RESEARCHMIRROR: CAN AI SCIENTISTS MATCH THE RESEARCH TASTE OF HUMAN RESEARCHERS?

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ABSTRACT

Research taste, the judgment of what to read, which problems to pursue, and which methods to try, increasingly shapes the work of AI scientists, yet it remains far less understood than their ability to execute research. We introduce ResearchMirror, a temporal benchmark for research taste that freezes the literature through 2025, generates research proposals from that snapshot, and compares them with work published by the same communities in 2026. Our experiments span six contemporary language models and four research areas from established to emerging fields, covering more than 90,000 proposals in total. AI scientists fall well short of human communities in both the literature they cite and the ideas they state, reaching about 26% of the human level on citation matching and only 18% on idea matching. Their populations can cite as diversely as a community and take up its tasks and methods, yet rarely arrive at the concrete approaches and research plans it pursues. Neither richer field context nor larger populations substantially close this gap. In blinded expert review, AI proposals read nearly as well as the 2026 papers yet are judged far less likely to succeed, and those whose ideas no human paper shares fare worst, suggesting weaker directions rather than overlooked opportunities. These results indicate that the main bottleneck in AI research taste lies less in finding the directions a community works on than in turning them into the concrete approaches it goes on to pursue. We will maintain ResearchMirror as an open, continuously updated leaderboard that benchmarks contemporary AI proposals against future publication cycles.

1 INTRODUCTION

AI scientists can now carry out much of the research process on their own, from generating ideas and grounding them in prior work to running experiments and writing papers (Lu et al., 2024; Yamada et al., 2025; Lu et al., 2026; Baek et al., 2025). Frontier laboratories are deploying them at growing scale (OpenAI, 2026; Anthropic, 2026; Gottweis et al., 2026; Chen et al., 2026a), and their work has begun to enter the scientific literature (Tang et al., 2026; Bianchi et al., 2026). Yet executing research well matters only when the research itself is worth doing, and this choice rests on research taste, the judgment of what to read, which problems to pursue, and which methods to try. As AI scientists take on a larger role in discovery, their taste increasingly shapes the research that comes next, but it remains far less understood than their ability to execute.

Evaluating research taste is challenging because it requires a reference for which choices are worth making. Existing work mostly judges one idea at a time, through expert ratings (Si et al., 2025; 2026), benchmarks with fixed targets (Guo et al., 2025; Qiu et al., 2025; Chen et al., 2025), or model judges that predict which directions will matter (Tian et al., 2026; Wu et al., 2026; Tong et al., 2026), and such judgments are not yet reliable (Sinhahajari et al., 2026; Ho et al., 2026; Baig et al., 2026). Population-level studies find that generated ideas are highly similar within and across models (Jiang et al., 2025; Wenger & Kenett, 2025; Chen et al., 2026b), but they measure how much a population repeats itself rather than whether its choices resemble those of human researchers. What is still missing is a direct comparison between the research choices of AI scientists and those of the human community working in the same area.

The work a community goes on to publish provides such a reference, since it records which of the many possible directions its researchers actually chose. Published papers have already been used

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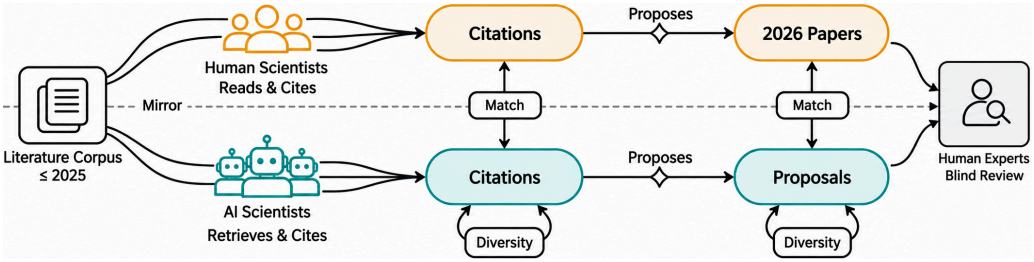


Figure 1: Overview of ResearchMirror. The literature corpus is frozen through 2025. In the upper branch, the human research community goes on to publish 2026 papers that cite work in the corpus. In the lower branch, a population of AI scientists retrieves from the corpus and writes research proposals. Matching compares the two branches, and diversity compares proposals with one another.

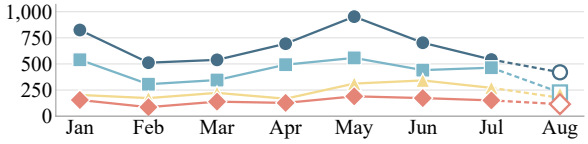
to score single ideas by their later impact and to reconstruct a held-out paper from its bibliography (Jiang, 2026; Chen et al., 2026c). We extend this reference from single papers to entire communities and introduce ResearchMirror, a temporal benchmark for research taste. As shown in Fig. 1, ResearchMirror freezes the literature of a research area through 2025, lets AI scientists write research proposals from this snapshot, and compares them with the papers the same community published in 2026. Since new research both builds on prior work and recombines it into new ideas (Uzzi et al., 2013; Foster et al., 2015), we compare proposals and papers at two levels. The literature they cite reflects what they read, and the ideas they state reflect which problems they pursue and which methods they propose. At each level, matching measures agreement with the human papers and diversity measures how varied the proposals are, and both are read against the level the 2026 papers reach among themselves. The benchmark covers four areas ranging from established to emerging fields, namely machine learning systems, code generation, world models, and automated research. Four methods differ in what an AI scientist knows about its area, from nothing beyond the corpus to a single topic (Lu et al., 2024), a map of the whole area, and the proposals its population wrote in earlier rounds (Schmidgall & Moor, 2025). We run each method with six recent language models, two of which were trained before 2026 and thus cannot have seen any reference paper.

Across more than 90,000 proposals, AI scientists fall well short of the research taste of human communities. Citation matching reaches about 26% of the human level on average and idea matching only 18%, and no population reaches half of it on either metric. The shortfall lies in what AI scientists propose more than in what they read. Given a direction, their populations can cite as diversely as a community and take up its tasks and methods, yet their proposals meet human papers far more often on problems and motivations than on concrete approaches and research plans. The gap also resists simple remedies. Models trained before 2026 match more human ideas than later ones that may have seen the reference, richer field context changes how widely a population spreads far more than how closely it follows human research, and populations up to 17 times larger level off well below the human level. In blinded expert review, AI proposals read nearly as well as the 2026 papers yet are judged far less likely to succeed, and those whose ideas no human paper shares fare worst, suggesting weaker directions rather than overlooked opportunities. The main bottleneck in AI research taste thus lies less in finding the directions a community works on than in turning them into the concrete approaches it goes on to pursue. We will maintain ResearchMirror as an open, continuously updated leaderboard that scores proposals written today against the research communities publish next. Our main contributions are as follows.

- We introduce ResearchMirror, a temporal benchmark that evaluates the research taste of AI scientists against the papers human communities publish after a frozen literature snapshot, scoring matching and diversity on cited literature and stated ideas across four research areas.
- Through experiments with six language models and four methods, covering more than 90,000 proposals, we find that AI scientists reach only a small fraction of the human level, lag more on ideas than on citations, and gain little from possible exposure to the reference, richer context, or larger populations.
- Through direction coverage, slot-level decomposition, and blinded expert review, we show that AI scientists reach the directions a community pursues far more readily than the approaches it proposes, and that proposals missing the human record are weaker rather than merely different.

Table 1: Data statistics. Left: sizes of the corpus U, published through 2025, and the human reference H, published in 2026. Right: papers in the human reference by publication month. Collection ends in August 2026, so the last month is incomplete.

Area	Corpus U	Reference H
Machine learning systems	88,184	5,188
Code generation	94,674	3,375
World models	50,271	1,867
Automated research	30,264	1,136



2 RESEARCHMIRROR

ResearchMirror evaluates the research taste of AI scientists by comparing the proposals they write from a frozen literature with the papers a human community later publishes. Sec. 2.1 builds the literature corpus and the human reference, Sec. 2.2 defines four metrics on what each side cites and proposes, and Sec. 2.3 describes the methods.

2.1 DATA CONSTRUCTION

We cover four research areas. Machine learning systems and code generation are established fields with large literatures, while world models and automated research are smaller and still emerging. For each area, we split the literature at the end of 2025. Papers published through 2025 form the corpus U, which AI scientists search and propose from. Papers published in 2026 form the human reference H, which records what the community actually pursued after this cutoff. The cutoff can be moved forward as new papers appear.

Both sets are collected by following citations from 20 to 22 landmark papers hand-picked for each area. The corpus first takes in papers published through 2025 that cite a landmark and then adds every paper cited by at least two of these citing papers. This second step brings in shared background that may not use the terminology of the area, such as program synthesis work for code generation. The human reference combines 2026 papers that cite a landmark with papers returned by topic search, screens them against a written area definition, and removes surveys. It covers January to August 2026, and Table 1 reports the sizes of both sets. Appendix B gives the area definitions, the landmarks, further construction details, and a coverage audit against authoritative surveys.

2.2 EVALUATION DESIGN

Writing a research document, whether a human paper or an AI scientist proposal, involves two choices, selecting the prior work to build on and formulating an idea in relation to it. AI scientists make these choices using only the frozen corpus U, while the human reference H records the community's subsequent choices after the cutoff. We therefore compare H with the proposals A of a population at the two corresponding levels (Uzzi et al., 2013; Foster et al., 2015). The resulting temporal information asymmetry is discussed in Appendix F.4. At the citation level, each document $d \in H \cup A$ is represented by its citation set $\mathcal{C}(d)$, the papers it cites that lie in U. At the idea level, it is represented by a summary that a language model extracts from its abstract under a fixed schema of five slots $\mathcal{I}$, namely contribution type, problem, motivation, proposed approach, and research plan, as detailed in Appendix C. At each level, matching measures agreement with the human reference and diversity measures how varied the proposals are, giving citation matching MATCH-CITE, citation diversity DIVERSITY-CITE, idea matching MATCH-IDEA, and idea diversity DIVERSITY-IDEA. All four lie in $[0, 1]$, and higher values mean closer agreement with the human reference or greater variety. Applying them to H itself, with each human paper compared only with the other human papers, gives the human level against which populations are read.

2.2.1 LEVEL 1: LITERATURE SELECTION

MATCH-CITE. We compare a human paper $d_h \in H$ and a proposal $d_a \in A$ by the Jaccard similarity of their citation sets, $J(d_h, d_a) = |\mathcal{C}(d_h) \cap \mathcal{C}(d_a)|/|\mathcal{C}(d_h) \cup \mathcal{C}(d_a)|$, and match each document with its closest counterpart on the other side:

$$J_{A\to H} = \frac{1}{|A|} \sum\nolimits_{d_a \in A} \max_{d_h \in H} J(d_h, d_a), \qquad J_{H\to A} = \frac{1}{|H|} \sum\nolimits_{d_h \in H} \max_{d_a \in A} J(d_h, d_a). \tag{1}$$

$J_{A\to H}$ measures whether each proposal cites like some human paper, which a population can achieve from a narrow corner of the literature. $J_{H\to A}$ measures whether the sources of each human paper appear among the proposals, which requires the population to spread across the literature. MATCH-CITE is $M_{\text{cite}} = 2J_{A\to H}J_{H\to A}/(J_{A\to H} + J_{H\to A})$, which is high only when both are.

DIVERSITY-CITE. Citation diversity asks whether proposals read enough without returning to the same sources. It is the product $D_{\text{cite}} = Q\,S$ of the sufficiency Q and the spread S,

$$Q = \frac{1}{|A|}\sum\nolimits_{d_a\in A} \min\left(|\mathcal{C}(d_a)|/\tau, 1\right), \qquad S = \left|\bigcup\nolimits_{d_a\in A} \mathcal{C}(d_a)\right| \Big/ \sum\nolimits_{d_a\in A} |\mathcal{C}(d_a)|, \tag{2}$$

where τ is the mean citation set size of the human papers in the area. See Appendix C.1. Because Q is capped at one, citing more than a typical human paper earns nothing, and S falls as proposals cite the same papers. D_{cite} is thus high only when proposals both read enough and read differently.

2.2.2 LEVEL 2: IDEA FORMULATION

A language-model judge compares two idea summaries slot by slot, with $b_i(d, d') \in \{0, 1\}$ recording whether d and d' agree on slot $i \in \mathcal{I}$. To keep judging feasible, each d is compared only with $\mathcal{N}_X(d)$, its five nearest other documents in a pool X under hybrid sparse and dense retrieval over titles and abstracts, and $m_i(d, Y) = \max_{d'\in Y} b_i(d, d')$ indicates whether slot i of d is matched within a set Y. As most paper pairs share a contribution type but few share a research plan, each slot is weighted by its rarity, $w_i = -\log_2 p_i$ for $p_i > 0$, where p_i is the fraction of human papers d_h whose slot i is matched within $\mathcal{N}_H(d_h)$. With the weights and their sum W fixed per area, $s(d, Y) = \sum_{i\in\mathcal{I}} w_i\, m_i(d, Y)/W$ is the weighted fraction of slots of d matched within Y.

MATCH-IDEA. A slot of a human paper counts as covered when at least one proposal retrieved for it matches on that slot, and MATCH-IDEA is the weighted fraction of human slots covered.

DIVERSITY-IDEA. Applying the same matching within a population, we compare each proposal with its peers $\mathcal{P}(d_a) = \mathcal{N}_A(d_a) \cup \{d_{a'} \in A : d_a \in \mathcal{N}_A(d_{a'})\}$, namely the proposals it retrieves and those that retrieve it, and DIVERSITY-IDEA is one minus the weighted fraction of its slots that some peer shares. Both idea metrics are thus averages of s, taken over human papers against the proposals and over proposals against their peers:

$$M_{\text{idea}} = \sum\nolimits_{d_h\in H} s\big(d_h, \mathcal{N}_A(d_h)\big)/|H|, \qquad D_{\text{idea}} = 1 - \sum\nolimits_{d_a\in A} s\big(d_a, \mathcal{P}(d_a)\big)/|A|. \tag{3}$$

Appendix C gives the retrieval and judging configurations that both idea metrics depend on, and validates the judge against human annotators.

2.3 METHODS

All four methods share one AI scientist implementation and differ only in what it knows about its area. The AI scientist receives the area definition used to screen the human reference and writes one proposal within a fixed step budget, taking one action per step: planning, searching the corpus, pinning retrieved papers, revising the draft, compressing its history into notes, or submitting. It can cite only retrieved papers, so its citations always lie in U. The methods vary its profile and actions:

- FREE only states that the AI scientist is a researcher in the area, revealing what it pursues without an explicit prior.
- TOPIC assigns one research topic and leaves the choice of problem open (Lu et al., 2024), testing how a broad direction shapes proposals. Topics are allocated in proportion to corpus frequency, with recent years upweighted.
- LANDSCAPE assigns no topic but lists the area's most common task tags, method tags, and task–method pairs with their shares among 2025 papers, plus an action to retrieve papers by tag or pair. It thus exposes the area's structure and how crowded each direction is, which researchers weigh when choosing between established and new directions (Foster et al., 2015).
- FRONTIER lets AI scientists see one another's work (Schmidgall & Moor, 2025). It assigns topics like TOPIC but runs in rounds, freezing each round's proposals and research traces into a snapshot that later rounds query through two extra actions, as researchers read peers' work. Peer records are separate from literature retrieval, uncitable, and marked as not scientifically validated.

Table 2: Main results (%). For each area, Match reports MATCH-CITE and MATCH-IDEA, and Diversity reports DIVERSITY-CITE and DIVERSITY-IDEA. The Human row scores the 2026 papers against one another and gives the human level. Model groups are ordered by release date, and bold marks the best score in each column within a group.

	Machine learning systems				Code generation				World models				Automated research			
	Match		Diversity		Match		Diversity		Match		Diversity		Match		Diversity	
Population	Cite	Idea	Cite	Idea	Cite	Idea	Cite	Idea	Cite	Idea	Cite	Idea	Cite	Idea	Cite	Idea
Human	20.84	13.56	13.50	84.97	18.75	11.25	18.64	87.41	16.38	13.87	14.68	84.31	18.51	10.53	21.69	87.52
2025-04-05, Llama 4 Scout (Meta AI, 2025a)																
FREE	3.44	4.32	3.89	34.91	2.72	3.41	5.35	42.70	2.65	2.74	2.96	35.32	**6.42**	**4.79**	3.87	38.58
TOPIC	**3.87**	4.93	13.71	67.47	**3.29**	**4.21**	12.77	63.90	3.42	**4.42**	9.41	61.39	5.44	3.85	13.84	**68.53**
LANDSCAPE	2.51	4.91	5.51	33.05	2.10	2.19	2.44	35.27	1.91	1.81	2.20	27.65	5.14	4.37	3.70	38.62
FRONTIER	2.76	**5.95**	**14.93**	**71.64**	3.14	3.72	**12.85**	**64.20**	**3.95**	3.94	**9.91**	**62.91**	4.71	3.32	**14.06**	67.21
2025-10-15, Claude Haiku 4.5 (Anthropic, 2025a)																
FREE	**4.48**	1.70	13.02	45.34	3.90	**1.93**	17.36	51.53	4.37	2.17	12.04	48.29	5.86	2.79	12.11	28.34
TOPIC	4.24	1.99	**30.78**	77.60	**4.00**	1.81	**31.68**	**72.51**	4.94	**2.85**	**22.31**	66.17	**6.14**	2.55	**27.86**	**67.64**
LANDSCAPE	3.97	1.48	12.79	45.83	3.71	1.57	17.78	57.87	4.29	2.59	12.06	40.44	5.80	3.14	13.20	33.69
FRONTIER	4.41	**2.30**	29.82	**80.66**	3.90	1.81	28.76	70.32	**5.03**	2.41	22.07	**69.06**	6.07	**3.17**	26.82	65.44
2026-07-21, Gemini 3.5 Flash-Lite (Google DeepMind, 2026)																
FREE	3.73	1.36	3.01	16.88	3.72	1.52	6.29	15.40	4.89	3.38	4.76	18.76	7.18	2.22	5.52	12.92
TOPIC	4.59	2.29	**14.11**	**53.98**	4.23	**2.19**	**17.19**	49.28	**5.33**	3.86	**13.35**	52.52	6.58	2.14	20.22	62.21
LANDSCAPE	3.67	1.38	2.85	15.01	3.88	1.47	6.07	16.56	4.44	2.31	3.62	14.35	**7.18**	2.14	5.12	9.86
FRONTIER	**4.65**	**2.32**	14.05	53.28	**4.23**	1.85	16.86	**52.38**	5.28	**3.87**	12.90	**52.68**	6.34	**2.28**	**20.57**	**63.31**
2026-07-31, DeepSeek-V4-Flash (DeepSeek-AI, 2026)																
FREE	3.94	0.92	7.65	33.13	3.51	0.79	13.00	35.38	4.77	1.45	13.50	42.79	6.40	1.67	7.57	23.16
TOPIC	4.63	**1.18**	33.88	67.65	**4.63**	0.99	37.46	64.30	**5.16**	1.76	32.51	69.06	**7.72**	**2.09**	25.39	55.80
LANDSCAPE	3.53	1.05	10.82	29.33	3.62	0.96	14.24	38.46	4.22	**1.90**	13.00	40.58	5.33	1.87	9.55	22.50
FRONTIER	**4.78**	0.94	**42.15**	**82.55**	4.58	**1.00**	**46.96**	**77.25**	4.98	1.41	**39.83**	**71.38**	7.02	1.83	**36.17**	**73.59**
2026-08-14, Qwen3.8-27B (Qwen Team, 2026)																
FREE	3.96	0.95	8.22	31.92	4.44	1.11	17.38	45.91	5.32	1.51	13.30	37.35	6.30	1.79	6.94	18.01
TOPIC	4.89	1.38	32.36	74.25	4.21	**1.40**	40.35	66.94	5.59	2.20	36.12	**66.34**	7.17	**2.66**	29.08	59.14
LANDSCAPE	3.70	1.00	10.92	37.27	3.47	1.01	16.18	45.42	4.73	1.59	11.28	25.58	6.58	1.86	8.98	22.32
FRONTIER	**4.94**	**1.49**	**37.97**	**78.03**	**5.05**	1.33	**46.53**	**67.09**	**5.91**	**2.35**	**36.94**	65.75	**7.72**	2.39	**31.05**	**63.81**
2026-09-03, K2 Horizon 375B A23B (Institute of Foundation Models, 2026)																
FREE	4.21	0.94	9.30	48.63	3.82	1.03	17.96	60.97	5.01	1.56	14.16	65.68	**7.21**	1.80	10.52	38.38
TOPIC	4.44	1.19	**35.70**	82.82	**4.56**	1.05	36.83	76.99	4.97	1.32	**29.70**	80.48	7.04	2.09	33.37	**80.26**
LANDSCAPE	4.09	1.10	10.31	51.96	3.73	**1.10**	21.35	66.92	4.51	**1.65**	12.00	53.09	6.75	1.87	10.40	39.87
FRONTIER	**4.59**	**1.27**	34.85	**84.58**	4.24	1.03	**38.14**	**77.50**	**5.05**	1.52	29.45	**82.76**	6.82	**2.36**	**34.13**	78.02

These methods test whether an AI scientist's view of its area changes the literature and ideas its population selects. See Appendix D for more details.

3 EXPERIMENTS

AI scientists. We run the four methods of Sec. 2.3 in every area with the six language models in Table 2. Each AI scientist has a budget of 20 steps, and each population holds 300 proposals, which FRONTIER writes in two rounds of 150. The six models form two groups by design. Four were released in 2026 and power current AI scientists, so their training data may overlap the human reference, but leaving them out would confine the benchmark to outdated models. The other two were trained before 2026 and cannot have seen any 2026 paper, so their results are free of leakage by construction. Comparing the two groups tests whether possible exposure to the reference helps AI scientists anticipate 2026 research. Appendix D gives implementation details.

Automatic evaluation. All populations are scored with the metrics of Sec. 2.2, and scoring the 2026 papers against one another gives the human level. The slot-level judge is GPT-5.6 Luna, outside the evaluated model families and validated against human annotators in Appendix C.4.

Human evaluation. Beyond whether AI scientists propose what the community pursues, we use human evaluation to examine how good their proposals are, and in particular whether those without a human counterpart are weak directions or sound ones the community has not yet taken. Eleven

Table 3: Human evaluation of idea quality. Reviewers score 2026 papers and AI scientist proposals without knowing their source, and scores are mapped onto $[0, 100]$. "Judged AI" is the share of reviews that label a document as AI-generated. Match is decided by slot-level judge MATCH-IDEA.

	Quality			Execution		Overall		
Population	Soundness	Presentation	Contribution	Feasibility	Success	Rating	Confidence	Judged AI
Human	49.83	62.50	53.99	**75.39**	**70.70**	**49.48**	56.51	39.06
AI scientist (mean)	38.54	58.16	45.31	63.80	50.39	38.54	59.90	86.46
Llama 4 Scout	13.54	30.21	17.71	55.47	35.94	22.50	60.94	81.25
Claude Haiku 4.5	38.54	57.29	41.67	67.97	50.78	39.38	55.47	84.38
Gemini 3.5 Flash-Lite	39.58	56.25	45.83	64.06	58.59	35.62	62.50	90.62
DeepSeek-V4-Flash	**51.04**	**75.00**	**63.54**	67.19	61.72	46.88	60.16	87.50
Qwen3.8-27B	44.79	70.83	52.08	60.94	46.88	44.38	59.38	87.50
K2 Horizon 375B A23B	43.75	59.38	51.04	67.19	48.44	42.50	60.94	87.50
Match, proposals and the 2026 papers they match								
Human	50.00	60.42	53.47	74.48	69.01	50.00	55.99	40.62
AI scientist	40.62	58.68	45.49	66.15	54.17	39.17	60.16	86.46
Δ AI scientist $-$ Human	-9.38	-1.74	-7.99	-8.33	-14.84	-10.83	$+4.17$	$+45.83$
Non-match, documents with no counterpart on the other side								
Human	49.65	64.58	54.51	76.30	72.40	48.96	57.03	37.50
AI scientist	36.46	57.64	45.14	61.46	46.61	37.92	59.64	86.46
Δ AI scientist $-$ Human	-13.19	-6.94	-9.37	-14.84	-25.79	-11.04	$+2.61$	$+48.96$

reviewers, all with reviewing experience, assess 192 documents without knowing their source. The documents are split evenly between proposals and 2026 papers and balanced across areas and models. Half come from matched pairs, each a proposal and the 2026 paper it overlaps under the judge of MATCH-IDEA, and the other half have no counterpart on the other side. Each document receives two reviews. Besides the dimensions of the ICLR review form, reviewers rate feasibility and expected success, since an idea can look original yet fail in execution (Si et al., 2026), and guess whether the document is AI-generated. Appendix C.5 details the design.

Main results. Table 2 scores every population on the four metrics against the human level, and Table 3 reports how reviewers rate a blinded sample of proposals and 2026 papers. Together they yield four findings.

- **AI scientists fall far short of the research taste of human communities.** On average, AI scientists reach about 26% of the human level on MATCH-CITE and only 18% on MATCH-IDEA, and no population, under any model or in any area, reaches half of it on either metric. The gap is narrowest in automated research, the newest and smallest area, and widens as the area grows, peaking in machine learning systems and code generation. AI scientists thus track a community most closely where it has least to choose from and fall furthest behind where it has most.
- **The gap lies in what AI scientists propose, not in what they read.** For five of the six models, matching falls further behind the human level on ideas than on citations, and diversity sharpens this split. Once TOPIC or FRONTIER assigns a direction, four of the six models cite up to three times as diversely as the community, yet no population reaches the human level of idea diversity. A population can thus read as widely as a community and still repeat itself in what it proposes, so drawing on the literature a community builds on is not enough to arrive at the ideas it pursues.
- **Knowing more, from training or from context, does not close the gap.** Although four of the six models may have seen the 2026 papers in training, the two trained before 2026 match more human ideas, about 26% of the human level against 14% as Appendix F.4 details. Idea matching thus follows neither recency nor capability, as Llama 4 Scout matches the most human ideas yet receives the lowest ratings in Table 3. More context does no better. Across the four methods, matching stays within a narrow band while citation diversity varies about threefold, so what an AI scientist is told shapes how widely its population spreads far more than how closely it follows human research. The fullest view helps least, as LANDSCAPE ranks last on MATCH-CITE in 19 of 24 settings, while the direction of TOPIC and the peer proposals of FRONTIER broaden a population without bringing it near the human level.
- **The quality gap centers on execution and deepens where proposals miss the human record.** In blind review, AI proposals score below the 2026 papers on every quality dimension, by 20 points on expected success but only 4 on presentation, so they read almost as well as papers yet are judged far less likely to work. Reviewers also flag 86% of them as AI-generated, against 39% of the papers. Even DeepSeek-V4-Flash, which surpasses the papers on soundness, presentation,

Case 1: a matched pair. Problem: Both documents falsify an AI scientist's own hypotheses before accepting them, rather than trusting a frozen evaluator, and reviewers place neither side.

Human **Let the Abyss Stare Back (Li et al., 2026a).** Co-evolve an innovator, an adversarial falsifier that builds counterexample environments, and a causal extractor, on a controlled loss-discovery problem.
Overall 75 · Soundness 50 · Success 40 · Guess: **unsure**

AI proposal (Gemini 3.5 Flash-Lite, FREE). Add a verification agent that writes adversarial tests, probes boundary conditions, and tries to falsify each hypothesis before ratifying it.
Overall 75 · Soundness **100** · Success 60 · Guess: **unsure**

Case 2: examples of score heterogeneity among non-matching documents.

Human **ResearchArena (Libon et al., 2026).** Pair four long-horizon AI research tasks with hidden side tasks that sabotage the submitted artifact, to test whether an untrusted agent's output is safe to deploy.
Overall **25** · Soundness 0 · Success 20 · Guess: **AI-generated**

AI proposal (Qwen3.8-27B, FRONTIER). Key the KV cache by a graph of mutation relations among propagating artifacts rather than by request prefix, so long-horizon agent-society simulations reuse cache across agents and turns.
Overall 50 · Feasibility **25** · Success **20** · Guess: AI-generated

AI proposal (Claude Haiku 4.5, FRONTIER). Augment a learned latent dynamics model with a topic model, so that recurring configurations and action-effect modes surface as discrete behavioral topics.
Overall **75** · Feasibility 75 · Success 40 · Guess: **human paper**

Figure 2: Cases from the blind review, with the scores and the source guess of one reviewer under each document. Case 1 pairs a proposal with the 2026 paper whose idea the judge marks as overlap, and Case 2 is three documents with no counterpart in the human record.

> and contribution, trails them in feasibility and expected success. Split by match, both groups of proposals trail the papers by the same 11 points in overall rating, but those with no human counterpart fall much further behind in execution, as the gap widens from 8 to 15 points in feasibility and from 15 to 26 in expected success. What AI scientists fail to anticipate is thus what reviewers expect least to succeed.

Together, these findings show that AI scientists come closer to a community in what they read than in what they propose, that neither newer models nor richer context closes this gap, and that the proposals outside the human record read to reviewers as weaker directions rather than overlooked opportunities. Low matching thus reflects a deficit in research taste rather than a mere difference in preference. Sec. 4 examines which part of an idea AI scientists miss and whether scale recovers it.

Case study. We provide interesting cases with expert review as shown in Figure 2. Case 1 shows that the proposal scored higher on soundness and on expected success. Case 2 collects three documents that no counterpart matched. The first is a 2026 paper rated below both and also taken for AI. The first proposal reads well enough for a middling overall rating, yet its feasibility and expected success sit near the bottom of the scale and the reviewer identified it as AI-generated. A reviewer took the second proposal for a published paper. Therefore, the averages in Table 3 place proposals below papers there, while individual documents on both sides span the range.

4 ANALYSIS

The main results show that AI scientists fall furthest behind on idea matching. We trace where this gap lies, first across research directions, then within the idea summary and in concrete cases, and finally ask whether larger populations close it.

Do AI scientists cover the human research directions? Low idea matching may arise because a population never takes up the directions the 2026 papers pursue, or because it takes them up and still arrives at different ideas. To tell these apart, we treat a direction as a task paired with a method, that is, what a paper works on and how, and label both sides with the task and method vocabulary that LANDSCAPE draws on. We run this comparison for DeepSeek-V4-Flash in automated research, with each population holding as many proposals as the area has papers so that both sides are compared at equal size. Figure 3 reports the share of human tag mass each population reaches. On each axis alone, the populations given a direction come close to the community, and FRONTIER misses only a small share of the human task mass and of the method mass. On pairs, every population falls away, and even FRONTIER reaches only about half of the human mass, so AI scientists work on

Population	# Task	# Method	# Pair
Human	200	268	2,871
FREE	36	103	710
TOPIC	125	191	1,734
LANDSCAPE	39	114	847
FRONTIER	192	220	3,441

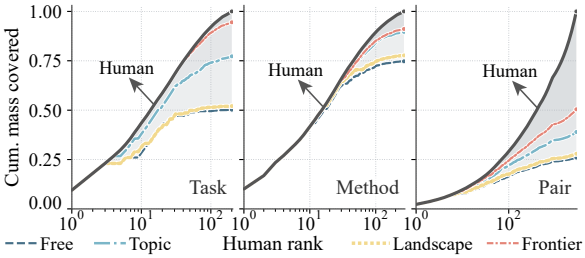


Figure 3: Tag use in automated research: the task a document works on, the method it uses, and the task–method pair. Left: how many distinct tags of each kind each population uses. Right: the cumulative share of human tag mass each population reaches, with human tags ordered from the most to the least used and the human curve as the ceiling.

Table 4: Per-slot MATCH-IDEA over the slots of the idea summary, namely problem, motivation, proposed approach, and research plan. Each entry is the share of human papers a population matches on that slot.

	Machine learning systems				Code generation				World models				Automated research			
Population	Problem	Motivation	Approach	Plan	Problem	Motivation	Approach	Plan	Problem	Motivation	Approach	Plan	Problem	Motivation	Approach	Plan
Human	28.32	42.58	3.99	7.21	24.74	33.19	4.21	3.64	25.12	29.41	7.12	6.16	19.10	38.29	4.49	2.99
2025-04-05, Llama 4 Scout (Meta AI, 2025a)																
FREE	7.09	17.62	0.81	1.45	6.73	6.99	**1.87**	1.07	4.02	5.25	1.18	0.91	**6.95**	14.96	**3.35**	0.44
TOPIC	10.00	20.34	0.87	0.94	6.13	10.10	1.63	**2.61**	**7.02**	**10.28**	2.09	1.23	5.28	14.08	1.58	0.53
LANDSCAPE	8.54	18.04	0.87	**2.35**	2.93	4.30	1.13	1.01	1.71	2.25	0.37	**1.45**	5.99	**15.32**	2.38	**0.62**
FRONTIER	**12.10**	**23.46**	**1.29**	1.52	**7.50**	**10.16**	1.63	0.77	5.52	8.03	**2.25**	1.39	4.23	13.12	1.41	0.09
2026-07-31, DeepSeek-V4-Flash (DeepSeek-AI, 2026)																
FREE	1.04	1.12	**0.23**	0.08	0.89	1.21	0.00	0.00	2.95	1.98	0.27	0.00	2.11	3.43	0.26	0.00
TOPIC	**1.77**	**3.01**	0.10	0.04	**1.63**	1.69	0.12	0.00	2.68	3.00	**0.64**	**0.21**	**3.35**	**4.75**	0.44	**0.09**
LANDSCAPE	1.31	2.18	0.12	**0.12**	1.19	1.60	0.18	0.00	**3.48**	**4.18**	0.16	0.05	2.38	3.43	**0.62**	**0.09**
FRONTIER	1.04	2.04	0.06	0.02	1.42	**2.04**	**0.21**	0.00	2.36	2.73	0.11	0.00	3.08	4.23	0.26	0.00

the community's tasks with its methods but combine the two differently. Neither kind of coverage, however, carries over to ideas. FRONTIER reaches about twice the human pair mass of FREE but matches barely more human ideas in Table 2, where the four methods sit within a narrow band. AI scientists thus reach the directions a community pursues and still propose something else, so what they miss lies inside a direction rather than in the choice of one.

Where do AI and human research ideas differ? To locate the difference inside an idea, we decompose MATCH-IDEA into the slots of the idea summary. Table 4 reports per-slot matching for Llama 4 Scout and DeepSeek-V4-Flash, one model from each side of the 2026 cutoff. Both populations reach the problems and motivations of human papers many times more often than their approaches and research plans, so AI scientists agree with a community on what to study and why far more readily than on how to do it. Part of this ordering is intrinsic, since the 2026 papers also match one another far more often on problems than on approaches, an approach being the more specific of the two. Read against this human level, the decline persists for DeepSeek-V4-Flash, which covers a small share of human problems and almost none of their research plans, while Llama 4 Scout stays at roughly a third of the human level on every slot. Either way, almost no human approach or research plan finds a counterpart among the proposals, and this is where the idea gap lies.

What do AI scientists propose instead? Figure 4 pairs each of two human papers with two proposals from one language model that share its problem. In both cases, the proposal that misses the human approach leaves the trained network unchanged and adds machinery around it, whereas the human paper and the matching proposal both modify the network itself. The Case 1 paper fine-tunes the router toward expert reuse, while proposal A predicts expert demand and prefetches experts around an unchanged network. The Case 2 paper updates low-rank adapters on a frozen network, while proposal A keeps the weights fixed and adapts through retrieved transitions. The same problem thus admits very different mechanisms, and a shared problem does not imply a shared approach. Appendix F.9 provides the source schemas and further examples.

Can more AI scientists close the gap? If the gap stemmed mainly from population size, sampling more proposals should close it. We grow the FREE and TOPIC populations of Gemini 3.5 Flash-Lite and DeepSeek-V4-Flash in every area from 300 proposals to the size of the human reference,

Case 1: fetching uncached MoE experts causes substantial I/O overhead.

Human **ReMoE (Zhu et al., 2026).** Fine-tune the router to favor recently used experts, reducing transfers without adding inference-time computation.

AI A: approach differs (Qwen3.8-27B, FRONTIER). Predict expert demand from prompt topics, then prefetch experts and coordinate caching and scheduling without changing the model.

AI B: approach matches (Qwen3.8-27B, TOPIC). Train only the router to increase expert reuse over consecutive tokens while preserving language-model performance.

Case 2: pretrained world models need to adapt to changing environments while retaining prior capabilities.

Human **SPREAD (Moon & Kim, 2026).** Freeze the pretrained model and update low-rank adapters online, aiming for rapid adaptation without replay.

AI A: approach differs (DeepSeek-V4-Flash, TOPIC). Keep model weights fixed, store observed transitions, and combine retrieved predictions with the model's predictions.

AI B: approach matches (DeepSeek-V4-Flash, FREE). Adapt a frozen model through low-rank updates and compose adapters for combinations of dynamics changes.

Figure 4: Two human papers, each paired with two AI proposals from a single language model. Under the stored automatic judgments, all four proposals match their human paper on problem and motivation, and only proposal B also matches on proposed approach and research plan.

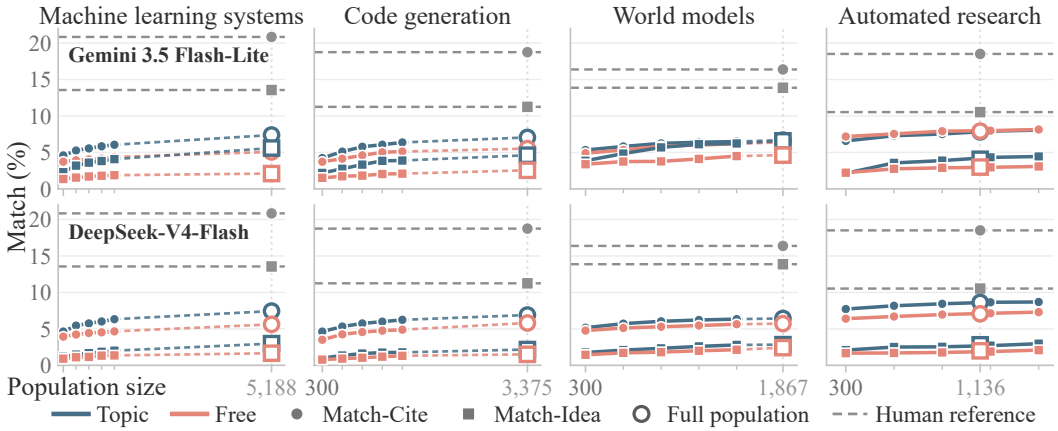


Figure 5: Matching against population size. Rows are Gemini 3.5 Flash-Lite and DeepSeek-V4-Flash from top to bottom, and columns are the four areas. Color marks the method, TOPIC or FREE, and marker shape the level, circles for MATCH-CITE and squares for MATCH-IDEA.

3.8 to 17 times larger, and report matching in Figure 5. Matching grows far more slowly than the population. Every curve rises only gently and levels off as proposals accumulate, staying well below the human level even when a population holds as many proposals as the community holds papers. An assigned direction helps somewhat, as TOPIC climbs more steeply on ideas than FREE in most settings, yet both remain far from the human level. The gap is thus not an artifact of population size. Together with the analyses above, this shows that neither reaching more of a community's directions nor writing more proposals brings AI scientists closer to the approaches the community arrives at. Improving research taste therefore means improving how a recognized problem becomes a concrete approach, not how widely or how much a population proposes.

5 CONCLUSION

We introduced ResearchMirror, a temporal benchmark that measures the research taste of AI scientists against the research human communities go on to publish. Our results point to a consistent picture. AI scientists share much of a community's literature and directions, yet seldom arrive at the concrete approaches it pursues, and the proposals that depart from human research tend to be weaker rather than overlooked. This picture holds across newer models, richer context, and larger populations. The research taste of AI scientists is thus limited less by knowing what to work on than by deciding how to pursue it, which we see as the central challenge for future AI scientists.

AI USE STATEMENT

Language models are both an object and an instrument of this study. They write the proposals we evaluate, and they also serve as measurement tools: the extractor that turns a document into the idea schema, the tagger that builds the task and method tags, the model that screens papers for an area, and the judge that decides slot agreement. Sec. 3 and Appendix E give the model and the settings behind each role. Beyond these roles, the authors used generative AI to refine the wording of the manuscript and to assist with code, and reviewed all such output. The authors take full responsibility for the content, methodology, analysis, and conclusions.

ETHICS STATEMENT

This study uses published scientific metadata and abstracts from OpenAlex and Semantic Scholar. It compares distributions of papers and generated proposals. Two parts of the evaluation involve people, the expert review of idea quality in Appendix C.5 and the annotation study for the idea judge in Appendix C.4. Participants are colleagues with reviewing experience, and participation was voluntary. In the quality review, the source of every document is hidden, so AI proposals and 2026 papers are judged on the same terms. Both studies collect only research judgments and a short self-reported background, and all responses are reported in aggregate, so no rating can be traced to a reviewer or read as a verdict on a single paper. They gather no sensitive personal information and, under the policy of our institution, require no ethics review.

REPRODUCIBILITY STATEMENT

Reproducing a result in this paper means fixing five things: the corpus snapshot, the method configuration, the proposal set, the extraction and judging models, and the metric parameters. Sec. 2.2 defines the four metrics, and the appendix specifies what they rest on. Appendix B gives the area definitions, the landmark papers, and how the corpus and the 2026 reference set are built, while Appendix C covers the extraction schema, the retrieval settings, the judging protocol, and the slot weights. The shared agent loop and the four method profiles appear in Appendix D, and the model, endpoint, and inference settings of every role in Appendix E. Appendix C.4 and Appendix C.5 describe the two human studies, their questionnaires, sampling designs, and score normalization. Upon acceptance we will release the corpus and the 2026 reference set of all four areas by paper identifier, together with the prompts, model versions, code, and inference settings behind every model call.

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A Related Work

AI scientists and research agents. AI scientists are now built to run much of the research loop, from idea to experiment to written paper (Lu et al., 2024; Yamada et al., 2025; Lu et al., 2026), and the space is growing quickly (Luo et al., 2025; Wei et al., 2025). Agent Laboratory executes a human-provided idea, Co-Scientist refines hypotheses through a team of agents (Schmidgall et al., 2025; Gottweis et al., 2026), SciAgents and the Virtual Lab carry multi-agent designs into materials and biomedical problems (Ghafarollahi & Buehler, 2025; Swanson et al., 2025), and CycleResearcher adds automated review (Weng et al., 2025). Evaluation has largely followed one unit, a single system, even as agent-written work begins to enter the record from deployments at scale and a conference with AI authors and reviewers (Tang et al., 2026; Bianchi et al., 2026). This paper moves up a level, to a population of AI scientists proposing research from one shared literature.

Automated idea generation. Within such systems the proposal comes from an ideation step, where methods turn retrieved prior work into problems, hypotheses, and experiment designs (Baek et al., 2025; Wang et al., 2024; Li et al., 2025; Hu et al., 2025), and related work forecasts active topics from a knowledge graph (Krenn et al., 2023; Gu & Krenn, 2025). Ideation has also been run at population scale, on a shared archive or inside a simulated research community (Schmidgall & Moor, 2025; Yu et al., 2024), where outputs turn out to be substantially similar within and across models (Jiang et al., 2025; Wenger & Kenett, 2025), with further work relating this to knowledge, group size, and crowding against human output (Deng et al., 2026; Chen et al., 2026b; Azad & Baten, 2026), as agent societies outside research also develop shared conventions and collective bias (Park et al., 2023; Ashery et al., 2025). Such comparisons are mostly internal to the population. This study measures that similarity in the literature a proposal cites and in the idea it states, and pairs each with agreement against human papers.

Evaluating research ideas. Evaluation supplies the external reference such comparisons lack. Experts judge one idea at a time, though the initial advantage of model ideas narrowed once executed (Si et al., 2025; 2026), while benchmarks score ideas against fixed targets (Guo et al., 2025; Qiu et al., 2025; Chen et al., 2025), often leaving the verdict to model judges (Zheng et al., 2023) now asked which directions will matter (Tian et al., 2026; Wu et al., 2026; Tong et al., 2026). Those verdicts are not yet reliable, as judges disagree with experts on novelty (Sinhahajari et al., 2026), trail them at comparison (Baig et al., 2026), and rate unsound ideas as sound (Ho et al., 2026), while human review is itself inconsistent (Cortes & Lawrence, 2021). Published research offers a steadier reference, used to score ideas by future impact (Jiang, 2026), to recover a held-out paper (Chen et al., 2026c), and to profile ideas against a taxonomy on which model output is narrower (Chen et al., 2026d), though citation lists are an imperfect standard (Sahu et al., 2026). This paper extends that reference from single papers to what a research community published after its literature was frozen, comparing that with what a population cites and proposes.

B Data Construction Details

Each area is represented by two sets of papers: a corpus U of work published through 2025, which is what AI scientists retrieve from, and a human reference H of papers from 2026, which is what proposals are measured against. The two are built to different standards. The corpus has to be wide enough that the background a 2026 paper builds on lies inside it, and it must carry nothing from 2026. The reference set has to be as complete as we can make it and has to hold research in the area. This appendix describes the area definitions, the sources data come from, data construction details, and the survey reference coverage audit.

B.1 Research Areas

Each area is defined in writing before collection begins, and that definition does not change afterwards. It states what belongs to the area and what does not, and it is what every screening step below applies. The AI scientists receive the same text as the description of their research community, so both sides work under one definition of the area. Table 5 gives the four definitions together with the topic search queries used to collect the reference set.

Table 5: Area definitions and topic search queries recorded in each area's frozen configuration. Topic search applies to the reference set only.

Area	Definition and topic search
Machine learning systems	Systems research for efficient training and inference of ML and LLM models: inference serving and scheduling, KV-cache and memory management, distributed training and parallelism, quantization, pruning and distillation for efficiency, speculative decoding, efficiency-motivated attention and architecture changes, ML compilers and kernels, hardware acceleration, and MoE systems. Not in scope: architecture work aimed at task quality, downstream applications that merely use these systems, retrieval-augmented generation, alignment, and generic high-performance computing unrelated to ML. Topic search: the OpenAlex topics Parallel Computing and Optimization Techniques and Stochastic Gradient Optimization Techniques, and title and abstract search for "llm serving", "inference serving", and "distributed training".
Code generation	Research on automatically producing program code from natural-language or other specifications with learned models: code LLMs and pretrained code models, program synthesis, natural language to code including text-to-SQL, code benchmarks and code-specific evaluation, program repair and self-debugging, coding agents and LLM-based software engineering, and code data curation. Not in scope: generic LLM and NLP foundation work such as GPT, LLaMA, RLHF and LoRA, generic agent or reasoning work without a code focus, generic machine translation metrics, and papers that merely use code as an application domain without studying generation. Topic search: OpenAlex keywords "code-generation" and "program-synthesis".
World models	Learned internal models of an environment that represent its current state and predict future states under actions, used for planning and decision-making, simulation, and data generation. The lineages are model-based reinforcement learning with latent dynamics, video-generative world simulators, JEPA-style predictive representation learning, and domain instances in robotics, autonomous driving and games. Not in scope: generic video generation or vision backbones not positioned as environment models, model-free reinforcement learning, and generic LLM and NLP work. Topic search: title and abstract search for "world model".
Automated research	AI systems, especially LLM agents, that automate stages of the scientific research process: hypothesis and idea generation, experiment planning and execution including ML engineering and laboratory automation, analysis, scientific writing and peer review, up to end-to-end autonomous AI scientists. Research-agent benchmarks and equation or function discovery are included. Not in scope: philosophy of science without AI, generic agent frameworks without a research-automation focus, domain-science papers that merely use AI as a tool, and generic literature-retrieval tools. Topic search: title and abstract search for "ai scientist", "research agent", "automated scientific discovery", and "autonomous research".

B.2 Data Collection

Collection has to satisfy one requirement: the corpus must hold the earlier work a 2026 paper builds on. We therefore run a single expansion out of hand-picked landmark papers along citation edges, and a paper's publication year decides which set it joins, the corpus through 2025 and the reference set in 2026. The reference set carries a second requirement, since it is the record every metric is read

against. Research the community did that we fail to collect is invisible to the scores, and a proposal that reached it would count as reaching nothing, so the set has to be as complete as we can make it. We therefore reach it by topic search over the area as well as by citation, and screen what both paths return against the area definition.

Landmark papers and citation expansion. Each area starts from 20 to 22 landmark papers chosen by hand, listed in Table 6. The corpus then grows in two steps. Descendants are papers published through 2025 that cite at least one landmark paper. Ancestors are papers cited by at least two distinct descendants. The second step brings in shared background that may not use the area's terminology, and the threshold of two is what keeps it from pulling in everything a descendant happens to cite. Nothing on this side is screened for the area, since the corpus is a pool to retrieve from and a paper outside the area costs little as long as the background is there.

Table 6: Landmark papers for each research area. Each area's corpus grows from these by the two-step citation expansion described above. Years are those recorded in the frozen area configuration.

Year	Landmark paper
Machine learning systems	
2018	TVM: An Automated End-to-End Optimizing Compiler for Deep Learning
2019	GPipe: Efficient Training of Giant Neural Networks using Pipeline Parallelism
2019	Megatron-LM: Training Multi-Billion Parameter Language Models Using Model Parallelism
2019	Triton: an intermediate language and compiler for tiled neural network computations
2020	DeepSpeed: System Optimizations Enable Training Deep Learning Models with Over 100 Billion Parameters
2020	ZeRO: Memory optimizations Toward Training Trillion Parameter Models
2021	Switch Transformers: Scaling to Trillion Parameter Models with Simple and Efficient Sparsity
2022	Alpa: Automating Inter- and Intra-Operator Parallelism for Distributed Deep Learning
2022	Efficiently Scaling Transformer Inference
2022	FlashAttention: Fast and Memory-Efficient Exact Attention with IO-Awareness
2022	LLM.int8(): 8-bit Matrix Multiplication for Transformers at Scale
2022	Orca: A Distributed Serving System for Transformer-Based Generative Models
2023	Efficient Memory Management for Large Language Model Serving with PagedAttention
2023	Fast Inference from Transformers via Speculative Decoding
2023	FlexGen: High-Throughput Generative Inference of Large Language Models with a Single GPU
2023	GPTQ: Accurate Post-Training Quantization for Generative Pre-trained Transformers
2023	SmoothQuant: Accurate and Efficient Post-Training Quantization for Large Language Models
2024	AWQ: Activation-aware Weight Quantization for LLM Compression and Acceleration
2024	DistServe: Disaggregating Prefill and Decoding for Goodput-optimized Large Language Model Serving
2024	FlashAttention-2: Faster Attention with Better Parallelism and Work Partitioning
2024	Mooncake: A KVCache-centric Disaggregated Architecture for LLM Serving
2024	SGLang: Efficient Execution of Structured Language Model Programs
Code generation	
2018	Spider: A Large-Scale Human-Labeled Dataset for Complex and Cross-Domain Semantic Parsing and Text-to-SQL Task
2020	CodeBERT: A Pre-Trained Model for Programming and Natural Languages
2021	CodeT5: Identifier-aware Unified Pre-trained Encoder-Decoder Models for Code Understanding and Generation
2021	CodeXGLUE: A Machine Learning Benchmark Dataset for Code Understanding and Generation
2021	Evaluating Large Language Models Trained on Code
2021	Measuring Coding Challenge Competence With APPS
2021	Program Synthesis with Large Language Models

Year	Landmark paper
2022	Competition-Level Code Generation with AlphaCode
2022	InCoder: A Generative Model for Code Infilling and Synthesis
2023	Code Llama: Open Foundation Models for Code
2023	CodeGen: An Open Large Language Model for Code with Multi-Turn Program Synthesis
2023	MetaGPT: Meta Programming for A Multi-Agent Collaborative Framework
2023	Reflexion: Language Agents with Verbal Reinforcement Learning
2023	StarCoder: may the source be with you!
2023	Teaching Large Language Models to Self-Debug
2023	WizardCoder: Empowering Code Large Language Models with Evol-Instruct
2024	BigCodeBench: Benchmarking Code Generation with Diverse Function Calls and Complex Instructions
2024	DeepSeek-Coder: When the Large Language Model Meets Programming
2024	Magicoder: Empowering Code Generation with OSS-Instruct
2024	Qwen2.5-Coder Technical Report
2024	SWE-agent: Agent-Computer Interfaces Enable Automated Software Engineering
2024	SWE-bench: Can Language Models Resolve Real-World GitHub Issues
World models	
2018	Recurrent World Models Facilitate Policy Evolution
2018	World Models
2019	Learning Latent Dynamics for Planning from Pixels
2020	Dream to Control: Learning Behaviors by Latent Imagination
2020	Mastering Atari, Go, chess and shogi by planning with a learned model
2021	Mastering Atari with Discrete World Models
2022	A Path Towards Autonomous Machine Intelligence
2022	DayDreamer: World Models for Physical Robot Learning
2023	DriveDreamer: Towards Real-world-driven World Models for Autonomous Driving
2023	GAIA-1: A Generative World Model for Autonomous Driving
2023	Mastering Diverse Domains through World Models
2023	Self-Supervised Learning from Images with a Joint-Embedding Predictive Architecture
2023	Transformers are Sample-Efficient World Models
2024	Diffusion for World Modeling: Visual Details Matter in Atari
2024	Genie: Generative Interactive Environments
2024	Learning Interactive Real-World Simulators
2024	Revisiting Feature Prediction for Learning Visual Representations from Video
2024	TD-MPC2: Scalable, Robust World Models for Continuous Control
2024	Video generation models as world simulators
2024	Vista: A Generalizable Driving World Model with High Fidelity and Versatile Controllability
2025	Cosmos World Foundation Model Platform for Physical AI
Automated research	
2020	AI Feynman: A physics-inspired method for symbolic regression
2021	Nobel Turing Challenge: creating the engine for scientific discovery
2023	Autonomous chemical research with large language models
2023	Emergent autonomous scientific research capabilities of large language models
2023	PaperQA: Retrieval-Augmented Generative Agent for Scientific Research
2024	Can LLMs Generate Novel Research Ideas: A Large-Scale Human Study with NLP Researchers
2024	ChemCrow: Augmenting large language models with chemistry tools
2024	Large Language Models for Automated Open-domain Scientific Hypotheses Discovery
2024	MLAgentBench: Evaluating Language Agents on Machine Learning Experimentation
2024	MLE-bench: Evaluating Machine Learning Agents on Machine Learning Engineering
2024	MLR-Copilot: Autonomous Machine Learning Research based on Large Language Models Agents
2024	Mathematical discoveries from program search with large language models
2024	ResearchAgent: Iterative Research Idea Generation over Scientific Literature with Large Language Models

Year	Landmark paper
2024	SciMON: Scientific Inspiration Machines Optimized for Novelty
2024	The AI Scientist: Towards Fully Automated Open-Ended Scientific Discovery
2025	Agent Laboratory: Using LLM Agents as Research Assistants
2025	CycleResearcher: Improving Automated Research via Automated Review
2025	SciAgents: Automating Scientific Discovery Through Bioinspired Multi-Agent Intelligent Graph Reasoning
2025	The AI Scientist-v2: Workshop-Level Automated Scientific Discovery via Agentic Tree Search
2025	Towards an AI co-scientist

Table 7 gives what the two steps collect, by publication year. 2025 sits below 2024 in every area. That gap belongs to the indexes. A paper may enter an index well after it first appears (Haustein et al., 2015), and even once it is there, an index carries a parsed reference list for only part of what it holds (Culbert et al., 2025), so the most recent year is still filling when we take the snapshot.

Reference set construction. The reference set is built in three stages.

- **Collection paths.** Papers published in 2026 that cite a landmark continue the citation expansion directly, but many of them only use a released model or system rather than doing research in the area. Topic search over the area reaches what that path misses, including work that cites no landmark at all, so we collect along both.
- **Screening.** Both paths are screened against the area definition, one DeepSeek-V4-Flash call per paper in JSON mode with the prompt and the rule it applies given in Figure 6. The model returns a decision, a confidence, and a one-sentence reason, and each paper is judged once. The reference set is the union of what survives.
- **Filtering.** We then remove surveys, duplicate records, and records that also appear in the corpus (using title and author list to filtering), which happens when a preprint and its published version are indexed separately.

Collection covers January to August 2026 as shown in Table 8, with the snapshot taken at the end of August, so the final month is not filled.

Sources and paper records. We collect one record per paper, carrying its title and abstract, its publication date, its reference list, and the papers that cite it. Records come from OpenAlex (Priem et al., 2022) and Semantic Scholar (Kinney et al., 2023). Records from the two sources are merged by identifier (DOI, arXiv id, etc.). Each index leaves reference lists unparsed for part of the corpus, and the edges they do report overlap only in part, so we merge the two and treat the union as a paper's reference list. Publication dates missing from both are recovered from the arXiv API for preprints and from Crossref otherwise. Abstracts that neither index carried were recovered from the Springer, Elsevier and IEEE metadata services, from the first page of open-access PDFs, and by hand from a publisher's page. Reference lists for 2026 papers that no index had parsed were recovered from full text where an index held it and otherwise from the PDF itself. After this pass every paper in the reference set has an abstract and almost all carry reference lists that resolve into the corpus for their area, while in the corpus nearly all records have abstracts and about two thirds carry reference lists as shown in Table 9.

B.3 Coverage of Survey References

References from authoritative surveys provide an external check on how much of an area's literature the collection holds. The audit screens each survey's references for the area and measures how many of them that area's own collection holds, its corpus together with its reference set. A reference we collected under another area counts as missing, since an AI scientist working in this area never retrieves it. Table 10 lists the surveys behind the audit. The references are screened one at a time by a language model with the same prompt shown in Figure 6, which decides from the title since a reference record carries no abstract.

Table 11 reports the result. For code generation the table also audits a corpus built by filtering OpenAlex (Priem et al., 2022) for the code generation keyword instead of expanding along citations,

Table 7: The collection by publication year.

	Corpus ($\leq$ 2025)								Reference
Area	Total	$\leq$2009	2010–14	2015–19	2020–21	2022–23	2024	2025	2026
Machine learning systems	88,184	5,626	3,646	16,572	14,393	19,383	14,868	13,696	5,188
Code generation	94,674	6,779	4,282	14,232	12,285	20,524	18,288	18,284	3,375
World models	50,271	5,541	3,116	11,245	8,758	10,591	6,004	5,016	1,867
Automated research	30,264	3,134	1,505	4,886	4,213	7,321	5,362	3,843	1,136

Table 8: The reference set by month of publication. The snapshot is taken at the end of August, so that month is only partly filled.

		Month of 2026							
Area	Total	01	02	03	04	05	06	07	08
Machine learning systems	5,188	825	512	539	694	953	703	542	420
Code generation	3,375	540	306	346	493	558	441	464	227
World models	1,867	203	173	223	167	312	342	271	176
Automated research	1,136	155	86	139	127	190	173	151	115

which reaches only a small fraction of the same references. That gap is the argument for expanding along citations: much of what an area builds on does not call itself by the area's name. Automated research has the lowest coverage of the four, and its audit is the one that reaches furthest into 2026. It carries the most references to 2026 work of any area, most of them from a 2026 survey (Ding et al., 2026). A paper enters the collection either because something already inside it cites the paper or because an index files the paper under the area, and a preprint posted weeks before the snapshot satisfies neither.

B.4 Interpretation of the Human Reference

The reference we score against is the set of 2026 papers in each area. By 2026 some of these papers are written with model assistance, and many are preprints that no venue has reviewed, so the set is not peer-reviewed, purely human work. This does not weaken its role in the benchmark as a measure of human research activity. Every paper in the reference was released by its authors. Releasing a paper is a human decision: the authors judged the problem worth pursuing and the work worth putting on the record. That judgment is what we compare against, and it stands whether or not a model helped write the text and whether or not a venue has reviewed it. What we compare against is research taste, i.e., the problems and ideas the authors chose. Whether a 2026 paper is strong or weak therefore does not change the measurement, since a weak paper still marks a direction a human researcher chose to pursue. What the benchmark asks is whether an AI scientist population proposes the problems and ideas that human researchers pursued, that is, whether it can reach ideas at the human level.

B.5 Interpretation of research taste.

ResearchMirror uses research taste in a descriptive sense. A research community faces many plausible problems and methods but chooses to pursue only a small subset. We therefore treat papers released after the cutoff as observations of these realized research choices. The human reference captures which prior work researchers build on, which problems they pursue, and which approaches they develop. It does not assume that every published paper is high quality or that publication defines scientific value. Accordingly, MATCH-CITE and MATCH-IDEA measure how closely an AI scientist population anticipates the subsequent choices of the corresponding human community. High matching does not by itself imply higher research quality, and low matching does not by itself imply lower quality. The benchmark measures agreement with realized community choices rather than a normative standard of scientific merit. The blinded expert study helps interpret the gap beyond matching alone. A non-matching proposal could represent a valuable direction that the human community did not pursue. However, non-matching AI proposals are judged less feasible and less likely to succeed than non-matching human papers. This suggests that the observed gap is not explained only by different research preferences. We therefore view ResearchMirror as measuring one oper-

System

```
You are a strict topic classifier for a research-paper corpus.  Decide whether the paper
below belongs to the research area defined here.
Area definition:
<the area's definition, as given in Table 5>
Judge by the paper's main contribution as described in its title and abstract; a paper that
only mentions the area in passing or uses its tools for another goal does NOT belong.  If
no abstract is given, judge from the title alone and lower your confidence.
Reply with JSON only:  {"relevant":  true or false, "confidence":  <0-1>, "reason":  "<one
short sentence>"}
```

User

```
Title:  <title>
Abstract:  <abstract>
```

Figure 6: The area screening prompt. One call decides one paper.

Table 9: Record completeness after gap-filling. "Abstract" means the percentage of papers with an abstract. "References" means the percentage of papers with a reference list. Every reference paper has an abstract and almost all of their reference lists resolve into the area's corpus.

	Corpus ($\leq$ 2025)			Reference (2026)		
Area	Papers	Abstract	References	Papers	Abstract	References
Machine learning systems	88,184	96.9	65.2	5,188	100	96.2
Code generation	94,674	96.5	62.5	3,375	100	97.6
World models	50,271	96.0	70.5	1,867	100	91.4
Automated research	30,264	95.3	71.8	1,136	100	93.7
All	263,393	96.4	66.0	11,566	100	95.6

ational aspect of research taste: whether AI scientists anticipate the research choices that a human community later makes.

B.6 Interpreting Corpus Size

Corpus ($\leq$ 2025) size follows from how the citation expansion runs rather than from how large an area is. Code generation ends with the largest corpus of the four and a smaller reference set than machine learning systems, and both follow from the same cause. Several code generation landmarks are cited across natural language processing, semantic parsing, and software engineering, so their descendants reach well beyond the area, while the machine learning systems landmarks are cited mostly inside the systems community. Ancestors are drawn from those descendants, so the difference compounds at the second step. For the reference set the same breadth works the other way, since screening for the area removes the general natural language processing papers that cite those landmarks. A corpus size therefore records how widely an area's research is built on elsewhere, not how much work the area itself produces.

B.7 Remaining Collection Gaps

Three gaps remain that no source we tried closes.

- The corpus records still without an abstract are older closed-access work that none of the indexes or publisher services carries.
- Every index also lags on recent preprints, which thins the most recent layer of the corpus and leaves a small share of reference papers without a parsed reference list; those papers stay in the reference set and are left out of the denominator when we report how citations resolve into the corpus.
- A preprint that nothing has cited yet may fall outside both collection paths, since a paper is reached either by a citation from inside the collection or by an index filing it under the area.

Table 10: The surveys behind the coverage audit. References is the length of a survey's reference list, read from Semantic Scholar, or parsed from the survey's arXiv page for those that Semantic Scholar returns no references for. In area is what remains after screening those references for the area. The area rows count such a work once, which is why they are smaller than the sum of the surveys below them, and they match the References column of Table 11.

Survey	arXiv	References	In area
Machine learning systems		**761**	**409**
Towards Efficient Generative LLM Serving	2312.15234	334	240
A Survey on Efficient Inference for LLMs	2404.14294	304	202
LLM Inference Serving: Recent Advances	2407.12391	63	54
A Comprehensive Survey of Speculative Decoding	2401.07851	60	31
Code generation		**1,482**	**718**
A Survey on Large Language Models for Code Generation	2406.00515	289	149
Unifying the Perspectives of NLP and Software Engineering	2311.07989	902	561
LLMs for Code Generation: Challenges, Techniques, Evaluation	2503.01245	60	38
AI Agentic Programming: A Survey	2508.11126	231	78
World models		**1,348**	**435**
Understanding World or Predicting Future? A Comprehensive Survey of World Models	2411.14499	340	109
Is Sora a World Simulator?	2405.03520	255	63
World Models for Autonomous Driving: An Initial Survey	2403.02622	116	57
World Models: Architectures, Methodologies, Reasoning Paradigms, and Applications	2606.00133	430	202
World Model for Robot Learning	2605.00080	207	113
Automated research		**814**	**457**
From Automation to Autonomy: LLMs in Scientific Discovery	2505.13259	117	80
LLM4SR: LLMs for Scientific Research	2501.04306	198	120
Autonomous Research Agents and the Verification Gap	2608.05179	499	315

Table 11: Survey-reference coverage. References is the number of survey references the screen places in the area, which Table 10 breaks down by survey, and Covered is matched by identifier (DOI or arXiv ID) or by title.

Area	Construction	References	Covered
Machine learning systems	Citation expansion	409	88.3%
Code generation	Citation expansion	718	92.9%
World models	Citation expansion	435	94.0%
Automated research	Citation expansion	457	79.0%
All	Citation expansion	2,019	89.1%
Code generation	Keyword search	718	17.8%

C Evaluation Details

We give here the details of the evaluation, including how the citation threshold τ is set, how the idea schema is extracted from abstracts, and how human evaluations assess the idea judge and idea quality.

C.1 Citation Sufficiency Threshold

Diversity-Cite needs a point at which a proposal counts as having read enough, and that point is τ. It is taken from the literature.

Definition. τ is the mean of $|\mathcal{C}(h)|$ over an area's human reference, computed after citations are restricted to the corpus U, so the threshold is measured on the same sets the metric scores. One value serves an area. We leave τ unrounded: citation counts are integers.

Table 12: The citation threshold τ for each area, with the human reference's DIVERSITY-CITE split into sufficiency Q and spread S. The last three columns are percentages; τ is a number of citations.

Area	τ	Q_H	S_H	$Q_H S_H$ (DIVERSITY-CITE)
Machine learning systems	20.81	70.68	19.10	13.50
Code generation	20.94	73.58	25.33	18.64
World models	26.46	68.05	21.57	14.68
Automated research	18.28	73.51	29.51	21.69

Interpretation. Table 12 gives the four thresholds with the human reference split into its two factors. The human papers do not reach the ceiling on Q, because τ is the mean of a right-skewed distribution and fewer than half of them cite that many papers. The human row of DIVERSITY-CITE is therefore a level a population can pass and a population that passes it reads more per proposal or spreads wider than the community does.

C.2 IDEA SCHEMA AND EXTRACTION

A language model reads each abstract and fills a fixed schema. The schema records the proposed work and has five slots: contribution type, problem, motivation, proposed approach, and research plan. A slot whose content the abstract does not state is recorded as "None". The language model we use for schema extraction is DeepSeek-V4-Pro. We use a strong model as we want to maximize the accuracy of the extracted schemas. The prompt is given in Figure 7.

System

```
You are a research schema extractor.  Given a paper abstract, extract that paper's idea
schema as a single JSON object.

FOUR RULES THAT OVERRIDE EVERYTHING BELOW

R1.  Faithfulness outranks the rubric.  The field descriptions below describe what a
well-posed research idea looks like; they are NOT a standard the paper must be edited to
meet.  Extract what this abstract actually says.  Where the abstract falls short of a
description --- an evaluation with no stated failure condition --- record it as it is and
note the shortfall in quality_note.  Never repair, sharpen, or complete the paper.  An
invented scope, baseline, metric, or failure condition is a far worse error than a thin
field.

R2.  Missing means missing.  If the abstract supplies nothing for a schema field, that
field's entire value is the string "None", and for a list field the single element
["None"].  Use that exact word --- not a sentence explaining what is missing, not JSON
null, not an empty string --- and never back-fill the field from another one that does have
content.  Three exemptions:  `contribution_type.primary` is always one of the listed types
(it is your classification, not something the abstract has to supply);
`contribution_type.secondary` is [] when there is no genuine second contribution; and the
three quality_check fields follow their own instructions below.

R3.  A defective abstract does not lower the bar and does not raise it.  If the text is
truncated, a stub, or otherwise not a real abstract, extract whatever it genuinely supports
and set every other field to "None" --- do not compensate by inferring from the title, the
venue, or what such papers usually do.  Report the defect through abstract_complete and
quality_note.  The schema of a defective abstract is expected to be mostly not-stated; that
is the correct output, not a failure.

R4.  Two bans apply to every field.

(a) Anonymity.  Do NOT copy any name this paper coins for its own contribution --- not the
system, tool, framework, benchmark or dataset it proposes, and equally not a metric,
principle, concept or phenomenon it names, in full form or as an acronym.  'We propose
FooBar' becomes 'the proposed framework'; 'introducing Near-Free Parallelism (NFP), the
maximum number of positions executable at near-free latency' becomes 'the maximum number of
positions executable at near-free latency', with every later NFP replaced the same way; 'we
introduce PASS@(k,T), a two-dimensional metric' becomes 'a two-dimensional metric'.  A
coined name is identifying even when it reads like ordinary technical vocabulary --- if the
abstract is the thing that introduces the term, describe the concept instead of naming it.
Also no title and no author names.  Names of PRIOR work, baselines, and third-party models,
datasets and libraries are NOT covered by this ban:  keep them wherever the abstract gives
them.

(b) No outcomes.  Do NOT copy results or performance numbers (accuracies, speedups,
improvement ratios, win rates, acceptance counts) into any field:  give the claims, the
approach, and the evaluation design, not how they turned out.  Quantities that define the
```

```
setting rather than report a result --- model scale, token budget, dataset size, number of
released tasks --- are allowed, and belong in a claim's scope or in the approach.

OUTPUT

English only, whatever the abstract's language.  Budgets, which are caps and not targets:

problem, motivation --- 1-2 sentences each.

proposed_approach --- 2-4 sentences.

research_plan --- up to 6 sentences (it usually needs them; the others usually do not).

quality_note --- 1 sentence.

When a field's content does not fit its budget, drop by this order rather than compressing
everything into an unreadable list:  in research_plan, keep which evidence bears on which
claim, then the failure conditions and what is held matched, and drop the enumeration of
every baseline and metric name first; in proposed_approach, keep the mechanism and drop
release/scale detail first.  Never drop a field to "None" to save room --- that value means
the abstract said nothing, and using it for anything else corrupts the downstream
not-stated statistics.

SCHEMA FIELDS

contribution_type --- The form of the contribution, exactly one of these five in `primary`:

theory --- establishes what is or is not possible, or gives a formalism:  proofs, bounds,
characterizations, and the framings and problem formulations they rest on.

method --- a new or modified technique meant to do a task better or newly at all.

empirical_analysis --- measures or explains behaviour of things that already exist; the
contribution is the finding, not a technique.

artifact --- a dataset, benchmark, system, library, or model release; the contribution is
the thing itself and its fitness for use.

position --- argues that the field should frame, evaluate, or prioritize something
differently; the contribution is the argument.

Put another type in `secondary` only if the work genuinely delivers it too, else [].  This
is a contribution axis, not a domain --- a paper applying diffusion models to protein
design is still `method`.  Classify by which kind of evidence the work must bring, not by
what it ships:  a benchmark paper whose point is what the benchmark reveals about existing
models is `empirical_analysis` with `artifact` secondary.  When the abstract is too thin to
classify confidently, choose the closest type anyway and say in quality_note that the
classification is uncertain.

problem --- What is currently not known, not achievable, or not correctly formulated.
Descriptive, and stated without naming the paper's solution:  someone who has not heard the
idea should still recognize it as a gap.  For `position` work the gap may be a defect in
how the field frames or evaluates something rather than an open technical question.

motivation --- Why this is worth solving now:  what becomes possible, what cost is avoided,
or what newly available capability makes it tractable.  Do not restate the gap.

proposed_approach --- What is built and how:  method design, proof strategy, construction
protocol, or system architecture, including what is released and at what scale.  Execution
only --- not the assertion, not the evidence it worked.

research_plan --- The evidence the paper brings to bear on its claims, and what would count
as support or as failure.  Number the claims when they get different evidence ('(1) ...
(2) ...').  Evidence means proofs and assumption-tightness arguments, experiments with
named baselines and metrics, ablations isolating the component a claim credits, robustness
checks, or quality audits; which of these counts depends on contribution_type (a `theory`
paper's evidence is its proof, an `artifact` paper's is its quality audit and coverage
analysis).  Give a failure condition only where the abstract implies one, and say what is
held matched (compute, parameters, latency) for trade-off claims when the abstract says.
Describe the design, never the outcome.

QUALITY CHECK --- about the abstract as a text, not about the paper.  These three fields
are exempt from R2:  they always carry a real value.

abstract_complete --- boolean.  true if this is a real, untruncated abstract; false if it
is a stub, a citation placeholder, a fragment, or otherwise not an abstract.

abstract_sufficient --- boolean.  true if it carries enough to fill the schema without
guessing.
```

System

```
You judge whether two research idea schemas describe the SAME core idea.  Each schema has
these 5 fields:  contribution_type, problem, motivation, proposed_approach, research_plan.
Judge in two stages and report both.
STAGE 1 (per field):  for each field in turn, decide whether A and B are substantially the
same ON THAT FIELD ALONE, as if the other fields were hidden from you.
If a field has no corresponding content in A or B (including when both are missing or use
the placeholder 'None'), its per-field verdict must be false.
STAGE 2 (whole idea):  same_idea is true only if the two schemas address substantially the
same problem AND propose substantially the same approach.  This is your own judgement on
the full schema, NOT a vote or an average over stage 1 --- agreeing on problem, motivation,
contribution_type alone is not enough.
In both stages:  different wording, naming, or level of detail does not matter; merely
sharing a topic, task, dataset, or a general technique family does NOT count as the same.
Reply JSON only:  {"fields":  {"contribution_type":  true/false, "problem":  true/false,
"motivation":  true/false, "proposed_approach":  true/false, "research_plan":  true/false},
"same_idea":  true/false, "reason":  "<one sentence>"}.
```

User

```
SCHEMA A:
<the first summary, one line per slot>
SCHEMA B:
<the second summary, in the same form>
```

Figure 8: The judging prompt for schemas for two research documents. Part one decides each slot on its own, so that a pair can agree on the problem and differ on the approach; a slot that either side leaves empty counts as a difference. Part two is the judge's own reading of the whole idea rather than a tally of part one.

```
quality_note --- one sentence naming which fields you left as "None", whether the
contribution_type classification is uncertain, and where the abstract fell short of a
field's description.  If none of those apply, the value is exactly "None".

Respond with a single JSON object only.
```

User

```
Abstract:

<abstract>

Return JSON with exactly this shape:

{"schema":  {"contribution_type":  {"primary":  "method", "secondary":  []}, "problem":
"...", "motivation":  "...", "proposed_approach":  "...", "research_plan":  "..."},
"quality_check":  {"abstract_complete":  true/false, "abstract_sufficient":  true/false,
"quality_note":  "..."}}

`primary` must be one of:  theory, method, empirical_analysis, artifact, position --- never
"None"; `secondary` is [] when there is no genuine second contribution.  Any other schema
field the abstract supplies nothing for is exactly "None".
```

Figure 7: The schema extraction prompt, run with the same model on all research documents. The rules hold a summary to what the abstract states: a name the paper coins for its own work becomes a description, and reported outcomes are dropped, so two documents are compared on their research idea rather than on their wording or their results.

C.3 Candidate Retrieval, Idea Matching, and Slot Weights

Retrieval. Retrieval runs over the title and abstract of each research document and combines a sparse and a dense channel. The sparse channel is BM25 with $k_1 = 1.5$ and $b = 0.75$. The dense channel encodes the same text with all-MiniLM-L6-v2 (Reimers & Gurevych, 2019) and ranks by cosine similarity. The two rankings are fused over the top 200 of each channel, where a document placed rth in a channel contributes $1/(60+r)$, and the five highest fused documents become $\mathcal{N}_X(d)$.

Pairwise idea matching. Each pair is judged once. The two summaries are presented in a random order, which removes a systematic position preference. The judge rules on every slot separately and

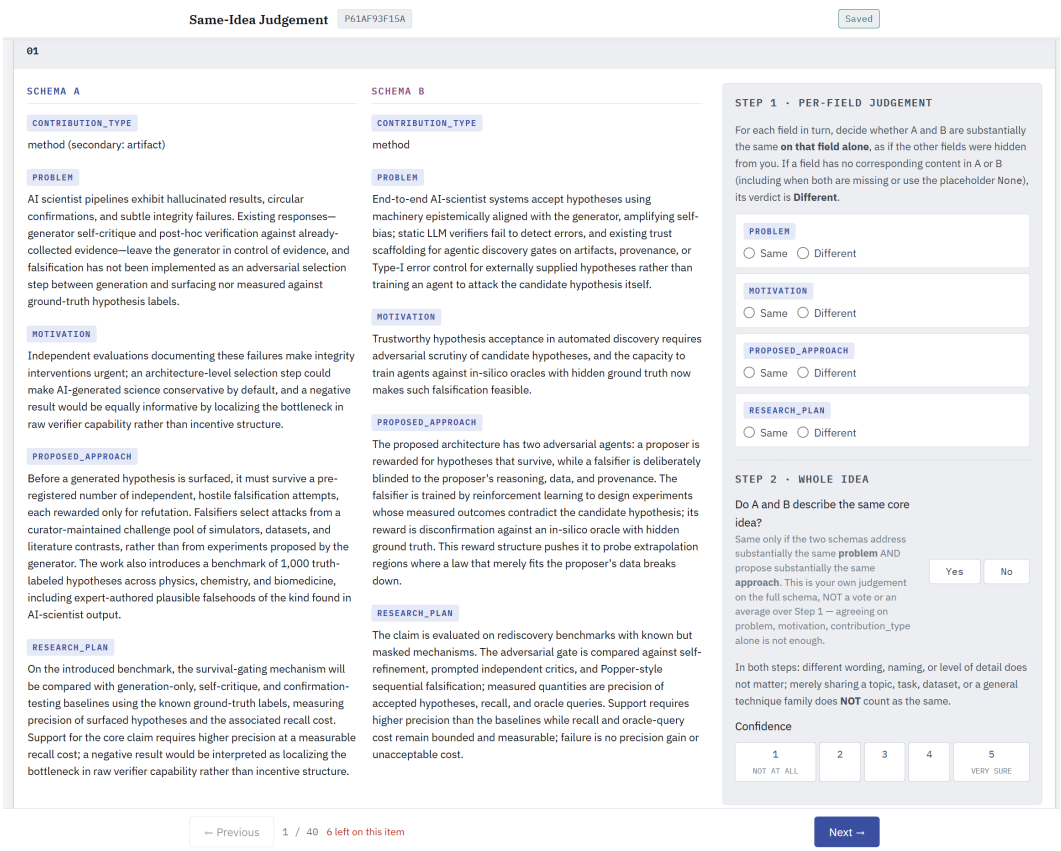

Figure 9: The same-idea judgement interface, showing one example. The left panes give the two idea summaries; the right pane states the criterion the judge is given and collects the four slot decisions, the whole-idea decision, and confidence.

also returns an overall verdict on whether the two documents state the same idea. The prompt is given in Figure 8. The judge is a language model, GPT-5.6 Luna, which is strong enough to read the summaries and apply the rules.

Slot weights. Weights come from the human reference for each research area. For each human 2026 paper we ask whether any of the other human 2026 papers retrieved for it matches on slot i; p_i is the fraction of human papers with such a match, and $w_i = -\log_2 p_i$. A slot that two papers share by default therefore carries almost no weight, while a slot that rarely matches carries more. The weights and their sum W are estimated once per area and held fixed across methods.

C.4 Human Evaluation of the Idea Judge

The idea metrics rest on one decision, whether two summaries agree on a given slot. In this section, we sample pairs the judge has already ruled on and have people make the same decision without seeing its answer.

Questionnaire. Figure 9 shows one example. The two left panes give the two idea summaries, the five slots contribution type, problem, motivation, proposed approach, and research plan, so an annotator decides on the same material the judge reads. The right pane carries the judge's own instruction, narrowed to the four slots asked, and collects the answers in the two stages the judge works in. First, problem, motivation, proposed approach, and research plan are each marked same or different, judged as if the other slots were hidden, and a slot that one side leaves empty counts as different. Second, the annotator says whether the two documents describe the same core idea, and records a confidence from one to five.

Table 13: Human study for the same-idea judge. Judge match counts the sampled pairs the judge marks as matching. Judge–judge (%) is the percentage agreement among the judge runs (robustness), and Judge–human (%) the percentage agreement between the judge and the annotators' majority.

Slot	Judge match	Judge–judge	Judge–human
Problem	20 / 40	83.00	87.50
Motivation	20 / 40	77.00	70.00
Proposed approach	19 / 40	90.00	87.50
Research plan	18 / 40	79.00	72.50

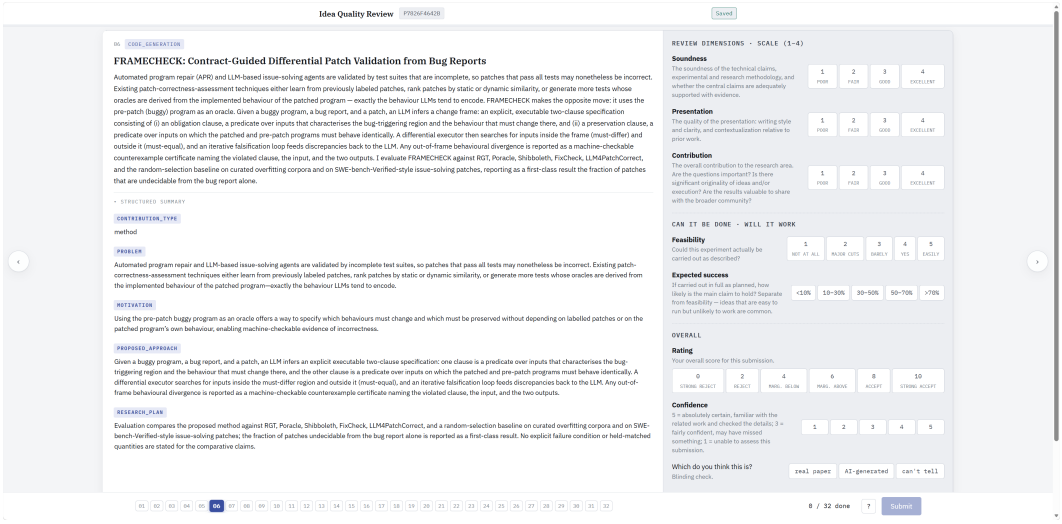

Figure 10: The idea quality review interface. The left pane gives the title, abstract, and structured summary; the right pane collects the review dimensions, the two execution questions, the overall rating and confidence, and the blinding check.

Sampling design. The study covers automated research and uses 40 judged summary pairs containing 160 slot pairs. Half are a proposal against a 2026 paper, taken from the MATCH-IDEA judgments, and half are a proposal against another proposal of the same population, taken from the DIVERSITY-IDEA judgments. Sampling at random would leave little to compare, since the judge finds agreement on the whole idea in fewer than one in a thousand of the MATCH-IDEA pairs it rules on, so nearly every drawn pair would be an easy disagreement. We instead stratify on what the judge decided: pair type crossed with its decisions on problem and motivation gives eight cells, and we draw five pairs from each. The sample then realizes 14 of the 16 possible combinations of the four decisions an annotator is asked to repeat, and is close to balanced on each of them as shown in Table 13.

Judge consistency and agreement with annotators. Three annotators, a master's student, a PhD student, and a PhD in computer science, each answer all 40 pairs, so every slot decision carries three independent human answers, which we reduce to a majority label. To gauge the judge's stability, we run it five times on the same pairs. Table 13 reports, slot by slot, how often the judge marks a match, how far its runs agree, and how closely it agrees with the annotators' majority. The five runs agree 77–90% of the time, so the verdict is largely reproducible. The judge also tracks the annotators' majority closely on the problem and the proposed approach, while the more interpretive motivation and research-plan slots run lower. On most slots this alignment matches or exceeds the agreement among the annotators themselves, so the judge reads a pair about as consistently as a human would.

Table 14: Sample composition of human study for idea quality. The four document types contribute equally and are balanced across the four areas. Proposals are further spread over the six models at 16 each, and the 192 documents are split into six blocks of 32.

Document type	Per area	Total
Proposal overlapping a 2026 paper	12	48
2026 paper overlapped by a proposal	12	48
Proposal, non-overlapping	12	48
2026 paper, non-overlapping	12	48
Total		192

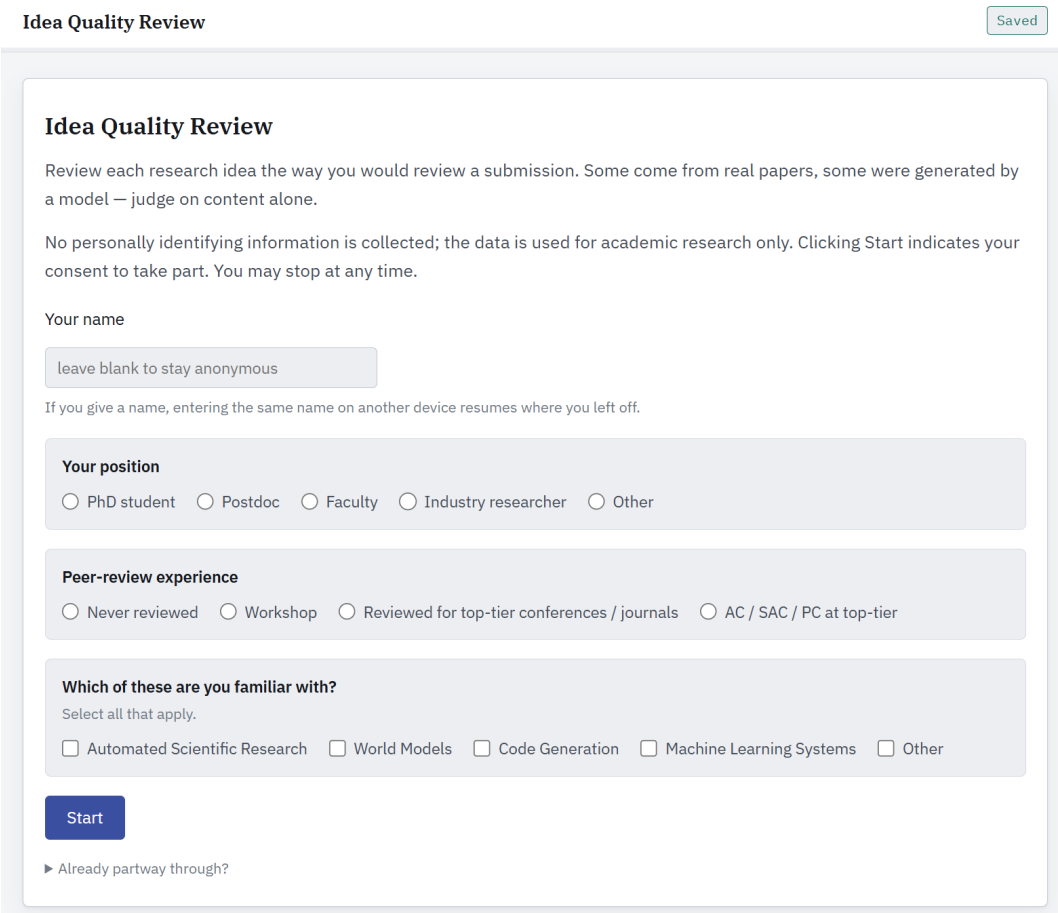

Figure 11: The idea quality review interface. Every human reviewer records their background and experience.

C.5 Human Evaluation of Idea Quality

This appendix describes the questionnaire of Sec. 3: what a rater sees, how the sample is composed, who rated it, and the comparison split by overlap with the human record.

Questionnaire. Figure 10 shows one example. The left pane presents the work as its title, abstract, and the structured summary of Sec. 2.2, the five slots contribution type, problem, motivation, proposed approach, and research plan. The right pane collects the ratings: soundness, presentation, and contribution on the review form's four-point scale, feasibility on a five-point scale from not at all to easily, expected success as one of five probability bands, an overall rating from strong reject to strong accept, a confidence from one to five, and a blinding check of real paper, AI-generated, or unclear.

Sampling design. The questionnaire holds 192 research documents, split evenly between AI scientist proposals and 2026 papers so the blinding check cannot be won by favoring the more common label. Each area contributes 48 documents and each model 16 proposals, drawn from the FREE, TOPIC, and LANDSCAPE. The documents come in four kinds, shown in Table 14: an AI proposal that overlaps a 2026 paper, the paper it overlaps, an AI proposal that overlaps no candidate paper, and a 2026 paper that no proposal overlaps. Overlap is decided by the slot-level judge of MATCH-IDEA. Among the overlapping proposals, some match their paper on the whole idea and some only on the problem, and both are kept.

Reviewer recruitment and block assignment. The documents are split into six blocks of 32, each covering the four areas and a subset of the models. A proposal and the 2026 paper it overlaps are placed in different blocks, so no human reviewers see both and a paired comparison cannot turn into a within-reviewer ranking; the paired comparison is therefore made across reviewers, with a reviewer random effect in the analysis. Each reviewer takes one block one time and rates all 32 documents one time. One reviewer may take multiple blocks and record their background and experience as shown in Figure 11. We only record reviewers who have review experience. We finally recruited 11 reviewers and collected two records for each block, that is, two review records for each research document.

Rating scales and score normalization. As shown in Figure 10, review design mainly follows the ICLR 2026 official review form and scores an idea on seven dimensions.

- Soundness, Presentation and Contribution use four levels (1 = poor, 2 = fair, 3 = good, 4 = excellent).
- Feasibility uses five levels (1 = not at all, 5 = easily).
- Expected success uses five probability bins ($<10\%$, 10–30%, 30–50%, 50–70%, $>70\%$), coded 1–5.
- Rating uses six levels (0 = strong reject, 2 = reject, 4 = marginally below, 6 = marginally above, 8 = accept, 10 = strong accept).
- Confidence uses five levels (1 = unable to assess, 5 = absolutely certain).
- Blinding check asks whether the reviewer thinks the entry is a real 2026 paper, an AI-generated proposal, or they cannot tell.

For each population we average the raw scores of a dimension and map the mean linearly onto $[0, 100]$ as shown in Table 3: $s = 100 \times \frac{\bar{x} - x_{\min}}{x_{\max} - x_{\min}}$, where $x_{\min}$ and $x_{\max}$ are the lowest and highest levels of that dimension's scale.

D METHOD DETAILS

All four methods run the same loop. This section specifies that loop and then the profile and actions each method changes.

D.1 SHARED AI SCIENTIST LOOP

For AI scientists, an agent harness provides the interface through which a language model observes and acts in an environment. Our harness follows ReAct (Yao et al., 2022), interleaving reasoning, actions, and observations in the model's prompt, similar tool-based interaction loops supporting research planning in Idea2Plan (Huang et al., 2025) and idea generation in The AI Scientist-v2 (Yamada et al., 2025). In our setting, one run of the AI scientist within this harness produces a single proposal. The harness provides the scientist with a profile, a step budget, and a set of available actions. The scientist follows the ReAct loop, deciding for itself which actions to take and how to spend the budget.

Actions. Every response carries exactly one tagged action, and every step costs one unit of a budget of at most 20 model calls. `plan` records the current working hypothesis and replaces the previous plan. `search` takes a query with an optional publication-year filter and runs the hybrid retrieval above over the area's corpus. `read_papers` pins retrieved documents into a working set of 50 cards, evicting the least recently requested card when the set is full. `draft` replaces the working draft. `summary` condenses the agent history into notes that replace it, leaving the working

set intact. `proposal` submits and ends the agent loop. Figure 12 gives the prompt that defines them.

System

```
You are a research scientist preparing ONE new research proposal.

Your research community is defined as:

<the area's definition, as given in Table 5>

The literature you can access ends at 2025-12-31.

You don't need to finish in one step --- you may plan, search, read, draft and revise
across multiple steps, one action per step.

You will be provided with:

1.  Your researcher profile.

2.  Your pinned papers --- the full cards you pinned with <read_papers>, listed in the
order you pinned them, with the count at the end of the block.  Nothing is ever lost:  the
corpus does not change, so any [CAND] id you have seen can be pinned back and its full card
reappears here.

3.  Your history --- an append-only log of what you did, one entry per step, in the order
it happened.  A <search> entry is followed by its <information> block (which opens with a
receipt counting new vs.  already-retrieved results); a <read_papers> entry is followed by
a receipt; a <plan> or <draft> entry records only that you rewrote it --- the text itself
lives in your workspace.  Past steps are never rewritten --- only a <summary> replaces the
earlier entries wholesale.  In the history every [CAND] result is a title-only line; a line
marked '(shown above)' is one that appeared earlier.

4.  Latest search results --- the full cards of your most recent search.  Once you search
again this block is replaced, so pin anything you want to keep reading.

5.  Your workspace --- what you are writing:  your latest <plan>, your latest <draft>,
and any <feedback>.  A <summary> clears the plan and the draft but keeps your pinned
papers, which is why that action asks you to carry them into your notes.

6.  Your remaining step budget (each response consumes one step).

IMPORTANT: You must strictly adhere to the following rules:

1.  Choose ONLY ONE action from the list below for each response, DO NOT perform more than
one action per step.

2.  Follow the exact syntax format for the selected action, DO NOT create or use any
actions other than those listed.

3.  The corpus is a bounded snapshot of one research community.  Thin or empty results mean
"not found in this corpus", NOT proof that no such work exists anywhere; ground
research-gap claims in the papers you actually retrieved and cited.

4.  Form a hypothesis early and let evidence attack it.  Put a first <plan> on the table
within your first few steps, then use <search> to test it --- searching is how you check,
refute or sharpen your idea.

5.  The episode ends when you output <proposal>, and you may output it on any step.
"Steps remaining:  1" is the deadline:  your response then MUST be the <proposal>,
otherwise the episode ends with nothing.

6.  Every id in your References section MUST be a paper you actually retrieved:  copy it
verbatim from a [CAND] line anywhere in your history --- search results, your working set,
or ids you kept in your summary notes.  You are NOT allowed to invent ids or cite papers
that never appeared.  List each paper at most once.

7.  Cite inline with bracketed numbers [1], [2], ...  matching your References entries.
The same paper always reuses the same number.  Do NOT write raw [CAND] ids inside the prose
--- they belong only in the References section.

8.  The proposal must be concrete and technically grounded:  a specific falsifiable core
idea, not a survey or a vague direction.  It must be new relative to the literature you
retrieved, and your proposal must say exactly what is new:  in its related-work discussion,
name the closest papers you found and state what your proposal does that they do not --- a
different problem framing, a different mechanism, a different evaluation that would settle
something they left open.  Restating or incrementally tuning a retrieved paper is not a
proposal.  Every proposal has related work:  if you found none, that almost always means
the search was too narrow, not that the idea is unprecedented --- claim the latter only if
you are prepared to defend it.  Claim novelty only against what you actually retrieved and
cited (see rule 3).

Valid actions:
```

```
1. <plan> research state </plan>: your current working hypothesis and anything else
worth carrying forward --- including but not limited to (a) the idea you are proposing,
stated as a specific falsifiable claim; (b) what would show it is wrong, already done, or
not worth doing; (c) a finding, a constraint you hit, or a question to settle later. A
rough hypothesis on little evidence is fine and expected. Issue <plan> again to replace
it: sharpen it as evidence accumulates, and when evidence kills it --- the claim is wrong,
or the retrieved literature already does it --- move to a different gap instead of
defending it. Apart from your <draft>, this is the only note that survives into the next
step.

2. <search> query </search>: search the local literature corpus (a short
natural-language or keyword query, <= 25 words). Optionally append a publication-year
filter after a pipe, e.g. <search> repository level code generation | years: 2020-2025
</search> (a single year also works). The engine combines keyword (BM25) and semantic
matching.

3. <read_papers> id1, id2, ... </read_papers>: pin papers you have already retrieved
into your <working_set> --- use it to read a paper whose card has been compressed to a
title-only line, or to keep an important one in full while you work. Copy the ids verbatim
from [CAND] lines. The working set holds 50 cards; when it is full the least recently
requested one is evicted. A card carries the paper's metadata and its abstract --- the
corpus has no full text, so the abstract is all there is of a paper's content.

4. <draft> revised or newly written working draft of your proposal </draft>: write or
revise your working draft based on what you have learned --- this is where your <plan>
hypothesis becomes an actual proposal. The latest draft replaces the previous one.
Ideally you start drafting while 5-10 steps remain, so there is room left to sharpen the
proposal rather than writing it in the last step.

5. <summary> research notes </summary>: condense your history into notes. Keep the
plan, the current draft state, key findings, and the [CAND] ids you may still want to cite
(one line per id is enough --- you can pin any of them back into your working set later
with <read_papers>). Your subsequent history will be replaced by this summary; your
<working_set> is preserved automatically.

6. <proposal> final proposal in markdown </proposal>: output the final proposal as a
self-contained markdown document:

- First line: "# <specific title>".

- Then a paragraph starting with "**Abstract**: " --- 4-8 sentences summarizing the whole
proposal (this is what the community will first see).

- Then a related-work section: the closest papers you retrieved, named, and what your
proposal does that they do not.

- Then the rest of the proposal body in free-form prose, structured however serves the idea
best. A strong proposal covers: motivation, the research gap that follows from the
related work, the core idea (crisp and falsifiable), method, implementation plan,
experiment plan (datasets, baselines, metrics, ablations), and expected contribution ---
but the organization, depth, and voice are yours.

- Cite inline with [1], [2], ... throughout the body.

- End with a "## References" section, exactly one line per cited paper, in the format:

[n] <the id copied from the [CAND] line, WITHOUT any brackets around it> | role:
method|baseline|motivation|extension|background | one sentence on how this paper is used

For example: [1] D3f2a9c01d2e4 | role: baseline | We compare against this
retrieval-augmented generator.

Format: use exactly one tag pair per response --- <plan>, <search>, <read_papers>,
<draft>, <summary>, or <proposal>. No text outside the tags.
```

Figure 12: The system prompt shared by every method. It fixes the loop: what the AI scientist is shown at each step and the six actions it may take, one per response.

D.2 Method Configurations

The methods differ in the profile placed at the top of that prompt and in the actions appended to it.

AI scientist profiles. FREE states only that the AI scientist is an independent researcher in the community defined above, with no direction and no prescription of how to work. TOPIC names one research area and adds that the AI scientist chooses its own problems within it. FRONTIER reuses the TOPIC profile and allocation unchanged, so that the only difference between them is access to earlier rounds.

Topic allocation. The areas named in TOPIC profiles come from the topic labels already carried by OpenAlex records. The set of topics itself was built from the citation network. OpenAlex started with works that have incoming and outgoing citations and clustered them by citation relationships (OpenAlex, 2024; van Eck, 2024). We collect topic label on a $\leq$ 2025 paper, and we weight topics by an exponential decay in publication year with a half-life of two years, which favors recent practice without cutting the earlier years off. The resulting distribution is allocated across the population by largest remainder. As shown in Table 15, topics read like Topic Modeling, Machine Learning in Materials Science, Scientific Computing and Data Management, and Multi-Agent Systems and Negotiation. Some topics look unrelated to the specific research area, but the topic allocation is a rough guide to the areas the AI scientist is expected to explore, and it does not constrain the search or the proposal. The AI scientist may search for any topic in the corpus and propose any idea it can justify. At a population of 300 the allocation reaches between 146 and 177 distinct topics out of the several thousand that carry prior mass.

Tag extraction. The tags behind LANDSCAPE are extracted from the 2025 papers. A language model with prompt as shown in Figure 13 reads one paper at a time and names the task it addresses and the method it uses, drawing on a tag set that starts empty and grows as papers are processed in publication order. After each batch a second pass merges newly proposed tags into existing entries. A final pass by hand merges the variants that survive, such as modifier and hyphen differences and the same name appearing on both axes. In automated research this yields task tags such as autonomous experimentation, equation discovery, AI scientist, and scientific hypothesis generation, and method tags such as llm agent, multi-agent system, benchmark construction, and retrieval-augmented generation.

System

```
You tag a paper with the tasks it addresses and the methods it uses, using a controlled
vocabulary that grows over time.

CURRENT TASK VOCABULARY

<every task tag introduced so far, one id and label per line>

CURRENT METHOD VOCABULARY

<every method tag introduced so far, one id and label per line>

task - WHAT is being done or improved:  the capability or object of study.

method - HOW: the mechanisms, one tag each.

FOR EACH TAG, PREFER AN EXISTING ONE.

Reuse an existing tag whenever it genuinely covers this paper, even if the paper's own
wording differs - that is the point of a controlled vocabulary.  Give its id.  Create a new
tag ONLY when no existing tag covers the concept:  give id "NEW" and put the new tag in the
label field.  Never create a near-duplicate of an existing tag.

TAGS ARE ATOMIC.

Each tag names ONE concept.  Never bundle two concepts into one tag.  "multi-stage llm
agents with human feedback" is WRONG - that is three concepts.  Emit them separately:  "llm
agent", "multi-stage pipeline", "human-in-the-loop".  1-3 task tags and 1-4 method tags for
the paper as a whole.

TAG STYLE

1-4 words, lowercase, no articles, no trailing punctuation.  A canonical name other papers
would also carry, not a description of this paper.  Discriminative:  a tag that would apply
to most papers in this area carries no information.  Specific enough to tell research
directions apart, general enough to recur.

RULES

R0.  English only, whatever the language of the input text.

R1.  Community vocabulary, never this paper's coined names.  NEVER use a name this paper
coins for its own system, framework, benchmark, metric or concept.  Names of PRIOR work,
third-party models, datasets and libraries ARE allowed.

R2.  Tags must be substantive AND discriminative.  These are BANNED as tags, and so is
anything equally broad:  machine learning, deep learning, artificial intelligence, natural
```

Table 15: The TOPIC allocation in each area. # Used is the number of topics that receive at least one AI scientist at a population of 300, out of the # $\leq$ 2025 topics that carry prior mass in the area's corpus. The last column lists the fifteen topics that take the largest share, in that order.

Area	# Used	# $\leq$ 2025	Topics, most allocated first
Machine learning systems	156	2,665	Topic Modeling, Natural Language Processing Techniques, Multimodal Machine Learning Applications, Advanced Neural Network Applications, Domain Adaptation and Few-Shot Learning, Parallel Computing and Optimization Techniques, Neural Networks and Applications, Speech Recognition and Synthesis, Advanced Image and Video Retrieval Techniques, Generative Adversarial Networks and Image Synthesis, Adversarial Robustness in Machine Learning, Semantic Web and Ontologies, Speech and dialogue systems, Explainable Artificial Intelligence (XAI), Artificial Intelligence in Healthcare and Education
Code generation	146	2,609	Topic Modeling, Natural Language Processing Techniques, Software Engineering Research, Multimodal Machine Learning Applications, Software Testing and Debugging Techniques, Semantic Web and Ontologies, Advanced Malware Detection Techniques, Artificial Intelligence in Healthcare and Education, Adversarial Robustness in Machine Learning, Explainable Artificial Intelligence (XAI), Domain Adaptation and Few-Shot Learning, Speech and dialogue systems, Software Reliability and Analysis Research, Multi-Agent Systems and Negotiation, Software System Performance and Reliability
World models	156	2,296	Reinforcement Learning in Robotics, Multimodal Machine Learning Applications, Generative Adversarial Networks and Image Synthesis, Topic Modeling, Domain Adaptation and Few-Shot Learning, Natural Language Processing Techniques, Human Pose and Action Recognition, Advanced Vision and Imaging, Robot Manipulation and Learning, Advanced Neural Network Applications, Autonomous Vehicle Technology and Safety, Adversarial Robustness in Machine Learning, Computer Graphics and Visualization Techniques, Human Motion and Animation, Advanced Image and Video Retrieval Techniques
Automated research	177	2,387	Topic Modeling, Machine Learning in Materials Science, Natural Language Processing Techniques, Computational Drug Discovery Methods, Artificial Intelligence in Healthcare and Education, Scientific Computing and Data Management, Explainable Artificial Intelligence (XAI), Multimodal Machine Learning Applications, Semantic Web and Ontologies, Model Reduction and Neural Networks, Multi-Agent Systems and Negotiation, Neural Networks and Applications, Biomedical Text Mining and Ontologies, Evolutionary Algorithms and Applications, Ethics and Social Impacts of AI

```
language processing, computer vision, neural network, large language model, llm,
transformer, foundation model, data analysis, optimization, evaluation, improving
performance, novel framework.  They name a whole field or a truism, not a research
direction.  If a side genuinely supports nothing more specific, emit fewer tags rather than
a broad one.

R3.  Do not invent.  Tag only what the text states.

R4.  No results or numbers anywhere.

R5.  A survey, review or taxonomy paper contributes no tags of its own:  return empty lists
with extractable=false.
```

Also return ONE contribution_type for the whole paper, exactly one of these five in 'primary':

<the five contribution type definitions of Figure 7>

Put another type in 'secondary' only if the work genuinely delivers it too, else [].

And ONE theme judgement for the whole paper.

Area definition:

<the area's definition, as given in Table 5>

Judge by the paper's main contribution. A paper that only mentions the area in passing, or uses its tools for another goal, does NOT belong.

User

Text: <title and abstract>

Return JSON with exactly this shape:

{"tasks": [{"id": "T001 or NEW", "label": "..."}], "methods": [{"id": "M001 or NEW", "label": "..."}], "contribution_type": {"primary": "method", "secondary": []}, "in_theme": true, "theme_confidence": 0.0, "theme_reason": "...", "extractable": true, "note": "..."}

Always fill both id and label: reusing an existing tag means giving its id and copying its label verbatim; creating one means id "NEW" and your new tag as the label. 'primary' must be one of: theory, method, empirical_analysis, artifact, position. contribution_type and the theme judgement are ALWAYS filled, even when the tag lists are empty.

Figure 13: The tag extraction prompt.

RESEARCH LANDSCAPE OF THIS COMMUNITY (2025)

The 2025 literature of this community is indexed into <task tags> task tags and <method tags> method tags; a typical paper carries <task tags per paper> task tags and <method tags per paper> method tags. The distribution is long-tailed --- about half of the tags appear in only one paper.

Listed below are the 100 most widely used tags on each axis and the 100 most common task-method combinations, each with the share of the papers carrying it, ordered from most to least common. Tags outside these lists exist and are queryable by name.

These tags describe what was studied in 2025. New work often continues these directions, but it also opens directions that are not in this list at all. Treat it as a reference, not a menu.

TASK TAGS

<the hundred most common task tags, each with its share, separated by semicolons>

METHOD TAGS

<the hundred most common method tags, each with its share>

COMMON TASK-METHOD COMBINATIONS

<the hundred most common task-method pairs, each with its share>

Figure 14: The landscape block, which closes the system prompt of LANDSCAPE and follows the description of the tag retrieval action. One block is built per area from that area's 2025 papers, and every LANDSCAPE AI scientist in that area receives the same text.

Table 16: What each area fills into the landscape block of Figure 14. Each group header gives the papers the shares are taken over and the size of the two tag vocabularies.

Axis	Ten most common, with the share of the area's 2025 papers carrying each
Machine learning systems, 824 task tags and 2,072 method tags	

Axis	Ten most common, with the share of the area's 2025 papers carrying each
Task	llm inference acceleration (7.6%), llm serving (5.6%), low-bit quantization (4.8%), mixture-of-experts (4.6%), large language model compression (4.1%), large language model training (3.7%), post-training quantization (3.7%), edge llm inference (3.6%), kv cache compression (3.5%), distributed training (3.2%)
Method	post-training quantization (4.3%), speculative decoding (4.1%), knowledge distillation (3.8%), sparse attention (3.4%), algorithm-hardware co-design (3.2%), token pruning (3.1%), mixture of experts (2.8%), mixed-precision quantization (2.4%), reinforcement learning (2.4%), performance modeling (2.3%)
Pair	low-bit quantization × post-training quantization (1.8%), post-training quantization × post-training quantization (1.6%), visual token compression × token pruning (1.5%), kv cache compression × key-value cache compression (1.2%), efficient vision-language model inference × token pruning (1.2%), autoregressive decoding acceleration × speculative decoding (1.2%), llm inference acceleration × speculative decoding (1.0%), mixture-of-experts × expert routing (1.0%), long-context inference × sparse attention (0.9%), low-bit quantization × mixed-precision quantization (0.9%)
Code generation, 618 task tags and 805 method tags	
Task	code generation (19.9%), text-to-sql (10.0%), code generation evaluation (8.3%), automated program repair (6.6%), benchmark construction (5.5%), code generation benchmark (3.2%), software engineering agent (3.1%), code translation (2.9%), verilog code generation (2.5%), code completion (2.3%)
Method	benchmarking (15.5%), comparative evaluation (13.8%), fine-tuning (12.3%), retrieval-augmented generation (8.5%), iterative refinement (7.8%), llm agent (7.3%), multi-agent system (7.0%), benchmark generation (6.9%), prompt engineering (6.2%), execution feedback (5.2%)
Pair	code generation evaluation × benchmarking (4.1%), code generation evaluation × comparative evaluation (3.3%), benchmark construction × benchmarking (2.8%), code generation × fine-tuning (2.6%), code generation × iterative refinement (2.5%), code generation × comparative evaluation (2.2%), code generation × retrieval-augmented generation (2.1%), code generation × benchmarking (2.0%), code generation benchmark × benchmarking (1.9%), code generation × prompt engineering (1.8%)
World models, 337 task tags and 516 method tags	
Task	world model learning (25.7%), autonomous driving (11.9%), robot manipulation (10.6%), model-based reinforcement learning (8.9%), future state prediction (4.5%), interactive world generation (4.4%), world model evaluation (4.0%), driving scene generation (2.3%), controllable video synthesis (2.0%), continuous control (1.9%)
Method	model-based reinforcement learning (16.3%), diffusion model (11.7%), generative world model (5.1%), autoregressive generation (4.9%), action-conditioned dynamics model (4.7%), model predictive control (3.9%), synthetic data generation (3.9%), benchmark framework (3.7%), model-based planning (3.7%), diffusion video generation (3.0%)
Pair	world model learning × diffusion model (3.7%), world model learning × autoregressive generation (2.8%), autonomous driving × model-based reinforcement learning (2.7%), world model evaluation × benchmark framework (2.3%), world model learning × model-based reinforcement learning (2.2%), model-based reinforcement learning × model-based reinforcement learning (2.0%), world model learning × action-conditioned dynamics model (2.0%), world model learning × generative world model (1.9%), autonomous driving × diffusion model (1.6%), robot manipulation × diffusion model (1.6%)
Automated research, 318 task tags and 424 method tags	
Task	autonomous experimentation (10.9%), equation discovery (10.6%), AI scientist (10.0%), symbolic regression (6.8%), scientific hypothesis generation (6.4%), research idea generation (5.2%), agent benchmarking (4.2%), human-AI collaboration (4.1%), automated peer review (3.9%), scientific discovery (3.5%)

Table 17: The language model behind each role. Context window is the vendor's stated limit for the checkpoint we called; our prompts stay far below it. Max output of Llama 4 Scout is the 8,192 as the model allows. The six AI scientist models are the ones compared in Table 2.

Role	Model	Context	Max output	Reply
Schema extraction	DeepSeek-V4-Pro	1M	16,384	JSON
Tag extraction	DeepSeek-V4-Flash	1M	16,384	JSON
Area screening	DeepSeek-V4-Flash	1M	4,096	JSON
Idea matching	GPT-5.6 Luna	1M	1,200	JSON
AI scientist	Llama 4 Scout	10M	8,192	text
AI scientist	Claude Haiku 4.5	200K	16,384	text
AI scientist	Gemini 3.5 Flash-Lite	1M	16,384	text
AI scientist	DeepSeek-V4-Flash	1M	16,384	text
AI scientist	Qwen3.8-27B	262K	16,384	text
AI scientist	K2 Horizon 375B A23B	512K	16,384	text

Axis	Ten most common, with the share of the area's 2025 papers carrying each
Method	llm agent (22.1%), multi-agent system (17.3%), benchmark construction (10.9%), retrieval-augmented generation (10.1%), iterative refinement (7.6%), symbolic regression (7.6%), human-in-the-loop (6.8%), llm-as-judge (4.8%), self-driving laboratory (4.6%), closed-loop discovery workflow (4.5%)
Pair	equation discovery × symbolic regression (6.0%), autonomous experimentation × self-driving laboratory (4.2%), AI scientist × llm agent (4.1%), agent benchmarking × benchmark construction (3.9%), AI scientist × multi-agent system (3.5%), autonomous experimentation × closed-loop discovery workflow (3.1%), autonomous experimentation × llm agent (2.7%), human-AI collaboration × human-in-the-loop (2.4%), autonomous experimentation × multi-agent system (2.1%), symbolic regression × genetic programming (1.9%)

Landscape prompt block. The prompt lists the hundred most common task tags and the hundred most common method tags among the area's 2025 papers, together with common task-method pairs, each with the share of those papers carrying it and ordered by that share. Figure 14 gives the block template and Table 16 what each area fills into it.

Frontier rounds. The population is split into equal rounds, so a run of 300 proposals is two rounds of 150.

E Language Models and Inference Settings

Five roles call a language model: the extractor that turns a document into the idea schema, the tagger that builds the task and method tags, the model that screens papers for relevance to a specific research area, the idea judge that decides schema slot agreement, and the AI scientists that write proposals. Table 17 lists the model behind each and the settings we set.

- **Schema extraction.** Both sides of every comparison are described by the same extractor, with the same prompt and the same retry policy. A different extractor on either side would compare two extraction styles rather than two ideas, so the model and the endpoint are pinned in code, independent of whichever model wrote the proposal. We pin DeepSeek-V4-Pro on the vendor's own endpoint, the largest checkpoint in that family rather than the Flash one an AI scientist runs, because extraction is an instrument: a field read wrong here moves every score computed from the schema.
- **Tag extraction.** The task and method tags behind LANDSCAPE are extracted by DeepSeek-V4-Flash in JSON mode. The vocabulary starts empty and grows batch by batch: each batch sees the vocabulary built so far, reuses an existing tag where one fits, and marks a new tag explicitly when none does. A separate merge pass resolves the aliases that survive.

- **Area screening.** The area screening model is DeepSeek-V4-Flash in JSON mode. It reads a paper's title and abstract and decides whether the paper is in the area, returning a boolean and a confidence score.
- **Idea matching.** Slot agreement is decided by GPT-5.6 Luna in JSON mode, with output capped at $1{,}200$ tokens. Each pair is judged once, and which document is shown first is drawn from a hash of the pair and a fixed seed: random across pairs, reproducible on a rerun, and unaffected by worker or retry order. Every call is logged with its input, its output, and the order it drew, since the judge is the only model whose output becomes a number we report; Appendix C reports its agreement with human annotators. No population is judged by its own model family.
- **AI scientists.** The six models of Table 2 run one implementation, one prompt, and one step budget of twenty steps. Replies are plain text, and the action tag is parsed from the text. The output cap is $16{,}384$ tokens, except on Bedrock, where Llama 4 Scout is capped at the $8{,}192$ the platform allows.

The request body carries the inputs and nothing else. Temperature, top-p, sampling seed, and tool definitions are never sent, so each endpoint runs at its own default. Two parameters are exceptions. JSON mode is set wherever the reply is parsed as JSON, and a maximum output length is sent where the API requires one or where a stage has its own output budget.

F Additional Analyses

This section reports the checks the main results rest on and the additional analyses of Sec. 4. The checks ask whether a finding survives a second run, a change of model, or the possibility that a model has already read the 2026 papers. The additional analyses give the counts, schemas, and distributions that the main text only summarizes.

F.1 Model Selection for Each Analysis

Every analysis in Sec. 4 includes DeepSeek-V4-Flash, so that its results can be read against one another. The model paired with it changes from one analysis to the next, chosen for what that analysis needs and, taken together, to cover as many of the six models as possible.

- **Direction coverage** (Sec. 4) uses DeepSeek-V4-Flash alone. It labels every proposal of four populations and every paper of the human reference with the task and method vocabulary.
- **Slot decomposition** (Sec. 4) adds Llama 4 Scout, which reaches the highest Match-Idea of the six models. Pairing it with DeepSeek-V4-Flash shows whether a high-matching and a low-matching population fall short in the same slots or in different ones.
- **Case study** (Sec. 4) draws Case 1 from Qwen3.8-27B and Case 2 from DeepSeek-V4-Flash. Each case needs one human paper matched by two proposals from a single model, one agreeing on the approach and one not, and these two models supply the clearest such triples.
- **Population scaling** (Sec. 4) adds Gemini 3.5 Flash-Lite, so that the shape of the scaling curve does not rest on one model.

Claude Haiku 4.5 and K2 Horizon 375B A23B do not enter these four analyses. Both are covered by Table 2, by the human evaluation of Sec. 3, by the contribution distribution of Appendix F.6, and by the leakage comparison of Appendix F.4, each of which reports all six models.

F.2 Robustness at a Fixed Population Size

Table 2 reports scores for one population of 300 proposals per setting. To assess the stability of the scores and model rankings across runs, we generate a second population of 300 proposals for the FREE and TOPIC settings with Gemini 3.5 Flash-Lite and DeepSeek-V4-Flash in world models and automated research. Table 18 compares the two runs and reports the change in each metric. Across the tested settings, absolute changes are at most 0.44 percentage points for the match metrics and 2.20 points for the diversity metrics. These results support the stability of these diversity and model-level patterns across the two runs.

Table 18: Comparison of two runs with 300 proposals per setting in world models and automated research. Scores are percentages for MATCH-CITE, MATCH-IDEA, DIVERSITY-CITE, and DIVERSITY-IDEA. Δ is Run 2 minus Run 1, in percentage points.

		World models			Automated research		
Method	Metric	Run 1	Run 2	Δ	Run 1	Run 2	Δ
Gemini 3.5 Flash-Lite (Google DeepMind, 2026)							
FREE	MATCH-CITE	4.89	4.74	-0.15	7.18	6.88	-0.30
	MATCH-IDEA	3.38	3.11	-0.27	2.22	2.42	$+0.20$
	DIVERSITY-CITE	4.76	4.99	$+0.23$	5.52	5.71	$+0.19$
	DIVERSITY-IDEA	18.76	18.73	-0.03	12.92	11.04	-1.88
TOPIC	MATCH-CITE	5.33	5.14	-0.19	6.58	6.36	-0.22
	MATCH-IDEA	3.86	3.97	$+0.11$	2.14	2.58	$+0.44$
	DIVERSITY-CITE	13.35	13.53	$+0.18$	20.22	20.11	-0.11
	DIVERSITY-IDEA	52.52	54.72	$+2.20$	62.21	61.24	-0.97
DeepSeek-V4-Flash (DeepSeek-AI, 2026)							
FREE	MATCH-CITE	4.77	4.70	-0.07	6.40	5.97	-0.43
	MATCH-IDEA	1.45	1.78	$+0.33$	1.67	1.69	$+0.02$
	DIVERSITY-CITE	13.50	13.50	0.00	7.57	7.25	-0.32
	DIVERSITY-IDEA	42.79	41.02	-1.77	23.16	22.52	-0.64
TOPIC	MATCH-CITE	5.16	5.17	$+0.01$	7.72	7.54	-0.18
	MATCH-IDEA	1.76	1.71	-0.05	2.09	2.01	-0.08
	DIVERSITY-CITE	32.51	32.68	$+0.17$	25.39	27.07	$+1.68$
	DIVERSITY-IDEA	69.06	67.82	-1.24	55.80	57.00	$+1.20$

F.3 THE SIZE OF HUMAN REFERENCE

Every score in Table 2 is measured against the complete set of 2026 papers in the area, from 1,136 to 5,188 of them, and the human level applies the same metrics to those papers themselves, each compared only with the others. The Human and AI scientist are sized for different reasons. The reference is complete because it is the record of what a community actually published that year, and the human level is meant to be a reference line for real research. Keeping it fixed also gives every population the same denominator, which is what makes scores comparable across models, methods, and areas. The 300 proposals per population are a deliberate trade-off. Sec. 4 grows populations to the size of the reference, 3.8 to 17 times larger, and matching rises slowly and then almost flattens, so we can see that for AI scientists, 300 proposals already place a population close to where a far larger one lands. Asking for more would raise the inference cost of running ResearchMirror without changing what it measures. Therefore, we keep the population size at 300 and let the human reference be whatever it is. In this setting, we can compare the performance of different AI scientists, and also see whether any of them reach the human level.

F.4 LEAKAGE AND BENCHMARK ROBUSTNESS

Four of the six models in Table 2 were released in 2026 and may have seen part of the reference, which covers January to August 2026, so they could in principle reproduce 2026 papers from memory rather than through research judgment. This choice is deliberate, since a benchmark of research taste should evaluate the models that current AI scientists are built on. We pair these releases with two 2025 models whose training data end before the reference year, which gives a setting free of exposure within the same benchmark. Below we describe one design constraint that limits exposure, test whether exposure helps, and check whether the findings differ between the two settings.

Retrieval restricted to the corpus. An AI scientist cites only papers it retrieves from the corpus of its area, which ends in 2025, so a 2026 paper can never enter its citation set. This constraint does not rule out indirect exposure, since a model that has read a 2026 paper could still reuse its references or restate its idea. The test below addresses this remaining channel.

Models released before and after the reference year. Meta reports an August 2024 pretraining cutoff for Llama 4 Scout, and Anthropic reports that the public internet data of Claude Haiku 4.5

end in February 2025 (Meta AI, 2025b; Anthropic, 2025b). Neither can have seen a paper first released in 2026, so the two serve as temporal controls for Gemini 3.5 Flash-Lite, DeepSeek-V4-Flash, Qwen3.8-27B, and K2 Horizon 375B A23B. If exposure helped, the later releases should lead at the idea level, where memorized content would matter most. They trail instead. Averaged over areas and methods, the two controls reach 3.10 on MATCH-IDEA against 1.68 for the 2026 releases, and Llama 4 Scout, with the earliest cutoff, scores highest of all six. The 2026 releases score slightly higher on MATCH-CITE, 5.06 against 4.14, but Claude Haiku 4.5 comes within 0.6 points of each of them, so this difference more plausibly reflects model capability than exposure. The two levels even move in opposite directions across models, as those with higher MATCH-CITE tend to have lower MATCH-IDEA. Access to the relevant literature is therefore not what limits recovery.

Consistent findings in both settings. The findings of Sec. 3 hold in both groups. Matching stays far below the human level, at 22% on citations and 26% on ideas for the 2025 models and 28% and 14% for the 2026 releases. No population in either group reaches the human DIVERSITY-IDEA, and LANDSCAPE ranks last on MATCH-CITE in most settings of both. The only difference is the relatively high MATCH-IDEA of Llama 4 Scout, which runs against exposure rather than with it. Including the 2026 releases thus extends the evaluation to the latest models without changing its conclusions, and ResearchMirror, though temporal by design, does not rest on memorization.

Extending to later years. The construction of ResearchMirror repeats for any year Y by freezing the corpus at the end of $Y - 1$, collecting the papers of Y as the reference, and applying the same metrics. Each new model can thus be evaluated against a reference published after its training data end, which removes the concern altogether.

Information access of AI scientists and human researchers. AI scientists can retrieve only literature published through 2025, whereas the 2026 papers are observed after the cutoff and their authors may have had access to work released during 2026. However, matching the information of an AI scientist to that of a paper would require knowing what each author had read and restricting retrieval to it, which cannot be reconstructed after publication. ResearchMirror aligns what can be aligned. Every population searches the same corpus, which ends on the same date, and runs under the same budget, prompt, and judge, so this design leaves comparisons among AI scientists intact. The human level is read accordingly, as a reference line for where research actually went rather than as a competing arm under matched conditions.

F.5 A POST-CUTOFF SLICE OF THE REFERENCE FOR LEAKAGE ANALYSIS

The controls above compare models released before and after the reference year. A sharper test splits the reference itself. Gemini 3.5 Flash-Lite is the one 2026 release whose model card states a data cutoff, March 2026, so its training data may cover the reference papers published in January to March 2026 and cannot cover those published from April onward (Google DeepMind, 2026). Scoring it separately on the two halves gives a within-model comparison in which only exposure differs. The other three 2026 releases state no data cutoff, and their release dates fall in the last two months of the reference or after it, so no comparable split exists and we leave them out of this analysis.

Table 19 reports matching for Gemini 3.5 Flash-Lite on the full reference and on each half, each half with its own human row. Exposure does not help. Citation matching runs against it, higher after the cutoff in all sixteen cells, and the human papers move the same way, so that difference belongs to the papers rather than to the model. Idea matching, where memorization would matter most, comes out even: read against the human level of its own half, the earlier half leads in nine of the sixteen cells. Its raw scores do lean earlier, in thirteen of sixteen, but so do the human rows in three of the four areas, which is why. The ranking of the four methods is the same in all three blocks, and the shortfall reported in Sec. 3 holds in each of them.

F.6 CONTRIBUTION DISTRIBUTION OF AI SCIENTISTS

AI scientists depart from the human record not only in which ideas they reach but in the kind of contribution they make. We label every proposal and 2026 paper with the contribution type its abstract states, one of method, empirical analysis, artifact, position, or theory as shown in Figure 15.

Table 19: MATCH-CITE and MATCH-IDEA for Gemini 3.5 Flash-Lite against the full 2026 reference and against the two halves that its March 2026 data cutoff separates. Each block header gives the number of reference papers per area, and the Human row scores the human papers of that block against one another. Bold marks the best of the four methods in each column within a block.

	Machine learning systems		Code generation		World models		Automated research	
Population	Cite	Idea	Cite	Idea	Cite	Idea	Cite	Idea
Full reference, January to August 2026 (5,188 / 3,375 / 1,867 / 1,136 papers)								
Human	20.84	13.56	18.75	11.25	16.38	13.87	18.51	10.53
FREE	3.73	1.36	3.72	1.52	4.89	3.38	7.18	2.22
TOPIC	4.59	2.29	4.23	**2.19**	**5.33**	3.86	6.58	2.14
LANDSCAPE	3.67	1.38	3.88	1.47	4.44	2.31	**7.18**	2.14
FRONTIER	**4.65**	**2.32**	**4.23**	1.85	5.28	**3.87**	6.34	**2.28**
Possibly seen, January to March 2026 (1,876 / 1,192 / 599 / 380 papers)								
Human	18.24	14.60	16.53	12.25	13.84	13.46	15.85	11.97
FREE	2.95	1.37	3.11	1.53	3.95	3.57	**6.29**	2.46
TOPIC	**3.75**	2.18	3.79	**2.31**	4.08	**4.29**	5.68	2.08
LANDSCAPE	2.96	1.53	3.29	1.36	3.44	2.54	6.12	2.43
FRONTIER	3.75	**2.59**	**3.82**	2.01	**4.15**	4.10	5.35	**2.51**
After the cutoff, April to August 2026 (3,312 / 2,183 / 1,268 / 756 papers)								
Human	20.55	12.97	18.35	10.70	16.18	14.06	18.21	10.44
FREE	4.06	1.36	3.90	1.51	5.07	3.28	7.24	2.10
TOPIC	4.79	**2.36**	**4.22**	**2.11**	**5.41**	3.65	6.05	**2.17**
LANDSCAPE	3.95	1.30	4.08	1.53	4.76	2.20	**7.40**	1.99
FRONTIER	**4.90**	2.16	4.17	1.76	5.34	**3.75**	6.00	2.16

Figure 15 compares contribution types extracted from proposal and paper abstracts, with one row for each of the six models in Table 2. AI proposals generally concentrate more heavily on methods than human papers, especially in machine learning systems and world models, while theory and position papers are rare. The concentration is strongest for Gemini 3.5 Flash-Lite, which writes methods in at least 99% of its proposals in every area and arm. Automated research is a partial exception, where DeepSeek-V4-Flash and K2 Horizon 375B A23B both produce more artifact contributions than the human reference, DeepSeek under FREE, TOPIC, and LANDSCAPE and K2 Horizon under all four arms. Matching human research taste therefore requires not only choosing problems and methods, but also deciding when to develop a method, conduct an empirical analysis, or build an artifact.

F.7 OVERLAP WITH $\leq$ 2025 LITERATURE

A proposal may be restating work the corpus already holds. Therefore, we score each document exactly as MATCH-IDEA does, with the same slot judge and the same weights, but against its nearest papers in the corpus U which AI scientist can access. The result is the weighted share of a document's slots that some earlier paper already states. Automated research is used throughout, and every population contributes as many proposals as the area has 2026 papers, so all rows in Table 20 rest on the same number of documents.

Every population repeats the earlier literature less than the 2026 papers do, so the proposals that miss the human record are not restatements of what the corpus already contains. The difference sits in the same two slots as the main result. Human papers restate an earlier approach or research plan many times more often than any population does, and those two slots carry most of the weight, while on problems and motivations the two sides are much closer. A proposal therefore tends to miss both the 2026 papers and the corpus at exactly the point where it commits to a mechanism. This does not make the proposals more original than the published work. The human reference contains cross-year continuations by the same group, which raise its overlap.



Figure 15: Contribution types across four research areas for the six models of Table 2, one row per model in release-date order. Stacked bars show the shares of non-method contributions in the human reference and each AI population; the remaining share consists of methods. The dashed rule carries the human non-method total of that area across the four arms.

Table 20: Overlap with the corpus U in automated research for DeepSeek-V4-Flash, scored as MATCH-IDEA is but against the papers in U. Every row covers 1,136 documents as Human 2026 papers. Overlap is the weighted share of a document's slots that an earlier paper already states; the four slot columns give the share of documents whose problem, motivation, proposed approach, or research plan is matched. These values describe measured overlap with earlier literature.

Population	Overlap	Problem	Motivation	Approach	Plan
Human	10.26	19.10	37.06	3.43	2.99
FREE	6.34	12.68	30.99	0.26	0.09
TOPIC	4.48	9.77	18.13	0.26	0.00
LANDSCAPE	4.26	8.36	17.61	0.35	0.09
FRONTIER	4.19	10.48	12.85	0.53	0.00

F.8 TAG COVERAGE AND DISTRIBUTIONS

Table 21 gives the counts behind Figure 3, on the task axis, the method axis, and on task–method pairs. Besides coverage it reports how many tags a document carries, how much of a population's tag mass sits in its ten most used tags, and the total variation distance between its tag distribution and the human one. Tags per document matters for reading the rest, since AI proposals carry more tags than the 2026 papers do, and FRONTIER carries twice as many pairs, so part of its coverage comes from tagging more per proposal rather than from spreading further.

Table 21: Tag use and coverage in automated research for DeepSeek-V4-Flash, by axis and population.

Axis	Population	Tags used	Per doc	Human tags covered	Missed human mass (%)	Head of the miss (%)	Top-10 share (%)	TVD
Task (2025 vocabulary: 318 tags; human 2026 uses 200)								
	Human reference	200	1.71	—	—	—	43.5	—
	Free	36	2.17	34 / 200	49.7	40.5	94.4	0.717
	Topic	125	2.19	106 / 200	22.7	48.1	77.7	0.554
	Landscape	39	2.18	37 / 200	47.9	41.7	91.5	0.663
	Frontier	192	2.81	155 / 200	5.5	53.3	55.3	0.499
Method (2025 vocabulary: 424 tags; human 2026 uses 268)								
	Human reference	268	2.95	—	—	—	41.6	—
	Free	103	3.09	91 / 268	25.3	32.3	68.3	0.659
	Topic	191	3.04	163 / 268	10.4	43.5	56.9	0.519
	Landscape	114	3.06	102 / 268	22.3	28.8	64.5	0.589
	Frontier	220	3.71	178 / 268	8.9	47.3	47.7	0.494
Task × *Method* (possible: 318 × 424 = 134,832; human 2026 uses 2,871)								
	Human reference	2,871	5.23	—	—	—	9.7	—
	Free	710	6.76	299 / 2,871	74.0	5.9	34.9	0.853
	Topic	1,734	6.77	564 / 2,871	61.1	5.5	20.9	0.772
	Landscape	847	6.76	333 / 2,871	72.1	5.6	26.9	0.831
	Frontier	3,441	10.44	889 / 2,871	49.6	5.4	12.3	0.757

Table 22: The three most used task tags, method tags, and task–method pairs of each population in automated research for DeepSeek-V4-Flash, with the share of that population's tag instances carrying each.

Population	Top task tags	Top method tags	Top task × method pairs
Human	AI scientist (9%) agent benchmarking (9%) autonomous experimentation (5%)	llm agent (10%) multi-agent system (7%) benchmark construction (7%)	agent benchmarking × benchmark construction (2.3%) AI scientist × llm agent (1.5%) AI scientist × multi-agent system (1.1%)
Free	agent benchmarking (24%) scientific claim verification (23%) AI scientist safety (16%)	benchmark construction (27%) execution-based evaluation (12%) provenance tracking (6%)	agent benchmarking × benchmark construction (7.7%) scientific claim verification × benchmark construction (6.3%) scientific claim verification × execution-based evaluation (4.6%)
Topic	agent benchmarking (23%) experimental design (9%) scientific claim verification (8%)	benchmark construction (22%) llm agent (8%) execution-based evaluation (5%)	agent benchmarking × benchmark construction (7.1%) scientific claim verification × benchmark construction (2.1%) experimental design × benchmark construction (1.9%)
Landscape	agent benchmarking (21%) scientific hypothesis evaluation (17%) experimental design (14%)	benchmark construction (24%) execution-based evaluation (8%) llm agent (7%)	agent benchmarking × benchmark construction (6.8%) scientific hypothesis evaluation × benchmark construction (3.6%) experimental design × benchmark construction (2.9%)
Frontier	experimental design (9%) agent benchmarking (9%) scientific hypothesis evaluation (7%)	llm agent (13%) benchmark construction (13%) information gain (4%)	experimental design × llm agent (1.9%) agent benchmarking × benchmark construction (1.9%) AI scientist safety × benchmark construction (1.1%)

Coverage is only part of the picture, since a population can reach a tag and still use it far more often than the community does. Every population puts more of its tag mass in its ten most used tags than the 2026 papers do, and the excess is largest for FREE and LANDSCAPE, which place almost all of their task mass there. FRONTIER comes closest to the human spread on all three axes, and Table 22 shows why: its leading task and method tags carry roughly the share the 2026 papers give theirs,

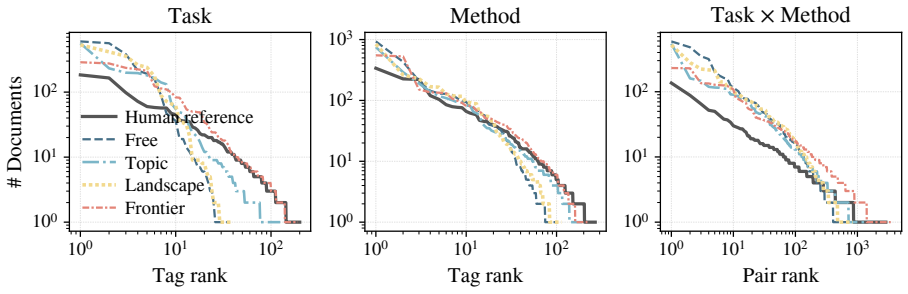

Figure 16: Tags ordered by how many documents carry them, for the human reference and for each population in automated research for DeepSeek-V4-Flash. Each AI scientist curve falls away faster than the human curve and ends earlier, which is the concentration in Table 21 seen directly.

while the other populations open with a single tag several times heavier. Figure 16 gives the full distributions, where each population's curve falls away faster than the human curve and ends earlier.

What the populations concentrate on is the same in every case. Benchmark construction leads or ties for the lead among the method tags of all four, at roughly twice to four times its share among the 2026 papers, and their most used pairs are that tag joined to whichever task they favour. The shortfall is widest on pairs, where even FRONTIER misses about half of the human mass and the other three miss between three fifths and three quarters. Reaching a community's tasks and its methods is therefore easier than combining them the way it does.

F.9 CASE STUDY

We provide the schemas behind Sec. 4 and two additional cases to show where proposals agree with human research and where their mechanisms differ. Each case pairs one human paper with two proposals from the same model. We selected pairs from stored MATCH-IDEA judgments and inspected their descriptions for a shared problem and a clear mechanism comparison. The cases illustrate the metric and do not estimate how often each pattern occurs.

Each box includes the full title and abstract, followed by the four text slots available in the exported schema: problem, motivation, proposed approach, and research plan. Text and bracketed reference numbers are retained from the source records. Proposal A matches the human paper on problem and motivation but not on proposed approach or research plan; proposal B matches all four, according to the stored GPT-5.6 Luna judgments. These are automatic agreement labels, not human quality ratings. Proposal identifiers refer to the source runs; some judgments were also reused in derived population subsets. Comparisons outside the boxes are our interpretations.

Case 1: Expert reuse in memory-constrained inference. Both proposals address expert-fetch overhead. ReMoE and LARC fine-tune the router to increase temporal expert reuse. TopicRoute instead leaves the model unchanged and predicts expert demand from prompt topics to guide prefetching and scheduling. The choice is whether to change routing behavior or anticipate it.

Human paper: ReMoE (Zhu et al., 2026)

Title. ReMoE: Boosting Expert Reuse through Router Fine-Tuning in Memory-Constrained MoE LLM Inference

Abstract. Fine-grained Mixture-of-Experts (MoE) models sparsely activate only a subset of experts per token, reducing activated computation while maintaining high model capacity. However, in memory-constrained inference scenarios, only a small set of experts can be cached. Experts not in the cache must be fetched from slow external storage (e.g., UFS), leading to frequent evictions and substantial I/O overhead. We propose ReMoE, a router fine-tuning framework designed to boost token-wise expert reuse. ReMoE biases the router toward recently selected experts, producing temporally stable routing that better matches cache locality constraints. By increasing short-horizon expert reuse, ReMoE reduces expert fetches from storage without adding inference-time computation. Experiments on DeepSeek and Qwen models show that ReMoE improves expert reuse by 26% while maintaining downstream task performance. Real-system evaluations further confirm these benefits, improving output throughput by 8.4% under vLLM GPU-CPU expert offloading and reducing TPOT by 43.6-49.8% under llama.cpp on Jetson Orin NX, corresponding to a 1.77-1.99× decode speedup across diverse workloads. Checkpoints and usage instructions are available at https://github.com/BUAA-OSCAR/ReMoE.

Problem. In memory-constrained inference for fine-grained Mixture-of-Experts (MoE) models, only a small set of experts can be cached; experts outside the cache must be fetched from slow external storage, causing frequent evictions and substantial I/O overhead.

Motivation. Reducing expert fetches would cut I/O overhead and improve throughput and latency in memory-constrained deployments.

Proposed approach. The proposed framework fine-tunes the router of fine-grained MoE models to bias it toward recently selected experts, producing temporally stable routing that better matches cache locality constraints. This increases short-horizon expert reuse and reduces expert fetches from slow external storage without adding inference-time computation. Checkpoints and usage instructions are released.

Research plan. The paper evaluates the framework through experiments on DeepSeek and Qwen models measuring expert reuse and downstream task performance, and through real-system evaluations under vLLM GPU-CPU expert offloading and llama.cpp on Jetson Orin NX measuring output throughput and time-per-output-token across diverse workloads.

AI proposal A: TopicRoute

Model: Qwen3.8-27B. **Method:** FRONTIER.

Title. TopicRoute: Prompt-Only Topic Modeling as a Zero-Forward-Pass Expert Predictor for MoE Offloading and Scheduling

Abstract. Mixture-of-Experts (MoE) LLMs deployed on memory-constrained devices are bottlenecked by expert cache misses, which trigger costly host-to-device weight transfers on the critical path. Existing predictive prefetchers rely on intermediate forward-pass activations [3,4] or dedicated predictor networks fed by in-flight computation [5,6,10], so none can issue a prefetch before the first layer executes. We propose TopicRoute, a serving system that applies a lightweight online topic model to prompt embeddings at request arrival, predicts the per-request, per-layer expert activation set with zero forward-pass overhead, and uses this single topic signal to drive (i) proactive expert prefetching, (ii) demand-driven cache replacement, and (iii) routing-preserving request co-scheduling. Our core claim is falsifiable: on models with high local routing consistency as measured by the SRP/SCH metrics of recent MoE analysis [1], topic-predicted prefetching reduces time-to-first-token by at least 30% and host-to-device transfer bytes by at least 20% versus locality-only (LRU, segment-best) policies at a fixed cache budget, while on low-routing-consistency models the gain collapses to under 5%, providing a built-in negative control. The approach is complementary to, not competitive with, router-decoupled designs [12] and device-level semantic co-scheduling [18]. We implement TopicRoute atop an open-source MoE offloading runtime and evaluate on Mixtral-8x7B, OLMoE-1B/7B, and DeepSeek-MoE across four workloads against seven offloading baselines including MoE-Infinity [2], ProMoE [3], Fate [4], and DuoServe-MoE [10], with an ablation matrix isolating the topic signal, the confidence gate, and each system component.

Problem. Mixture-of-Experts LLMs on memory-constrained devices are bottlenecked by expert cache misses, which trigger costly host-to-device weight transfers on the critical path; existing predictive prefetchers depend on intermediate forward-pass activations or dedicated predictor networks fed by in-flight computation, so none can issue a prefetch before the first layer executes.

Motivation. Removing this first-layer prefetch gap could take host-to-device transfer latency off the critical path and improve time-to-first-token for memory-constrained MoE serving.

Proposed approach. The proposed serving system applies a lightweight online topic model to prompt embeddings at request arrival, predicts the per-request, per-layer expert activation set with zero forward-pass overhead, and uses this single topic signal to drive proactive expert prefetching, demand-driven cache replacement, and routing-preserving request co-scheduling. A confidence gate is included as a separate component. The system is implemented atop an open-source MoE offloading runtime and evaluated on Mixtral-8x7B, OLMoE-1B/7B, and DeepSeek-MoE across four workloads.

Research plan. (1) The core claim is evaluated by comparing time-to-first-token and host-to-device transfer bytes against locality-only (LRU, segment-best) policies at a fixed cache budget, separating high- and low-routing-consistency models using the SRP/SCH metrics; the low-consistency condition serves as a built-in negative control in which the predicted gain should fall below 5%. (2) Evaluation spans Mixtral-8x7B, OLMoE-1B/7B, and DeepSeek-MoE across four workloads against seven offloading baselines including MoE-Infinity [2], ProMoE [3], Fate [4], and DuoServe-MoE [10]. (3) An ablation matrix isolates the topic signal, the confidence gate, and each system component.

Automatic judgments. Problem: match; motivation: match; proposed approach: no match; research plan: no match.

AI proposal B: LARC

Model: Qwen3.8-27B. **Method:** TOPIC.

Title. LARC: Post-Training Only the Routers of Frozen MoE LLMs for Local Routing Consistency and Faster Offloaded Inference

Abstract. Expert offloading for memory-constrained MoE LLM serving hinges on a model property - local routing consistency, the tendency of consecutive tokens to reuse the same experts - that varies widely across models and, in the literature we retrieved, has only ever been measured, never trained [1]. We propose LARC (Local-routing-Aware Router post-Training), a one-time procedure that post-trains only the gating networks of a frozen pretrained MoE LLM with a windowed, differentiable expert-set-overlap objective against a running cache-set surrogate, combined with the language-modeling loss and a global load-balance term. Our falsifiable claim: this model-side change measurably raises local routing consistency (SRP/SCH [1]) while holding perplexity degradation to $\leq$ ~2%, and - at fixed GPU memory - lowers end-to-end decode latency under expert offloading by $\geq$10% with zero per-step routing overhead, in contrast to inference-time cache-aware or batch-aware re-routing [2][3], which re-pay a per-token cost and make a per-request quality trade-off

on every request. Where offloading systems adapt the system to whatever routing the model exhibits [4][5][6][7][8][9][10][20], LARC adapts the model to the deployment's memory constraint; where prior routing objectives are pretraining-time and target convergence, stability, or communication volume [11][12][13], LARC is a cheap deployment-aware post-processing step on a frozen model. We specify the objective, a router-only training protocol (100–500M tokens; router weights are <0.1% of model parameters, so this is hours-to-a-day per model), an evaluation plan against system-side, static-compilation, and inference-time re-routing baselines, and the ablations and kill criteria that would falsify the claim.

Problem. Expert offloading for memory-constrained MoE LLM serving depends on local routing consistency–the tendency of consecutive tokens to reuse the same experts–which varies widely across models and, in prior work, has only been measured, not trained; inference-time cache-aware or batch-aware re-routing incurs per-token cost and per-request quality trade-offs, while offloading systems adapt to whatever routing the model exhibits.

Motivation. A model-side change that raises local routing consistency while preserving perplexity could lower end-to-end decode latency under expert offloading at fixed GPU memory without per-step routing overhead or per-request quality trade-off, and is cheap because only router weights are trained.

Proposed approach. The proposed procedure post-trains only the gating networks of a frozen pretrained MoE LLM. It combines a windowed, differentiable expert-set-overlap objective computed against a running cache-set surrogate with the language-modeling loss and a global load-balance term. Training uses a router-only protocol over 100–500M tokens; router weights are less than 0.1% of model parameters, making the one-time step hours-to-a-day per model.

Research plan. The paper evaluates the consistency/perplexity claim and the latency claim against system-side, static-compilation, and inference-time re-routing baselines, with ablations and kill criteria to falsify the claims; fixed GPU memory is stated as the matched condition for the latency trade-off claim. The abstract specifies the 100–500M token router-only protocol but does not give exact metrics beyond SRP/SCH or the kill criteria.

Automatic judgments. Problem: match; motivation: match; proposed approach: match; research plan: match.

Case 2: Online adaptation of world models. All three works seek adaptation to changing environments while retaining prior capabilities. SPREAD and DynaLoRA update low-rank adapters on a frozen model. ERALD instead stores observed transitions and combines retrieved predictions with the frozen model. DynaLoRA additionally proposes composing adapters for unseen combinations of dynamics changes; this extension is not part of the shared mechanism.

Human paper: SPREAD (Moon & Kim, 2026)

Title. SPREAD: Scalable Pre-Trained World Model for Adaptive Dynamics Model

Abstract. Autonomous robots must be capable of adapting not only to training datasets but also to unfamiliar environments. World models, which learn predictive dynamics of the environment, have been proposed to overcome the task-specific limitations of conventional RL. However, their capability is typically restricted to training distributions. In this paper, we introduce SPREAD, the first framework that enables a pre-trained world model to learn environmental changes online, and continuously. SPREAD freezes the pre-trained model and updates only a set of LoRA adapters. This design jointly achieves three goals: (i) real-time adaptation, (ii) robustness to forgetting without a replay buffer, and (iii) forward transfer. Experiments demonstrate that SPREAD reduces prediction error by 40% within just 100 steps under diverse visual and dynamic changes, and that such adaptation directly translates into improved task success rates. Moreover, SPREAD validates its effectiveness in continual learning settings. By extending pre-trained world models to the domain of online continual learning, this work highlights world models that autonomously adapt to real-world dynamics.

Problem. Pre-trained world models learn predictive environment dynamics but their capability is typically restricted to training distributions, so they cannot adapt to environmental changes online and continuously.

Motivation. Autonomous robots must adapt to unfamiliar environments beyond training datasets; enabling world models to update online would overcome the task-specific limitations of conventional RL and support real-world dynamics.

Proposed approach. The method freezes a pre-trained world model and updates only a set of low-rank adapters online. This keeps the base model fixed while learning environmental changes, and is designed to provide real-time adaptation, robustness to forgetting without a replay buffer, and forward transfer.

Research plan. (1) The paper evaluates whether the adaptation reduces prediction error within 100 steps under diverse visual and dynamic changes. (2) It tests whether this adaptation translates into improved task success rates. (3) It validates the method in continual learning settings.

AI proposal A: ERALD

Model: DeepSeek-V4-Flash. **Method:** TOPIC.

Title. ERALD: Episodic Retrieval-Augmented Latent Dynamics - Gated Fusion of Parametric and Memory-Based Next-State Prediction for Gradient-Free World-Model Adaptation

Abstract. Latent world models of the PlaNet/Dreamer family predict environment transitions with fixed network weights and consequently degrade the moment the environment changes (mass, friction, gravity, layout). Existing remedies either fine-tune the transition model on replay mixtures, inheriting a plasticity-forgetting trade-off and stale-data interference, or compress experience into an amortized context vector that fixed weights must still decode. We propose ERALD, a hybrid latent world model that keeps a frozen recurrent state-space model as a parametric prior and adds a bounded, continuously maintained episodic store of latent transitions. At every step of an imagined rollout, a contrastively learned, dynamics-aware key retrieves stored (state, action, next-state) items whose local dynamics match the current regime, and the parametric forecast is fused with the kernel-weighted episodic estimate by an online, residual-driven arbitration rule rather than by learned gating parameters. A regime shift is absorbed by appending observed transitions to the store and re-optimizing the policy inside ERALD imagination, with zero updates to the transition-model weights. We claim that under abrupt, recombinatorial dynamics switches, ERALD recovers a target return in fewer environment steps than replay- and generative-replay-based continual world models, achieves lower multi-step predictive error than both the frozen parametric model and a pure search-based world model given identical memory, and exhibits no measurable forgetting of the source regime. The claim is falsified if the hybrid never beats the better of its two components, if the online arbitration rule adds nothing over a fixed blend, if a replay-based baseline reaches the target return within the same environment budget, or if a dynamics-agnostic key space performs equally.

Problem. Latent world models of the PlaNet/Dreamer family predict environment transitions with fixed network weights and consequently degrade when the environment changes (mass, friction, gravity, layout); existing remedies either fine-tune the transition model on replay mixtures, inheriting a plasticity-forgetting trade-off and stale-data interference, or compress experience into an amortized context vector that fixed weights must still decode.

Motivation. Continual model-based control needs to adapt quickly to abrupt environment changes while retaining prior regimes, and avoiding transition-model fine-tuning removes the plasticity-forgetting trade-off and stale-data interference of existing remedies.

Proposed approach. The proposed hybrid latent world model keeps a frozen recurrent state-space model as a parametric prior and adds a bounded, continuously maintained episodic store of latent transitions. During imagined rollouts, a contrastively learned dynamics-aware key retrieves stored (state, action, next-state) items whose local dynamics match the current regime. The parametric forecast is fused with a kernel-weighted episodic estimate by an online, residual-driven arbitration rule rather than learned gating parameters. Regime shifts are absorbed by appending observed transitions to the store and re-optimizing the policy inside the proposed framework's imagination, with zero updates to the transition-model weights.

Research plan. The paper evaluates the claims under abrupt, recombinatorial dynamics switches: (1) sample efficiency of target-return recovery versus replay- and generative-replay-based continual world models, (2) multi-step predictive error versus the frozen parametric model and a pure search-based world model with identical memory, and (3) forgetting of the source regime. The stated falsification conditions are: the hybrid never beats the better of its two components, the online arbitration rule adds nothing over a fixed blend, a replay-based baseline reaches the target return within the same environment budget, or a dynamics-agnostic key space performs equally.

Automatic judgments. Problem: match; motivation: match; proposed approach: no match; research plan: no match.

AI proposal B: DynaLoRA

Model: DeepSeek-V4-Flash. **Method:** FREE.

Title. DynaLoRA: Composable Low-Rank Latent-Dynamics Adapters for Forgetting-Free, Few-Shot World-Model Adaptation

Abstract. Latent-dynamics world models (e.g., Dreamer-style RSSMs) are pretrained in one environment and must be adapted when dynamics change - mass, friction, gravity, or actuation scale - while retaining old skills and ideally composing knowledge of perturbations seen separately into models of combinations never jointly experienced. Existing approaches either fine-tune a monolithic latent residual for a single target environment [1], condition the world model on explicit or inferred context for zero-shot generalization [2, 3], mitigate forgetting with replay or generative rehearsal [4, 5, 6, 7], or discover modular mechanisms by training jointly across environments [8, 9, 10]. None provides a plug-in, parameter-efficient, forgetting-free-by-construction mechanism for adapting a frozen pretrained world model to a stream of dynamics-shifted environments, whose per-environment corrections are closed-form composable so an agent can imagine rollouts under compound perturbations (e.g., mass × friction) it has never jointly experienced. We propose DynaLoRA: low-rank adapters on the linear projections of a frozen RSSM transition model, each trained on a handful of interactions under one perturbation by distilling the frozen posterior's latent sequence, leaving base weights untouched. Because each environment contributes an additive low-rank perturbation $\Delta W_i = B_i A_i$ to the same base matrix, DynaLoRA is forgetting-free without replay, costs under ˜0.5% trainable parameters per environment, and supports closed-form parameter-space composition for held-out compound dynamics. We validate on vision-based DMControl/CARL-style perturbations that few-shot adapters reach ≈90% of converged full-fine-tuning fidelity and control return with under ˜0.5% of the interaction budget, that a stream of five perturbations causes ˜zero forgetting of prior environments, and that composed adapters outperform matched-budget from-scratch training on unseen combinations.

Problem. Existing approaches for adapting pretrained latent-dynamics world models to dynamics shift either fine-tune a monolithic residual for a single target environment, condition on context for zero-shot generalization, mitigate forgetting with replay or rehearsal, or discover modular mechanisms by training jointly across environments; none provides a plug-in, parameter-efficient, forgetting-free-by-construction mechanism for adapting a frozen pretrained world model to a stream of dynamics-shifted environments whose per-environment corrections are closed-form composable into models of compound perturbations never jointly experienced.

Motivation. Such a mechanism would let an agent retain old skills across changing dynamics, adapt with few interactions and parameters, and imagine rollouts under combinations of perturbations seen separately, which is important for real-world deployment where dynamics drift over time and exact joint perturbations cannot be anticipated.

Proposed approach. The method inserts low-rank adapters on the linear projections of a frozen RSSM transition model. Each adapter is trained on a handful of interactions under a single perturbation by distilling the latent sequence of the frozen posterior, leaving the base weights untouched. Each environment contributes an additive low-rank perturbation to the same base matrix, so the adapters are parameter-efficient and can be composed in closed form in parameter space for compound dynamics. The adapters are intended to be plug-in and forgetting-free by construction.

Research plan. Validation uses vision-based DMControl/CARL-style dynamics perturbations. The evidence is: (1) few-shot adapters are compared to converged full fine-tuning on fidelity and control return under a reduced interaction budget; (2) a stream of five perturbations is used to measure forgetting of prior environments; (3) composed adapters are compared to matched-budget from-scratch training on unseen compound perturbations. Success conditions implied by the abstract are approaching full-fine-tuning performance, negligible forgetting, and superior performance on composed compounds; no explicit failure thresholds are stated. The comparisons for the composed setting hold interaction budget matched; other matched factors are not detailed.

Automatic judgments. Problem: match; motivation: match; proposed approach: match; research plan: match.

Case 3: Joint KV-cache eviction and quantization. All three works jointly allocate storage to retention and precision. RDKV and ASYM-RD use a rate-distortion objective and reverse water-filling, with eviction represented by zero bits. TriAdmit learns retention scores for a three-action controller and passes them to an online budget solver. RDKV and ASYM-RD still differ in their distortion definitions and allocation timing. Their agreement concerns the allocation principle, not identical implementations.

Human paper: RDKV (Zhang et al., 2026)

Title. RDKV: Rate-Distortion Bit Allocation for Joint Eviction and Quantization of the KV Cache

Abstract. Large language models (LLMs) have shown strong performance across diverse tasks, but their inference with long input contexts is bottlenecked by memory size and bandwidth. The Key-Value (KV) cache size grows linearly with sequence length and needs to be re-read

from off-chip high-bandwidth memory (HBM) to on-chip memory at every decoding step, resulting in memory-bound inference. Existing methods reduce the cache by either eviction or quantization, but typically treat the two in isolation. In this paper, we cast KV cache compression as a rate-distortion problem, under which eviction and quantization are two end-points of the same bit allocation scheme. This exposes the need to optimize them jointly, motivating our method, RDKV (Rate-Distortion KV cache compression). RDKV derives the weight of each token or channel from the distortion that compression induces on the attention computation. Based on these weights, it assigns each token or channel a bit-width ranging from full precision down to zero bits guided by reverse water-filling, applied once after the prefilling stage. Experiments on LongBench, RULER, and InfiniteBench show that RDKV outperforms the best evaluated baseline by 9.1% on average. On LongBench it recovers 97.81% of full-cache accuracy with only 2.48% cache retention. Compared with full-cache FlashAttention-2 decoding, it achieves 4.5x decode speedup and 1.9x peak memory reduction with 128K context length, while maintaining comparable performance.

Problem. Inference with long input contexts is bottlenecked by memory size and bandwidth because the KV cache grows linearly with sequence length and must be re-read from off-chip high-bandwidth memory to on-chip memory at every decoding step, making decoding memory-bound.

Motivation. Existing KV cache compression methods reduce the cache through eviction or quantization in isolation, leaving unexploited the potential gains from jointly optimizing the two under a shared bit allocation.

Proposed approach. The method casts KV cache compression as a rate-distortion problem. It derives the weight of each token or channel from the distortion that compression induces on the attention computation, then assigns each token or channel a bit-width from full precision down to zero bits using reverse water-filling, applied once after the prefilling stage.

Research plan. Evidence consists of experiments on LongBench, RULER, and InfiniteBench comparing against the best evaluated baseline. LongBench evaluation reports full-cache accuracy recovery as a function of cache retention, and 128K-context decoding is compared with full-cache FlashAttention-2 on decode speed and peak memory while checking comparable performance. No explicit failure condition or ablation design is stated.

AI proposal A: TriAdmit

Model: DeepSeek-V4-Flash. **Method:** TOPIC.

Title. TriAdmit: Learned Three-Way KV-Cache Admission - Retain, Demote, Evict - under Joint Byte Budgets

Abstract. Long-context LLM inference is bottlenecked by a KV cache whose bytes and per-decode attention cost grow linearly with context length. Prior work attacks this by learning a binary write-time policy that evicts or keeps each token [1,2,3], by quantizing an entire cache at layer/chunk granularity [7,8,9,10], or by heuristically mixing the two [4,5,6]. These literatures are split along a false axis: a token's storage is not a keep/drop coin flip, nor is precision a property of a layer - each cached element has a rate-retention curve describing how much future-generation utility is lost as its storage is reduced from full precision to low precision to zero bits. We propose TriAdmit, a write-time admission controller that learns, for each (token, layer, head), a joint action over {retain at full precision, demote to low precision, evict}, and feeds the resulting per-element retention scores to an online budget solver that respects both byte and attention budgets. The core falsifiable claims are: (C1) there exist byte budgets at which all three actions are jointly necessary - the best two-action oracle cannot match the three-action oracle; and (C2) a lightweight distillation-trained scorer predicts these retention curves well enough to come within a small margin of the oracle. TriAdmit is evaluated on LongBench, RULER, and LongMemEval with Llama-3.1 and Qwen models, in a paged layout where demoted tokens live in separate low-precision pages and evicted tokens cost zero bytes and zero decode bandwidth.

Problem. Long-context LLM inference is bottlenecked by a KV cache whose bytes and per-decode attention cost grow linearly with context length. Existing methods treat token storage as a binary keep/evict choice or treat precision as a layer/chunk-level property, missing that each cached element has a rate-retention curve describing how much future-generation utility is lost as its storage is reduced.

Motivation. Modeling storage utility as a per-element rate-retention curve makes it possible to allocate scarce byte and attention budgets where they matter most and avoid paying full cost for tokens with little future-generation utility.

Proposed approach. The proposed admission controller learns, for each (token, layer, head), a joint action over retaining at full precision, demoting to low precision, and evicting, and feeds the resulting per-element retention scores to an online budget solver

that respects both byte and attention budgets. The scorer is trained via distillation to predict retention curves. In a paged layout, demoted tokens live in separate low-precision pages and evicted tokens cost zero bytes and zero decode bandwidth.

Research plan. Evidence for the first claim is an oracle comparison across byte budgets, with the failure condition being that no budget exists where the three-action oracle beats every two-action oracle. Evidence for the second claim is comparing the distillation-trained scorer against the oracle, with the failure condition being that its predicted retention curves do not come within the claimed small margin. The full system is evaluated on LongBench, RULER, and LongMemEval with Llama-3.1 and Qwen models in a paged layout where demoted tokens live in separate low-precision pages and evicted tokens cost zero bytes and zero decode bandwidth.

Automatic judgments. Problem: match; motivation: match; proposed approach: no match; research plan: no match.

AI proposal B: ASYM-RD

Model: DeepSeek-V4-Flash. **Method:** FRONTIER.

Title. ASYM-RD: Rate-Distortion-Optimal Joint Bit-Allocation and Token Retention for the KV Cache under a Single Memory Budget

Abstract. KV-cache compression is currently attacked one axis at a time: token eviction [1,2,3], uniform or mixed-precision quantization [4,5,6,7,8,9,10,11], or low-rank/channel compression [12]. The token-precision trade-off study [13] shows empirically that more tokens at lower precision usually beats fewer tokens at higher precision, but treats the split as a discrete choice, and existing mixed-precision KV papers allocate precision with layer- or channel-level saliency heuristics [5,6,7,8,9]. We propose to formulate KV compression as one rate-distortion allocation problem, solved once per model on a short calibration pass, whose distortion is the attention-output error, not the K/V reconstruction error. A first-order expansion of the softmax shows that a key error at token j is weighted by $p_j^2\|v_j - o\|^2$ while a value error is weighted only by p_j^2, so keys and values must be allocated asymmetrically as a matter of theory, not convention. Minimizing D + λR over (layer, head, token, channel-group) cells gives a reverse-water-filling rule in which eviction is the interior b = 0 corner rather than a separate heuristic. We will test two falsifiable claims at equal KV bytes: (i) joint allocation beats uniform-bit, attention-saliency, layer-wise mixed-precision, and evict-then-uniform-precision baselines on RULER/LongBench, with the margin growing as the budget falls below 2 bits/token; (ii) the predicted key-sensitivity rank correlates better with measured per-token bit-shift damage than the attention score does, which would explain why low-bit KV methods that protect high-attention tokens still lose retrieval accuracy.

Problem. KV-cache compression is currently attacked one axis at a time: token eviction, uniform or mixed-precision quantization, or low-rank/channel compression. The token-precision trade-off treats the split as a discrete choice, and existing mixed-precision methods allocate precision with layer- or channel-level saliency heuristics.

Motivation. A jointly solved rate-distortion allocation with attention-output distortion could enable principled asymmetric key/value allocation and better compression under low KV budgets.

Proposed approach. Formulate KV compression as one rate-distortion allocation problem over (layer, head, token, channel-group) cells, solved once per model on a short calibration pass, with distortion defined as attention-output error rather than K/V reconstruction error. A first-order expansion of the softmax weights key error at token j by $p_j^2//v_j-o//^2$ and value error by p_j^2; minimizing D + λR yields a reverse-water-filling rule in which eviction is the interior b = 0 corner.

Research plan. (1) Joint allocation is compared against uniform-bit, attention-saliency, layer-wise mixed-precision, and evict-then-uniform-precision baselines on RULER/LongBench at equal KV bytes; support requires joint allocation to outperform these baselines with a margin that grows as the budget falls below 2 bits/token, while failure would be baselines matching or reversing the trend. (2) The predicted key-sensitivity rank is correlated with measured per-token bit-shift damage; support requires this correlation to exceed that of the attention score, and failure would be the attention score correlating equally well or better, holding the KV budget matched.

Automatic judgments. Problem: match; motivation: match; proposed approach: match; research plan: match.

Case 4: Detecting code-benchmark contamination. SrDetection and ReformGap detect leakage by comparing performance on an original problem and semantically equivalent variants. Shrinking Solution Ensembles instead tests whether memorization reduces the diversity of correct solutions.

Both routes use controlled contamination experiments, but the experiments test different detection signals. Shared evaluation settings therefore do not by themselves establish agreement on the research plan.

Human paper: SrDetection (Li et al., 2026b)

Title. SrDetection: A Self-Referential Framework for Data Leakage Detection in Code Large Language Models

Abstract. Evaluating code large language models (Code LLMs) requires reliable detection of data leakage, where benchmark performance is artificially inflated by exposure to benchmark data during pre-training. Existing approaches either assume access to proprietary training corpora, rely on brittle heuristics such as timestamp filtering, or use external reference sets with manually tuned, non-generalizable thresholds. To address these limitations, we introduce SrDetection , a unified s elf- r eferential leakage detection framework for both gray-box (access to model logits) and black-box (access to model outputs) settings. SrDetection generates semantically equivalent variants of a benchmark sample and detects leakage by contrasting the model's behavior on the original versus its variants, flagging cases where the original is disproportionately easier for the model. We further design a controlled leakage detection testbed and evaluate SrDetection in this environment. Across different models and training stages, SrDetection improves average F1 by 21.52 points in the gray-box setting and 14.46 points in the black-box setting over strong baselines, demonstrating robust, threshold-independent leakage detection. Finally, a gray-box study of 15 widely used Code LLMs on four popular benchmarks reveals benchmark-specific leakage patterns beyond prior overlap-based analyses[Source code and data are available at https://github.com/SMinL/SrDetectionCode].

Problem. Reliable detection of data leakage is lacking for code large language models: existing approaches either assume access to proprietary training corpora, rely on brittle heuristics such as timestamp filtering, or require external reference sets with manually tuned, non-generalizable thresholds.

Motivation. Without reliable leakage detection, benchmark performance of code large language models can be artificially inflated by pre-training exposure, so trustworthy evaluation requires a method that works in both gray-box and black-box settings without manual threshold tuning.

Proposed approach. The proposed framework generates semantically equivalent variants of a benchmark sample and contrasts the model's behavior on the original with its behavior on the variants, flagging cases where the original is disproportionately easier. It supports gray-box operation using model logits and black-box operation using model outputs. A controlled leakage detection testbed is also constructed for evaluation.

Research plan. (1) The detection claim is evaluated in the controlled leakage detection testbed with known leakage labels, comparing the proposed framework against strong baselines in gray-box and black-box settings using average F1. (2) Robustness and threshold independence are assessed across different models and training stages. (3) A gray-box study of 15 widely used code large language models on four popular benchmarks is conducted to examine benchmark-specific leakage patterns beyond prior overlap-based analyses.

AI proposal A: Shrinking Solution Ensembles

Model: DeepSeek-V4-Flash. **Method:** LANDSCAPE.

Title. Shrinking Solution Ensembles: Detecting Benchmark Contamination in Code LLMs from Sampling Behavior Under Controlled Leakage

Abstract. Benchmark contamination - the presence of evaluation problems and their reference solutions in a code LLM's training data - is widely suspected of inflating pass@k leaderboards, yet existing contamination detectors are validated only on uncontrolled model-benchmark pairs in which the ground truth of leakage is unknown; several recent studies show these detectors disagree with each other, fail on instruction-tuned and RL-trained models, and can even be evaded. This proposal has two parts. First, we build a controlled-contamination corpus for code generation: open code LLMs are fine-tuned on known fractions (0-50%) of uncontaminated code benchmarks, giving per-problem ground-truth leakage labels, dose-response measurements of pass@1/pass@k inflation, and quantification of leaderboard rank flips between contaminated and clean evaluations. Second, we introduce LeakScore, a black-box, per-instance contamination test exploiting a signal no existing detector uses: the diversity of a model's functionally correct solution ensemble. Our hypothesis is that leaked problems cause the model's conditional sampling distribution to collapse onto the memorized reference solution, so an executable sample set for a leaked problem has measurably lower cluster entropy and higher self-overlap than the model's samples on matched, certainly-unseen problems. We will test whether LeakScore detects per-problem leakage at fractions where Min-K% Prob, DiffMIA, CDD, and PEARL-style signals are at chance, and whether the same signal tracks pass@k inflation and ranking distortion

across models. If confirmed, LeakScore gives evaluators a leakage test needing no training-data access, no ground-truth contamination labels, and no benchmark rewrite, and provides a quantitative answer to when pass@k numbers should be distrusted.

Problem. Existing code LLM benchmark contamination detectors are validated only on uncontrolled model-benchmark pairs with unknown leakage, and recent studies show they disagree, fail on instruction-tuned and RL-trained models, and can be evaded.

Motivation. A leakage test needing no training-data access, ground-truth contamination labels, or benchmark rewrite would make pass@k leaderboards more trustworthy, and controlled fine-tuning of open code LLMs makes it possible to validate such tests against known leakage.

Proposed approach. The work builds a controlled-contamination corpus by fine-tuning open code LLMs on known fractions (0–50%) of uncontaminated code benchmarks, producing per-problem ground-truth leakage labels, dose-response measurements of pass@1/pass@k inflation, and quantification of leaderboard rank flips between contaminated and clean evaluations. It also develops a black-box, per-instance contamination test that measures the diversity of a model's functionally correct solution ensemble, using cluster entropy and self-overlap of executable samples relative to matched, certainly-unseen problems to detect memorization-induced sampling collapse.

Research plan. (1) The controlled corpus will be used to test whether the proposed diversity signal detects per-problem leakage at contamination fractions where Min-K% Prob, DiffMIA, CDD, and PEARL-style signals are at chance. (2) It will also test whether the same signal tracks pass@k inflation and ranking distortion across models. (3) Ground-truth leakage labels, dose-response measurements, and rank-flip quantification provide the evaluation setting; support for the detection claim requires the proposed signal to detect leakage in regimes where the named existing detectors perform at chance.

Automatic judgments. Problem: match; motivation: match; proposed approach: no match; research plan: no match.

AI proposal B: ReformGap

Model: DeepSeek-V4-Flash. **Method:** FREE.

Title. ReformGap: Detecting Memorized Code-Benchmark Items via Execution-Grounded Prompt Reformulation

Abstract. Data contamination in code-generation benchmarks such as HumanEval threatens the validity of model evaluation, yet existing detection tools either match against training corpora [5], require token-level loss or output-distribution access that API-only models do not expose [1][2], or sidestep the problem by continuously refreshing benchmarks [8][9]. We propose ReformGap, a purely black-box, per-item contamination detector built on the one asset code benchmarks have and text benchmarks lack: executable hidden test oracles. For each benchmark item, ReformGap generates semantically equivalent natural-language reformulations of the problem statement, accepts only reformulations verified by a reference model to be behavior-identical (execution-grounded equivalence), and measures the target model's reformulation gap Γ = pass@k(original) − pass@k(reformulation). The falsifiable core claim is that items whose (prompt→solution) pair was memorized produce a large Γ, because recall of the memorized mapping is brittle under surface change, while items solved by genuine competence transfer produce $\Gamma \approx 0$. We validate under simulated contamination with known membership ground truth – the gold-standard protocol that real-world contamination studies lack [3][4] – and additionally test on API-only black-box models where no loss signal exists. If memorized items do not exhibit a reformulation gap, or if difficulty-matched competent solves do, the detector fails its own decisive experiment exactly as specified.

Problem. Data contamination in code-generation benchmarks threatens evaluation validity, but existing detectors require training-corpus matching or internal model access that API-only models do not expose, or avoid detection by continually refreshing benchmarks; no purely black-box, per-item detector exists.

Motivation. Code benchmarks uniquely provide executable hidden test oracles, so black-box equivalence checking via reformulation can make contamination detection possible without model internals.

Proposed approach. For each benchmark item, the proposed detector generates semantically equivalent natural-language reformulations of the problem statement, retains only reformulations verified by a reference model to be behavior-identical via execution-grounded equivalence, and computes a gap score as pass@k on the original item minus pass@k on the reformulations. The detector operates purely black-box and uses the benchmark's executable hidden test oracles as the equivalence signal.

Research plan. The core claim is tested under simulated contamination where membership ground truth is known, the protocol the abstract calls the gold standard, and additionally

on API-only black-box models where no loss signal exists. The decisive failure condition is specified: if memorized items do not exhibit a gap score under reformulation, or if difficulty-matched competent solves do, the detector fails.

Automatic judgments. Problem: match; motivation: match; proposed approach: match; research plan: match.