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Fallibilism and the Logic of Scientific Discovery: Integrating Abduction, falsification, and theory Development

Tushabomwe Leonard [1*], Specioza Asiimwe [2], Barigye Jimmy [3], Kanaaba Deus [4], Murlangira Jonan [5]
[1] Institute of Education and Lifelong Learning, Victoria University, Kampala, Uganda
[2] School of Education and Long-Distance Learning, Kampala International University, Kampala, Uganda
[3] School of Law, Kampala International University, Kampala, Uganda
[4] School of Natural and Agricultural Sciences, Kampala University, Kampala, Uganda
[5] School of Education, Kampala University, Kampala, Uganda

* Corresponding Author: **Tushabomwe Leonard**

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Abstract
Fallibilism holds that scientific knowledge may be rationally warranted while remaining open to error and revision. This article critically examines whether Popperian falsification can adequately account for scientific discovery and argues that falsification is better understood as one component of a broader fallibilist account of inquiry. The study employs conceptual and critical philosophical analysis of major contributions by Peirce, Popper, Duhem, Kuhn, Lakatos, and selected contemporary scholarship on scientific discovery and abduction. The analysis distinguishes three interconnected functions of inquiry: the generation of explanatory possibilities, the critical testing of those possibilities, and the historical development of theories and research programmes. Peircean abduction helps explain how surprising phenomena can stimulate explanatory hypotheses; Popperian critical rationalism emphasizes risky testing and error elimination; the Duhem Quine problem shows that empirical tests involve networks of auxiliary assumptions; Kuhn demonstrates that inquiry is historically and communally situated; and Lakatos provides a framework for evaluating theory development across research programmes. On this basis, the article proposes an integrated fallibilist model in which scientific inquiry proceeds through problem recognition, abductive hypothesis generation, deductive development, empirical investigation, critical comparison, diagnostic analysis of error, revision, and renewed inquiry. The article's contribution is not to claim that all discoveries follow a fixed algorithm, but to show that fallibilism can provide a unifying epistemic principle for understanding why creative hypothesis generation and disciplined criticism belong to the same self-correcting process. The model also clarifies the relationship between discovery and justification and identifies implications for scientific methodology and education.

Keywords: fallibilism, scientific discovery, abduction, falsification, critical rationalism, scientific inquiry, theory development, Peirce, Popper

1. Introduction

Science is epistemically distinctive not because scientists are immune to error, but because scientific inquiry institutionalizes practices through which claims, methods, measurements, and explanations can be criticized and revised. This is the central intuition of fallibilism: even well-supported knowledge claims may be mistaken, and rational acceptance does not require certainty (Peirce, 1934–1958; Popper, 1959) [11, 12]. Fallibilism therefore differs from radical scepticism. The possibility of error does not make knowledge impossible; rather, it makes systematic criticism, evidential scrutiny, and correction necessary.

The issue becomes more difficult when the focus shifts from the justification of scientific claims to scientific discovery. Popper's critical rationalism decisively challenged the idea that universal scientific laws can be logically established by accumulating confirming observations. His emphasis on conjectures, deductive consequences, severe tests, and falsifiability provides a powerful account of critical evaluation (Popper, 1959, 1963) [12, 13]. Yet the fact that a proposed hypothesis can be tested does not by itself explain how scientists arrive at new explanatory possibilities in the first place. Contemporary philosophical discussions continue to distinguish discovery as hypothesis generation from subsequent assessment, while also questioning whether discovery can be reduced to a single logical procedure (Schickore, 2024) [15].

Peirce's concept of abduction is consequently important because it addresses a generative dimension of inquiry. Abduction concerns the adoption or pursuit of an explanatory hypothesis in response to a surprising fact or problem. Recent scholarship continues to treat abduction as a significant resource for understanding scientific discovery, while also emphasizing that abduction alone does not settle whether a hypothesis is true or sufficiently justified (Bellucci & Pietarinen, 2020; Marks, 2026) [1, 9].

The problem addressed in this article is therefore not whether Popper is correct and Peirce is incorrect, or whether Kuhn or Lakatos should replace Popper. The more useful question is whether these apparently competing traditions illuminate different functions within a fallible process of inquiry. The article asks whether fallibilism can serve as an overarching epistemic principle while allowing abduction, falsification, testing holism, historical practice, and research-programme development to retain their distinctive roles.

1.1. Research Questions

a. To what extent does Popperian falsification explain scientific discovery?
b. What role does Peircean abduction play in generating explanatory hypotheses?
c. How do the Duhem Quine problem, Kuhnian scientific practice, and Lakatosian research programmes qualify simple falsificationism?
d. Can fallibilism provide an integrated framework connecting hypothesis generation, critical testing, and theory development?

1.2. Central Argument and Contribution

The article advances four related claims. First, falsification is indispensable to critical scientific rationality but is not, by itself, a complete account of discovery. Second, abduction provides a useful account of the generative and explanatory dimensions of inquiry, although it does not guarantee truth. Third, empirical criticism is more complex than a simple theory-versus-observation confrontation because tests involve auxiliary assumptions, instruments, models, and background conditions. Fourth, scientific development is historically and institutionally structured, making theory evaluation a process that extends beyond isolated tests. The distinctive contribution proposed here is an integrated fallibilist model that connects these dimensions without reducing their philosophical differences to a single method.

2. Conceptual and Theoretical Framework

2.1. Fallibilism and Scientific Knowledge

Fallibilism is the view that a belief or theory can be rationally or epistemically acceptable without being infallible. Peirce's conception of inquiry is especially important because it treats knowledge as a communal and self-correcting enterprise rather than as a collection of indubitable foundations (Peirce, 1934–1958) [11]. Popper similarly rejects final verification and emphasizes the provisional character of scientific conjectures (Popper, 1959) [12].

Fallibilism can be understood at three connected levels. Epistemic fallibilism concerns the possibility that accepted claims may be wrong. Methodological fallibilism concerns the possibility that methods, measurements, models, and inferential procedures may fail. Institutional fallibilism concerns the organization of inquiry through criticism, replication, transparency, peer evaluation, and competing explanations. These levels matter because correcting a scientific error may require revising not only a proposition but also the assumptions and procedures through which it was investigated.

2.2. Scientific Discovery

Scientific discovery should not be restricted to the moment at which a scientist first has a novel idea. Discovery may include identifying an unexpected phenomenon, generating an explanatory hypothesis, developing a new model or mechanism, or recognizing a previously unnoticed relationship. Contemporary philosophical treatments commonly distinguish discovery understood as reasoning or problem solving from psychological accounts of creativity, and they note that abductive reasoning is one important way of analysing discovery (Schickore, 2024) [15].

This broader definition is important for the present argument. If discovery is reduced solely to the first occurrence of an idea in a scientist's mind, a logical account may be impossible or incomplete. If discovery is instead understood as the structured generation, pursuit, development, and recognition of explanatory possibilities, then philosophical analysis can illuminate important reasoning processes without claiming to explain every psychological source of creativity.

2.3. The Problem of Induction

Hume's problem of induction challenges the inference from observed regularities to unrestricted universal or future claims. No finite set of observations deductively entails a universal law (Hume, 2007) [4]. Popper accepts the force of this challenge and rejects the idea that repeated confirmation can logically establish universal theories (Popper, 1959) [12]. The resulting problem is not solved by pretending that science achieves certainty, but by asking how conjectures can be critically exposed to possible error.

2.4. Falsifiability and Critical Rationalism

For Popper, a scientific theory must exclude some conceivable states of affairs; otherwise no possible observation could place it at empirical risk (Popper, 1959) [12]. The logical asymmetry between universal claims and counter-instances is central to his account. Yet logical falsifiability should not be confused with naïve methodological falsification. Actual tests depend upon auxiliary assumptions, instruments, initial conditions, mathematical models, and background knowledge.

Consequently, a failed prediction does not automatically identify the central theory as the sole source of error.

2.5. Discovery and Justification

The traditional distinction between the context of discovery and the context of justification remains useful, but a rigid separation can misrepresent scientific practice. Experiments may generate anomalies that stimulate new hypotheses; models can reveal previously unrecognized problems; and attempts to test an explanation can lead researchers to reformulate it. Abduction therefore belongs not only to an initial moment of inspiration but also to an iterative process in which scientists pursue promising explanations while responding to evidence and criticism.

3. Methodology

This study employs conceptual and critical philosophical analysis. It is not an empirical systematic review and does not claim to measure the frequency or success of particular scientific methods. Its primary materials are major philosophical works by Peirce, Popper, Duhem, Kuhn, Lakatos, Hume, Hanson, and Reichenbach, supplemented by contemporary scholarship on scientific discovery, abduction, and scientific rationality.

The analysis proceeds in four stages. First, key concepts—including fallibilism, discovery, abduction, deduction, induction, falsification, corroboration, theory development, and research programmes—are clarified. Second, the historical development of these concepts is reconstructed through the selected philosophical literature. Third, the internal tensions and complementarities among the positions are critically compared. Fourth, the analysis synthesizes the results into an integrated fallibilist model. The objective is philosophical reconstruction and argument rather than empirical generalization.

3.1. Scope and Limitations

The proposed model is normative and explanatory rather than an algorithm that every scientist consciously follows. Scientific disciplines differ in their objects, instruments, standards, and institutional practices. The article also does not attempt to explain the full psychology or sociology of creativity. Its narrower claim is that several recurrent epistemic functions of inquiry can be connected within a fallibilist framework while preserving important differences among the philosophers considered.

4. Critical Analysis

4.1. Peirce: Abduction and the Generation of Hypotheses

Peirce's account is particularly relevant to the discovery problem because it identifies abduction as a mode of reasoning through which explanatory hypotheses are proposed in response to surprising phenomena (Peirce, 1934–1958) [11]. In a simplified inquiry sequence, abduction suggests a possible explanation, deduction derives consequences from that explanation, and subsequent inquiry investigates those consequences. Abduction is therefore generative without being conclusive.

The contemporary literature reinforces both the importance and the limits of this account. Abduction can be understood as a logic of discovery or as a rational basis for pursuing a hypothesis, but the explanatory fit of a hypothesis alone does not establish its truth (Bellucci & Pietarinen, 2020; Niiniluoto, 2022; Schickore, 2024) [1, 10, 15]. The distinction is crucial: a promising hypothesis is a candidate for inquiry, not a conclusion insulated from criticism.

4.2. Popper: Conjectures, Testing, and Error Elimination

Popper's major contribution lies in the critical phase of inquiry. A strong scientific theory should make informative claims that risk empirical failure. A theory that survives demanding tests is corroborated rather than verified (Popper, 1959, 1963) [12, 13]. The value of criticism is therefore not that it produces certainty but that it identifies weaknesses and constrains the range of explanations that remain defensible.

The limitation emerges when this account is asked to explain the generation of hypotheses. Deductive testing can establish what follows if a hypothesis is accepted, but it does not by itself explain the creative or explanatory processes through which new hypotheses are generated. This does not make Popper's account irrelevant to discovery; rather, it suggests that critical testing is one phase within a larger inquiry process.

4.3. The Duhem–Quine Challenge: Testing Networks Rather than Isolated Theories

Scientific predictions are rarely derived from a single theoretical proposition. They normally depend upon auxiliary hypotheses, mathematical models, initial conditions, measurement assumptions, and functioning instruments. Duhem's analysis therefore complicates simple falsification: when an expected observation fails, the result challenges a network of commitments rather than identifying one proposition as false (Duhem, 1954) [2].

This qualification strengthens rather than destroys fallibilism. A fallibilist researcher must ask where the failure lies: in the central theory, an auxiliary assumption, the experimental design, the measurement procedure, or an unrecognized background condition. Scientific criticism consequently requires diagnostic judgment. The practical lesson is that failed predictions are epistemically valuable precisely because they trigger investigation into the structure of the test itself.

4.4. Kuhn: Paradigms, Normal Science, and Historical Practice

Kuhn's historical analysis shows that scientists ordinarily work within established conceptual frameworks rather than continuously attempting to overthrow foundational theories. During periods of normal science, researchers solve puzzles defined by a paradigm; anomalies can persist without immediately producing rejection. Scientific revolutions involve more substantial changes in problems, concepts, standards, and theoretical frameworks (Kuhn, 1962) [5].

Kuhn therefore complicates the image of science as a continuous series of isolated falsifications. His contribution can be incorporated into a fallibilist account if historical and communal structure is treated as part of the conditions under which criticism operates. The resulting view does not require choosing between rational criticism and historical practice. Instead, it recognizes that criticism is exercised by trained communities operating with inherited concepts, instruments, standards, and research priorities.

4.5. Lakatos: Research Programmes and Theory Development

Lakatos developed a methodology intended to preserve rational criticism while accounting for the fact that scientific theories develop in connected sequences rather than as isolated propositions. Research programmes contain a relatively stable hard core and a protective belt of auxiliary assumptions. The rational question is not whether every anomaly immediately destroys a programme, but whether the programme remains progressive by generating theoretical developments and novel empirical successes (Lakatos, 1970, 1978) [6, 7].

Lakatos consequently provides a bridge between Popperian criticism and Kuhnian historical development. Recent scholarship continues to revisit this relationship, including the question of how critical testing and longer-term research-programme assessment should be balanced (Worrall, 2025) [18]. The significance for the present article is that fallibility does not imply instantaneous rejection. Rational correction can involve sustained comparison of competing lines of inquiry over time.

5. An Integrated Fallibilist Model of Scientific Discovery

The preceding analysis suggests that scientific discovery is neither mechanical induction nor falsification alone. A more comprehensive model can be represented as follows:

Table 1:

Stage	Primary Function	Philosophical Emphasis
1. Existing knowledge	Establish background concepts, evidence, models, and unresolved questions	Peirce/Kuhn
2. Problem or anomaly	Recognize a surprising result, conceptual difficulty, or unresolved problem	Peirce/Kuhn
3. Abductive hypothesis	Generate or pursue a plausible explanatory possibility	Peirce
4. Deductive development	Derive consequences and specify conditions under which the hypothesis can be challenged	Popper
5. Empirical investigation	Confront consequences with observations, experiments, models, or other evidence	Popper/Duhem
6. Critical comparison	Compare results with rival explanations and examine assumptions	Popper/Duhem
7. Diagnosis of error	Locate possible problems in theory, auxiliaries, instruments, methods, or conditions	Duhem–Quine
8. Revision and programme development	Modify, replace, extend, or reorganize explanations over time	Lakatos/Kuhn
9. Renewed inquiry	Generate new questions, anomalies, hypotheses, and tests	Fallibilism as the unifying principle

The model should not be interpreted as a rigid chronological algorithm. Scientific inquiry can move backward and forward among stages. An experiment may generate the problem; a failed test may produce an abductive insight; a new model may reveal an anomaly; and historical comparison may influence what counts as a promising research direction. The sequence is therefore a conceptual map of epistemic functions rather than a universal recipe.

The unifying principle is fallibility. Problems can be misconceived, hypotheses can be poorly formulated, deductions can depend on inappropriate assumptions, measurements can be inaccurate, and interpretations can be biased. Because each stage is fallible, scientific rationality requires mechanisms that make errors detectable and revisions possible. This gives fallibilism a role broader than simply admitting uncertainty: it provides the epistemic rationale for criticism, transparency, replication, comparison, and revision.

5.1. Why Falsification Is Necessary but Not Sufficient

Falsification remains necessary because scientific inquiry requires opportunities for explanations to fail. A framework that cannot be challenged by any possible evidence lacks the critical vulnerability central to empirical science. Yet falsification is not sufficient as a complete logic of discovery because a failed prediction does not by itself generate a replacement explanation, and because actual testing involves interconnected assumptions. The integrated model therefore places falsification within a larger cycle of abductive generation, empirical criticism, diagnostic reasoning, and theory development.

5.2. Discovery, Justification, and Pursuit

The model also supports a qualified rejection of a rigid separation between discovery and justification. The first conception of a hypothesis may be creative and difficult to formalize, but its pursuit is not epistemically neutral. Scientists choose which hypotheses to investigate, what evidence to seek, what experiments to construct, and which anomalies to pursue. Abduction therefore operates alongside testing and evaluation rather than in a completely isolated context of discovery.

5.3. Scientific Rationality Without Certainty

The integrated model defines rationality procedurally rather than as possession of indubitable conclusions. A scientific claim is rationally treated when it is exposed to criticism, supported by relevant evidence, compared with alternatives, and kept open to revision. This conception is compatible with the fallibilist insight that today's strongest explanation can become tomorrow's problem. Rationality is therefore expressed through disciplined corrigibility rather than final certainty.

6. Discussion

The synthesis developed here has three principal implications. First, the logic of scientific discovery should not be reduced to one inferential form. Abduction, deduction, empirical testing, and comparative evaluation perform different functions. Second, scientific criticism is not exhausted by a binary outcome of falsified versus unfalsified. The Duhem–Quine problem shows that researchers must diagnose the source and significance of unexpected results, while Lakatos shows why theories may be assessed across developing research programmes. Third, scientific inquiry is institutionally and historically embedded. Kuhn's account reminds us that standards, instruments, training, and disciplinary communities shape what scientists regard as problems and acceptable solutions.

The model consequently offers a middle position between two extremes. At one extreme is a purely algorithmic conception in which discovery is imagined as a fixed sequence that mechanically produces new knowledge. At the other is a conception in which discovery is so dependent on creativity, history, or social context that rational analysis becomes impossible. The fallibilist model accepts creativity and historical situatedness while maintaining that hypotheses can subsequently be subjected to disciplined criticism and comparative evaluation.

This interpretation also helps clarify the relationship among the major philosophers considered. Peirce contributes an account of explanatory hypothesis generation; Popper emphasizes criticism and exposure to possible failure; Duhem identifies the interconnected assumptions involved in testing; Kuhn explains the historical and communal organization of inquiry; and Lakatos provides a framework for assessing the development of research programmes. Their positions remain philosophically distinct, but the functions they illuminate can be connected within a broader fallibilist conception of self-correcting inquiry.

The model should nevertheless be treated cautiously. It does not establish that every discovery proceeds through the same stages, nor does it settle all disputes concerning the rationality of abduction, theory choice, or scientific progress. Contemporary work continues to debate the relationship between abductive reasoning and other forms of epistemic updating (Skipper, 2025) [16], and current research on creative abduction shows that the cognitive and institutional conditions of discovery remain open questions (Magnani, 2024; Marks, 2026) [8, 9]. The contribution of the present framework is therefore integrative rather than final.

7. Implications for Scientific Methodology and Education

For scientific methodology, the fallibilist model implies that researchers should formulate explanations in ways that permit meaningful criticism, make assumptions explicit, document methods transparently, investigate anomalous findings, and compare competing explanations rather than selectively attending to confirming evidence. Failed predictions should be treated as prompts for diagnosis rather than as automatic proof that a single proposition is false.

For scientific education, students should learn that uncertainty is not evidence of scientific weakness. They should distinguish evidence from certainty, explanation from proof, and corroboration from verification. Teaching should also provide opportunities for students to formulate hypotheses, derive predictions, investigate unexpected results, identify assumptions, compare alternatives, and revise conclusions. Such practices make fallibilism an active intellectual habit rather than a purely philosophical doctrine.

At the institutional level, peer criticism, replication, transparent reporting, data and methodological openness where appropriate, and the comparison of competing explanations create conditions under which individual and collective errors can be detected. Scientific objectivity can therefore be understood not only as a property of individual researchers but also as a property of institutional practices that distribute criticism and make correction possible.

8. Conclusion

This article has argued that fallibilism provides a useful unifying epistemic principle for understanding scientific discovery without reducing scientific inquiry to a single method. Popperian falsification remains central to critical testing and error elimination, but it does not by itself explain how explanatory hypotheses are generated or how theories develop within historically situated research communities. Peircean abduction illuminates the generative role of explanatory hypotheses; Duhem highlights the holistic character of empirical testing; Kuhn reveals the historical and communal organization of scientific practice; and Lakatos explains the longitudinal development and evaluation of research programmes.

The resulting integrated model characterizes scientific inquiry as an iterative process of problem recognition, abductive hypothesis generation, deductive development, empirical investigation, critical comparison, diagnosis of possible error, revision, and renewed inquiry. Its central claim is not that scientific discovery follows a fixed algorithm, but that these epistemic functions can be understood as components of a self-correcting fallibilist practice. Scientific rationality therefore does not depend upon final certainty. It depends upon the disciplined capacity of scientific communities to expose claims and methods to criticism, identify possible error, learn from anomalies, and revise explanations in response to better reasons and evidence.

The principal implication is consequently methodological as well as philosophical: the strength of science lies not in eliminating the possibility of error, which is unattainable, but in organizing inquiry so that errors can be detected, criticized, and corrected. In this sense, fallibility is not merely a limitation of scientific knowledge; it is one of the conditions that make scientific rationality possible.

9. Implications and Recommendations for Scientific Methodology and Education

The integrated fallibilist model has important implications for scientific methodology, research practice, and scientific education. It suggests that scientific inquiry should not be understood simply as the search for confirmation or as the mechanical rejection of theories after a failed prediction. Rather, scientific progress depends on the continuous interaction of hypothesis generation, deductive development, empirical investigation, critical comparison, error diagnosis, and theoretical revision. This broader understanding provides a more realistic account of how researchers can pursue knowledge while recognizing the possibility of error.

9.1. Implications for Scientific Methodology

First, researchers should formulate explanations in ways that make them open to meaningful criticism and empirical testing. Hypotheses should not only be plausible but should generate consequences that can be examined against evidence. This requires researchers to distinguish clearly between observations, assumptions, explanatory propositions, and empirical predictions. Such explicitness strengthens the possibility of identifying where an explanation succeeds or fails.

Second, hypothesis generation should be treated as an essential component of scientific inquiry rather than as a stage outside scientific methodology. Peirce's concept of abduction demonstrates that researchers often begin with an unexpected observation, problem, or anomaly and seek an explanation that could account for it. However, abductive plausibility does not establish truth. Candidate explanations must subsequently undergo deductive development and empirical examination. Scientific methodology should therefore accommodate both the creative generation of explanations and the critical testing of their consequences.

Third, unexpected or contradictory findings should be subjected to systematic diagnostic analysis. A failed prediction should not automatically be interpreted as definitive falsification of the central theory. Consistent with the Duhem–Quine challenge, empirical tests generally involve a network of theoretical assumptions, auxiliary hypotheses, measurement procedures, instruments, models, and contextual conditions. Consequently, researchers should investigate whether an unexpected result reflects a weakness in the central theory, an auxiliary assumption, measurement error, methodological limitations, or an inadequately specified research context.

Fourth, researchers should compare competing explanations rather than evaluate individual theories in isolation. A theory becomes scientifically more persuasive when it provides a better explanation of the evidence than credible alternatives and continues to generate successful or fruitful predictions. This comparative orientation strengthens critical inquiry and reduces the risk of protecting favoured theories through selective interpretation of evidence.

9.2. Longitudinal Evaluation of Theories and Research Programmes

The analysis also recommends that theories be evaluated over time rather than judged exclusively on the basis of isolated successes or failures. Lakatos's concept of research programmes is particularly useful in this respect because scientific theories develop through sequences of related hypotheses, auxiliary assumptions, and modifications.

Researchers should therefore distinguish between progressive theoretical development and modifications introduced merely to protect a theory from criticism. A research programme becomes more scientifically valuable when modifications contribute to new explanations, predictions, or empirical successes rather than simply accommodating already-known evidence.

This approach is particularly relevant to interdisciplinary and applied research, where scientific explanations may require continuing refinement as new evidence, technologies, social conditions, and environmental realities emerge. Scientific progress should consequently be understood as an ongoing process of development and correction rather than as a final achievement of certainty.

9.3. Implications for Scientific and Postgraduate Education

Scientific education should also reflect the fallibilist character of knowledge. Students and researchers should be trained not merely to memorize established theories but to understand how scientific claims are generated, tested, challenged, revised, and sometimes abandoned.

At postgraduate level, this requires learning activities that enable students to:

- identify significant research problems and anomalies;
- generate plausible explanatory hypotheses through abductive reasoning;
- derive testable consequences from theoretical propositions;
- design appropriate empirical investigations;
- identify assumptions underlying research claims;
- evaluate unexpected or contradictory findings;
- compare competing explanations;
- distinguish methodological limitations from theoretical weaknesses; and
- revise explanations in response to credible criticism and evidence.

Such an approach would cultivate researchers who are intellectually confident but epistemically cautious. Importantly, recognizing uncertainty should not be presented as a weakness of science. Instead, fallibility can be understood as a condition that makes systematic criticism, correction, replication, and methodological improvement possible.

9.4. Institutional and Research-Practice Recommendations

The fallibilist perspective further implies that institutions should create environments in which scientific criticism and correction are valued rather than discouraged. Research institutions, universities, and journals should encourage transparent reporting of methods, assumptions, limitations, unexpected findings, and negative results.

Peer criticism, replication, methodological transparency, appropriate data and materials sharing, and clear reporting of limitations can strengthen the institutional mechanisms through which scientific error is identified and corrected. Such practices are particularly important because individual researchers cannot guarantee their own objectivity. Scientific objectivity therefore depends partly on institutional arrangements that allow claims to be exposed to independent scrutiny.

Researchers should also resist the temptation to treat anomalous findings as inconvenient results to be ignored. Instead, anomalies can provide important opportunities for discovering limitations in existing explanations and developing improved theoretical or methodological accounts.

9.5. Directions for Future Research

The integrated model also provides opportunities for further empirical and philosophical investigation. Historical case studies could examine how abductive reasoning, falsification, anomaly recognition, and theoretical revision have operated in major scientific discoveries. Comparative studies across disciplines could determine whether the relative importance of these processes varies between the natural sciences, social sciences, agricultural sciences, medicine, and other fields.

Further research could also investigate how the fallibilist model relates to contemporary approaches to scientific reasoning, including Bayesian approaches to evidence and other accounts of epistemic updating. Such studies would help determine whether the integrated framework can provide

a useful bridge between classical philosophical accounts of scientific inquiry and contemporary research practice.

Importantly, the proposed model should not be treated as a rigid algorithm that every scientific investigation must follow in an identical sequence. Scientific inquiry is historically, socially, and disciplinary situated. The model is therefore best understood as an integrative framework for understanding and guiding scientific inquiry, capable of accommodating iteration, feedback, uncertainty, and alternative pathways of discovery.

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