Answers for Reflection

1. *Awad distinguishes between different "types" of AI. What classification scheme does the paper use and why do these types matter for scientific research?*

Awad distinguishes between seven different types of AI based on the role they could play in scientific research and discovery: predictive AI, descriptive AI, generative AI, optimization AI, causal and interpretive AI, privacy-aware AI, and meta-scientific AI. Predictive AI refers to algorithms that use data to learn patterns and trends and produce a prediction based on those trends. This has applications in forecasting public health trends, responding to climate shifts or optimizing infrastructure planning. Descriptive AI similarly uses training data to recognize patterns in datasets, but unlike predictive AI, it uncovers potential patterns and connections, making it valuable for early-stage research. Generative AI can create entirely new content like text, images, or code. In a scientific context, GenAI is primarily used to create synthetic data, which can bolster research in areas where data is hard to collect. Optimization AI, or reinforcement learning, enables AI to learn through interacting with a changing environment and make decisions based on its goals and reward mechanism. In scientific research, RL has been used to automate experiment design. Causal and interpretive AI are methods that allow for scientists to better understand cause-and-effect relationships and the inner workings of complex AI systems. This allows scientists to analyze causal relationships and verify the integrity of models. Privacy-aware AI is the development of AI systems while ensuring that sensitive data remains protected. This approach is essential in health and climate research, where data cannot be centralized. Finally, meta-scientific AI refers to systems that can autonomously carry out the scientific process, from generating hypotheses, experimentation, and data collection.

2. *Does Awad make a clear distinction between AI as a tool and AI as a scientific collaborator? If so, what are the differences and what are some examples given to support the differences? Do these examples suggest a real shift in how science is conducted, or mostly an extension of existing methods?*

Awad makes a clear distinction between AI as a tool and AI as a scientific collaborator. She refers to AI as a tool when its primary purpose is to assist human researchers in carrying out the scientific process. This includes data processing, pattern detection, and data synthesis workflows that are ultimately designed to be used and interpreted by a human scientist. Awad mentions surrogate modelling using neural networks or decision trees to replicate system behavior in a cost-effective manner. In this instance, the AI is used as a tool by scientists to aid in their research.

Awad refers to AI as a collaborator to define systems that actively participate in and contribute to the scientific process at the same level as human scientists. These systems act as autonomous agents, able to plan, reason, and act towards a scientific goal. Real-world examples are primarily semi-autonomous LLMs integrated within symbolic reasoning frameworks, such as IBM's Generative Toolkit for Scientific Discovery and SciAgents. These

frameworks enable AI to generate new ideas and act on those ideas rather than simply present patterns in data.

Together, these examples suggest a real shift in how science is conducted rather than just an extension of existing methods. While many applications, such as surrogate modelling, are continuations of existing computational practices, the rise in adoption of generative and inferential AI points to a deeper transformation of how science itself is conducted.

3. *What are some limitations or risks of using AI in science? How do these relate to issues such as interpretability, bias, reproducibility, or theory formation?*

There are several limitations and risks to using AI in science that directly affect interpretability, bias, reproducibility, and theory formation. The primary concern is interpretability. Many high-performing AI systems are opaque, meaning their inner mechanics are difficult to understand and explain. This conflicts with scientific norms that prioritize understanding the mechanisms behind discoveries rather than simply accurate prediction. The “black box” nature of complex AI systems risks producing shallow results that can be used effectively but are not explainable, which contradicts the nature of scientific progress. Any new information and data must be interpretable; it must be possible to justify why a given approach is valid and should be replicated. Another prominent concern is bias. AI systems inherit and often amplify biases present in training data or measurement practices. This can skew scientific findings, marginalize underrepresented populations in biomedical or social data, and lead to systematically distorted inferences that appear objective. The overreliance on AI in science could also lead to issues with the reproducibility of experiments. Complex model systems and dependence on massive datasets could make it difficult for other researchers to replicate results, undermining a core aspect of scientific validation. These risks could culminate in a negative effect on theory formation. Awad notes that heavy reliance on predictive or generative AI can incentivize correlation-based discovery at the expense of grounded causal explanation. This may shift science toward empirically successful but conceptually thin models that weaken the role of theory and human judgment in scientific discovery.

4. *According to Awad’s arguments, is AI more likely to accelerate scientific discovery or to reshape the scientific method itself? Do you agree or disagree?*

According to Awad’s arguments, AI will not only accelerate scientific discovery, but will also reshape the scientific method itself. Awad emphasizes that AI’s role extends beyond speeding up data processing and increasingly enters the epistemic core of science, including hypothesis generation, pattern discovery, and advanced reasoning and inference. This shifts scientific practice away from models centered around human-generated hypotheses toward a mixed process in which AI-generated suggestions influence what questions are asked, what counts as plausible explanation, and how causal structure is inferred. While many current applications still resemble acceleration of existing workflows, the growing reliance on AI systems that participate in theory formation, design experiments, and shape interpretation suggests a

transformation rather than simple efficiency gains. In this sense, AI is transitioning from an advanced tool to a new component of scientific reasoning, altering how knowledge is produced.