publications

MDPI

Article

Some Insights into the Factors Influencing Continuous Citation of Retracted Scientific Papers

Bor Luen Tang

Department of Biochemistry, Yong Loo Lin School of Medicine, National University of Singapore, Singapore 117596, Singapore; bchtbl@nus.edu.sg

Abstract: Once retracted, the citation count of a research paper might be intuitively expected to drop precipitously. Here, we assessed the post-retraction citation of life and medical sciences papers from two top-ranked, multidisciplinary journals *Nature* and *Science*, from 2010 to 2018. Post-retraction citations accounted for a staggering 47.7% and 40.9% of total citations (median values), respectively, of the papers included in our analysis. These numbers are comparable with those from two journals with lower impact factors, and with retracted papers from the physical sciences discipline. A more qualitative assessment of five papers from the two journals with a high percentage (>50%) of post-retraction citations, all of which are associated with misconduct, reveal different contributing reasons and factors. Retracted papers associated with highly publicized misconduct cases are more prone to being cited with the retraction status indicated, or projected negatively (such as in the context of research ethics and misconduct discussions), with the latter also indicated by cross-disciplinary citations by humanities and social sciences articles. Retracted papers that retained significant validity in their main findings/conclusions may receive a large number of neutral citations that are somewhat blind to the retraction. Retracted papers in popular subject areas with massive publication outputs, particularly secondary publications such as reviews, may also have a high background citation noise. Our findings add further insights to the nature of post-retraction citations beyond the plain notion that these are largely made through sheer ignorance or negligence by the citing authors.

Keywords: citation; retraction; publication; post-retraction citation

Citation: Tang, B.L. Some Insights into the Factors Influencing Continuous Citation of Retracted Scientific Papers. *Publications* **2023**, *11*, 47. https://doi.org/10.3390/publications11040047

Academic Editor: Guangwei Hu

Received: 11 July 2023
Revised: 22 September 2023
Accepted: 7 October 2023
Published: 8 October 2023

1. Introduction

When emerging evidence indicates that a published scientific article has significant flaws that renders its findings or conclusions no longer valid or reliable and unamendable by mere corrections, a common course of action taken would be to retract the article. Such retractions occur rarely, with an estimated rate of occurrence of roughly 4 in 10,000 papers across different scientific and research disciplines [1]. However, this retraction rate has risen steadily over the years, and the Retraction Watch database (RWD) [2] has now close to 36,000 retractions on record. Notably, the retraction rate of papers in the broad discipline of life and biomedical sciences has risen steeply in recent years [3,4]. This, in conjunction with a perceived reproducibility crisis in multiple scientific disciplines [5], is cause for concern for all involved in the practice and administration of scientific endeavors. Although articles could be retracted because of honest or inadvertent errors, a large fraction of retractions are due to some form of research misconduct [6–8].

While one would have intuitively thought that a retracted article would be deemed invalid by others in the field and would no longer be cited by the scientific literature that comes after, many analyses of the biomedical sciences literature have shown that quite the opposite is true [9–18], and citations are often made without reference to the retraction. In fact, such post-retraction citations are also prevalent among articles retracted due to research misconduct [9,19–21]. This phenomenon of persistent post-retraction citation appears at odds with the truth-seeking and self-correcting nature of science and scientists.

Furthermore, no strict rules have been erected within the scientific establishment to rid the community of such a practice. Such broad tolerance of an apparent malpractice in a field that prides itself in honesty and accountability is somewhat puzzling.

In the sections below, we first assess the previous analyses on post-retraction citation and provide a brief overview of the phenomena documented, as well as various takes on explanations and consequences. We then present our own assessment of the extent of post-retraction citation of the life and health sciences papers in two top multidisciplinary journals, *Nature* and *Science*, as well as our analyses of five papers with the highest percentages of post-retraction citation to explore the reasons behind the high numbers of post-retraction citations.

2. Post-Retraction Citation of Retracted Papers—Concerns and Reasons

Analysis of post-retraction citations has been performed rather extensively for biomedical sciences and its sub-disciplines [9,12–14,17–19,21,22], as well as from multi-disciplinary perspectives [10,11,15,16,20]. Although the numbers vary considerably and each study has its own constraints, a general conclusion that could be derived from all these studies is that post-retraction citation is rather rampant, with most of such citations making no reference to the fact that the cited paper has been retracted. This conclusion raised concerns, as it appears that the primary purpose for retracting a paper has been defeated. If retracted papers continue to be cited, there would be no effective correction of erroneous or fraudulent instances in the literature, which would, in turn, negatively impact scientific knowledge archiving, dissemination, and progress.

An obvious negative consequence of citations of retracted articles is that erroneous or invalidated findings and/or their conclusions shall continue to be propagated. Citation network analyses [10,23] have shown that propagation of erroneous results are more limited to direct citations [23]. However, some retracted papers are more undesirable than others if they continue to be cited, particularly those that have significance influence on societal perception on healthcare. One such example is the continued citation of Andrew Wakefield's article, whose purported link between autism and vaccination has been debunked [24], but may still be influential amongst anti-vaccination activists and believers. While the analyses of post-retraction citation of Wakefield's article indicated that many of these are made in a negative sense and there is a prevalence in indication of its retraction [25–27], there are still concerns as there are citations that did not document the retraction [25], and that because, as pointed out by Leta and colleagues, "recent citing articles are highly cited and, even in a negative context, they contribute to the diffusion of a fraudulent article in the science context" [27]. Another potentially worrying example of post-retraction citation pertains to those associated with retracted COVID-19 papers [28,29], which are largely made without reference to their retractions and in a non-critical manner. These citations could potential extend the myths built on the unproven effectiveness of certain drugs, such as hydroxyquinoline or ivermectin, whose efficacy as off-the-shelf therapeutics in the treatment or prevention of COVID-19 have been discredited by well-conducted clinical studies.

Why do researchers and authors cite retracted articles? Several possible reasons have been proposed, mainly by da Silva and colleagues [30,31]. One reason might be that the same or other authors continue to believe in the validity of the main finding or ideas behind a retracted paper, with the paper being retracted due to erroneous or fraudulent components that does not negate the entire study. As such, post-retraction citation is deliberate, made with an intention to support the overall credibility of the retracted paper, and are, thus, often made without any indication of the retraction. Logically, barring an oversight, most if not all citing papers that would cite a retracted paper in a negative sense would refer to its retracted status (or cite the retraction notice instead of the paper).

A second reason for the citation of a retracted paper is that such a citation is made inadvertently. In other words, authors could have cited a paper without knowing that it has been retracted. This oversight could arise because retraction notices were unclear, which is conceivable as not all journals (and for that matter, databases) clearly mark retracted papers

as such on their websites (Only a fraction of journals clearly mark a retracted article as retracted, and some go as far as watermarking the .pdf copy that readers could download. Retractions are typically published in print and online, with the latter bearing a digital object identifier (DOI). However, a status of retraction might not have been made obvious in certain databases. PubMed clearly marks retractions as "retracted" in red, but the same retracted papers are not prominently labelled as in some other databases). Authors who extract and cite papers from private collections or databases during writing might also not be adequately informed of the status of a paper being cited. Of course, post-retraction citations could also be made by some authors in either a negligent or reckless manner, with no regard for retraction status being a barrier to citation.

Below, we sought to explore the phenomenon of citation of retracted papers by performing our own analysis of post-retraction citation with several questions in mind. These include how large is the fraction of post-retraction citation for retracted papers of significant impact and citation count, why are post-retraction citations so common and rampant, and why such citations have, thus far, not been outlawed.

3. Post-Retraction Citation Analysis Methodology

In our attempt at gauging the extent of post-retraction citations of biomedical sciences papers, we wanted to explore beyond a particular subfield of life sciences or medicine, or that of individual authors, as these have been performed previously by others. We also wished to look at papers with high impact and citation count, so that there is sufficient scope for both quantitative and qualitative analysis of the post-retraction citations. We have, therefore, focused on papers retracted from two top-ranking and historically renowned multi-disciplinary science journals, namely, *Nature* (impact factor (IF) 2021—69.504) and *Science* (IF 2021—63.798). We first searched for papers retracted by these two journals using RWD (http://retractiondatabase.org/ accessed on 1 May 2023) and Scopus (https://www.scopus.com/sources) searches (accessed on 1 May 2023) in the broad disciplines of "life sciences" and "health sciences", and confined the hits to those retracted between 2010 and 2018. Citations to these retracted articles, from the year the paper is published up to 2021, were then obtained by Scopus searches. For a retracted paper, pre-retraction citation is defined as citations that appeared up to the year of retraction, while post-retraction citations are those made after the year of retraction (up to 2021). As citations are expected to diminish over time, we focused on papers that were retracted less than five years after their publication. Retracted papers with a total citation <10 were also not included. Data of articles found and their analyses were entered manually into Microsoft Excel worksheets. Computations and graphics generation were performed using the functions of Excel.

To further explore the reasons underlying post-retraction citation, we focused on five papers with a high percentage (>50%) of post-retraction citations. We compared their citation trend over the years post-retraction with five non-retracted papers from the same issues. We then performed qualitative assessment of these papers based on (a) whether misconduct is indicated in the citations, (b) whether the major conclusions remain valid, and (c) the types of papers that cite these retracted papers (e.g., citations by papers from other disciplines and citations by reviews versus primary papers).

4. Results and Discussion

4.1. A High Percentage of Post-Retraction Citation across Journal Ranks and Research Disciplines in the Sciences

Expression of post-retraction citation over total citation as a percentage shows that all retracted papers included in the analysis have a significant post-retraction citation percentage, with median values of 47.7 and 40.9 for *Nature* and *Science*, respectively (see Figure 1).

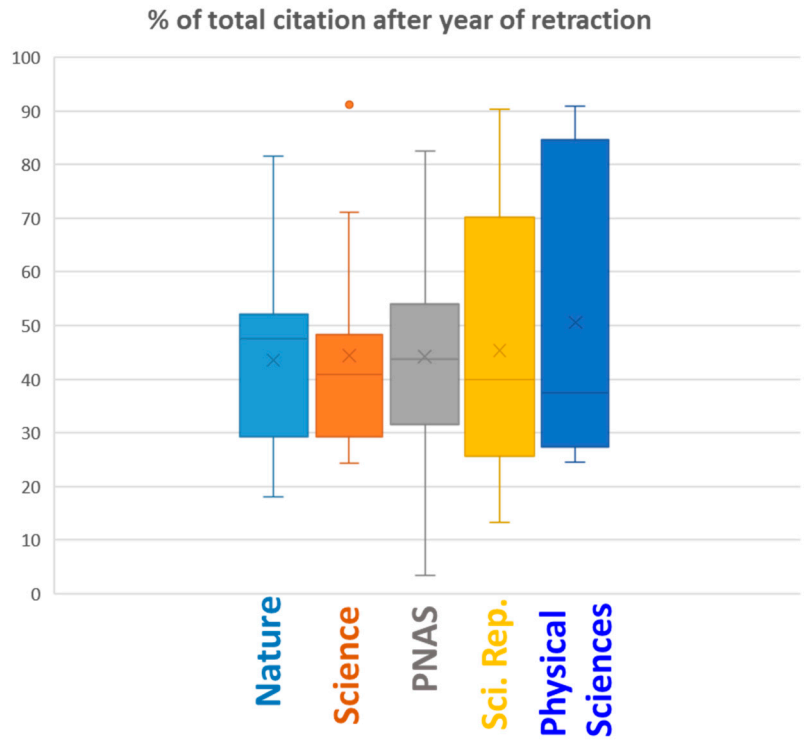

Figure 1. Box plots of post-retraction citation as a percentage of total citations for papers included in our analysis (retraction between 2010 and 2018, occurring <5 years after publication) for "basic life sciences" and "health sciences" papers in the journals *Nature*, *Science*, *Proceedings of the National Academy of Science, USA* (*PNAS*), and *Scientific Reports* (*Sci. Rep.*). The blue bar (far right) shows the same percentage distribution for retracted papers under "physical sciences" for all four journals combined.

To gauge if this high proportion of post-retraction citation is unique to these two top-ranked journals, we extended similar searches to two other journals. The *Proceedings of the National Academy of Science, USA* (PNAS) is another multidisciplinary journal with a long publication history, albeit with a smaller impact factor (IF 2021—12.779). *Scientific Reports* (IF 2021—4.996) is a multi-disciplinary mega-journal that publishes a large number of papers annually that are deemed technically sound with no particular emphasis on impact. Retracted "basic life sciences" and "health sciences" papers for *PNAS* and *Scientific Reports* return medians of post-retraction citation percentages of 41.9 and 43.3, which are similar in magnitude to those of *Nature* and *Science*. We also ask if retracted papers from the "physical sciences" discipline from these journals have similar post-retraction citations. As the number of retracted papers in this discipline is smaller, papers from all four journals are combined and analyzed, and the median value for these is 37.5% (Figure 1).

While the analyses above are limited to only four journals, the multidisciplinary nature of these journals and the wide range of the journal's impact factors (a widely used proxy for journal ranking) allowed for two additional insights. Firstly, at least for those retracted papers that fall within our inclusion criteria for analysis, post-retraction citation of biomedical papers appears equally rampant across journal ranks. Secondly, such citations are not confined to the biomedical sciences but also found across different disciplines. These findings, thus, attest to the widespread practice of post-retraction citations in the sciences, and further beg the question as to why the practice is persistent and tolerated.

4.2. Qualitative Analysis of Five Papers with High Percentages of Post-Retraction Citation Reveal Different Nature of Citations and Reasons for Citation

We further analyzed the retracted papers in *Nature* and *Science* by zooming in on five papers with a high percentage (>50%) of post-retraction citations (Another retracted paper in *Nature* (Venters BJ, Pugh BF. Genomic organization of human transcription initiation

complexes. *Nature*. 2013, 502(7469):53-8. Retraction in: Venters BJ, Pugh BF. *Nature*. 2014, 513(7518):444) also makes the cut (at 54/3%) but is left out. This is because the case is complicated by the same authors subsequently republishing a refurbished version of the paper with the same title in another journal (Pugh BF, Venters BJ. Genomic Organization of Human Transcription Initiation Complexes. *PLoS One*. 2016, 11(2):e0149339), which also carries its own citations). Obviously, one reason for this high percentage is that all five papers were retracted rather quickly after their publications, three in the same year and two others in the year after. When the number of citations for these five papers are plotted against years, the effect of retraction on the citation counts is apparent for at least three of these papers, as illustrated by the steep drop in citations after the year of retraction (Figure 2). By comparison, such steep drops are not seen for five "normal" (i.e., not-retracted) papers from the same issues of the five retracted papers above.

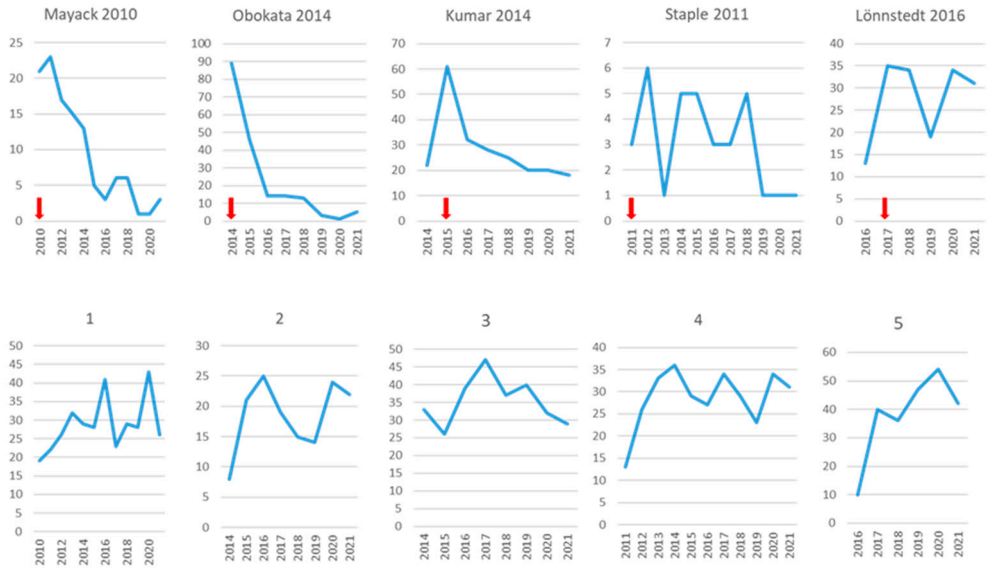

Figure 2. Plots of citation numbers over time for five life/medical sciences papers retracted from *Nature* and *Science* with a high percentage (>50%) of post-retraction citations (upper panel). The red arrows mark the respective years of retraction. Plots for five non-retracted papers from the same journal issues as the above are shown (lower panel) for comparison.

All five papers have been retracted primarily because of irregularities and unreliable data/results stemming from documented research misconduct on the part of at least one of the papers' co-authors, as indicated in the links provided in Table 1. In this regard, the result of a search of the citations with the terms "retraction" or "retracted", which would broadly indicate that retracted status of the papers are reflected in the citing documents, divided the retracted papers into two groups. The first group of three has a low percentage of citations bearing these terms (<5%), while the second group of two retracted papers have markedly higher citations that reflect retraction (30.2% and 38.7%). Likewise, a search of the citations with the terms "fraud" or "misconduct", which would indicate that the cited papers are highlighted in a bad or negative light, returned the same grouping pattern. Bearing in mind that these retracted papers in question are all life/medical science papers, it is interesting to note that the second group also have an overwhelmingly larger number of citations by papers from the humanities and social sciences disciplines, and these numbers are in proportion with those bearing indicators of retraction or misconduct above.

Table 1. Analysis of five life/medical sciences papers retracted from two top multidisciplinary journals *Nature* and *Science* with a high percentage (>50%) of post-retraction citations. Searches for citations for these papers and analysis of the hits with further searches are performed using Scopus (https://www.elsevier.com/solutions/scopus) (accessed on 1 May 2023).

Retracted Papers (Misconduct Associated with Retraction)	Post-Retraction Citation Number/% of Total	Citations with "Retraction" or "Retracted"/% of Total	Citations with "Fraud" or "Misconduct"/% of Total	Citations by Papers in Humanities and Social Sciences	Citations by Research Articles/% of Total
Mayack SR, Shadrach JL, Kim FS, Wagers AJ. **Systemic signals regulate ageing and rejuvenation of blood stem cell niches**. *Nature*. 2010, 463(7280):495–500. Retraction in: *Nature*. 2010, 467(7317):872. Information on associated misconduct: https://www.science.org/content/article/us-misconduct-regulators-sanction-stem-cell-researcher (accessed on 1 May 2023)	93, 81.6%	3, 3.2%	1, 1.1%	1	43, 46.2%
Obokata H, Wakayama T, Sasai Y, Kojima K, Vacanti MP, Niwa H, Yamato M, Vacanti CA. **Stimulus-triggered fate conversion of somatic cells into pluripotency**. *Nature*. 2014, 505(7485):641–647. Retraction in: Obokata H, Wakayama T, Sasai Y, Kojima K, Vacanti MP, Niwa H, Yamato M, Vacanti CA. *Nature*. 2014, 511(7507):112. Information on associated misconduct: https://www.nature.com/articles/nature.2014.14974 (accessed on 1 May 2023)	96, 51.9%	29, 30.2%	28, 29.2%	16	38, 39.6%
Kumar MS, Armenteros-Monterroso E, East P, Chakravorty P, Matthews N, Winslow MM, Downward J. **HMGA2 functions as a competing endogenous RNA to promote lung cancer progression**. *Nature*. 2014, 505(7482):212-7. Retraction in: *Nature*. 2015, 523(7560):370. Information on associated misconduct: https://retractionwatch.com/2015/06/12/nature-retraction-resignation-result-after-lung-cancer-cell-lines-cannot-be-those-specified (accessed on 1 May 2023)	143, 63.3%	3, 2.1%	0, 0%	0	122, 85.3%
Stapel DA, Lindenberg S. **Coping with chaos: how disordered contexts promote stereotyping and discrimination**. *Science*. 2011, 332(6026):251-3. Retraction in: Stapel DA, Lindenberg S. *Science*. 2011, 334(6060):1202. Information on associated misconduct: https://www.apa.org/science/about/psa/2011/12/diederik-stapel (accessed on 1 May 2023)	31, 91.2%	12, 38.7%	15, 48.4%	19	19, 61.3%
Lönnstedt OM, Eklöv P. **Environmentally relevant concentrations of microplastic particles influence larval fish ecology**. *Science*. 2016, 352(6290):1213-6. Retraction in: *Science*. 2017, 356(6340):812 Information on associated misconduct: https://www.uu.se/en/press/press-release/?id=9816&typ=artikel (accessed on 1 May 2023)	118, 71.1%	5, 4.2%	4, 3.4%	6	92, 78.0%

Of note, the group of two papers with a high percentage of citations bearing indication of retraction and misconduct are among those retracted in two high-profile and much publicized cases of research misconduct. The 2011 Stapel paper (we shall refer to these papers by their first authors not merely out of convenience, but also because the first authors of all five papers are the main perpetrators of the associated misconduct) is but 1 of 58 retracted papers co-authored by social psychologist Diederick Stapel, who has extensively fabricated and manipulated research data for a prolonged period [32,33]. The widely known and discussed Stapel case has impacted the field, and has plausibly further fueled the unease felt in social psychology already reflecting upon a prevalence of replication and confidence crisis [34,35]. Stapel himself has in fact contributed to the publicity of his own misconduct with a published memoir, as well as appearances in public media (Staple authored a book in Dutch entitled *Ontsporing* ("*Derailment*", with an English translation by Nicholas Brown now available), an autobiographical account of his scientific career tainted by fraud. He has also given public talks, such as one in a TEDx forum (see https://www.youtube.com/watch?v=nJhvYpMxG_k, accessed on 1 May 2023)).

The 2014 Obokata paper is one of two papers retracted in *Nature* that are first-authored by stem cell researcher Haruko Obokata, which initially elicited much interest and excitement that rapidly spiraled downwards into a dramatic case of misconduct [36,37]. In what might be called the stimulus-triggered acquisition of pluripotency (STAP) cells affair, the purported findings of somatic cells being readily reprogrammed into pluripotent stem-cell-like states in an acidic bath were quickly shown to be irreproducible by others eager to verify the phenomenon, and ultimately failed to be replicated even by the authors themselves [38,39]. Stem cell research is an intensely hope-inciting and competitive field of biomedical research with much socio-economic impact, and Obokata's initial papers elicited feverish interest. With the advent of social media, the STAP cells case is widely discussed in public forums and blogs. A researcher had even live-blogged his lab's attempt to replicate the study. The publicity of the case is due, in part, to the awe and excitement elicited by Obokata's initially perceived breakthrough success as a young female scientist. It is also fuelled by the tragic death by suicide of Yoshiki Sasai, Obokata's supervisor and co-author on the paper, apparently due to stress exerted by the media and the institution stemming from the irreproducible results and allegations of fraud)

In comparison, misconduct associated with the papers in the other group are much lesser known. The particular details of investigations and findings underlying the acts of misconduct associated with the Mayack and Kumar papers were not widely publicized. (Mayack did not agree to the retraction, and although was investigated and found to have committed misconduct by the US Office of Research Integrity, has maintained in a blog post that "*. . . errors, not fabrications, were made in assembling figures for these manuscripts*" (Marcus 2012). Kumar was adjudicated as guilty of research misconduct by two institutional panels and an appeal panel, in manipulation of data presented in extended data of Figure 4 of the paper, but resigned from his position before the ultimate report was written (Palus 2015)). Although the retraction of the Lönnstedt paper has received some publicity, with the official reports of misconduct investigations being publicly available (https://www.uu.se/digitalAssets/640/c_640434-l_1-k_ufv-2016-1074-investigation-report{-}{-}-incl-appendix.pdf, accessed on 1 May 2023), and the fact it should be known to workers in the field [40,41], it is arguably not as high-profile and widespread as those of Staple and Obokata.

The above findings, albeit made with only a small number of papers, suggest that the publicity level of the fraud or misconduct associated with a retracted paper could be significant in influencing the nature and characteristics of its post-retraction citations. A recent study shows that the reporting of retractions on Retraction Watch (https://retractionwatch.com) significantly reduces post-retraction citations of non-swiftly retracted articles [42]. Furthermore, these may attract citations that are clear about its retracted status or portray it in a negative way, as well as attracting citations from papers in other disciplines that might cite or discuss it from the perspective of humanities scholars. It is clear that the

negative post-retraction citations that indicate the retraction status, or those that cite or discuss the fraudulent or erroneous findings in the light of contemporary knowledge or in the context of controversies, or those that draw ethical examples or lessons from the retracted paper, would all have academic values and contribute to the literature with no compromise in accuracy.

What about the papers that cite these retracted papers in a way that is apparently blind to, or ignorant of, the retraction status, as if the findings or conclusions are factually correct? Are these really citing the retracted papers in a fallaciously positive light, thus, potentially promoting fraudulent results or helping these to remain in the literature? One possible reason for citing a retracted paper would be despite critical errors or evidence of misconduct, many if not most of the findings are in fact authentic and the major conclusions of the paper remain valid. Analyses with Scopus show that all five papers are relatively free of principle or co-author-perpetuated self-citations after retraction. We, thus, further assessed the five retracted papers qualitatively on the following points: (1) the reasons for each retraction cited at RWD and the contents of the respective retraction notices, (2) perceived validity of the major findings/conclusions in these retracted papers, and (3) potential interest in the field shown by subsequent works published on the same subject matter. Some of this information is summarized in Table 2 and elaborated on further below.

Table 2. Qualitative assessment of papers retracted from *Nature* and *Science* with a high percentage (>50%) of post-retraction citations in terms of their reasons for retraction and the potential validity of their findings and conclusions, or parts thereof.

Title and Brief Abstracts of Retracted Papers	Reasons for Retraction	Relevant Excepts from Retraction Notice
Mayack et al., **Systemic signals regulate ageing and rejuvenation of blood stem cell niches**. Age-associated changes in stem-cell-supportive niche cells deregulate normal hematopoiesis by causing haematopoietic stem cell dysfunction. These age-dependent defects in niche cells can be reversed by exposure to a young circulation or by neutralization of the conserved longevity regulator, insulin-like growth factor-1, in the marrow microenvironment.	RWD: Error in data, unreliable data, unreliable results. Notes: (1) In the ORI report, errors and manipulations of data were noted for several figures, which rendered at least part of the findings and the major conclusions unreliable. (2) Findings did not seem to have been followed up specifically, with recent papers by others demonstrating the opposite.	"...concerns have undermined the authors' confidence in the support for the scientific conclusions reported, specifically the role of osteopontin-positive niche cells in the rejuvenation of haematopoietic stem cells in aged mice"
Obokata et al., **Stimulus-triggered fate conversion of somatic cells into pluripotency**. In STAP, strong external stimuli such as a transient low-pH stressor reprogrammed mammalian somatic cells, resulting in the generation of pluripotent cells. Committed somatic cells give rise to STAP cells by reprogramming rather than selection.	RWD: Error in images, unreliable images, unreliable results. Notes: (1) Multiple errors and inaccuracies in retracted paper rendered findings and conclusion unreliable. (2) Main findings are irreproducible and main conclusions have been invalidated by carefully conducted replication studies that were subsequently published.	"...multiple errors impair the credibility of the study as a whole and we are unable to say without doubt whether the STAP-SC phenomenon is real"

Table 2. *Cont.*

Title and Brief Abstracts of Retracted Papers	Reasons for Retraction	Relevant Excepts from Retraction Notice
Kumar et al., **HMGA2 functions as a competing endogenous RNA to promote lung cancer progression**. Hmga2 promotes lung cancer progression in mouse and human cells by operating as a competing endogenous RNA (ceRNA) for the let-7 microRNA (miRNA) family. Hmga2 can promote the transformation of lung cancer cells independent of protein-coding function but dependent upon the presence of let-7 sites. Hmga2 promotes lung carcinogenesis both as a protein-coding gene and as a non-coding RNA; such dual-function regulation of gene-expression networks reflects a novel means by which oncogenes promote disease progression.	RWD: Error in data, error in image, manipulation of images, unreliable image. Notes: (1) Issues with a figure in extended data. Investigations indicated that other data may be authentic. (2) The main findings and the major conclusions may still be relatively valid. (3) Findings and main conclusions seem to be accepted as by others.	"...cell lines used in the RNA sequencing (RNA-seq) experiment presented in Extended Data Figure 4 of the Letter cannot be those specified in the figure legend... replication of other experiments in the Letter have not uncovered any further inconsistencies..."
Stapel and Lindenberg. **Coping with chaos: how disordered contexts promote stereotyping and discrimination**. In two field experiments, disordered contexts (such as litter or a broken-up sidewalk and an abandoned bicycle) promoted stereotyping and discrimination in real-world situations and, in three lab experiments, that there is a heightened need for structure that mediates these effects	RWD: Fabrication/falsification of data. Notes: (1) According to Tilburg report of coordinated enquiries by three committees from Tilburg, Groningen, and Amsterdam, the primary data were likely to have been completely fabricated. (2) Main findings and conclusions completely untrustworthy in light of the above.	"On 31 October 2011, Tilburg University held a press conference to announce findings of its investigation into possible data fraud on the part of author Stapel. These findings of the university's interim report included fabrication of data in this *Science* paper"
Lönnstedt and Eklöv. **Environmentally relevant concentrations of microplastic particles influence larval fish ecology**. Exposure to environmentally relevant concentrations of microplastic polystyrene particles (90 µm) inhibits hatching, decreases growth rates, and alters feeding preferences and innate behaviors of European perch (*Perca fluviatilis*) larvae. Furthermore, individuals exposed to microplastics do not respond to olfactory threat cues, which greatly increases predator-induced mortality rates.	RWD: Fabrication/falsification of data. Notes: (1) Unavailability of original data and lack of clarity in the records of experiments—unclear how much data were authentic and how much were fabricated. (2) Main conclusions untrustworthy in light of the above. (3) The effect of microplastics on various aspects of fish larvae ecology remains an intensively researched topic.	"The Review Board's report, dated 21 April 2017, cited the following reasons for their recommendation: (i) lack of ethical approval for the experiments; (ii) absence of original data for the experiments reported in the paper; (iii) widespread lack of clarity concerning how the experiments were conducted.

Of the five papers, the findings/conclusions of the Obokata paper and the Staple paper are perhaps the most thoroughly discredited. RIKEN conducted closely supervised replications of the STAP cells work that involved Obokata herself, with the negative results obtained subsequently peer-reviewed and published [38,39]. To date, no publications have validated the feasibility of the STAP cell protocol for the reprogramming of somatic cells to a pluripotent state. Although there is no longer any conceivable interest in STAP cells per se, the Obokata paper could, nonetheless, still be cited by papers addressing related subjects, such as those investigating the influence of pH on cellular physiology and pathology [43,44]. On the other hand, the primary data associated with the Stapel paper on which interpretations and conclusions are based upon are likely largely, if not completely,

fabricated technically rendering the latter as absolutely untrustworthy. (This could be surmised from the Tilburg interim report of 31 October 2011. Although the link cited in the retraction notice in *Science* is now broken, an archived copy can be found at https://studylib.net/doc/10483458/interim-report-regarding-the-breach-of-scientific{-}{-}tilbur... (accessed on 1 May 2023)). Post-retraction citations of the Stapel paper are, therefore, largely on replicability in psychology and research misconduct.

Investigations into the Lönnstedt paper have shown that primary or original data are unavailable, that there is "widespread lack of clarity concerning how the experiments were conducted" [45], and at least part of the data were fabricated. Although it would probably remain unclear as to the fraction of fabricated as opposed to genuine data, the findings and conclusions of the retracted paper would be highly untrustworthy if not completely invalid. The massive contamination of the natural environment by microplastics and the effect of microplastics on the behavior of marine organisms is, however, a popular topic of intense interest among ecologist and environmental scientists. That these particles when ingested would harm marine invertebrates and juvenile fishes in some manner is also a popular notion with a body of supporting evidence. As such, there are a good number of subsequent reports with findings along similar or related lines that have cited the retracted paper [46–48]. In this regard, the findings and conclusions of the Lönnstedt paper, despite its retraction, have become embedded as part of the literature background of an emerging or established popular notion.

We noted earlier that the Mayack and Kumar papers have very low counts of citations that are retraction-apparent or misconduct-relevant, and might portray their findings and conclusions in a more neutral or relatively positive light. The reasons for Mayack paper's retraction [49] and the ORI report on the details of misconduct [50] suggest that at least part of the findings are erroneous and falsified. An aspect of the overall conclusion, "specifically the role of osteopontin-positive niche cells in the rejuvenation of haematopoietic stem cells in aged mice. . .", would, thus, be unreliable. However, an important aspect of the Mayack paper is that age-dependent defects in stem cells in hematopoietic niches in the bone marrow can be reversed by exposure to blood from younger animals. The senior author of the paper, Amy Wagers, as well as others, have continued to pursue this line of research and have extended their findings to other organs and systems, including the brain. However, although there continues to be work conducted on hematopoietic stem cell aging, a visual scan of the citing papers showed that the findings on hematopoietic stem cell rejuvenations did not seem to have been specifically revisited. On the other hand, two recent papers have, in fact, shown results to the opposite, i.e., that aged hematopoietic stems cells do not rejuvenate well with either exposure to young blood or when transplanted into young bone marrow niches [51,52]. It, thus, appears that Mayack's paper's findings are not reproducible, nor was there much effort spent to try and reproduce these.

Notably, only about 46% of the citing articles of the Mayack paper are research articles, with the larger half being secondary publications such as reviews, editorials, and book/book chapters (Table 1). The post-retraction citations of Mayack's paper that are not retraction-specifying, therefore, do not indicate specific or extended interest in the original findings, and, as such, these could simply reflect a high background "citation noise". In the latter regard, citations made might not be particularly targeted or specific, or with the purpose of elaborating on the contents of the cited paper. Rather, these might simply be part of a string of relevant or semi-relevant papers included to provide referencing support for a statement. Such citation noise would be somewhat expected if the study and its findings remained within a Khunian paradigm [53,54]. A noisy citation background could also be reasonably expected for a popular field such as stem cell research, which boasts a large number of researchers and publications, particularly secondary articles such as reviews and perspectives. In line with this notion, only 40% of the post-retraction citations of the Obokata paper are by research articles, whereas those for the other three non-stem cell papers are markedly less noisy, i.e., cited by original research articles instead of secondary articles (Table 1). The precipitous drop in citations of both the Mayack and Obokata papers

after their respective year of retraction (Figure 2) is in line with their residual and noisy nature. This background citation noise could, nonetheless, contribute significantly to post-retraction citation counts.

In the Kumar paper, the authors found a novel way whereby the oncogene HMGA2 could promote lung cancer progression not simply through the oncoprotein it generates, but because its RNA transcript also acts as a competing endogenous RNA (ceRNA) that targets the tumor-suppressing let-7 microRNA (miRNA) family members, thus, affecting the expression of downstream genes such as the encoding the TGF-β co-receptor TGFBR3. An examination of the retraction notice [55] and a description of the misconduct [56] associated with the Kumar paper suggest that the manipulated or fraudulent portion of the paper pertain largely to Figure 4 of extended data., and that "...replication of other experiments in the Letter have not uncovered any further inconsistencies" [55]. In comparison with others, the retracted Kumar paper, thus, appears to have retained a significantly higher degree of validity in terms of its main findings and conclusions. (That HMGA2 is a ceRNA for let-7s is also archived and searchable in a ceRNA database that has gone online recently: http://bio-bigdata.hrbmu.edu.cn/LncACTdb/Res_CeExp.jsp?searchname=HMGA2&is_quick=1, accessed on 1 May 2023). Of the five papers, the Kumar paper has the lowest percentage of post-retraction citations that indicate retraction or discuss misconduct, is not cited by humanities and social sciences papers, and has the highest percentage of citation by research articles (85.3%, see Table 1). A visual scan of the citing articles indicate that these largely pertained to work on non-coding RNAs in cancer, including HMGA2, let-7, and lung cancer. The retracted Kumar paper has, thus, probably attracted more specific and relevant citations that, albeit not specifically attesting to its validity, have collectively integrated the paper's main findings and conclusion into the literature. Notably, citations of the Kumar paper also dropped steeply after the year of retraction (Figure 2), which suggest that its post-retraction citation number is likely sustained by a noisy citation background.

5. Concluding Remarks

From our analyses presented above, post-retraction citations are apparently prevalent across the board, which is in agreement with previous findings. We further found that retracted papers attract different types of citations, and whether these citations portray the retracted papers in a negative or a more neutral manner are influenced by the degrees of misconduct publicity, the perceived validity of the main findings and conclusions, as well as the degree of background citation noise. Of the five retracted papers examined in further detail, there is no obvious sign that there are post-retraction citations that unduly promote the retracted results, and the senior authors that had continued research in same field have avoided citing the retracted papers in subsequent work. The first authors of the five papers, who are also the ones found to have committed misconduct, have all left science (or at least have not published in science after their respective misconduct convictions). These findings might add to explanations of the prevalence of post-retraction citations beyond sheer ignorance or negligence on the part of the citing authors. The notion of citation noise and its effect on post-retraction citations is only superficially explored here, and could be the basis of a further study.

Although there are calls for action against post-retraction citation [57], it might appear somewhat puzzling as to why post-retraction citations, particularly those without indication of retraction, have remained prevalent and are not already being curbed by the collective action of the scientific establishment, or have strict rules and sanctions erected against them. Mandatory identification of post-retraction citations in manuscripts submitted is readily implementable, as electronic files could be just as routinely scanned against a retraction database as they are for plagiarism. Such screening could also be performed at the proofing stage of accepted manuscripts so that retracted papers cited could be visibly tagged as such. These measures, however, are not yet in practice.

Here, we suggest one plausible explanation of the scientific community's tolerance, or lack of action. Citations that cite and project a retracted paper negatively (in discussing ethical or misconduct issues, for example) or in a more neutral sense (discussing as part of controversies or consensual take on a subject matter), would be academically meaningful. Even citations that are blind to a paper's retraction may provide a temporally relevant backdrop of information upon which current findings could be compared to and contrasted with. As such, post-retraction citations, albeit technically defeating the purpose of retraction, are not completely without academic value. Whether this would explain their persistence and a current lack of strict censorship would need to be further explored.

Funding: This research received no external funding.

Data Availability Statement: Analyses of returns from Scopus searches for Figures 1 and 2 in the form of Excel file sheets can be provided upon request.

Acknowledgments: The author is grateful to the reviewers and editors, whose constructive comments improved the manuscript.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Brainard, J.; You, J. What a massive database of retracted papers reveals about science publishing's 'death penalty'. *Science* **2018**, *25*, 1–5. [CrossRef]
2. The Center for Scientific Integrity. The Retraction Watch Database [Internet]. The Center for Scientific Integrity, March 2023. 2018. Available online: http://retractiondatabase.org/RetractionSearch.aspx? (accessed on 1 May 2023).
3. Singh, H.P.; Mahendra, A.; Yadav, B.; Singh, H.; Arora, N.; Arora, M. A comprehensive analysis of articles retracted between 2004 and 2013 from biomedical literature—A call for reforms. *J. Tradit. Complement. Med.* **2014**, *4*, 136–139. [CrossRef] [PubMed]
4. Yeo-Teh, N.S.; Tang, B.L. Sustained Rise in Retractions in the Life Sciences Literature during the Pandemic Years 2020 and 2021. *Publications* **2022**, *10*, 29. [CrossRef]
5. Baker, M. 1500 scientists lift the lid on reproducibility. *Nature* **2016**, *533*, 452–454. [CrossRef]
6. Fang, F.C.; Steen, R.G.; Casadevall, A. Misconduct accounts for the majority of retracted scientific publications. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 17028–17033. [CrossRef]
7. Wang, T.; Xing, Q.R.; Wang, H.; Chen, W. Retracted Publications in the Biomedical Literature from Open Access Journals. *Sci. Eng. Ethics* **2019**, *25*, 855–868. [CrossRef]
8. Xie, Y.; Wang, K.; Kong, Y. Prevalence of Research Misconduct and Questionable Research Practices: A Systematic Review and Meta-Analysis. *Sci. Eng. Ethics* **2021**, *27*, 41. [CrossRef]
9. Korpela, K.M. How long does it take for the scientific literature to purge itself of fraudulent material?: The Breuning case revisited. *Curr. Med. Res. Opin.* **2010**, *26*, 843–847. [CrossRef]
10. Madlock-Brown, C.R.; Eichmann, D. The (lack of) impact of retraction on citation networks. *Sci. Eng. Ethics* **2015**, *21*, 127–137. [CrossRef]
11. Bar-Ilan, J.; Halevi, G. Temporal characteristics of retracted articles. *Scientometrics* **2018**, *116*, 1771–1783. [CrossRef]
12. Rapani, A.; Lombardi, T.; Berton, F.; Del Lupo, V.; Di Lenarda, R.; Stacchi, C. Retracted publications and their citation in dental literature: A systematic review. *Clin. Exp. Dent. Res.* **2020**, *6*, 383–390. [CrossRef] [PubMed]
13. Hagberg, J.M. The unfortunately long life of some retracted biomedical research publications. *J. Appl. Physiol.* **2020**, *128*, 1381–1391. [CrossRef] [PubMed]
14. Dal-Ré, R.; Ayuso, C. For how long and with what relevance do genetics articles retracted due to research misconduct remain active in the scientific literature. *Account. Res.* **2021**, *28*, 280–296. [CrossRef] [PubMed]
15. Hsiao, T.K.; Schneider, J. Continued use of retracted papers: Temporal trends in citations and (lack of) awareness of retractions shown in citation contexts in biomedicine. *Quant. Sci. Stud.* **2021**, *2*, 1144–1169. [CrossRef] [PubMed]
16. Sharma, K. Team size and retracted citations reveal the patterns of retractions from 1981 to 2020. *Scientometrics* **2021**, *126*, 8363–8374. [CrossRef]
17. De Cassai, A.; Geraldini, F.; De Pinto, S.; Carbonari, I.; Cascella, M.; Boscolo, A.; Sella, N.; Monteleone, F.; Cavaliere, F.; Munari, M.; et al. Inappropriate Citation of Retracted Articles in Anesthesiology and Intensive Care Medicine Publications. *Anesthesiology* **2022**, *137*, 341–350. [CrossRef]
18. Wang, Z.; Shi, Q.; Zhou, Q.; Zhao, S.; Hou, R.; Lu, S.; Gao, X.; Chen, Y.; PRESS Working Group. Retracted systematic reviews were continued to be frequently cited: A citation analysis. *J. Clin. Epidemiol.* **2022**, *149*, 137–145. [CrossRef]
19. Neale, A.V.; Dailey, R.K.; Abrams, J. Analysis of citations to biomedical articles affected by scientific misconduct. *Sci. Eng. Ethics* **2010**, *16*, 251–261. [CrossRef]
20. Bar-Ilan, J.; Halevi, G. Post retraction citations in context: A case study. *Scientometrics* **2017**, *113*, 547–565. [CrossRef]

21. Candal-Pedreira, C.; Ruano-Ravina, A.; Fernández, E.; Ramos, J.; Campos-Varela, I.; Pérez-Ríos, M. Does retraction after misconduct have an impact on citations? A pre–post study. *BMJ Glob. Health* **2020**, *5*, e003719. [CrossRef]
22. Szilagyi, I.S.; Schittek, G.A.; Klivinyi, C.; Simonis, H.; Ulrich, T.; Bornemann-Cimenti, H. Citation of retracted research: A case-controlled, ten-year follow-up scientometric analysis of Scott S. Reuben's malpractice. *Scientometrics* **2022**, *127*, 2611–2620. [CrossRef]
23. van der Vet, P.E.; Nijveen, H. Propagation of errors in citation networks: A study involving the entire citation network of a widely cited paper published in, and later retracted from, the journal Nature. *Res. Integr. Peer Rev.* **2016**, *1*, 3. [CrossRef] [PubMed]
24. Flaherty, D.K. The vaccine-autism connection: A public health crisis caused by unethical medical practices and fraudulent science. *Ann. Pharmacother.* **2011**, *45*, 1302–1304. [CrossRef]
25. Suelzer, E.M.; Deal, J.; Hanus, K.L.; Ruggeri, B.; Sieracki, R.; Witkowski, E. Assessment of Citations of the Retracted Article by Wakefield et al With Fraudulent Claims of an Association Between Vaccination and Autism. *JAMA Netw. Open* **2019**, *2*, e1915552. [CrossRef]
26. Heibi, I.; Peroni, S. A qualitative and quantitative analysis of open citations to retracted articles: The Wakefield 1998 et al.'s case. *Scientometrics* **2021**, *126*, 8433–8470. [CrossRef] [PubMed]
27. Leta, J.; Araujo, K.; Treiber, S. Citing documents of Wakefield's retracted article: The domino effect of authors and journals. *Scientometrics* **2022**, *127*, 7333–7349. [CrossRef]
28. Piller, C. Many scientists citing two scandalous COVID-19 papers ignore their retractions. *Science* **2021**. [CrossRef]
29. Meyerowitz-Katz, G.; Sekhar, P.; Besançon, L.; Turner, T.; McDonald, S. The Citation of Retracted COVID-19 Papers is Common and Rarely Critical. *medRxiv* **2022**. [CrossRef]
30. Teixeira da Silva, J.A.; Bornemann-Cimenti, H. Why do some retracted papers continue to be cited? *Scientometrics* **2017**, *110*, 365–370. [CrossRef]
31. Teixeira da Silva, J.A.; Dobránszki, J. Highly cited retracted papers. *Scientometrics* **2017**, *110*, 1653–1661. [CrossRef]
32. Verfaellie, M.; McGwin, J. The Case of Diederik Stapel. American Psychological Association, September 2022. 2011. Available online: https://www.apa.org/science/about/psa/2011/12/diederik-stapel (accessed on 1 May 2023).
33. Bhattacharjee, Y. The Mind of a Con Man. New York Times. 2013. Available online: https://www.nytimes.com/2013/04/28/magazine/diederik-stapels-audacious-academic-fraud.html (accessed on 1 May 2023).
34. Pashler, H.; Wagenmakers, E. Editors' Introduction to the Special Section on Replicability in Psychological Science: A Crisis of Confidence? *Perspect. Psychol. Sci.* **2012**, *7*, 528–530. [CrossRef] [PubMed]
35. Earp, B.D.; Trafimow, D. Replication, falsification, and the crisis of confidence in social psychology. *Front. Psychol.* **2015**, *6*, 621. [CrossRef] [PubMed]
36. Cyranoski, D. Stem-cell scientist found guilty of misconduct. *Nature* **2014**. [CrossRef]
37. Lancaster, C. The acid test for biological science: STAP cells, trust, and replication. *Sci. Eng. Ethics* **2016**, *22*, 147–167. [CrossRef] [PubMed]
38. Aizawa, S. Results of an attempt to reproduce the STAP phenomenon. *F1000Research* **2016**, *5*, 1056. [CrossRef]
39. Niwa, H. Investigation of the cellular reprogramming phenomenon referred to as stimulus-triggered acquisition of pluripotency (STAP). *Sci. Rep.* **2016**, *6*, 28003. [CrossRef]
40. LeMieux, J. A Long Time Coming: Two Swedish Scientists Are Found Guilty of Scientific Misconduct. American Council of Science and Health, 2018. 2017. Available online: https://www.acsh.org/news/2017/12/08/long-time-coming-two-swedish-scientists-are-found-guilty-scientific-misconduct-12256 (accessed on 1 May 2023).
41. Enserink, M. Swedish plastics study fabricated, panel finds. *Science* **2017**, *358*, 1367. [CrossRef]
42. Xu, H.; Ding, Y.; Zhang, C.; Tan, B.C. Too official to be effective: An empirical examination of unofficial information channel and continued use of retracted articles. *Res. Policy* **2023**, *52*, 104815. [CrossRef]
43. Kim, J.Y.; Cheng, X.; Wölfl, S. Acidic stress induced G1 cell cycle arrest and intrinsic apoptotic pathway in Jurkat T-lymphocytes. *Exp. Cell Res.* **2017**, *350*, 140–146. [CrossRef]
44. Charruyer, A.; Ghadially, R. Influence of pH on Skin Stem Cells and Their Differentiation. *Curr. Probl. Dermatol.* **2018**, *54*, 71–78.
45. Berg, J. Editorial retraction. *Science* **2017**, *356*, 812. [CrossRef] [PubMed]
46. Wen, B.; Zhang, N.; Jin, S.R.; Chen, Z.Z.; Gao, J.Z.; Liu, Y.; Liu, H.P.; Xu, Z. Microplastics have a more profound impact than elevated temperatures on the predatory performance, digestion and energy metabolism of an Amazonian cichlid. *Aqua Toxicol.* **2018**, *195*, 67–76.
47. Wang, J.; Li, Y.; Lu, L.; Zheng, M.; Zhang, X.; Tian, H.; Wang, W.; Ru, S. Polystyrene microplastics cause tissue damages, sex-specific reproductive disruption and transgenerational effects in marine medaka (*Oryzias melastigma*). *Environ. Pollut.* **2019**, *254*, 113024. [CrossRef]
48. Zitouni, N.; Bousserrhine, N.; Missawi, O.; Boughattas, I.; Chèvre, N.; Santos, R.; Belbekhouche, S.; Alphonse, V.; Tisserand, F.; Balmassiere, L.; et al. Uptake, tissue distribution and toxicological effects of environmental microplastics in early juvenile fish Dicentrarchus labrax. *J. Hazard. Mater.* **2021**, *403*, 124055. [PubMed]
49. Mayack, S.R.; Shadrach, J.L.; Kim, F.S.; Wagers, A.J. Retraction Note: Systemic signals regulate ageing and rejuvenation of blood stem cell niches. *Nature* **2010**, *467*, 872. [CrossRef] [PubMed]

50. Marcus, A. ORI Finds Harvard Stem Cell Lab Post-Doc Mayack Manipulated Images. Retraction Watch, September 2022. 2012. Available online: https://retractionwatch.com/2012/08/29/ori-finds-harvard-stem-cell-lab-post-doc-mayack-manipulated-images/ (accessed on 1 May 2023).
51. Kuribayashi, W.; Oshima, M.; Itokawa, N.; Koide, S.; Nakajima-Takagi, Y.; Yamashita, M.; Yamazaki, S.; Rahmutulla, B.; Miura, F.; Ito, T.; et al. Limited rejuvenation of aged hematopoietic stem cells in young bone marrow niche. *J. Exp. Med.* **2020**, *218*, e20192283. [CrossRef] [PubMed]
52. Ho, T.T.; Dellorusso, P.V.; Verovskaya, E.V.; Bakker, S.T.; Flach, J.; Smith, L.K.; Ventura, P.B.; Lansinger, O.M.; Hérault, A.; Zhang, S.Y.; et al. Aged hematopoietic stem cells are refractory to bloodborne systemic rejuvenation interventions. *J. Exp. Med.* **2021**, *218*, e20210223.
53. Kuhn, T. *The Structure of Scientific Revolutions*; University of Chicago Press: Chicago, IL, USA, 2012.
54. Tang, B.L. Nature and causes of questionable research practice and research misconduct from a philosophy of science perspective. *Ethics Behav.* **2023**. [CrossRef]
55. Kumar, M.S.; Armenteros-Monterroso, E.; East, P.; Chakravorty, P.; Matthews, N.; Winslow, M.M.; Downward, J. Retraction Note: HMGA2 functions as a competing endogenous RNA to promote lung cancer progression. *Nature* **2015**, *523*, 370. [CrossRef]
56. Palus, S. Nature Retraction, Resignation Result after Lung Cancer Cell Lines "Cannot Be Those Specified". Retraction Watch, September 2022. 2015. Available online: https://retractionwatch.com/2015/06/12/nature-retraction-resignation-result-after-lung-cancer-cell-lines-cannot-be-those-specified/ (accessed on 1 May 2023).
57. Schneider, J.; Woods, N.D.; Proescholdt, R.; RISRS Team. Reducing the Inadvertent Spread of Retracted Science: Recommendations from the RISRS report. *Res. Integr. Peer Rev.* **2022**, *7*, 6.