are inferred from others.'[47] Reasoning may be seen as a chain as captured in fig. 2 where hypotheses are put in

[39] The Black's Law dictionary (n 22).

[40] G Harman, Logic and reasoning, In *Foundations: logic, language, and mathematics* (Springer Dordrecht 1984) 107-127

[41] J Mackenzie, Factors affecting repeated cessations of injecting drug use and relapses during the entire injecting career among the Edinburgh addiction cohort (Elsevier 2015).

[42] DN Walton, The new dialectic: Conversational contexts of argument (University of Toronto Press 1998).

[43] SS Khemlani, Reasoning, In *Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience, Language and Thought 3* (2018) 385.

[44] P Angeles, *A dictionary of philosophy* (Philbooks 1981).

[45] Khemlani (n 41).

[46] Ibid.

[47]DN Walton, What is reasoning? What is an argument? *The journal of Philosophy*, *87* 8 (1990) 404.

text boxes.[48] In this model, a rule applied qualifies to be applied to another similar one until a decision is arrived at which becomes a rule of law.

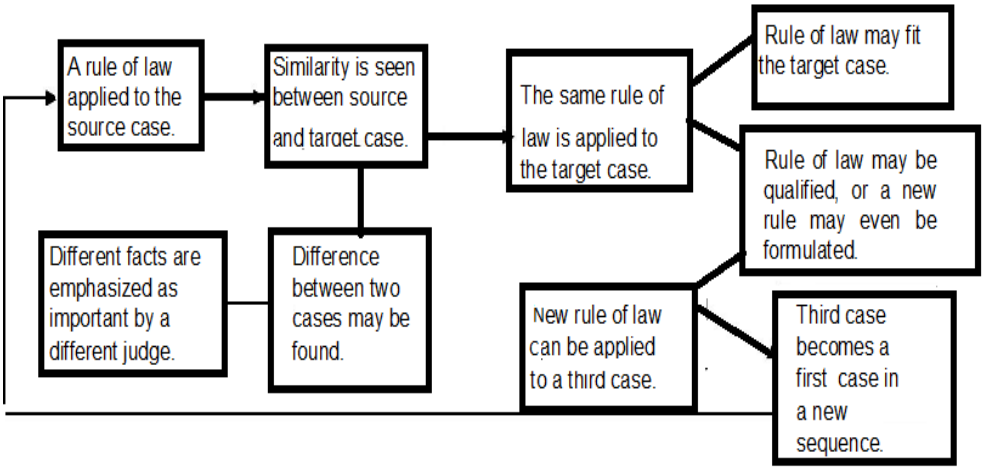


Fig. 2: Sequence of case-based similarity reasoning (Walton)[49]

According to the author, reasoning can have a multiplicity of points where it starts (premises), but in all the inference drawn invariably leads to a single conclusion. legal reasoning develops usually from inferences made in arguments. Further, reasoning from a precedent - rests on foundational principles based on decisions reached in earlier cases.[50] From this model, rules continue to be modified as it is applied to a series of cases over time.

FUNDAMENTAL PRINCIPLES THAT UNDERPIN LEGAL REASONING

Simon[51]has suggested that there is no acceptable consensus by scholars on what constitute legal reasoning. Legal reasoning can be defined as 'legal expression or justification that explain laws and other related subjects.'[52] Viewed from another angle, legal reasoning is a thought process that is associated with lawyers and judges, who in their day-to-day work seek the application of legal rules to apply to specific factual

[48] J Walton, Legal reasoning and argumentation *ResearchGate* (University of Windsor July 2018).
[49] Walton (n 46).
[50] Ibid.
[51] D Simon, A psychological model of judicial decision making (HeineOnline 1998).
[52] The Black's law dictionary (n 22).

patterns to reach decisions that are enforceable. According to Ellsworth[53] legal scholars have the strong hope that:

> …legal reasoning is distinctive, that it is not the same as logic, or scientific reasoning, or ordinary decision making, and there have been dozens of attempts to describe what it is that sets it apart from these other forms of thinking. These attempts generate criticism, the critics devise new formulations that generate further criticism, and the process continues.

The reasoning process relative to the law starts when a legal issue crops up and has to be dealt with by a lawyer.[54] Legal reasoning can be viewed as a rational process where judges as well legal practitioners use acceptable norms (statutes or regulations) and precedents to resolve legal problems. The two forms of reasoning which are usually adopted in litigation are reasoning by deduction and reasoning by analogy.[55] Burton[56] sees legal reasoning as more than 'deduction' whereby lawyers rely on 'annotations and key materials such as reports, practising guides, precedents and textbooks to help add some contextual information to legal rules.' Vossos et al.[57] sees legal reasoning as "an attempt to interpret statutes initially through the use of the rules, referencing precedent cases only when the 'rules run out, or when the use of rules prove insufficient in eliciting concepts."

Wahlgren[58] has again emphasised that writings on the study of legal reasoning are often part of general discussions on the nature of law. Further, legal reasoning is used as a collective term for a number of rational processes that leads to a legal decision.[59] Legal reasoning is a crucial task since reasons that are formulated and choices that are made during the process are used as arguments either in favour of a decision[60]or in the decline of a decision. Poor legal reasoning and shallow analysis, on the other hand, can

---

[53]PC Ellsworth, Legal reasoning (University of Michigan 2005). Available at https://repository.law.umich.edu/cgi/viewcontent.cgi?article=1050&context=book_chapters accessed on 19/08/2022.

[54] P Wahlgren, Legal reasoning-a jurisprudential description. In *Proceedings of the 2nd international conference on Artificial intelligence and law* (1989) 147-156.

[55] EH Levi, An introduction to legal reasoning (University of Chicago Press 2013).

[56] SJ Burton, Reaffirming legal reasoning: The challenge from left *Journal of Legal Education* (1985).

[57] G Vossos, Zeleznikow J, Dillon T and Vossos V, An example of integrating legal case based reasoning with object-oriented rule-based systems: IKBALS II. In *Proceedings of the 3rd international conference on Artificial intelligence and law* (May 1991) 31-41.

[58] Wahlgren (n 53).

[59] Ibid.

[60] Ibid.

lead to poor arguments and result in legal decisions of low quality.[61] A legal reasoning process may also be very comprehensive and drawn out. It may also engage several individuals.[62] Antoniou[63] sees Legal reasoning as follows:

> ….is a complex reasoning task, as illustrated by the abovementioned approaches, with applicability depending on the volume of data. Related work on large scale semantic reasoning includes several approaches applied on different logic formalisms, often restricting expressiveness in order to increase performance.

According to Wahlgren[64]legal decisions are the result of the legal reasoning processes, and they may be more or less explicit. Legal decisions may be for instance visible in that, they have a direct effect due to formal reasons. The mechanisms involved sometimes may focus on the event that has initiated the issue under discussion and concerns 'situation-identification, interpretation and fact evaluation.'[65]The process also involves continuous assessment of possible decisions and institutionalisation of various activities. Legal reasoning is most often neglected in works of analytical jurisprudence, but as emphasised in the writings of Benjamin Cardozo:[66]

> Of the cases that come before the court in which I sit, a majority, I think, could not, with semblance of reason, be decided in any way but one. The law and its application alike are plain. Such cases are predestined, so to speak, to affirmance without opinion.

In legal reasoning, policy arguments usually justify a particular decision taken as the one that will lead to the state of affairs that is desirable.[67]It most often depends on available data, information and facts that exist in compiling and building what the outcome is.[68]The expected reasons assist to consolidate the law both in theory and practice through its unique characteristics. In addition, legal reasoning leads to

---

[61] Ibid
[62] Ibid
[63] G Antoniou, Baryannis G, Batsakis S, Governatori G, Robaldo L, Siragusa G and Tachmazidis I, *Legal reasoning and big data: Opportunities and challenges* (2018).
[64] Wahlgren (n 53).
[65] Ibid.
[66] BN Cardozo, *The Nature of the Judicial Process* (1921) 164.
[67] N MacCormick, *Legal reasoning and legal theory* (Clarendon Press 1994) 263.
[68] JN Pardede and PA Poluakan, Law and truth: Critical construction as an ideal legal reasoning method on Indonesia's post-truth era society *Volksgeist -Jurnal Iimu Hakum* (2021).

consistency in the rule of law and legal decisions.[69]Embedded in legal reasoning is dialectical reasoning, where opposing and conflicting claims are weighed in the debate on legal formation, which invariably is about the consideration of the views and facts advanced by parties in the judicial process or in negotiating an agreement.[70]

Sidharta[71] has explained that there are six main steps in legal reasoning. The first is about the identification of facts which will lead to the production of a framework of cases that the judge really believes is the real reason. Secondly, the case structure must relate to relevant legal sources, to enable one arrive at the legal actions to be taken. The third also involves the selection of relevant legal sources and rules to bring out the policies in the rules, which ostensibly will produce a framework that is well standardised.[72] Fourthly, the standardised rule is then linked to the case. The fifth emphasise possible alternatives in resolving the issue on hand, while the last, but not the least, is about coming out with other alternatives to figure out the final decision to be formulated.[73]

Regardless of the legal system applied, legal reasoning at its core is about the process of argumentation, where parties opposed to each other attempt to make convincing arguments as to why their interpretation should be taken.[74] Legal reasoning moreover transcends the 'literal meaning of rules' to include the use of 'precedents, principles, policy and purpose' and how documents are constructed to providing arguments on why the opposing sides argument may be flawed.[75] Legal reasoning could be the integration of data coming from disparate sources including the sciences. In *Lupton v FA and AB Ltd*[76]Lord Simon, a law lord in the United Kingdom defined legal reasoning as follows:

> 'A judicial decision will often be reached by a process of reasoning which can be reduced into a sort of complex syllogism, with the major premise consisting of a pre-existing rule of law (either statutory or judge-made) and with the minor premise consisting of the material facts of the case under immediate consideration. The conclusion is the decision of the case, which may or may not establish new law – in the

[69] MacCormick (n 66) 263.
[70] Pardede and Poluakan (n 67).
[71] Sidharta (n 11).
[72] Sidharta (n 11).
[73] Ibid.
[74] Robaldo et al. Large-Scale legal reasoning with rules and databases *Journal of Applied Logics and their Applications* 8 4 (2021).
[75] Ibid.
[76] [1972] AC 634 at 658–659.

> vast majority of cases it will merely be the application of existing law to the facts judicially ascertained.'

This means, legal reasoning is 'a form of reasoning which is not empirical' in its fundamental structure on the valid premise that it is not based on 'observation but on propositions' ('laws' or 'axioms') from information already sourced or posited.[77] Raz[78] has opined that 'to establish the law we engage in factual reasoning.' He again emphasised that:

> There is no denying that legal reasoning is predominantly interpretive.' It consists in discovering the meaning of the law's constituents, through retrieving and disclosing attributes that have always characterised them. Notably, interpretations explain and do not change their objects, nor do they produce new objects which explain themselves.

Thus, the term "legal reasoning" refers to reasoning by a group of people who are involved in the legal system and it is about what that group subset reason about.[79]

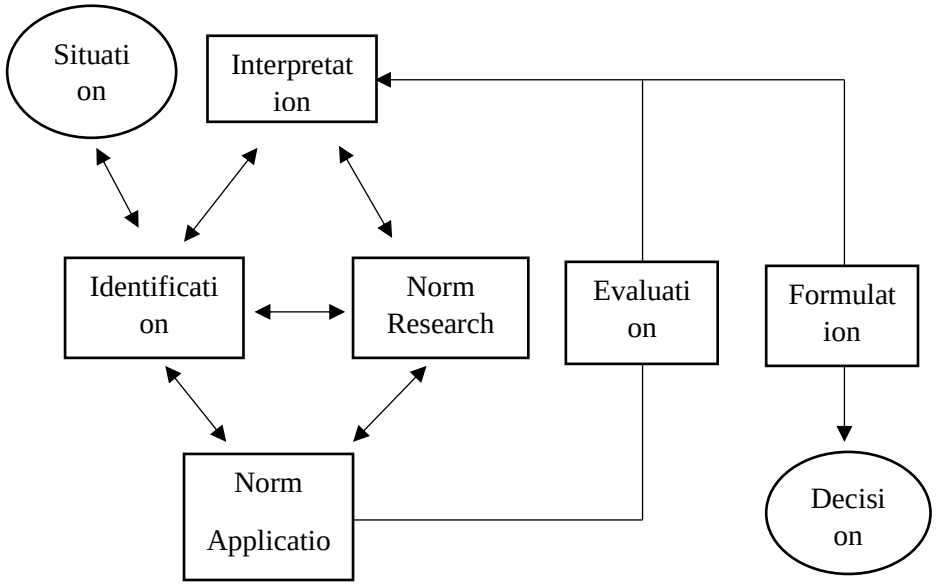
THEORIES AND PHILOSOPHICAL ANALYSIS OF LEGAL REASONING

"Legal reasoning" is considered to be a distinctive form of reasoning which is included as a separate topic in the *Cambridge Handbook on Thinking and Reasoning.*[80] The essence of legal formalism is the idea that "a few basic top-level categories and principles formed a conceptually ordered system above a large number of bottom-level rules."[81] Legal Realism on the other hand arose to counter formalism and it is seen as Holme's idea. Legal realists opposed the formalist school of thought that, 'the law was a self-contained logical system providing for the scientific, deductive derivation of the right answer in all new cases.' They considered this view to be a fantasy which has no connection with the real world and influence legal decisions, consequently the label "legal realism."[82]

---

[77] S Geoffrey, Can legal reasoning be demystified? *Legal Studies* 29 2 (June 2009) 181–210.
[78] J Raz, *Between Authority and Interpretation: On the theory of law and practical reason* (Oxford University Press 2009).
[79] B Spellman, Public law and legal theory (University of Virginia School of Law Working Paper Series 2012).
[80] KJ Holyoak and Morrison RG, *Cambridge Handbook on Thinking and Reasoning* (Academia 2005).
[81] Ellsworth (n 50).
[82] Ibid.

Fig 3: Activities involved in Legal Reasoning by Wahlgren[83]



The first of the legal reasoning processes involves the identification and consideration of the case leaving out the case in which the judge or lawyer immediately recognises the situation and seek additional information.[84] The same process is adhered to when drafting legal instruments as well and in negotiating agreements. The next stage involves finding out the relevant norm-material, and putting together all information that may result in the taking of a prudent decision, because not assembling the right information may be fatal of which the outcome will be detrimental to one's decision taken.[85] The Interpretation level deals with the abstract descriptions usually depicted by precedents which brings to the fore how a norm was applied previously and the interpretation that was placed on it. Precedents put together provides a valid ground for how a norm has been applied or functions. Norm-application deals with searching for few identified concepts related to and applicable to the relevant precedent in order to apply.[86]

Every norm-application must be evaluated to see the effects it brings.[87] Few of the effects may sometimes manifest itself, while others may be hidden. Consequently, there

[83] Wahlgren (n 53).
[84] Ibid
[85] Ibid.
[86] Ibid.
[87] Ibid.

must be an evaluation to unearth all these effects. Some of the effects may be visible and easily recognised, others may be more or less hidden.[88]Lastly, but not the least, the legal decision must be taken. The available norm may provide a form or structure to enable the decision to be taken which will either be spoken or written down. Legal reasoning is a complex process.

Legal positivists such as Hart,[89] is of the view that, the law consist of two strands of rules. The primary rules consist of the legal norms that regulate the activity of citizens and other persons, whiles the secondary rules represent procedural norms that regulate the processes whereby the legislatures and courts put the primary legal rules into place and modify and apply them.[90] According to Bongiovanni,[91] Hart recognised that both kinds of legal rules are inherently defeasible, which meant there could be exceptions. Dunbar and Fugelsang[92] are of the view that, in deductive scientific reasoning 'there is a general law or theory, and the scientist uses that theory to infer what will happen in some particular fact situation, makes a prediction, and designs an experiment to test it.' On the other hand, "the law determines which facts are relevant while at the same time, the facts determine which law is relevant" according to Burton.[93]

CONVERGENCE BETWEEN DEDUCTIVE REASONING AND SCIENTIFIC METHOD

Deductive reasoning has three functions in scientific methodology which is recognised worldwide.[94] First, it helps lawyers to develop the consequences of 'propositions' and thus try to come out with what it is meant.[95] Knowledge grows exponentially when previous knowledge is used as a reference point. Discoveries are usually made by those who have previous knowledge.[96]Moreover, deduction contributes to make our 'assumptions' clear which help develop a "critical attitude towards them. Thirdly, deduction helps one 'to deal, not only with the actual, but with the possible' according to Brewer.[97] This brings to the fore the opportunity to look beyond the field of possibility where many better things can be found as compared to the actual.[98]

---

[88] Wahlgren (n 53).
[89] N Lacey, The path not taken: HLA Hart's essay on discretion (Harvard Law Review 2013).
[90] Ibid.
[91] G Bongiovanni, Postema G, Rotolo A, Sartor G, Valentini C, and Walton D (eds.), *Handbook of legal reasoning and argumentation* (Springer 2018).
[92] K Dunbar and Fugelsang J, Scientific thinking and reasoning. *The Cambridge handbook of thinking and reasoning* (2005) 705-725.
[93] Burton (n 53).
[94] Brewer (n 1).
[95] Ibid.
[96] Ibid.
[97] Ibid.
[98] Ibid.

Deductive reasoning always begins with hypothesis or assumptions. It will always occur as if 'obvious truths 'are being dealt with.'[99] But propositions seem to us self-evident simply because it has never occurred to us to doubt them. It is however, the business of scientific method to doubt all that pretends to be self-evident.'[100] Professor Delaney has opined that " legal reasoning is an art."[101] This art encompasses 'discipline and creativity,' which provides valuable 'insights into the methods of legal reasoning.' In his view, these approaches are brought to the fore 'when the metaphor of art is contrasted with that of science.'[102]Science assumes to represent the 'objective truth,' within data that can be verified, which can be discovered.[103] The art aspect encapsulates an 'inter-subjective reality, a human artifact,' which comes into existence after 'creative human impulses have interacted with technical skills that have been honed over the years with exacting practice and patience.'[104]

Levi[105] has stipulated that, deductive reasoning encompasses three levels of processes in relation to the law. First, is the emphasis on the doctrine of judicial precedent or *stare decisis* where a relevant norm seen in a case is made into a rule of law which can then be replicated in a subsequent similar case. The similarity unearthed between current case and the precedent develops to become the rule of law which is then applied to future cases.[106] The legal reasoning processes follow along these steps and helps to distinguish the scientific groups on how 'the sciences use arguments of reasoning in law' in their scientific activities, which invariably leads to the production of reasoning that has the features of a scientific discipline.[107]

Conclusive results are not expected in science since it is an ongoing process. If the evidence is disjointed, scientists can wait, and replicate a study or research before coming out with findings.[108] Researchers can plan what further study needs to be done to answer unresolved issues.[109] But with the judicial process, it is not possible for a judge to reserve a judgment or go beyond the data presented in court, however ambiguous the data might be. They cannot carry out any further research, nor wait until others have done so, before making decisions. And the judge's decision, whether the

[99] Brewer (n 1).
[100] Ibid.
[101] J Delaney, *Learning legal reasoning: Briefing, analysis and theory* (John Delaney Publications 1987).
[102] Ibid.
[103] Ibid.
[104] Ibid.
[105] Levi (n 54).
[106] Ibid.
[107] Pardede and Poluakan (n 67).
[108] Ibid.
[109] Ibid

evidence is conclusive or completely inadequate, has the same precedential force,[110] it is final. The scientist's conclusions are always work in progress as new developments or further research may always be needed to confirm a study.[111] In all litigation that comes before the court, one side must win. The scientist's decision that the truth may not be in the current study but in another, this is not available with the legal process.

Perelman and Olbrechts–Tyteca[112] and Toulmin[113] have accepted the distinction between day-to-day reasoning and scientific reasoning from premises of mathematics. Justice Oliver Wendell Holmes Jr.[114] and several of his followers stressed that "the life of the law has not been logic, but one of experience." Holmes meant deductive logic here. A judge in England once remarked that, 'he thanked God that the law of England was not a science.[115] He again stated that, the English Bar has tended to neglect the science of law, and treated it with aversion. Rapahel Cohen[116] has intimated that, law schools are under constant pressure to prepare students for practical success at the Bar, rather than advancing the science of the law. When these are viewed abstractly, it is imperative to admit that ultimately the most practical thing that law schools should do for the community is to promote the science of law.[117]

NEXUS BETWEEN SCIENTIFIC DATA AND LEGAL REASONING

From the period of ancient Greece – where the agora became the first space for public discussion and final decisions taken on a wide array of matters of national importance, dialectical reasoning has provided an impetus for the understanding of 'science and constitution of a society.'[118] Scientific evidence has increasingly become part of legal cases which ostensibly influence the decisions given by trial courts at both the international and municipal level together with decisions reached in agreements. Ellsworth[119]is of the view that, 'scientific testimony' is usually not helpful as expected in unravelling the truth before the courts or agreements reached. The key terms applicable to the two disciplines, science and law also have varied meanings. Examples here include "evidence," "relevance," and "reliability."[120]

---

[110] Levi (n 54).
[111] Ibid.
[112] C Perelman and Olbrechts–Tyteca L, The new rhetoric (Philosophy Today 1958)
[113] S Toulmin, *The uses of argument* (Cambridge University Press 1958).
[114] Justice Oliver Wendell Holmes Jr, *de Justitia mediatrix no direito* (1923).
[115] Cohen (n 2).
[116] Ibid.
[117] Ibid.
[118]S Abuzaid, The unified equation of gravity and QM: The case of non-relativistic motion *Al-Mukhatabat* (2014).
[119] Ellsworth (n 52).
[120] Ellsworth (n 52).

Science was the peak of human intelligence in 1870, which consequently motivated Langdell to view law as a science so as 'to transform law into an empirical discipline' instead of a discipline in the arts.[121] The problem with this analogy is that, there is no legal means for experimenting with the law, and there is no way by which one can also have access to data before a verdict is reached. "Information" available are precedents from earlier decisions.[122]Langdell does not state that the law really applies consistency and abstract concepts. Judges and legal advocates usually rely on precedents and legal principles, societal norms and values.[123] Levi has opined that:

> Whatever services scientific method is to render, it is reasonable to demand that it shall not hinder the growth of the science to which it ministers. But this is precisely what the method known- as positivism or behaviorism does when it denies that there can be any normative branch of jurisprudence—that is, when it denies scientific character to questions as to what the law ought to be.

Duguit and Ardigò[124] who are positivists, have intimated that 'a science of the law should restrict itself to the law that is, which generally fall into a crypto idealism,' and translates to setting up the ideal of the actual law that ought to be in society. Morris Cohen[125] has argued that, the methodology of stating hypotheses and making deductive conclusions and comparing it to real life situations is what constitute the scientific method. The law does not abandon consistency.[126] In the practice of the law, one person will always win while another loses. This is consistency.[127] We do this through scientific method.[128]The law like other institutions of civilisation is organised to advance the good life, and what distinguishes that is not to be attained by abandoning our intelligence:[129]

> Law without concepts or rational ideas, law that is not logical, is like prescientific medicine—'a hodge-podge of superstition, as has indeed been most of the world's common sense as distinguished from science.'

[121] Cohen (n 2)
[122] Ibid.
[123] Levi (n 54).
[124] Cohen (n 2)
[125] Cohen (n 2).
[126] Ibid.
[127] ibid
[128] ibid
[129] Wendell Holmes (n 113).

While science can hold on to a final decision where there is lack of sufficient knowledge, it is incumbent on the judge to give a decision in a case that is before the court.[130] There are robust built-in mechanisms within the law that makes it possible to examine its own processes and assumptions.[131] The knowledge used in legal reasoning is diverse, ranging from common sense to specialised legal knowledge, and it varies greatly in structure, character and use.[132] Keat[133] has intimated that, "for the positivist, it is the aim of science to provide us with predictive/explanatory knowledge" and the "scientific theories are to be seen, primarily as sets of highly general law-like statements." Wigmore[134] has emphasised that there is a science of proof underlying legal reasoning. He intimates that, this science of proof was inductive legal reasoning which is divided into two broad categories. Comparative and teleological methods in legal science, provide a solid ground to assume that in legal research, a creation, application and interpretation of a legal norm are related to numerous societal variables.[135]

THE BEARING OF SCIENTIFIC DATA ON LEGAL JURISPRUDENCE

Science plays a crucial role in decisions concerning the environment, medicine and key international conventions and agreements. Challenges relating to the environment are most often deduced and verified from scientific research. There are a lot of international agreements, conventions and judicial decisions that are reached and resolved not only through ordinary laws, but through scientific data before decisions can be taken. In some of them, reasoning is reached based on research by scientists and scientific institutions. There has been a growth in the awareness of both civil society as well as national and international institutions on the potential risks faced by humanity on the threats to the environment. These have been highlighted in contemporary times due to scientific data. Science data plays a key role in verdicts reached at the courts as well as several other international agreements.[136]

The depletion of the ozone regime led to the establishment of a scientific assessment system in the Montreal Protocol.[137] It is as a result of this scientific assessment structures that have provided independent scientific data about the progress of ozone depletion in relation to climate change.[138]The Subsidiary Body for Scientific and

[130] Cohen (n 2).
[131] ibid
[132] Ibid
[133] J Keats, From one of the most beloved English romantic poets best known for his Odes, Ode to a nightingale, Ode to indolence, Ode to psyche, Ode to fanny (2017).
[134] Wigmore (n 4).
[135] Ibid.
[136] P Birnie and A Boyle, *International law and the environment* (Oxford 2nd edn 2002).
[137] T Koivurova, *Introduction to international environmental law* (Routledge Taylor & Francis 2014).
[138] Ibid.

Technological Advice (SBSTA) help filter the Intergovernmental Panel on Climate Change's (IPCC) scientific assessments into the climate regime for governments to take decisions regarding the environment.[139] This has also influenced a number of judicial decisions. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services which commenced in April 2012 have been the source of scientific data for United Nations Commission on Environment and Development (UNCED) and United Nations Environmental Programme (UNEP).[140] Through scientific data, proof of the occurrence of forest and land fires are determined as a result of laboratory analysis undertaken by experts.[141]

A number of international agreements relating to the environment were arrived at as a result of scientific data.[142] The Convention on Biodiversity 1992, the 1976 'Convention on the Prohibition of Military or Other Hostile Use of Environmental Modification Techniques' (ENMOD), the Protocol to the Geneva Conventions of 1949 (Protocol I) that came into force in 1977 are examples of international agreements that resulted from scientific data.[143] Further, the UN Watercourses Convention codified into customary international law regarding international water law in 2014 was a result of expert opinion from scientific data. The International Court of Justice (ICJ) decision on the legal basis in the 'Threat or Use of Nuclear Weapons'[144] were arrived at with the help of expert opinion from the sciences.

In addition, United Nations Convention on the Laws of the Sea (UNCLOS),[145] the International Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) (1992),[146] the Basle Convention on the Control of Transboundary Movement of Hazardous Wastes, 1989,[147] the International Convention for the Prevention of Pollution of the Sea by Oil (1954),[148] the International Convention for the Prevention of Pollution from Ships (1973), the Kyoto Protocol,[149] decisions on Climate Change are all based on scientific data compiled by the Intergovernmental Panel on Climate Change (IPCC). The 1992 Rio de Janeiro summit "Earth Summit" was

---

[139] MN Shaw, *International law* (Cambridge University Press 7th edn. 2014).
[140] Koivurova (n 136).
[141] BH Saharjo, *Bukti Ilmiah dalam Penegakan Hukum Kasus Kebakaran Hutan dan Lahan dengan Pendekatan Multidoor* (2015).
[142] Koivurova (n 136).
[143] Shaw (n 138).
[144] Legality of the Threat or Use of Nuclear Weapons <http:www.icj-cij.org/en/case/95> accessed 20th October 2022.
[145] MD Evans, The law of the sea In MD Evans (ed.) *International law* (2006).
[146] Shaw (n 138).
[147] Ibid.
[148] Ibid.
[149] United Nations Framework Convention on Climate Change (Kyoto Protocol 1997).

held as a result of potential dangers to the environment revealed by scientific assessments. Data was also provided by the scientific community at the global 2001 Stockholm Convention on POPs.[150] It was scientific assessments that led to the formation of the Arctic Monitoring and Assessment Programme (AMAP) for the protection of the Arctic area. All these international agreements were reached with the help of scientific data.[151] International environmental law has created innovative environmental regimes with the aid of environmental scientific research.[152] These frameworks have been created to augment existing ones that makes it possible for scientific knowledge to be used to respond to emerging threats.

JUDICIAL DECISIONS AND SCIENTIFIC DATA

In contemporary times, satellite images, drones providing data on images of crimes against humanity in conflict areas such as Syria, Lybia, Democratic Republic of Congo and the ongoing war between Russia and Ukraine serve as rich sources of information when the perpetrators are due for trial. Evidence of satellite images of mass graves committed by combatants against international law such as the Geneva Convention regarding the Protection of Civilians in times of War,[153] Geneva Convention on the Treatment of Prisoners[154] together with its Additional Protocols[155] and the Statute of the International Criminal Court[156] all provide cogent information that are used by the courts during the trial of perpetrators. Further, atrocities against civilians, troop movements and presence as well as Geographical Positioning Systems (GPS) information and triangulation of mobile phones all provide significant tools for legal reasoning and pronouncing final verdicts in the courts.

The Trail Smelter tribunal of arbitration in 1941 was able to reach its verdict by the award of compensation to the US through scientific assessments of the danger posed by the smelter.[157] Again, in Hungary and Slovakia over the *Gabcikovo-Nagymaros* Project in 1997, the International Court of Justice (ICJ) acknowledged the UN Watercourses Convention as an important source of international water law based on

[150] Koivurova (n 136).
[151] Ibid.
[152] Ibid.
[153] Geneva Convention Relative to the Protection of Civilian Persons in Times of War adopted 12th August 1948 and entered into force on 21st October 1959.
[154] Geneva Convention Relative to the Treatment of Prisoners of War adopted on 12th August 1949 and entered into force on 21st October 1950.
[155] Protocol Additional to the Geneva Convention of 12th August 1949 relating to the Protection of Victims of International Armed Conflicts adopted on 8th June 1977 and entered into force on 7th December 1978.
[156] The Rome Statute of the International Criminal Court (Amended 2010) (17 July 1998).
[157] Shaw (n 138).

the scientific data from the environmental Impact Assessments that were done.[158] Another important illustration where expert opinion was used in the legal reasoning by the House of Lords' was in the decided case of *Ireland v Burstow.*[159] Relying on the ratio in the decided case of *R v Chan-Fook,*[160] the House of Lords established whether psychiatric illnesses are composed of the term 'bodily harm' stipulated in sections 18, 20 and 47 of the Offences Against the Person Act 1861.[161] The court held that in such important interpretations the 'courts of law can only act on the best scientific understanding of the day' (*Ireland and Burstow*). The Law Lords then concluded that the expression 'bodily harm' includes psychiatric illnesses.[162]

In *R v Malcherek and Steel* the Court of Appeal emphasised that, the law must be interpreted with due regard to medical developments that have occurred since, and this hinges significantly on scientific data. It is a result of new scientific data that enabled the Court of Appeal to define death in *R v Malcherek and Steel*[163] as follows:

> Modern techniques have undoubtedly resulted in the blurring of many of the conventional and traditional concepts of death. A person's heart can now be removed altogether without death supervening; machines can keep the blood circulating through the vessels of the body until a new heart can be implanted in the patient, and even though a person is no longer able to breathe spontaneously a ventilating machine can, so to speak, do his breathing for him … There is, it seems, a body of opinion in the medical profession that there is only one true test of death and that is the irreversible death of the brain stem, which controls the basic functions of the body such as breathing. When that occurs, it is said the body has died, even though by mechanical means the lungs are being caused to operate and some circulation of blood is taking place.

In *Airedale NHS Trust v Bland,*[164] the House of Lords reasoned that it is only when the 'brain stem' is dead that the human being can be said not to be alive. This is the legal

[158] Gabcikovo-Nagymaros Project (*Hungary* v *Slovakia*) 1997 I.C.J 140 (September 25 1979).
[159] [1998] AC 147.
[160] [1994] 1 WLR 689.
[161] Sections 18, 20 and 47 of the Offences Against the Person Act 1861.
[162] *Ireland and Burstow* (n 150).
[163] Ibid.
[164] [1993] AC 789.

definition of 'death' according to the court, and they further stressed that it is important that the law is kept in line with the most advanced medical understanding and practices. His Lordship Keith of Kinkel at page 856 held that, 'in the eyes of the medical world and of the law a person is not clinically dead so long as the brain stem retains its function.'[165]On the basis of a science-driven reconstruction, the House of Lords decided to uphold the meaning that the Court of Appeal had previously put forward.[166] In addition, in *Hume v Hume & McAuliffe* [167]the Times wrote that "a finding of adultery was made against a wife on the evidence that she had given birth to a child of whom blood tests established that the husband could not be the father." This was established by the use of Deoxyribonucleic acid (DNA) analysis. In *Clemons v The State*,[168]the court held that, "the conclusory aspects of the comparative bullet lead analysis (CBLA) that was done, was not generally accepted within the scientific community and thus was not admissible under the *Frye-Reed* standard for admitting scientific expert testimony"[169] before the court.

Moreover, the courts have had to deal with a number of suits that bother on the environment and in most of these legal proceedings 'scientists and engineers' have had to authenticate their findings and make available their research data and methods and be prepared to be cross examined on them before being admitted in court. Aminudin et al.[170] in their study of the role of scientific evidence in the adjudication of dispute concerning forest restoration and land use concluded that, 'scientific evidence/data in the form of scientific studies and expert opinion and testimony' that are admitted before the court as evidence play a significant role in proving cases of environmental damage. The authors cited the case of *Environment and Forestry* v *PT. National Sago Prima*[171] as a case study.

In the Ghanaian context, in almost all cases that come before the courts in murder, rape and narcotics the courts usually rely on scientific assessments before reaching the verdict. In murder cases, the pathology report as to the cause of death must be established before the jury and the court can arrive at a verdict. In rape cases, unless the accused person pleads guilty *simpliciter* medical report as to whether the victim has

---

[165] *Airedale NHS Trust v Bland* [1993] AC 789.
[166] F Picinali, Legal reasoning as fact finding? A Contribution to the analysis of criminal adjudication *Jurisprudence* (Routledge Taylor & Francis Group 2014).
[167] [1965] Times on February 25.
[168] 896 A.2d 1059 (Md 2006)
[169] McCormack et al., MAA868, a novel fxi antibody with a unique binding mode shows durable effects on markers of anticoagulation in humans *The Journal of American Society of Haematology* 133 13 (2019).
[170] Aminudin et al. (n 13)
[171] *Environment and Forestry* v *PT. National Sago Prima* cited in Aminudin et al. (2020).

been raped and forensic analysis of whether an alleged narcotic substance is what it really is or prohibited must be established respectively before the court can arrive at a verdict. The Supreme Court in Ghana in *In re Presidential Election Petition; Akuffo - Addo, Bawumia & Obetsebi-Lamptey v Mahama & Electoral Commission (National Democratic Congress Interested Party)*[172] used scientific data from the audited pink sheets given by Political Party agents to reach its verdict.

Moreover, in *Gloria Odartey Lamptey vrs Nii Odartey Lamptey*[173] *(2017)* the High Court held as follows:

> the evidence is undisputed, backed by Exhibit '1', the results of a deoxyribonucleic acid (DNA) test which indicates that the children, Latifah, Kadijah and Moesha Odartey Lamptey are not biologically, the children of the respondent and the circumstances of the case lead me to make a finding that the children were procreated in adultery.

CONCLUSION

From the discussion and analysis supra, it could be stated categorically and emphatically that scientific data has a bearing on legal reasoning. Reasoning reached in verdicts before the courts, as well as legal instruments that are drafted in domestic as well as international settings to protect the environment and humanity are most often influenced by certain considerations inclusive of scientific knowledge or assessments as a key factor. Moreover, with respect to cases that come before the judicial bodies, it is jurisprudence from earlier decisions that are applied to similar cases that become the rule of law. This brings about consistency and certainty in the legal process which is crucial for the protection of the rights of people that appear before the courts. Consistency in legal reasoning leading to established rules guarantee restricted regulatory authority which contributes to sustainable peace in a country. This is the main reason why conclusions reached by courts are significant in any society and should always follow the due process. And in situations where expert opinion together with available scientific data are used the jurisprudence must always inure to the benefit of humanity in totality as could be gleaned from some of the international agreements analysed above to protect the environment as well as the decided cases.

---

[172] *(2013) SCGLR* Special Edition.
[173] *Gloria Odartey Lamptey vrs Nii Odartey Lamptey (*2017).

REFERENCES

Abuzaid L, The unified equation of gravity and QM: The case of non-relativistic motion *Al-Mukhatabat* (2014)

Aminudin C, Fakhriah, E L, Nurlinda, I and Ikhwansyah, I, Role of scientific evidence in the adjudication of dispute for restoration of burned forest and land, In *E3S Web of Conferences* (2020)

Antoniou G, Baryannis G, Batsakis S, Governatori G, Robaldo L, Siragusa G and Tachmazidis I, *Legal reasoning and big data: Opportunities and challenges* (2018)

Bongiovanni G, Postema, G, Rotolo, A, Sartor, G, Valentini, C, and Walton, D (eds.) *Handbook of legal reasoning and argumentation* (Springer 2018)

Brewer S, *Scientific Models of Legal Reasoning: Economics, Artificial Intelligence, and the Physical Sciences* (Routledge 2011)

Burton SJ, Reaffirming legal reasoning: The challenge from left *Journal of Legal Education* (1985)

Canter D, In the Kingdom of the blind, in D Canter and R Žukauskiené (eds.) *Psychology and law bridging the gap* (2008) 1-4

Cardozo BN, *The Nature of the Judicial Process* (1921) 164

Chen et al., Inflammatory responses and inflammation associated diseases in organs (Oncotarget 2018)

Cohen MR, Law and scientific method, Address delivered at the twenty fifth Annual Meeting of the Association of American law schools (December 29 1927)

Delaney J, *Learning legal reasoning: Briefing, analysis and theory* (John Delaney Publications 1987)

Dunbar K and Fugelsang J, Scientific thinking and reasoning *The Cambridge handbook of thinking and reasoning* (2005) 705-725

Elliott KC, Kendra S C, Georgina M M and Soranno PA, Conceptions of good science in our data-rich world (ResearchGate 2016) Accessed on 12/06/22 at 8am

Ellsworth PC, Legal reasoning (University of Michigan 2005). Available at https://repository.law.umich.edu/cgi/viewcontent.cgi?article=1050&context=book_chapters accessed on 19/08/2022

Garner BA, Black's law dictionary (St. Paul MN: West Group 1999) 1276

Garner BA, Black's law dictionary (Thomas Reuters USA 10th Edition 2014)

Geoffrey S, Can legal reasoning be demystified? *Legal Studies* 29 2 (June 2009) 181–210

Harman G, Logic and reasoning, In *Foundations: logic, language and mathematics* (Springer Dordrecht 1984) 107-127

Holyoak KJ and Morrison, RG, *Cambridge Handbook on Thinking and Reasoning* (Academia 2005)

Joshua Lederberg, Collections of Information on Antipiracy Act (March 18 1999)

Justice Oliver Wendell Holmes Jr, de "Justitia mediatrix" no direito (1923)

Kantorowicz H, Some rationalism about realism *The Yale Law Journal 43* 8 (1934) 1248-1249

Keats J, From one of the most beloved English romantic poets, best known for his Odes, Ode to a nightingale, Ode to indolence, Ode to psyche, Ode to fanny (2017)

Lacey N, The path not taken: HLA Hart's essay on discretion (Harvard Law Review 2013)

Legality of the Threat or Use of Nuclear Weapons <http:www.icj-cij.org/en/case/95> accessed 20/10/2022 at 5am

Leonelli S, Why the current insistence on open access to scientific data? Big data, Knowledge production and the political economy of contemporary biology *Bulletin of Science, Technology & Society* 33 1 2 (Sage 2013) 6-1 1

Levi EH, An introduction to legal reasoning (University of Chicago Press 2013)

MacCormick N, *Legal reasoning and legal theory* (Clarendon Press 1994) 263

Mackenzie J, Factors affecting repeated cessations of injecting drug use and relapses during the entire injecting career among the Edinburgh addiction cohort (Elsevier 2015)

McCormack HBM, Scientific evidence *Science Bench Book for Judges 13* 14 (2019) 1-118

National Research Council, A question of balance: private rights and the public interest in scientific and technical databases (1999)

Nguyen et al.,Vindr-cxr: An open dataset of chest x-rays with radiologists annotations (Springer Nature 2022)

Oxford Paperback Thesaurus Dictionary (OUP 2006)

Pardede JN and PA Poluakan PA, Law and truth: Critical construction as an ideal legal reasoning method on Indonesia's post-truth era society *Volksgeist -Jurnal Iimu Hakum* (2021)

Perelman C and Olbrechts–Tyteca L, The new rhetoric (Philosophy Today 1958)

Raz J, *Between Authority and Interpretation: On the theory of law and practical reason* (Oxford University Press 2009)

Robaldo et al., Large-scale legal reasoning with rules and databases *Journal of Applied Logics 8 4* (2021) 911-939

Sartor G, *Legal reasoning*: *A treatise of legal philosophy and general jurisprudence* (Springer 2005)

Sidharta BA, *Refleksi tentang struktur ilmu hukum: sebuah penelitian tentang fundasi kefilsafatan dan sifat keilmuan ilmu*, Mandar Maju (2009)

Simon DA, Psychological model of judicial decision making (HeineOnline 1998)

Smits, Legal reasoning and argumentation (2014) 81

Spellman B, Public law and legal theory (University of Virginia School of Law Working Paper Series 2012)

Toulmin S, *The Uses of Argument* (Cambridge University Press 1958)

Vossos G, Zeleznikow J, Dillon T and Vossos V, An example of integrating legal case based reasoning with object-oriented rule-based systems: IKBALS II. In *Proceedings of the 3rd international conference on Artificial intelligence and law* (May 1991) 31-41

Wahlgren P, Legal reasoning a jurisprudential description. In *Proceedings of the 2nd international conference on Artificial intelligence and law* (1989) 147-156

Walton DN, *The new dialectic: conversational contexts of argument* (University of Toronto Press 1998)

Walton DN, What is reasoning? What is an argument? *The journal of Philosophy 87* 8 (1990) 404

Walton J, *Legal reasoning and argumentation* (ResearchGate University of Windsor July 2018)

Wigmore JH, Jottings on comparative legal ideas and institutions *6 1 Tulane Law Review* (1931-1932*)* 48-82

Yin ET, Atupare PA. Rights and religious belief in maintaining prison social order: Rights and religious belief. *UCC Faculty of Law Journal* (2021) 1(1): 1-6

STATUTE

The Offences Against the Person Act 1861.

INTERNATIONAL CONVENTIONS

The Convention on the Prohibition of Military or Other Hostile Use of Environmental Modification Techniques' (ENMOD) (1976)

The Basle Convention on the Control of Transboundary Movement of Hazardous Wastes (1989)

The Convention on Biodiversity (1992)

The International Convention for the Prevention of Pollution from Ships (1973)

The International Convention for the Prevention of Pollution of the Sea by Oil (1954)

The International Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) (1992)

The Protocol to the Geneva Conventions of 1949 (Protocol I) that came into force in 1977

The UN Watercourses Convention (2014)

United Nations Convention on the Laws of the Sea (UNCLOS) (1982)

United Nations Framework Convention on Climate Change (Kyoto Protocol 1997)

CASE LAWS

Airedale NHS Trust v Bland [1993] AC 789

Clemone v The State 896 A.2d 1059 (Md 2006)

Daubert v Merrill Dow Pharm 509 U.S 579, 590 (1993)

Forestry v PT. National Sago Prima cited in Aminudin et al. (2020)

Gabcikovo-Nagymaros Project (Hungary v Slovakia) 1997 I.C.J 140 (September 25 1979)

Gloria Odartey Lamptey vrs Nii Odartey Lamptey (2017)

Hume v Hume & McAuliffe [1965] Times on February 25

In re Presidential Election Petition; Akuffo -Addo, Bawumia & Obetsebi-Lamptey v Mahama & Electoral Commission (National Democratic Congress Interested Party) (2013) SCGLR Special Edition

Ireland v Burnstow [1998] AC 147

Legality of the Threat or Use of Nuclear Weapons <http:www.icj-cij.org/en/case/95> accessed 20 /10/ 2022 at 630am

Lupton FA v FA and AB Ltd [1972] AC 634 at 658–659

R v Chan-Fook [1994] 1 WLR 689

R v Malcherek and Steel [1981] 1 WLR 690 694