Horsepox and Hype: A Science Journalism Experiment

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Abstract:
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This thesis utilized model-based test journalism (Amend, Capurro and Secko 2014) to study how synthetic biology was reported by science journalists within a hype context. It explored whether it was possible to create a new model of science journalism which was resistant to critiques of hype. Synthetic biology is a rapidly emerging field of scientific inquiry that seeks to engineer and redesign biological parts and organisms. Many definitions of 'synthetic biology' are found in scholarly literature. This thesis defines synthetic biology as "the design and construction of new biological parts, devices and systems, and the re-design of existing natural biological systems for useful purposes with a strong focus on engineering" (Bogner et al. 2014). This project limited its scope to textual journalism focused on synthetic biology vaccine research associated with the threat of bioterrorism. Bioterrorism is cited as a serious concern for harmful outcomes of synthetic biology, including the release of dangerous re-engineered pathogens (Schmidt et al. 2009) and is therefore sensitive to the issue of hype. Theoretically, this thesis built on past research into models of science journalism (Secko, Amend and Friday, 2012), expanding this work to address issues of hype in science journalism production. Methodologically, this thesis recruited four professional science journalists to create test stories that varied in their approach to hype, followed by analyzing how this journalism was read and perceived by non-specialist audience focus groups. The results show that the communication of synthetic biology could be improved moving forward by altering the criteria surrounding hype in textual journalism that was developed for this thesis to include issues of scientific language, purposes of research and intended uses of new technologies. The outcomes

of this thesis will prove useful in the design of hype resistant guidelines that will help address the major challenge of misinformation in science journalism.

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CHAPTER 1: Introduction

1.1 The Research Problem

This thesis examines how the deliberate presence or absence of elements of hype in science journalism may influence a reader's opinion and perception of synthetic biology (see Rinaldi 2012 for a discussion of hype in science journalism). Although hype may present itself in many mediums of journalistic coverage, including broadcast television and radio, for the purposes of this research, hype in synthetic biology was examined related to text, which is applicable to both traditional newspaper and digital coverage. Hype is an enduring issue in science journalism (Caulfield 2018) and can be clearly identified in textual reporting which focuses on synthetic biology innovations (see this article and this article as examples). Furthering the understanding of hype in science journalism and its resulting impact on audiences is a significant issue in need of study, as for example, the excessive promotion or deceit of scientific findings, despite being done with or without intent, negates the guiding principles of science communication which include both honesty and transparency (Jamieson, Kahan and Scheufele (eds.) 2017). It is also clear that many science journalists can become trapped in a cycle of hype that is difficult to break (Caulfield and Condit 2012, Caulfield 2018, Marcon et al. 2020, Weingart 2017).

A prime example of print journalism focused on synthetic biology that directly relates to hype involves a story published by STAT News online in October of 2019, which covered growing concerns surrounding a Russian scientist, Denis Rebrikov, who planned to use gene editing technology in embryos (see this link to access this article). While the article explains that Russian authorities have agreed with the World Health Organization that work of this kind using human embryos is alarming and should be postponed until the ramifications of such research are

further understood, the language used throughout suggests that Rebrikov is hoping to move forward with his research despite pushback from global health authorities. The use of this language throughout the article is problematic, as this could potentially ignite fear among non-expert audiences regarding the ability to easily alter human life. This article can be deemed particularly relevant in terms of evaluating hyped coverage as it includes a quote from a bioethicist, Elena Grebenshchikova, regarding journalists' tendency to amplify comments from experts and further stir debate in public discourse. Few studies have explored hype outside of completing a traditional textual/media analysis (e.g., Bubela and Caulfield 2004), and to my knowledge, none of them have explored model-based solutions through the creation of test journalism. This is a novel approach to study both how hype is created, or removed, from textual journalism in addition to examining how these modifications impact audience opinions and perceptions.

In order to better understand why it is imperative to study how hype impacts public opinions and perceptions of synthetic biology, it is first necessary to explain why journalism on synthetic biology may be subject to hyped coverage. Synthetic biology is a rapidly advancing field which has yielded technological innovations in medicine and agriculture in recent decades, among other areas (for a thorough review of synthetic biology, see Kronberger 2012). As synthetic biology applications have emerged, press coverage of this field has increased as well, markedly in languages other than English. German press coverage of synthetic biology has been increasing since 2004 despite some coverage not ever using the term 'synthetic biology' explicitly (Gschmeidler and Seiringer 2012). Technologies such as CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), which permits the ability to more easily edit genomes, have garnered much press attention (please see this link for a recent example of

CRISPR coverage). Another prime example of a synthetic biology advance that has made headlines in recent years involves scientists at the Scripps Research Institute in California who successfully engineered bacterial cells which were able to replicate an artificially made DNA base pair (Cepelewicz 2018). Despite the many helpful applications of synthetic biology that are intended to improve human health, slow environmental destruction and make resources such as food more accessible across the globe, many innovations in this field also have the potential to spur controversy amongst the public (Fernau, Braun and Dabrock 2020, Gómez-Tatay and Hérnandez-Andreu 2019, McLeod and Nerlich 2017). Due to this tremendous potential for differing thoughts regarding the implementation of synthetic biology innovations in public sectors, it is important to examine how print journalism coverage of this topic could impact public discourse.

This ultimately makes synthetic biology an excellent case study for potential model-based resolutions which could either prevent hype in journalistic coverage moving forward or allow for the distinct identification of hype in print journalism more easily.

1.2 Theoretical Approach to the Research Problem (Models of Science Journalism)

To examine hype in the production of science journalism on synthetic biology, a theoretical approach was developed to add elements of hype recognition to four models of science journalism (labelled Model A, Model B, Model C and Model D in the work of Secko, Amend and Friday, 2012). Firstly, it is important to note that these models of science journalism are codified into two main categories according to their objectives for delivering science information journalistically (Secko, Amend and Friday, 2012). The main objective of theoretical models A and B are codified as information delivery, while the main objectives of theoretical models C and D are codified as public engagement (Secko, Amend and Friday, 2012). Given that

these existing four models of science journalism serve as the theoretical framework for this thesis, it is important to briefly review them before explaining how a new model was explored to address hype within a broader context of misinformation.

Model A (Science Literacy) aims to provide the non-expert public with scientific information. This model assumes that the general public have limited knowledge of the scientific topic at hand (Secko, Amend and Friday, 2012). Model A regards scientific information as being passed down from researchers to journalists and then on to audiences in a linear fashion and regards the role of journalists as making the scientific topic being covered accessible and digestible to a general audience (Secko, Amend and Friday, 2012). Model A considers scientific information to be both valid and truthful, as the scientific process inherently does not allow for results to be interpreted in varying ways (Secko, Amend and Friday, 2012).

Model B (Contextual) which is codified under the information delivery objective much like model A, delivers scientific information to the public in a similar manner as model A where information is gathered from researchers and then relayed to non-expert audiences through reportage. Model B differs from model A in that model B aims to demonstrate scientific information as relevant to specific audiences and their specific context (Secko, Amend and Friday, 2012). Some factors that may make scientific information contextually relevant to specific audiences include social dynamics and geographical location (Secko, Amend and Friday, 2012). Model B is also unique from model A in that it recognizes that scientific information may not be absorbed by non-expert audiences universally, and some information may be regarded as more important in some locations or populations as opposed to others (Secko, Amend and Friday, 2012).

Differing from models A and B, model C (Lay Expertise), which is codified in the public engagement category, does not aim to deliver scientific information in a linear manner but rather aims to allow for the participation of non-expert audiences in an attempt to contribute to the research process (Secko, Amend and Friday, 2012). Model C also aims to inspire non-expert audiences to engage with science directly and become active participants in the process of making meaning of science, whereas this is not an aim of models A or B (Secko, Amend and Friday, 2012). Model C differs from models A and B in that this model considers other sources of information outside of science (lay expertise) to be valuable and accurate sources of knowledge, as well while also considering that science is not limitless (Secko, Amend and Friday, 2012). Finally, this model aims to address questions, concerns and opinions from non-expert audiences in just as significant of a manner to addressing the questions, concerns and opinions given by science experts (Secko, Amend and Friday, 2012).

Much like model C, model D (Public Engagement) is also codified under the public engagement category and aims to foster discussion and differences of opinion between those who have personal or professional stake in scientific research (Secko, Amend and Friday, 2012). In a similar way to model C, model D encourages those outside of research to become involved in the scientific process and regards non-expert participation as valuable (Secko, Amend and Friday, 2012). Model D also aims to connect science to society and demonstrate the ways in which these two entities interact with one another (Secko, Amend and Friday, 2012).

These models of science journalism form the basis from which this thesis sought to examine the role of hype in science journalism production. In this context, models should only be considered as representation of the complex processes of science journalism. There may be many such models, and they can overlap, but for this thesis they simply form one example of

how to conceptualize how journalists produce, and audiences respond to, the issue of hype and misinformation.

1.3 Research Questions

This thesis focused on a synthetic biology case study published by researchers at the University of Alberta that sparked concerns regarding bioterrorism. To better understand how the presence or absence of hype could influence reader's opinions and perceptions of this synthetic biology case study, the following research questions guided this thesis:

1. Is it possible to create a new model of science journalism that consistently avoids hype?
2. How does the deliberate absence of hype in textual journalism impact audience opinions and perceptions of synthetic biology?

As described in the subsequent chapters, these questions were explored through the creation of test journalism stories that were then distributed to focus groups. This approach assessed how the presence or absence of hype impacted participant opinions and perceptions of the field of synthetic biology. Overall, a detailed thematic analysis is presented regarding the production of model-based science journalism on synthetic biology that incorporates newly created hype and non-hype guidelines.

CHAPTER 2: Literature Review

2.1 The Communication of Synthetic Biology

Although this thesis employs a case study that easily connects to the topic of bioterrorism as its focus, it is important to understand the context of the peer-reviewed literature which has been published on journalism and synthetic biology to date. While science coverage can cause debate or controversy in public discourse (Bubela et al. 2009), synthetic biology projects are often highly controversial and stretch the limits of what is defined as organic and inorganic, as

well as which organisms have evolved rather than having been designed (Van den Belt, 2009, pg. 259). According to author Henk Van den Belt, when synthetic biology issues appear in the media, they most commonly connect to the consequences surrounding the idea of human beings manipulating nature (2009). While the academic literature that currently exists surrounding this topic addresses a variety of themes, it is apparent that ethics is a dominant motif throughout the literature (Daniel 2012, Häyry 2017, Newson 2015, Schmidt et al. 2009). Despite there being evidence of a disconnect in the synthetic biology community among various actors (Porcar and Peretó 2018), author Andrea Vicini poses that journalism can be of aid in terms of ethics, as journalism often makes stories personal through narration and furthermore has the potential to uphold justice and dignity (2012, pg. 179). Vicini also notes that journalism is one of few fields that has questioned and challenged the field of bioethics (2012, pg. 171).

Of importance to this thesis is the concept of "dual-use technology" as related to the ethics of synthetic biology research. Dual-use technology is not specific to synthetic biology, however, "dual-use tech" can refer to any scientific innovation or advance that can be used for beneficial purposes or alternatively with the intent to harm (Daniel, 2012, pg. 151). As author Yim Guo Rong Daniel notes in a 2012 paper titled "Ethical Theory for "Dual-Use" Dilemmas in Synthetic Biology", examples of the positive applications of synthetic biology include the potential to produce medicine in an increasingly cost-effective way, while harmful or dangerous applications include concerns regarding the use of synthetic biology for bioterrorism, as well as the possibility to reintroduce (on purpose or by accident) diseases that were previously eradicated (pg. 151). Daniel concludes that both the "means" and the "ends" of synthetic biology work need to be examined when making decisions regarding how to proceed with such dual-use tech and further argues that there is a need to build an integrated theory to serve as a framework

to address these ethical issues, as individual theories on their own are not sufficient (2012, pg. 154).

Published in the *Journal of Science Communication*, authors Giordano and Chung explored similar concepts to those posed for this thesis and conducted a study focused on news reporting from the *New York Times* about synthetic biology from 2005 to 2015. Specifically, Giordano and Chung probed how synthetic biology was being reported by the *New York Times* during this period (2018). Although Giordano and Chung's research question is very different from the research questions posed for this thesis (see 1.3), their study, which analyzed 32 articles in total, called for additional research regarding public opinions of synthetic biology in addition to identifying the need to further explore how ambiguity surrounding the field of synthetic biology may enable researchers from having to publicly address ethical concerns (Giordano and Chung 2018). Giordano and Chung argue specifically that the vague definition of synthetic biology may consequently allow synthetic biology experts to feel less accountable in terms of answering to the public on ethical issues (Giordano and Chung 2018). Their work concluded that synthetic biology was covered infrequently, ultimately signaling to readers that synthetic biology was not a topic that required significant attention (Giordano and Chung 2018).

Aside from ethics, other prominent themes referenced in the peer-reviewed literature about the communication of synthetic biology include risk assessment (Newson 2015), framing (Betten, Broerse and Kupper 2018), metaphor use (Gschmeidler and Seiringer 2012, Hellsten and Nerlich, 2011) and participation (Schmidt et al. 2009). With regards to risk assessment, authors Bubela, Hagen and Einsiedel argue that the public seeks a balanced representation of the risks and potential benefits associated with synthetic biology innovations (2012). With respect to the theme of framing, authors Gschmeidler and Seiringer found that religious framing was

common in their study of synthetic biology coverage in German language media between 2004 to 2009, noting that 34% of articles included in their dataset centered on the "creation" (2012, pg. 169). In terms of participation, authors Schmidt, Ganguli-Mitra, Torgersen, Kelle, Deplazes and Biller-Andorno argue that stakeholders who have vested interests in synthetic biology have a responsibility to be involved, as technology advances very quickly in this field and stakeholders can play a key role in preventing misuse (Schmidt et al. 2009). Stakeholders, researchers and the public will, however, engage with synthetic biology from very different standpoints (Kronberger, 2012, pg. 132).

Despite the debate regarding the disconnect between synthetic biology stakeholders, academia and the public, for the purposes of this thesis it is useful to examine the literature focused on metaphors, which is a major theme in the literature that is directly relevant to reportage. While this thesis is limited in that it only explores hype in the context of print journalism that is written in English, metaphors are commonly used in media coverage of science globally and are impactful as they can influence audience perceptions of scientific fields (Braun, Fernau and Dabrock, 2018).

Despite metaphors being commonly used in science reportage in a variety of languages, metaphors are not employed in a universal manner (Braun, Fernau and Dabrock, 2018). Many of the metaphors that are used to describe synthetic biology highlights the control or manipulation of biological systems, much in the same way that computers can be controlled and operated (Hellsten and Nerlich, 2011). While metaphors can be of aid to in making synthetic biology more accessible to non-expert audiences, metaphors can also be problematic as they can downplay the considerations surrounding risk that researchers need to account for when conducting their work and also imply that it is very easy to manipulate or alter existing biological systems (Kueffer and

Larson, 2014). Authors Kueffer and Larson suggest that adjusting the terms that are often used in metaphors, such as employing the word "tinker" instead of "design", recognizes the complexity of organisms and could change public opinion and perception of synthetic biology (2014, pg. 720). Kueffer and Larson further suggest that referring to certain aspects of scientific innovations as "problematic" instead of using terms such as "monstrous" is more appropriate, as using labels such as "monstrous" may be misleading and connote that the technology as a whole is bad (2014, pg. 721).

Other common metaphors compare synthetic biology to the idea of scientists creating monsters such as Frankenstein, ultimately inciting fear that more and more organisms will be designed or engineered rather than derived from existing life (Van den Belt 2009). While it is possible to identify the ways in which using monster-related metaphors can be problematic in journalistic coverage, employing these sorts of metaphors may conversely allow for the public to more tangibly connect to the ethical, social or religious dilemmas that synthetic biology innovations may create (Van den Belt 2009). Studying metaphor use in media coverage also serves in the examination of societal views and opinions, as metaphors can provide insight into views of those that use them (Braun, Fernau and Dabrock, 2018). This makes it clear that there is a complex interconnection between how synthetic biology is communicated and the impact that this communication may have on our understanding of the field.

2.2 Hype in Science Journalism

The above issues all relate to hype in science journalism. Hype has been identified by academics in the context of science news through health and medicine stories as prime examples of sensationalistic coverage (Weingart 2017). While past criticism of hype placed the onus on the media, several other actors have been identified by academics as contributing to the production

of hype as well (Caulfield 2018, Weingart 2017). These actors include public relations offices at universities and in industry as well as researchers (Caulfield 2018,Weingart 2017). Hype is nothing new in science journalism, as there has always been a strong interest in gee-whiz stories that seek to fascinate people (Dunwoody 2014) and the science literacy model itself can be an engine for the promotion of science (Secko, Amend and Friday 2012). This thesis specifically addresses the issue of hype in print news coverage, and while there are a variety of media that consumers may prefer to receive news from, a "cultural legacy" of print media remains dominant, even if consumed digitally, as news organizations continue to compete with one another for readership and audience engagement ("Spin Cycle", 2014, pg. 288). The recent interest in the issue of hype in relation to science news coverage emerged in the mid 1990s, as this is when the connection between science and the media became evidently troublesome (Weingart 2017). This worry about hype became especially clear in inflammatory health and medicine news during this decade, including stories that promoted discoveries as "cures" for disease when not fully warranted (Weingart 2017). These types of hyped health stories received criticism for inducing fear amongst the public without significant reason, as medical stories impact people's choices about health (Weingart 2017). To date, there is a great deal of literature which is focused on this topic. Markedly, Law Professor Timothy Caulfield from the University of Alberta has published extensively on the topic of hype in science coverage with particular attention to the analysis of hype in print media. Despite being possible to define the term "hype" in numerous ways, for the purposes of this project it is helpful to employ Caulfield's definition of hype as follows: "Hype can be described as an inappropriate exaggeration of the significance or potential value of a particular study or area of science" (2018).) Apart from academics, science journalists have also written stories which center on the issue of hype (see this link as an

example). A 2017 editorial published in *Nature* titled "Science journalism can be evidence-based, compelling- and wrong" includes a quote from the American Council of Science and Health, which claimed that science journalism was in worse shape than the entire field of journalism at this time, as it is susceptible to "outrageous sensationalism" in conjunction with other examples of unfairness that can be found in reporting on topics outside of science (see article here).

The exaggeration component of Caulfield's definition is emphasized by other academics publishing in this area as well, as Weingart identifies hype as including inflammatory claims about the potential benefits or effects of a new finding (2017). To expand on this point, Weingart relays how hyped coverage can provide or encourage feelings of hope among audiences when hope is not justified, such as labeling a new scientific discovery as a "cure" when in reality, more research is needed (2017). On the contrary to falsely promoting feelings of hope among media audiences, hyped coverage of science news can also instill fear or panic amongst audiences through reporting that does not accurately delineate between cause and effect (Weingart 2017). It is key to note while hyped coverage may not always be produced intentionally, hype may provide positive outcomes rather than solely negative ones (Caulfield 2018). Coverage that elicits excitement about science has the potential to bring together researchers, spark interest amongst the public as well as draw the attention of institutions which may be able to offer funding (Caulfield 2018).

Notably Caulfield has also published scholarly work regarding suggested ethical recommendations for genome-sequencing research, which is important as the ability to edit genes has been a significant advancement for synthetic biology (Caulfield et al. 2008). As noted by Bubela and Caulfield in their classic, heavily cited study "Do the print media "hype" genetic

research? A Comparison of Newspaper Stories and Peer-Reviewed Research Papers" (2004), it is often argued that the general public receives most of their knowledge surrounding genetics, including innovations in this field and advances in research, from media sources. While the diverse online environment and social media somewhat challenge this idea, it is nevertheless well accepted that the media provide a framework of expectations for the public understanding of science (Nelkin 1995). Although Bubela and Caulfield's study focuses specifically on hype in print media surrounding genetics, the same concept can apply to the public's knowledge of bioterrorism. Bubela and Caulfield found that 11% of newspaper articles in their dataset had highly exaggerated claims and 26% had slightly exaggerated claims, making for a total of 37% of the total newspaper articles examined including some element of hype related to genetics coverage (2004).

While some individuals who work or study in fields related to synthetic biology may have greater knowledge of bioterrorism, it can be assumed that the media still plays a role in how the public receives information about bioterrorism. The ability to produce science journalism which consistently avoids hype is critical to future synthetic biology innovations, as public opinion can have great influence with regards to the creation of policy surrounding this field (Caulfield et al. 2016, Weiss 2017).

2.3 How Hype Is Produced as Related to Science Journalism

As Author Dorothy Nelkin states in her 1995 book *Selling Science: How the Press Covers Science and Technology*, a principal function of science journalism is to inform the general public of science advancements. This duty of science journalism to transmit accurate information is crucial, as authors Scheufele and Krause discuss the precariousness of

understanding the scientific process in their study focused on citizens in the United States (2019). When considering hyped news coverage of scientific topics, it is critical to examine how hype is generated. In particular, Caulfield has published extensively regarding a 'hype pipeline', which outlines that it is impossible to target a single source of hype but rather identifies several actors to blame including press releases from public relations offices, the pressures of academia in addition to journalists (Caulfield and Condit 2012). Caulfield notes that each actor has unique aims for contributing to the production of hype, ultimately meaning that there is no one driving force for the creation of sensationalistic science coverage (Caulfield and Condit 2012).

Caulfield claims that press releases, which are commonly written by communications offices at universities in addition to being published by private companies in industry, are an important source of hype, which are then used by journalists to write their stories, as opposed to hype originating from journalists themselves (Caulfield 2018). Press releases, by design, are meant to attract media attention to universities and promote both researchers and the universities themselves (Caulfield and Condit 2012). Due to the nature of the press release as a sort of promotional tool, Caulfield and Condit claim that it is very commonplace for them to include elements of hype (2012).

While academics have outlined the ways in which press releases can be problematic in the creation of science news (King 2019), an online discussion hosted by *The Guardian* which focused on finding ways to allow academia and the media to work in conjunction to generate more accurate science coverage posed a possible solution. Dr. Etchells, one of the participants in the discussion, suggested that future press releases include a distinct section at the end which states what the research/study can conclude, what the study cannot conclude, and the limitations of the study (E.R. 2015). Another possible solution mentioned in the literature surrounding hype

in science journalism to date is for researchers to create a guide, or Frequently Asked Questions packet, for journalists and other media professionals to use when reporting on their work. This might include detailed conclusions of a study alongside information about research processes (Pyatt 2019). Finally, a third suggestion posed in the literature to date recommends that science writers include hyperlinks or URLs where readers can access studies directly in their articles in an attempt to make the article both more transparent and the study itself more accessible (Pyatt 2019).

Alongside the possible origins of hype from press releases, according to Caulfield (2018) it is necessary to acknowledge the role that researchers play in the creation of hype. Researchers often work in highly competitive academic environments which require the need to apply for funding to conduct their work. When writing grant applications to apply for funding, it is not uncommon for researchers to emphasize the potential social benefits associated with their projects as well as "playing to heightened expectations" in an attempt to be granted government funding (Caulfield 2018, pg. 563). Government funding for research has been identified as a contributing factor that bolsters overall economic growth, ultimately meaning that researchers in academia may feel compelled to show that their projects could become useful in clinical settings in short amounts of time (Caulfield and Condit 2012). In conjunction with motivations to receive government funding for their work, researchers may also feel it necessary for the sake of their careers to publish their work in prestigious academic journals (Caulfield and Condit 2012). These highly regarded academic journals are commonly seeking to publish research that is extremely new and innovative, therefore further adding to the demands placed on researchers and moreover contributing to hype (Caulfield and Condit 2012, Scheufele and Krause 2019). It is possible that issues relating to hype may begin with researchers at very early stages in the

scientific process, as there is concern among some academics surrounding the concept of "medialisation" (E.R. 2015). The "medialisation" of science refers to projects that are proposed and prepared with the goal of gaining media attention (E.R. 2015), and indeed there is a growing thread of research that is tracking scientists increasingly being strategically oriented to the media (Guenther 2019).

Alongside considering how hype can be generated by researchers through grant and funding applications, researchers can also be responsible for contributing to the creation of hyped coverage in their interactions with the media. News coverage of scientific topics may be characterized as "overly optimistic" while inadequately conveying the potential risks of an emerging technology or innovation as the media commonly relies upon a small pool of researchers and politicians as expert authorities for use as sources in their reporting (Caulfield and Condit, 2012, pg. 213). This select group of researchers and politicians often have their own goals in mind when promoting and discussing scientific news (Caulfield and Condit, 2012). While science journalists are responsible for crafting a story, researchers are largely responsible for providing journalists with material to include in their reportage, ultimately making researchers partially culpable for the science news which reaches the public ("Don't Feed the Hype", 2003). While researchers may not always agree with how journalists portray their work, researchers are not entirely powerless as they can control the information that they provide journalists with (Condit, 2007).

While recognizing the ways in which researchers contribute to creating hyped science coverage is critical, it is also imperative to examine the use of sensationalistic or dramatized language in science journalism. Dr. Rob Pyatt, an Assistant Professor at the New Jersey Center for Science, Technology and Mathematics at Kean University, published an opinion style piece

in *Quill* Magazine in which he argues that science writing should avoid or eliminate absolute terms, which include but are not limited to words such as “all”, “always”, “never” and “must” (2019). Pyatt further argues that these terms can be misleading to audiences, as science is very rarely absolute (2019). In the same regard, Pyatt warns against science journalists including the word “cure” in their work as well, as very few absolute cures for diseases exist and finding absolute cures for disease is generally very rare (2019). As such, while there are many careful and excellent reporters, journalists are not excused from being factors in the production of hype. Allan (2011) clearly acknowledges that journalists can hype new scientific findings to secure inclusion of their stories in journalism publications or to increase its relative importance (see Wilcox 2003). Journalists can also unwittingly hype stories due to a lack of background knowledge or the difficulties in recognizing of scientific limitations, let alone job pressures and media constraints (Amend and Secko 2012). Rinaldi (2012) states “journalists must take their fair share of reproach” due to some rushing to publish stories first and prioritizing audience attention. Journalists are, nevertheless, uniquely situated to solve some of these issues, as well as those discussed below (Elliott 2019).

Furthermore, journalists themselves may not be the only employees within a news organization contributing to the creation of hyped science coverage, as editors are commonly tasked with creating headlines for stories. Headlines are commonly subject to hype or sensationalistic language and are often read on mobile devices such as smartphones through social media platforms which disseminate news as part of their content, including but not limited to platforms such as Twitter and Facebook (Caulfield 2018, Molek-Kozakowska 2017). Recognizing the role that headlines play in the creation of hyped science news is imperative, as headlines play a critical role in the overall consumption of science news in addition to how

science news is consumed (Caulfield 2018). While social media is not a major facet of this thesis, it is necessary to address social media's role with regards to the dissemination of science coverage, particularly in terms of headlines, as print reportage focused on scientific topics does not exist in a vacuum. While print science journalism can prove to be quite harmful for the public if inaccurate information is included, social media posts which disseminate the same information can be equally harmful, consequently making it necessary to address and manage both print journalism and social media when aiming to find solutions for relaying more accurate scientific information to the public (E.R. 2015).

In addition to considering exaggeration or inflammatory claims in hyped news coverage of science, it is essential to pay attention to timelines (e.g. the time from a basic discovery to application, which may never successfully occur). Excluding the very slow process of most science from news coverage can be problematic to audiences as they may assume that the benefits of a new discovery, or the ability to implement the new discovery or technology into practice, is fast-approaching while experts may disagree (Bubela et al. 2009). Nevertheless, while misrepresenting the readiness of a new scientific discovery can be detrimental to audiences, the coverage of scientific advances can be positive and exhilarating for scientific experts, the general public and potential stakeholders (Caulfield 2018).

Lastly, when exploring hype in media coverage of science is it helpful to call upon the agenda-setting theory, which details that although the mass media itself cannot dictate what people think directly, it still has the power to shed light on certain issues and avoid coverage of others, ultimately having an influence on which topics are called to public attention and debate (Kamenova and Caulfield 2015). It is key to note that the spread of misinformation is not always malicious, as the transmissions of inaccuracies can be unintentional (Scheufele and Krause

2019). Although the spread of faulty information may happen inadvertently, it is vital to consider the repercussions of publishing inaccurate scientific information, as science information plays a major role in the creation of policy (Weiss, 2017). While factual scientific information is critical with regards to the creation of policy, science information also has profound social impacts, which Weiss (2017) clearly shows as related to the spread of inaccurate information relating to climate change and vaccines (2017). The advent of the internet vastly changed the ability to spread information quickly. Publishing information that is misleading, inaccurate or false entirely has become exceptionally easy, as anyone with internet access can distribute any content regardless of whether or not the information has been verified (Weiss 2017).

Overall, the goal is not to stop reporting on scientific discoveries, but to consider the impact of hype on society (Scheufele and Krause 2019) and the role of science journalism practices in the process (Jensen 2010). Despite there being a variety of sources that actively contribute to the creation of hyped science coverage, it is plausible that different solutions for different contributing entities may be necessary, as opposed to attempting to devise a single overarching solution (Caulfield 2018). To this end, this thesis explores new territory focused on hype resistance in combination with model-based science journalism.

CHAPTER 3: Methods

This thesis implemented three phases to explore the proposed research questions. The below stages were implemented in the following order:

1. **Phase 1**-Theoretical Creation of Hype versus Hype-Resistant Criteria
2. **Phase 2**-Test Story Creation with Professional Science Journalists
3. **Phase 3**-Audience Assessment with Focus Groups

3.1 Phase 1: Theoretical Creation of Hype versus Hype-Resistant Criteria

As described in Chapter 1 (pg.3), the theoretical framework outlined by Secko, Amend and Friday in their scholarly work "Four Models of Science Journalism" (2012) was first expanded upon to include a fifth suggested model which aimed to successfully prevent sensationalism and hype. Models in this context are considered a heuristic tool and research probe to allow the examination of the research questions posed in Chapter 1. The basis for this development is the four models described by Secko et al.:

A. Science Literacy Model

B. Contextual Model

C. Lay Expertise Model

D. Public Participation Model

As described previously, these models can be generally divided into information-oriented approaches (models A and B) and public engagement-oriented approaches (models C and D) (Secko, Amend and Friday 2012). The fifth model created during this phase was labeled as "Model E: Hype". Unlike the existing four models of science journalism, Model E cannot be enforced alone but rather is meant to be used in conjunction with any of the existing models (i.e. as an adjunct to models A through D to help enable hype resistance). Model E is unique as it does not explicitly fall into either the informational (Models A and B) or participation (Models C and D) categories. The aim of Model E is to directly address sensationalism and hype in textual science journalism (see Chapter 2, pg.10) through criteria which enables a journalist to either identify elements of hype in a story or eliminate critiques of hype from their print science news stories.

In order to develop criteria surrounding both elements of hype/sensationalism and hype resistance the academic literature on this topic was reviewed. This was done through strategic

database searches using Concordia University's library. The search terms "hype" and "science journalism" were used along with the Boolean Operator "AND" to generate relevant academic publications. In total, 14 publications were deemed pertinent to the purpose of this thesis (Bubela et al. 2009, Caulfield and Condit 2012, Caulfield 2018, Condit 2007, "Don't Feed the Hype" 2003, E.R. 2015, Gilbert and Ovadia 2011, Kamenova and Caulfield 2015, Molek-Kozakowska 2016, Pyatt 2019, Rachul et al. 2017, "Spin Cycle" 2014, Weingart 2017, Weiss 2017). Any publications examined beyond these 14 studies only consisted of repetitive information. Publications ranged in date from 2003 to 2019. The use of a reading grid (Paterson et al. 2001, pg. 135) as an extraction tool to document important information was employed during the examination of each publication. Aside from their helpfulness in terms of organization, the decision to use reading grids was done to follow similar synthesis methods as those used by Secko, Amend and Friday in "Four Models of Science Journalism" (2012). Publications were examined for identified critiques of hype and sensationalism in science reportage, in addition to commentary on the ways in which hyped science coverage can be problematic. After the extraction phase, a set of hype and hype resistance criteria, which functioned as Model E, were developed (reported in Chapter 4). These criteria were ultimately included in a supplementary materials packet which were distributed to science journalists to aid in story production during phase 2.

3.2 Phase 2: Test Story Creation with Recruited Professional Science Journalists

Upon finalizing the criteria for Model E, four professional science journalists were recruited to create test stories for use with focus groups during phase 3. Recruited science journalists were compensated $500 for their efforts. Journalists were only eligible for compensation after signing a consent form and submitting both of their assigned test stories.

Recruited science journalists were found through the professional network of faculty and staff in the journalism department at Concordia University. Recruited science journalists were initially contacted via email to gauge their interest in participating in this study. Once science journalists indicated interest, they were asked to sign a consent form acknowledging the tasks, story deadlines and risks associated with participation. The science journalists recruited for this thesis are referred to throughout as Journalist 1, Journalist 2, Journalist 3 and Journalist 4. Science journalists were screened during the recruitment phase via examination of their CVs to ensure they were actively practicing journalism (i.e. working for recognized journalism outlets, actively publishing, and over five years of journalism experience). In addition, each of the recruited journalists self-identified as freelance journalists who focus on science, technology and/or medical reporting. Two female and two male science journalists were included. Their experience as practicing science journalists ranged from seven to 22 years and each received university degrees ranging from a bachelor's to PhD.

Journalists were informed of the purpose of the project and their right to withdraw at any time. After providing informed consent to be included, the four science journalists were sent instructions and supplementary materials packets via email to aid in the production of their test stories. These packets included (i) instructions and deadlines for the production of the test journalism stories, (ii) an information page detailing the criteria for an existing theoretical model of science journalism and (iii) a Model E worksheet consisting of the hype criteria produced in Phase 1 (see Appendix II). Each journalist was assigned a different existing model of science journalism, meaning that no two journalists were creating test stories for the same theoretical model. Please see table 1 below for clarification regarding recruited science journalist assignments.

Table 1

Journalist Number:	Theoretical Model Assigned (Secko, Amend and Friday, 2012):	Assignments for Test Journalism Stories:
1	A	One model A story + One [model A + model E] story
2	B	One model B story + One [model B + model E] story
3	C	One model C story + One [model C + model E] story
4	D	One model D story + One [model D + model E] story

The recruited science journalists were asked to write two print news stories based on a case study (please see this link for the published study which served as the case study, Noyce, Lederman and Evans 2018). The case study involves research from 2018 published by scientists at the University of Alberta, who synthesized a horsepox virus using synthetic biology techniques for vaccine study purposes. This specific case study was chosen due to (i) it being a recent Canadian example of synthetic biology research, (ii) it involving a topic of importance to Canadians as related to vaccine research, and (iii) there being previous reporting on the research paper that reference bioterrorism. In fact, past journalism criticized the study's lead researcher, Dr. David Evans, for producing material that could potentially become a bioweapon if it were to escape the lab (see Greenfieldboyce's 2018 article "Did Pox Virus Research Put Potential Profits Ahead of Public Safety?"). Further, in a 2018 NPR article published online by journalist Nell Greenfieldboyce titled "Report for Defense Department Ranks Top Threats from 'Synthetic Biology'", University of Michigan microbiologist Dr. Michael Imperiale references the case

study. Imperiale is quoted in Greenfieldboyce's article with regards to the ability to create viruses in the laboratory through a seemingly easy process. Because the case study was published in 2018 and already received media coverage, recruited science journalists were asked to write follow up stories for the purposes of this study.

Each test story was approximately 500 words in length, however no less than 400 words and no more than 600 words, meaning each journalist was assigned to write approximately 1000 words total. They were given 12 business days (16 days total) to complete the stories. Journalists were asked to use their professional expertise to produce the test journalism (i.e. meaning what level of interviewing, research and/or word-craft needed) as guided by the instructions and supplementary materials packet provided. In addition, recruited science journalists were given the option to choose if they wanted to add elements of hype into their second story **or** create a second story which followed the guidelines for hype resistance (Model E). Recruited science journalists were given the option to either create hype or follow guidelines for hype resistance in order to ensure that their second stories followed criteria developed for model E (see Appendix I). Although recruited science journalists were given this option, they were not allowed to follow both sets of criteria. Each journalist was asked to indicate which option they chose upon submitting their second story. Journalists were instructed to not include any identifying information about themselves (such as their name) in their test stories, ultimately meaning that recruited focus group participants were unable to identify the journalist who wrote the stories (they were therefore blinded). This also means that upon receiving their test stories, focus group participants were unaware if they were reading test stories that followed an existing model alone or if they were reading a version that followed the criteria for hype or hype-resistance.

3.3 Phase 3: Audience Assessment with Focus Groups

Once the test stories were submitted, they were then used as research probes with online focus groups (Amend, Capurro and Secko 2014). Focus groups in this context are considered as a method able to capture real-life data in a social setting, explore concepts from multiple perspectives, and produce collaborative thinking and problem solving (Krueger and Casey 2009). Each group was limited to two to six participants to allow ample opportunity for everyone to share their opinions but still allow the group to hold a diversity of perspectives (Krueger and Casey 2009). Due to the COVID-19 pandemic and the need for social distancing guidelines for public health and safety, all focus groups were held online via the video conferencing platform Zoom.

Focus group participants were recruited through Leger Opinion. In total, six focus groups were held throughout late May 2020, which included 29 participants in total. Demographics for recruited focus group participants were based on the most recent census data for the population of Montreal (Metropolitan Area) from 2016. Focus group participants were at least 20 years of age and stratified based on gender, age and education level to minimize selection bias (Amend, Capurro and Secko, 2014). Leger Opinion was provided with a materials packet for recruiting purposes which included a screener script, a breakdown of demographics in addition to a list of dates/times for the six scheduled focus groups. Leger Opinion recruited 120 participants total, with over-recruiting to 20 individuals for each focus group to ensure participation. Recruited focus group participants were required to be proficient in English, as the group discussion was conducted in English and the test stories were written in English. Finally, focus group participants included those who worked in a range of occupations; however, it was necessary that participants had not studied or previously worked in the field of synthetic biology, journalism,

media and public relations. This restriction in terms of occupation was designed to gain insight regarding how textual journalism could influence opinion and perception of synthetic biology applications from nonexpert audiences.

Once 20 individuals meeting these criteria were recruited for each focus group, introductory emails were sent to each individual. If interested, focus group participants were required to sign a consent form prior to joining an online group discussion. The consent form detailed the tasks required and the risks associated with participating. Participants of a focus group were compensated $50 to offset their time and efforts, as each participant was required to read two test stories in preparation for group discussions. In addition to reading two test stories, focus group participants were required to be available for a full hour of discussion. This meant participants were required to dedicate approximately 90 minutes of their time in total to this study, as it was estimated that reading the two test journalism stories would take 30 minutes. Focus group participants received their assigned test stories via email as PDFs immediately after submitting their signed consent forms. Recruited focus group members also had the option to withdraw from the study at any time. Focus group participants were assigned pseudonyms to protect their identity. For a breakdown of recruited participants who were active members of each focus group, in addition to their assigned test journalism stories, please see Table 2.

Table 2

Focus Group Number/Date:	Total Number of Active Participants:	Active Participant Names (Pseudonyms Only):	Recruited Science Journalist Test Stories Assigned:	Test Journalism Stories Read (Theoretical Models):
Group 1-May 19th 5:30pm to 7pm EST	4	Ashley William Fiona Salvador	Journalist 1	Model A Alone + Model A with Hype
Group 2- May 21st 5:30pm to 7pm EST	6	Yosef Victor Penelope Claire James Joanie	Journalist 2	Model B Alone + Model B with Hype Resistance
Group 3- May 22nd 4:30pm to 6pm EST	6	Gordon Robert Fernando Isabelle Abbie Ian	Journalist 3	Model C Alone + Model C with Hype
Group 4-May 23rd 10:30am to 12pm EST	5	Audrey Brittany Yardley Violet Derek	Journalist 4	Model D Alone + Model D with Hype
Group 5-May 26th 5:30pm to 7pm EST	6	Dylan Edie Graham Mason Teddy Dexter	Journalist 1	Model A Alone + Model A with Hype
Group 6-May 28th 5:30pm to 7pm EST	2	Miles Stanley	Journalist 4	Model D Alone + Model D with Hype

Focus group participants were moderated by the researcher to ensure they stayed on topic while being allowed to flow naturally (Krueger and Casey 2009). Focus group participants consented to having these groups audio and video recorded, however, after data collection was

complete video recordings were destroyed. Audio recordings are stored within in the journalism department at Concordia University in a secure (locked and/or password protected) location. The study was approved by Concordia University's Human Research Ethics Committee (Certificate #30008917). During group discussions, a script was utilized to promote and encourage responses from participants. This script included four main questions:

1. What was your opinion of the field of synthetic biology? (referring to participant opinions prior to being contacted about their interest in joining a focus group discussion)
2. After reading these stories, what was your initial reaction? (referring to the two test journalism stories each participant was sent)
3. What did you think about the language or tone of the two stories you read?
4. Please list any words that come to mind to improve the communication of synthetic biology moving forward, or anything about the topic that you feel is important.

In addition to the four main questions outlined above, additional probe questions included:

- Have you read, seen or heard anything about synthetic biology in the media?
- Was the journalism you saw positive or negative?
- What knowledge did you have of this field?
- Has reading these stories changed your opinions/perceptions of synthetic biology?
- Can you give an example of how your opinions/thoughts have changed?
- Were the two stories different? Perhaps the same?
- Did you find any of the language used in the stories to be dramatized or sensationalistic at all?

- Given COVID-19 and what you read, should synthetic biology be utilized to create vaccines for diseases currently threatening global health?
- Do you feel that synthetic biology is a positive or potentially threatening area for society?
- Would you be interested in reading print news that is focused on synthetic biology innovations again in the future? If so, explain why? If you wouldn't be interested, why not?

While the four main questions were posed with each focus group consistently, it is important to note that additional probe questions were only used amongst focus groups as necessary to foster discussion.

3.4 Data Analysis

Audio recordings were transcribed, and a note-taker was present for each focus group. Transcribed data was analyzed followed the methods of Priest, where data was coded according to distinct identified concepts and frequency (Priest 2010) and to produce a thematic analysis that sought to identify similarities and differences in opinions and perceptions of participants (Priest 2010). In addition, particular interest and attention was paid to examining whether hype-resistant test stories or stories which included elements of hype influenced participant opinions, as well as the impact of Model E on the focus group discussions. Discrepancies were resolved through discussion between the researcher and thesis supervisor.

3.5 Ethical Concerns and Considerations:

Due to the nature of this project, which involved significant contact and cooperation from many people, it is necessary to examine the ethical concerns and considerations associated with this research. This project received approval from Concordia University's Office of Research Ethics under certificate #: 30008917. Both recruited science journalists as well as recruited focus

group participants provided written consent prior to engaging in any discussions or completing any tasks for this study. A template from Concordia University's Ethics webpage served as the template for participant consent forms. A separate consent form was created for recruited science journalists and for recruited focus group participants, which explained their assigned tasks and further detailed the intent of this study. The aim of this study was listed as to better understand how science journalism focused on synthetic biology may have an impact on audience opinions and perceptions surrounding the field of synthetic biology. Participants who expressed interest in the study but who did not provide written consent were ineligible to participate. Participating recruited science journalists and focus group participants faced no additional harm from their involvement in this study aside from the harms and dangers that they may be subjected to in their daily lives. Specifically, recruited science journalists were made aware via consent form that the test journalism produced for this project would be used for the purposes of this study only and not published publicly. Participants, both at the science journalist and focus group participant levels, were informed that they could remove themselves from the study if desired and any information collected would not be included. Participants at both the science journalist and focus group levels were made aware via consent form that their identity would remain confidential, as it is not possible to identify any participants individually throughout this thesis. Focus group participants were assigned pseudonyms for the purposes of this study, ultimately meaning that the given name of focus group participants is not listed anywhere throughout this thesis. Similarly, recruited science journalists are referred to throughout only by assigned journalist number, ranging from one to four. Identifying information of any kind was not pertinent to probe any of the research questions at hand.

CHAPTER 4: Results

4.1 Creation of Hype-Resistant Criteria (Theoretical Development of Model E)

After reviewing the academic literature centered on hype and science journalism, it was possible to begin to develop a theoretical approach to the development of criteria for adding elements of hype into print news stories (to be used for Phase 2, see Chapter 3 and below) or adversely creating textual science news stories that were resistant to critiques of hype. The creation of criteria to hype a science journalism story may seem counterintuitive but the contrast between hyped and non-hyped approaches proved useful to helping journalists engage with this new adjunct to various models of science journalism (cf. Secko, Amend and Friday 2012). The idea was to create a new model E as a research probe that was theoretically informed, but practical in use. Seven themes directly related to print journalism were identified as troublesome in terms of hype in science reportage (see Chapter 3), and were utilized to create the following lists:

A. **Criteria for Hype Resistance:**

1. Avoid downplaying the risks associated with a new technology or scientific finding (i.e. placing an emphasis on the positive aspects of an innovation while failing to fully address any potential negative aspects or concerns).

2. Diversify sources for your story as much as possible, avoid (if possible) limiting your sources to only the researcher(s) and a few other well-known scientists. As best as possible, demonstrate how widely supported a new scientific finding or tech is supported by experts in the field.

3. Evade using press releases (either from private industry or from universities) as the principal source for information for your story, as press releases are commonly designed to attract positive attention.

4. Unless specifically stated in a published study or by an expert, avoid either specifically stating or implying cause and effect. Rather, be as clear as possible in explaining that a correlation between two factors and cause/effect are not synonymous.

5. When including a timeline in your story, be both as accurate and realistic as possible. Avoid statements which are vague, including but not limited to "in the very near future" or "right around the corner", or other such phrases which allude to inevitable progress in the field.

6. Be mindful of the headline which accompanies your story, as headlines initially draw readers in but have been critiqued by academics as being easily inflammatory.

7. Abstain from qualifying scientific findings or innovations through the use of sensationalistic language (i.e. using adjectives to describe new scientific tech/discoveries as "groundbreaking" or "revolutionary").

B. **Criteria for Creating Hype:**

1. Focus largely on the positive or potentially beneficial aspects of a new technology or scientific finding, place lesser emphasis on negative or potentially harmful aspects.

2. Limit the sources for your story to primarily the researcher(s) involved with the study as well as a few other well-known or "celebrity" scientists in the field.

3. Utilize press releases from universities or from companies in private industry as a primary source of information for your story, include limited other information in your story aside from what was included in the press release.

4. If reporting on a published study which links two factors, do not over-explain the difference between a correlation and cause/effect.

5. Include exaggerated or sensationalistic language in your story to describe the scientific findings or innovations, avoid using terms which are neutral.

6. Create a headline for your story that is designed solely to attract the reader and peak interest rather than crafting a headline for accuracy.

7. Qualify scientific findings or innovations through the use of inflammatory terms and adjectives, describe the finding/innovation as a "cure" or dramatic advance in research that does not indicate to readers that future research is still necessary.

Theoretically, the focus of these criteria is to mitigate the production of textual science coverage that is vulnerable to scholarly critiques of hype. The purpose being, for example, relying too heavily upon press releases as sources of information for science news stories is problematic, as press releases often generate hype which is then transferred into the media (Caulfield 2018). This may be solved by using press releases as sources for coverage ideas while

expanding the number and types of entities which contribute information to a science story. The same goes for the importance of crafting headlines, as headlines can determine how many readers interact with a science story, which the literature suggests can be mitigated through minimizing the use of inflammatory language (see Pyatt 2019 and Caulfield 2018). As for the other five criteria, the concept is to focus the attention of journalists on how these items may be sensitive to critiques of hype and further impact audience interpretation of topics such as bioterrorism, for example, portraying timelines inaccurately or omitting them entirely (Bubela et al. 2009) or using metaphors or other language which are ultimately misleading (Condit 2007). The goal is to provide tools to address the journalistic component of the 'hype pipeline' (Caulfield and Condit 2012) as a single universal solution is not feasible given the numerous entities involved in the production of hype (Caulfield 2018). These seven criteria are meant to be easy to follow guidelines and were distributed to the recruited science journalists.

4.2: Test Science Journalism on Synthesized Horsepox Virus:

The four recruited science journalists produced eight stories (Table 3; Appendix II). These stories can be summarized as focusing on researchers from the University of Alberta that synthesized a horsepox virus using synthetic biology techniques for vaccine research, how this type of synthesis could impact treatment/research of other diseases and risks and/or ethical concerns associated with this type of work. They can be read in Appendix II. While recruited science journalists were able to choose whether they wanted to write their second story as a hype resistant story or to create a second story that included elements of hype, only one journalist (Journalist 2) chose to follow the hype resistance criteria. The remaining three recruited science journalists decided to add elements of hype into their second story.

Table 3

Journalist	Story A	Story B
1	1A: "A Controversial Resurrection" (Model A)	1B: "A New Smallpox Vaccine is on his Way" (Model A with Added Elements of Hype)
2	2A: "Synthetic Smallpox Vaccine Shows Early Promise in Mice: Study" (Model B)	2B: "Synthetic Smallpox Vaccine Raises Ethical Concerns" (Model B with Hype Resistance)
3	3A: "Skirting the Scourge: Synthetic Biology Faces its "Atom Bomb" Moment (Model C)	3B: "Company Recruits Another Virus to Vanquish COVID-19" (Model C with Added Elements of Hype)
4	4A: N/A (Model D)	4B: "Living Virus Related to Smallpox Built Using Frankenstein Science" (Model D with Added Elements of Hype)

4.2.1 *Journalist 1 Stories*

The two stories written by Journalist 1 have key differences in their headlines. The story 1A (model A alone, see pg. 4) headline reads "A controversial resurrection: Creation of an extinct poxvirus, which could lead to a safer, more effective smallpox vaccine, creates concern in the scientific community", which immediately alerts readers of the innovation and that it is causing controversy. The story 1B (model A + with added elements of hype; Table 3) headline reads "A new smallpox vaccine is on his way: Using revolutionary techniques, researchers hope to develop a smallpox vaccine that is safer and more effective than existing ones". The two headlines clearly link to criteria 6 of model E (see Chapter 4.1) and how headlines can be used to attract readers and generate interest and/or create a headline with the goal of transparency. For instance, the headline for story 1B makes no mention of any potential controversy or risks (as the story 1A headline does) giving the impression that this new smallpox vaccine resolves safety concerns that surrounded the previous vaccine without any downsides. The headline for story 1B also employs that word "revolutionary", which implies a dramatic change that feeds into the

promotion of synthetic biology research. This 1B story headline is thereby hyped with reference to model E. In contrast, and despite including information about the new smallpox vaccine being safer and more effective than the previous smallpox vaccine, the story 1A headline (model A alone) seeks to alerts audiences to there being various opinions on the topic amongst science experts.

There are also differences with the use of section headers throughout the 1A and 1B stories. The first section header in story 1A (model A alone) reads "A safer vaccine", while the second header reads as "Bioterrorism?". Without reading any of the actual text in story 1A, readers gain information from these section headers about the new smallpox vaccine having both beneficial and dangerous applications merely from reading these headings alone, while the two section headers in story 1B (model A with added elements of hype) only imply favorable outcomes: "High hopes" and "An important achievement".

Upon reading the text of Journalist 1's stories, it possible to detect connections to the theoretical ideas in Model E (see 4.1). For example, early on in story 1A (model A alone; Appendix II), Journalist 1 contextualizes the new smallpox related research by explaining that researchers synthesized a horsepox virus in an attempt to create a more effective vaccine for the eradicated disease than the one currently available. Journalist 1 writes early in story 1A that the smallpox virus was responsible for the death of 300 million people during the 20th century alone, making it clear that this disease caused many fatalities prior to having the ability to treat it and, now, to re-create it via synthetic biology techniques. After providing this information and explaining the ways in which a new smallpox vaccine could benefit society, story 1A states, from a scientific perspective, the advances are not unprecedented. In addition to not being overly significant, story 1A goes on to explain that, while the horsepox virus no longer poses a threat to

human health, the methods used to synthesize it could be potentially applied to replicate diseases that do in fact pose a significant threat to global health. This textual approach connects to the criteria of portraying risk in Model E.

Despite including the same information early on in story 1B (model A with added elements of hype), Journalist 1 contextualizes smallpox early in this alternative story by explaining that medical professionals in Canada have chosen to stop immunizing citizens for smallpox in an effort to avoid severe side effects that appear in some patients including encephalitis, myopericarditis and rashes. Story 1B explains how the methods used in the study can be applied to other vaccines to eradicate other troublesome diseases, focusing on only the positive aspects of the research and thereby linking to criteria 1 and 5 of Model E.

4.2.2 *Journalist 2 Stories*

Journalist 2 was the only recruited science journalist who chose to follow the hype resistance criteria developed for Model E while writing their second story, 2B. This is significant for the second research question (see 1.3), as story 2B was the only test story distributed to focus group audiences during phase 3 which incorporated Model E criteria for hype resistance. The headline for story 2A (model B alone) reads as "Synthetic Smallpox Vaccine Shows Early Promise in Mice: Study", while the headline for story 2B (model B with hype resistance) reads as "Synthetic Smallpox Vaccine Raises Ethical Concerns". The distinction between these two headlines is directly associated with the newly created criteria for creating hype resistant stories (criteria #6), as the hype resistance guidelines cautioned the recruited journalists to be wary in their creation of inflammatory or sensationalistic headlines. While story 2B's headline alerts audiences of the potential risks surrounding the synthetic

smallpox vaccine, story 2A's (model B alone) headline adversely connotes an advance for vaccine studies based on this research.

Aside from the differences between headlines for stories 2A and 2B, it is also critical to note the differences regarding the explanation of risks and ethical concerns between both of these model B stories, as the portrayal of risk is linked to Model E criteria #1 (see Appendix I). Story 2A (see Appendix II) notes that samples of smallpox are housed in designated laboratories throughout the world, however, there is concern amongst some experts that samples of smallpox that are undocumented may be stored elsewhere with the intention of being used for bioterrorism. Story 2A further states that while this is a concern, there is no evidence of such copies of the virus being secretly stashed and that the researchers from the University of Alberta who synthesized the horsepox virus for vaccine research were rigorous in following protocols for safety and security. While story 2A provides details regarding the risks associated with this kind of synthetic biology research, story 2B (model B plus hype resistance) provides an exhaustive explanation regarding safety and ethical concerns. Story 2B includes the same points regarding compliance with Canadian containment protocols and the precautions that the researchers took regarding their interactions with livestock while working on this vaccine study as story 2A does, however, story 2B goes further to include mention of another *Public Understanding of Science* study which focused on the dangers of vaccine research and concerns regarding pandemics. This extensive explanation regarding risk and the potential negative impacts associated with the case study research can be directly linked to Model E criteria #1 for hype resistance, which iterates that journalists should avoid downplaying risks.

4.2.3 *Journalist 3 Stories*

In the same manner as Journalist 1, Journalist 3 chose to craft their second story following the criteria for creating hype. In keeping with the other test journalism stories written by the other recruited science journalists for this thesis, the headlines for each of the stories written by Journalist 3 appear quite differently. Story 3A's (model C alone) headline reads "Skirting the Scourge: Synthetic Biology Faces Its Atom Bomb Moment", while story 3B's (model C with added elements of hype) headline reads "Company Recruits Another Virus to Vanquish COVID-19". Without reading any of the text for story 3B, the headline already features criteria #6 for creating hype in Model E. It is key to note that the coronavirus pandemic was ongoing during both the production of the test journalism stories as well as during the focus group discussions for this thesis. The intentional use of the word "vanquish" in the headline of story 3B alerts audiences that there has been progress made in terms of controlling the spread of the coronavirus, which began wreaking havoc on global health in early 2020. This headline is in stark comparison to the headline of story 3A (model C alone), which connotes ideas of an explosion. The use of this language sends a strong message to audiences even before they have read any text. These examples connect to criteria #6 in Model E regarding headlines.

One focus group participant, Gordon, claimed that he was worried about countries having the ability to utilize biological warfare, which he qualified as disturbing, and furthered his thoughts by mentioning a theory that the coronavirus was potentially made by humans. Although Gordon stated that he did not agree with this theory, this comment in comparison to the title of story 3A should be regarded as significant for this thesis as it very likely that non-expert audiences, such as those included as participants for this project, were exposed to a tremendous amount of science news around the proximity of these focus groups given the timing of the

coronavirus pandemic. Given the likely increase in science news that non-expert audiences were engaging with around the time that the focus groups for this thesis were held, it is not surprising that focus groups participants who read these model C stories were sensitive to the language and overall phrasing of these stories in their remarks, ultimately relating to criteria #7 in model E regarding sensationalistic language.

4.2.4 *Journalist 4 Stories*

Stories produced by Journalist 4, written as model D alone and model D with hype, included evidence of many of the criteria included in Model E. Audrey, who was sent both model D test journalism stories, noted all of the hyperlinks included throughout story 4A (model D alone) during focus group discussions and how, in her opinion, they were confusing. Despite the ease to navigate these links, the inclusion of this information directly relates to criteria #3 in Model E, which addresses the use of press releases as primary sources of information for science stories. Journalist 4's decision to include links allows readers the opportunity to conveniently access the numerous sources of information which contributed to the production of story 4A. While numerous focus group participants who received these model D stories reported feeling confused by the hyperlinks included throughout story 4A (model D alone) the inclusion of these hyperlinks can easily be connected to theme of transparency. Providing access to studies within a news story provides audiences with the choice to interpret the meaning or significance of the study independently rather than reading the interpretation of the journalist.

Another meaningful point that should be raised in the examination of stories produced by Journalist 4 relates to the use of sensationalistic language, criteria #7 in Model E, and connections to metaphors that may ultimately be misleading. Specifically, story 4B (see Appendix II) includes the term "Frankenstein Science" in the headline. Because this term was

used in the headline of story 4B this choice also directly connects to criteria #6 in Model E which addresses inflammatory headlines. The use of "Frankenstein" in the title of story 4B, and the connection to criteria #6 in Model E, is particularly noteworthy as academics have been critical of journalists for perpetuating motifs such as "playing god" or "creating Frankenstein" when covering stories not only about synthetic biologically specifically, but other advances in other areas of life sciences as well (Van Den Belt, 2009). Despite this criticism, these motifs of "playing god" or "creating Frankenstein" may enable non-expert audiences to effectively discuss ethical or moral considerations surrounding the implementation of these new innovations into society, therefore, author Henk Van Den Belt argues that these themes cannot be banned in reportage (2009).

4.3 Audience Focus Groups with Test Journalism on Synthetic Biology

The eight test journalism stories in Table 3 were distributed to various focus groups (see Table 2) in order to explore how the creation of hype or absence of hype had an impact on participant perceptions and opinions of the field of synthetic biology. Not all participants read every story, but those together in a group had read the same stories.

4.3.1 *Prior Opinion of Synthetic Biology*

To open each focus group, the 29 participants were asked about their prior opinion of the field of synthetic biology. Despite a multitude of responses received, most of the groups started with participants reflecting on this question followed by many participants across the groups indicating that they did not know much about the field. As participants began to share the key terms (see Appendix IV) that they felt were mostly closely associated with synthetic biology, it became increasingly easier for them to engage with one another as some of the key terms were common amongst multiple participants in the same group.

It was clear participants wanted to talk about engineering, as four out of 29 participants discussed synthetic biology innovations being made by humankind. The most common individual responses were "I did not have much knowledge of this field", as six out of 29 participants provided this answer. This result is significant to this thesis as those who had worked or studied in the field of synthetic biology were ineligible for participation in focus group discussions. This ultimately indicates that while the remaining 23 participants may not have had extensive knowledge of this field, they were familiar with a variety of synthetic biology concepts.

The next most common response was that the field of synthetic biology is in some way "helpful", with five out of 29 participants responding in this way. Many other terms were also mentioned by participants and are documented in Appendix IV. Overall, the participants expressed perceptions and opinions about innovations in medicine and medical biology, and what they thought about this before the project. Audrey summed this up by sharing a few keywords that she felt directly connected to the field of synthetic biology despite reporting not having much knowledge, including "vaccination, cancer treatment, healthcare, curing, treating and systems different than natural systems". This points to participants making connections between synthetic biology innovations and the ways in which these innovations interact with the human body.

4.3.2 *Positive and Negative Tone in the Test Journalism on Synthetic Biology*

Secondly, participants were asked of their impressions of the test journalism that they received. Despite there being a diverse range of impressions amongst participants, ten out of 29 individuals commented on the stories having either a positive or negative tone. In this context, participants talked about positive tones as relating to test stories that left them with hopeful or

helpful feelings about synthetic biology innovations versus stories that warned of potential threats, which conjured up feelings of being nervous or scared amongst participants.

A focus on tone suggests that participants wanted to discuss synthetic biology as being helpful or harmful to humankind as related to the test journalism. For example, during the first focus group discussion with included model A stories from Journalist 1, Ashley commented that the second story she received (1B, Model A with added elements of hype) had a better view of the case study overall, while the first story she received (1A, Model A alone) was more factual and was not particularly negative in tone but rather more neutral. On the contrary, William was left with many questions about what he referred to as assumptions in story 1A (model A alone). He questioned, after reading story 1A, whether the synthesis of the horsepox virus for vaccine study purposes could be used for bioterror purposes and generally asked whether or not this research could be harmful. He said: "Story 1A had a lot of assumptions, can it be used in bioterrorism? Is it harmful?". William lamented that story 1A did not report what was new about this research from the University of Alberta. Alternatively, William spoke about story 1B (model A with added elements of hype) as having a very direct tone that left him with a positive impression (see correlation as related to section 4.2.1 above). Fellow group member Salvador concurred, saying "Story 1A was more negative" and emphasized that story 1A left him feeling that "this could be taken to bad people to do something dangerous". Salvador reported that story 1B was (model A with added elements of hype) all positive. Finally, Fiona had many questions regarding who may have been paying the journalist and concerns regarding conflicts of interest during this first group. Fiona was skeptical about whether Journalist 1 may have had connections to the researchers who published this study and wondered who may have paid

Journalist 1. Fiona also wondered whether Journalist 1 had a particular interest in reporting on this topic, suggesting she felt that these factors may be conflicts of interest to neutral coverage.

Despite having received stories 2A and 2B by Journalist 2, which included a model B story alone and a model B story with hype resistance criteria, James reported similar thoughts in terms of positive and negative tone during the second focus group discussion. James said one article had a positive overall tone (2A) while the other article (2B) gave him the impression that there was a need to proceed with caution and monitor this type of research. James further commented that it would be scary if this technology were to get into the wrong hands.

Participants in the third focus group reported similar initial reactions to the stories that they received, which included one article written as model C alone (3A) and an article written as model C with added elements of hype (3B). Robert felt that while both stories were similar, they portrayed different views, saying "Similar stories just presenting a different slant on the topic". According to Robert, story 3A one was generally more negative, while story 3B felt more optimistic. Robert said, "The first story focused more on the negative aspects while the second story focused more on the positive/helpful". Fellow participant Abbie reported similar initial impressions to Robert but was concerned she was not knowledgeable enough about the field of synthetic biology. Abbie felt lost at times, however, she also saw a noticeable difference between article 3A being negative and article 3B more positive or helpful. These sets of focus groups show that tone–discussed as either positive or negative in relation to helpful versus harmful outcomes--was important to how participants engaged with bioterrorism as related to synthetic biology and further suggests that the presence/absence of hype affected this more strongly than the model type.

There were, however, differences in the response of groups. For example, differing from the participants in the first three focus groups, Yardley, who was a participant in the fourth focus group, felt that story 4A (model D alone) switched back and forth throughout from a positive tone to a negative tone. Yardley talked about not having a clear idea as to whether the research was good or bad. He said "The slant on the different articles was quite interesting. Story 1 (4A) kept trying to swing between positive and negative the whole time, at the end it didn't leave a clear picture of what is good and bad, waffling between these two….". Yardley indicated that story 4A included quotes from numerous people, as might be expected with a model D story (see 4.2.4), however, Yardley expressed confusion surrounding the inclusion of quotes from so many sources as it was unclear to him what was "good or bad". In the opposite direction, Yardley felt that story 4B (model D with added elements of hype) was generally much more positive in tone with few negative aspects. He said: "The second one (4B) was much more positive, barely any negative aspects to this, talking about what kind of advancements this could bring science…". Yardley commented that given the coronavirus pandemic, much of the news he has consumed recently has been very negative, therefore Yardley felt that story 4B was more uplifting and interesting due to its focus on the positive.

The distinction between positive and negative reporting was apparent in each of the focus group discussions. This common theme points to the importance of the feelings that hype versus non-hype test stories left with participants after reading, ultimately leading them to think about synthetic biology in terms of "good or bad".

This point can be exemplified in the fifth focus group, when Dylan reported being unsure if the tone of stories was set intentionally due to concerns surrounding bioterrorism. Dylan felt

that the first story that she received (1A) was more explicit than the second story (1B) thereby ensuring negative aspects were emphasized. Fellow group members Edie and Teddie agreed.

4.3.3 *The Role of Bioterrorism*

Aside from describing the stories that they received in terms of either a positive or negative tone, eight out of 29 participants raised the theme of bioterrorism or biological warfare explicitly in response to the test journalism stories.

While these eight participants initiated the discussion of bioterrorism, the remaining 21 participants did not comment about this theme extensively. In particular, Joanie, a participant in the second focus group, stated that she felt horrified after reading the two stories (2A and 2B; see section 4.2.2). Joanie questioned why researchers would choose to recreate a virus that was previously eradicated, saying "I was horrified. Why would we reintroduce a disease that no longer exists?". Joanie was clearly worried about the possibility of another pathogen impacting public health, regardless of whether the pathogen was released into society intentionally or accidentally. Fellow group participant Claire agreed with Joanie's feelings and had fears surrounding the accessibility of a synthesized horsepox virus, in addition to the potential to produce a more severe version of the virus than existed previously. James, another participant in this same group, agreed and drew connections between the COVID-19 pandemic and bioterrorism, saying "it's scary if this tech gets into the wrong hands". Many of the participants used words such as "scary", "dangerous", "shocking", "warfare" and "disturbing".

Once a participant raised the topic of bioterrorism the discussion generally followed a pattern of addressing the topics of managing or monitoring which individuals have control over synthetic biology. For example, Dylan relayed that her impression of story 1A was generally more negative than story 1B, which made her continue to think concerns surrounding

bioterrorism after reading. Fellow participant Graham said he had similar thoughts and detailed that because story 1A focused on the creation of bioweapons, he was left with lingering thoughts about bioterrorism after he finished reading, as opposed to how the technology could be used for positive outcomes. Another participant in this fifth group, Mason, built off of Graham's thoughts to discuss how the stories made him think about biological warfare, saying "Bioterrorism is really shocking and scary, especially as countries are starting to use it or look up information or research about it". However, apart from bioterrorism, Mason was also fascinated by the ability for scientists to develop vaccines for diseases that have plagued society for centuries. Others used words such as "interesting" and "science fiction" to speak about this topic. It was clear from these discussions that it was the test stories that sparked these thoughts as related to synthetic biology, as opposed to it being on the participant's minds beforehand. The role of different model types was weak, while the role of hyped stories was discussed in all focus groups. For example, during the last focus group Stanley said: "Story 2 (4B) sounded like a marketing piece", which is significant to this thesis as other participants in this group did not reference either test story that they received explicitly but rather expressed concern about scientific stories portraying innovations as being beneficial prematurely without having sufficient evidence.

The 'intent to harm' was a common aspect of the bioterrorism theme in the results. For example, James openly worried about the virus getting into the hands of dangerous people with the intent to harm others. Gordon expressed fear that particular countries would take advantage of synthesizing viruses or other biological agents. Gordon was left thinking about conspiracy theories, saying "Makes you wonder about conspiracy theories, coronavirus being potentially made by humankind, but I don't think so". This group responded by saying that they agreed with Gordon's thinking, as Ian and Fernando commented about the potential scariness of synthetic

biology. Additionally, Ian noted that reading the test stories reminded him of the television series *Star Trek*. Such discussion points to how the role of hype in the test journalism stories seemed to connect ideas surrounding synthetic biology and popular science fiction for participants.

4.3.4 *The Role of Background Knowledge and Audience Intent*

Another common theme in the focus groups related to participant knowledge of the synthetic biology field and concerns about being able to fully participate in group discussions without having a scientific background. Several participants expressed that they felt that they either needed to do more research after reading the stories that they received in preparation for group discussions or would have been less confused or lost after reading the two stories if they had more background knowledge of the synthetic biology field prior to reading. During the second focus group discussion, Penelope felt that she needed to do more research to fully understand the topic after reading both stories 2A and 2B. Penelope explained that she compared both articles side by side to one another and found that despite being separate articles, they had many similar sentences. Nevertheless, Penelope felt that one article was written more in layman's terms and was likely intended for a general audience (2A), while the second article was perhaps written for an audience outside of the general public (2B). This is exemplified when Penelope said, "My first reaction was like 'oh my goodness I'm going to have to Google this' and do a bit more research, what have I gotten myself into. Then when I went back to the two articles after reading more background I actually put them on a split screen on my computer and you can actually see that there are certain sentences that are very close to being the same, some words have been taken out or added, I'm thinking that was maybe done journalistically in order to have our opinion on that…..The one is more in layman's terms so maybe for anyone that is able to read it while the other one was more…not scientific…but written a bit differently".

These feelings were echoed by Isabelle during the third focus group, as after reading the two stories she received (3A and 3B), she wondered who the intended audiences were for both. Isabelle said: "I wondered based on sort of the language, sort of who the audience were for these two articles. I had some questions about that. I think you need to have at least a sort of basic level of understanding of scientific development and cooperation to be able to understand some of the concepts." It is clear based on Isabelle's remarks that she felt that in order to have a concrete understanding of the content of the two stories, it was necessary to have basic scientific knowledge at minimum. Dexter, who participated in the fifth focus group, responded similarly when commenting on the impressions of the journalism he received, as he felt that story 1A (model A alone) was more technical and raised more questions with regards to ethics. Dexter felt that the second story 1B was written for an ordinary audience consisting of people who are not experts in any sort of biological field. Dexter concluded "…The first article was more technical and raised questions of ethics while the second one was written mostly for ordinary people, not for biology specialists. So, anybody could understand the second one but the first one I think was a bit more difficult to read, more technical."

Synthetic biology is a complex topic but each of the journalists were instructed to write their stories for a general news audience (see Appendix I). Regardless, this common theme shows that participants were quite active in comparing their two stories to each other. They searched for differences between the stories, as well as an explanation for any perceived differences, often commenting that the intended audience for the stories was different (even if ultimately the intended audience was the focus group participants themselves). The role of hype in these responses was important, while the role of the different models contributed minimally to

participant's comments when discussing the intended audience and levels of scientific knowledge.

4.3.5 *The Readability of the Test Stories on Synthetic Biology as Related to Hype*

When probed with the third question during group discussions, which asked participants to comment specifically on the language and tone of the two stories they read, the theme of readability was became prominent. 18 out of 29 participants shared ideas about readability when discussing this question alone. During the first focus group, participants Ashley and Fiona both agreed that changing the wording or phrasing in a story can have an impact on the perspective that is portrayed. During the second focus group, Victor said both stories he read (2A and 2B) conveyed the same message, however, he argued that story 2B (model B with hype resistance) was more effective than story 2A (model B alone). According to Victor, the scientific questions that were posed in story 2B were answered in a much clearer way. He said: "The two articles are trying to convey the same message, however, the second article does it much more smoothly, much more clearly, at least from my point of view. It explains the ethical scientific method or the principle in a much simpler way than the first article". Claire agreed with Victor and felt that story 2B was clearer than story 2A. Claire said "I felt like story 2 was a lot more understandable than the first one. Right away I kind of understood what they were talking about whereas with story one I think I took a bit more time on it, I was kind of just trying to figure out 'ok, what is this about', the second one…I just read through it ". There was diversity in this response, as James and Penelope in the same group felt differently than Victor and Claire when speaking about the language and tone of the two stories, as they thought that story 2A was clearer. They spoke about this being due to their opinions that story 2A included more description and being overall easier to read. Penelope said, "I actually feel the opposite, I actually felt that story

one…was actually clearer when I reread them. The first time that I read them they were both kind of confusing."

The theme of comparing stories against each other appeared frequently in all the groups. For example, Fernando, who participated in the third focus group and read stories 3A and 3B (model C alone and model C with added elements of hype), shared that regardless of the content of the two stories, 3A was written with more accessible language than 3B. This suggests that the readability of the stories was linked to the participant's impressions regarding the ease of understanding the language used throughout as well as the participant's ability to comprehend the stories without feeling lost or confused.

In contrast, the fourth focus group discussed readability of stories 4A and 4B (model D alone and model D with added elements of hype) as linked to structure and organization. Here, Audrey felt story 4B included more language that a nonexpert would be comfortable reading. Audrey said "Well I guess similar to what the others said, I find also there was better structure in the second one, you kind of knew from step to step where we were going. The first one, especially with the links, because I had to click on the links, I found it was hard to understand where we were trying to get at." Yardley agreed with Audrey during this group and said story 4Bwas easier to read, while he had to reread story 4A multiple times in order to fully understand it. This was due to the organization of story 4B for Yardley. In the same group, Violet and Derek also agreed, linking this to story 4A having more technical language. Indeed, story 4B does use phrases such as "recreated a living horsepox virus" and "infecting and killing cancer cells", in contrast to 4A including terms such as "myopericarditis" (see section 4.2.4 and Appendix II). This points to the model D stories having an impact of audience views related to story

organization and the inclusion of technical language with the element of hype seeming to not affect audience opinions of the synthetic biology field.

When asked about whether or not the stories that they received included any sensationalistic or dramatic language, four out of 29 participants said no, while two participants, Isabelle and Audrey, felt strongly that the stories they read were sensationalistic in their writing. There was much discussion about this during the third focus group specifically, where Isabelle mentioned that story 3A made reference to science fiction. The story notes criticism of the synthetic biology techniques used in the vaccine research that served as the case study for this thesis as posing a threat to "provide the foundation for a sophisticated viral arsenal" which could create bioweapons directed towards specific populations. The story read "While such imagery may smack of science fiction…." (see Appendix II). Isabelle felt Journalist 3 made this connection between the horsepox vaccine research and science fiction intentionally and was aware of the drama this may connote for audiences upon including this reference. Audrey raised similar concerns, saying the title of story 4B, "Living Virus Related to Smallpox Built Using Frankenstein Science", was sensationalistic in her opinion compared to story 4A. Both Isabelle and Audrey viewed sensationalism as linked to dramatic or inflammatory terms and phrases, while never explicitly using the term hype, but rather commenting on the story connections to science fiction (story 3A) and monsters (story 4B) as problematic. This suggests that the criteria for creating hype as linked to model D stories emerged for participants as being helpful in terms of comprehension. A key aim of model D stories is to democratize scientific processes (Secko, Amend and Friday 2012). The inclusion of many links and sources in story 4A, as criticized by Yardley and Audrey, indicates that the criteria for creating hype (see Appendix I), which

included limiting sources and relying on press releases as primary sources of information, made story 4B easier for participants to understand overall.

Participant feelings regarding sensationalistic language differed from the opinions shared by Isabelle and Audrey during the first focus group, where participants Ashley and William both indicated that they felt there was not any sensationalistic or dramatic language included in stories 1A and 1B (model A alone and model A with added elements of hype; model A stories are theoretically meant to be factual). In addition, Gordon, who read stories 3A and 3B, also reported that he did not find any language to be dramatized. Thus, even though journalists attempted to specifically hype stories 1B and 3B (see 4.2), some participants did not see any indication of these efforts, indicating that hype is not universally recognized in a journalism story.

The results of the focus groups show that there is a variability to hype and how it was perceived. For example, Fiona challenged the views of others during this first focus group by questioning the transparency of story 1B (model A with added elements of hype). Fiona became skeptical upon noticing a quote included in this story from an individual who was considered a stakeholder in the horsepox vaccine research (see Appendix II, pg. 89). Because this individual could potentially profit from the commercialization of a new smallpox vaccine as a result of this research, Fiona questioned whether or not the inclusion of this quote provided an objective point of view. Fiona's comments regarding concerns about transparency paralleled comments made by Penelope, who hypothesized that due to the coronavirus pandemic, nonexpert or lay audiences would likely be consuming more science news than they were previously. Penelope posed that in the past, some readers may not have been inclined to read a science news story whereas because of the pandemic, those same readers may be more interested in science news than they were before. This is exemplified when Penelope said "Due to what we are living right now (COVID-

19), the regular layman, like us, are going to be reading more articles like this and so perhaps that is part of this focus group. In the past we would not pick up a scientific journal, I would not necessarily pick that up and read that, but due to the current situation more and more, and especially with the fake news going around…I think people are realizing more and more, 'is this the truth, is this not the truth' ". Penelope's comments portray her view that fake news is becoming an increasingly important issue associated with journalism and that more audiences may be cautious about regarding what they read as the truth. Penelope noted a lack of trust amongst news audiences and cited that finding truth in a news story may be up to each individual reader alone. Overall, this suggests that the readability of the test stories on synthetic biology is important in terms of assessing how the hype criteria created for this thesis, in conjunction with the models, impacts audience comprehension.

4.3.6 *Improvements to the Communication of Synthetic Biology*

Finally, when asked about how the communication of synthetic biology could be improved moving forward as the last question during each of the focus groups, a variety of ideas were posed by participants. Most commonly, participants voiced the need to use layman's terms, or terms that were understandable for general audiences. 14 out of 29 focus group participants responded with this answer when asked this final question. Penelope stated that the communication of synthetic biology should be simple and straightforward in order to make synthetic biology information accessible to the general public, ultimately suggesting that the test stories created by the recruited science journalists for this project were not effective in this manner. Penelope also stated that the field of synthetic biology should be introduced to the audience and explained early on in an attempt to eliminate any audience confusion about the topic. Joanie agreed with Penelope's thoughts and furthered her ideas by adding that, in her

opinion, the term "synthetic biology" is very confusing, and perhaps it would be helpful to refer to this field by a different name so that those who do not have a science background can become more easily familiar with it. James, who also participated in the second focus group with Penelope and Joanie, argued that people are easily frightened and that more stories about synthetic biology should be written with a focus on the positive such as the first story that he read, 2A (model B alone). James put it this way: "I feel like we need to take a positive approach like the first article. People scare easily. Simplify language for the average person."

Abbie continued these ideas when sharing her thoughts, saying that it is possible that some people may be using the media as a way to learn more about the field of synthetic biology. Abbie stated that if people who are non-experts are using the media as a way to learn more about this field, with print news being a prime example of written communication, then it is imperative to include language that is digestible for all. This form of science literacy is embedded in model A and B, suggesting these types may suit Abbie well. Fellow focus group member Ian agreed with Abbie's opinions about finding ways to ensure that the communication of synthetic biology was more understandable for a wider audience and further elaborated that it would be helpful to include both the positive and negative aspects about the methods used to conduct synthetic biology work. Violet and Derek shared similar ideas during the fourth focus group, where Violet said that it would be helpful if future print news focused on synthetic biology was more organized than the stories that she received (model D alone and model D with added elements of hype). Violet and David both agreed that the use of technical terms in the stories they read (model D alone and model D with added elements of hype) made them lose interest after they felt that they could no longer follow along. Derek argued that people who are less educated about synthetic biology will need to do more research while reading a synthetic biology story or after

having finished reading in order to understand the topic about which they read. While stories 4A and 4B (see Appendix II), both written as model D stories, include information from a variety of sources, these sources are experts, including biodefense researcher Dr. Gregory Koblentz, the "Dual Use Research of Concern" Committee at the journal *Public Understanding of Science* and Dr. Volker Thiel, who story 4A refers to as an infectious disease researcher. Derek may have been more satisfied or increasingly engaged while reading if story 4A had included more information from non-expert sources.

Participants in the fifth and sixth focus groups all expressed similar ideas, as Edie noted that it would also be helpful for future communication of synthetic biology to address the limits of the research rather than merely focusing on what the new innovation will improve. Edie said, "Making more links to things the audience already knows for the technical terms or more examples, more accessible language and addressing the limits of the research". Graham claimed that it is vital for those who are communicating information about synthetic biology to understand who the audience is, as if the audience are non-experts it will be required to explain any technical terms. Graham's comment suggests that although the intended audience for these test stories was the focus group participants, the language of the test stories he read would have ultimately been more effective, in his opinion, if the scientific terms included were explained more simply for those who are non-experts, as story does 1A references multiple viruses by name (see Appendix II, pg. 87).

Mason and Teddy both agreed with Graham's thoughts about how using technical terms in coverage of synthetic biology news without providing detailed explanations of those terms to general audiences is problematic. Dexter agreed while also adding that the communication of synthetic biology would be improved by contextualizing the story with current events and raising

more awareness around the ethical concerns that could arise with synthetic biology innovations. Based on Dexter's remark, he may have been better suited to read model B stories produced by Journalist 2. Dexter read stories written as model A alone and model A with added elements of hype (1A and 1B) while stories 2A and 2B directly address ethical considerations (see Appendix II, pgs. 89-92). Finally, Stanley contended that mainstream media can be utilized as a powerful tool to educate the general public about the field of synthetic biology and noted the importance of debunking conspiracy theories that are addressed in the media. Stanley also emphasized that researchers in the scientific community should be transparent when working with members of the media who are covering their work regarding what the technology is being used for. Stanley detailed that synthetic biology technology may be used for medicinal purposes, for defense purposes or for modification of existing natural systems and it is paramount for researchers to express the aim of the technology when working with the media so that this information is included in the coverage that is disseminated to the public. Stanley's did not refer to either of the test stories he read (4A and 4B, see section 4.2) when making this comment, therefore Stanley's remark can be considered as a general opinion.

After discussing the importance of using language that is tangible for a wide audience, five out of 29 focus group participants called for the communication of synthetic biology to include information that supports multiple points of view in coverage moving forward. William was the first focus group participant to express this opinion about the inclusion of information that supports multiple viewpoints, followed by Robert in the third focus group who claimed that the communication of synthetic biology moving forward would be improved by including a more balanced range of views. Abbie agreed with Robert and said that the communication of synthetic biology should be as transparent as possible. Dylan echoed this same sentiment and claimed that

both the positive and negative aspects of synthetic biology innovations should be explained in media coverage as opposed to solely focusing on either aspect alone. Dylan said "Give both positive and negative. Give the reason behind the research to help better understand why it was done". Dylan's statement reflects her opinion that it is important for audiences to understand the context surrounding synthetic biology research.

Opposingly, four out of 29 participants asserted that the communication of synthetic biology should only focus on the positive or beneficial aspects of the innovation. Salvador explained that coverage of this topic should explain how the innovation can benefit society and potentially eradicate disease. However, Salvador also added that it is important for coverage to also explain how the synthetic biology innovation being reported on will be monitored. James made similar remarks and reiterated that more coverage of synthetic biology should be written in a similar way to story 2A that he received (model B alone), as, in his opinion, this first story had a more positive approach than story 2B. Yardley and James both stated that the general public is easily frightened, and that producing reportage which incites fear is dubious. Yardley furthered these ideas by stating that it is critical for the communication of synthetic biology to clearly identify the benefits of the research being covered. Specifically, Yardley said "…I'd say in general, in reporting, keeping to the positive aspects of it really, keeping to how does this benefit things, the fact that it is synthetic or not synthetic… in the first one (story) other than trying to stir debate there was no clear evidence about why it should be negative. Why bring up that it is synthetic when it can make things better?". Lastly, Dexter said that emphasizing the positive aspects of a synthetic biology innovation was important in reporting on this topic.

Aside from using accessible language in the communication of synthetic biology and calling for an emphasis on the positive aspects of a technology, four out of 29 participants

specifically discussed that coverage should be clear about what the technology will be used for. For example, Fiona answered this question by saying that the communication of synthetic biology would be improved by including explanations of the regulations surrounding emerging technologies. Fiona also explained that communication should include what the technology can be used for in the future or explain if a similar technology was used utilized in the past. Fiona said "…Explaining the regulations of new technologies, as well as providing examples of when the tech has been used, if it has been used, just to build trust." Fernando made similar comments and stated it would be important to keep synthetic biology innovations in the hands of those who will handle the technology responsibly. Miles and Stanley, who both participated in the sixth focus group, also were in agreeance that synthetic biology can be harnessed to create new vaccines and that using this technology to help humankind is positive. Stanley further explained that it is important for reportage to assess the technology as transparently as is feasible based on information from synthetic biology experts. Stanley said "…Make sure that the science community is transparent in what this is being used for, is it being used to modify things, it is used for defense purposes or for relief to save humanity".

Another theme related to improvement revolved around conflicts of interest between journalists and the companies and/or universities which produced the synthetic biology innovation being covered. Specifically, Fiona highlighted this concern regarding conflicts of interest after making note of a quote used in story 1B (see Appendix II) from an individual who has the potential to financially benefit in industries where the synthetic biology techniques used in the vaccine research from the case study would be applicable. Fiona said "In story 2 (1B) they quote someone from the company, and they say like 'in complete transparency' by this man who has an interest in the company. You know, how can you ensure complete transparency? Both of

them (test stories) are sketchy in their use of words". Three of the 29 participants said that journalists should disclose any professional ties to companies or universities that they may personally have when reporting on synthetic biology. Ashley noted during the first focus group that audiences should be made aware of who was the lead investigator of a scientific study, in addition to being made aware of what companies or organizations may have been involved in funding the work. Ashley argued that both the lead investigator and funders may have personal or financial stakes in the outcomes of a study, potentially leading to conflicts of interest. Fiona also shared these same concerns regarding conflicts of interest during the first focus group. Thirdly, Isabelle expressed these worries but rather focused on journalists who are writing about synthetic biology. Isabelle argued that often times journalists write about topics which they already know much about and some may have had past work experience in the field that they are covering. Isabelle suggested that it is important for journalists to disclose whether certain innovations that they are reporting on were funded by a certain industry and claimed it is also important for journalists to be politically neutral. Isabelle further stated that it is paramount for audiences to understand where the journalist is coming from when reading their coverage of science news and trust audiences to understand complex topics.

CHAPTER 5: Discussion

5.1 A New Model of Science Journalism that Consistently Avoids Hype

To address the first research question that this thesis aims to explore, it is necessary to assess the effectiveness of the newly created criteria distributed to the recruited science journalists for adding or preventing critiques of hype in textual journalism focused on synthetic biology. Each of the four recruited science journalists approached their assigned task in a different manner, ultimately making it possible to compare the choices they made between each

of the stories that they produced following the same existing theoretical model (Secko, Amend and Friday 2012). As noted in chapter 4 (see section 4.2) only one of the recruited science journalists, Journalist 2, chose to follow the hype resistance criteria developed for model E while the other three journalists (Journalist 1, Journalist 3 and Journalist 4) followed model E criteria for creating hype. There is evidence that each of the four recruited journalists incorporated criteria from model E into their test stories (see 4.2). Specifically, Journalist 1's stories included model E criteria #1 regarding portrayal of risk and criteria #5 regarding timelines. Journalist 2's stories incorporate criteria #1 as well in addition to criteria #6 regarding headlines. Journalist 3's stories incorporate criteria #6 of model E as well as criteria #7 regarding sensationalistic language. Finally, Journalist 4's stories incorporate criteria #3 regarding the use of press releases, as well as criteria #6 and criteria #7. Because there is evidence of this inclusion of the created criteria for model E by all four recruited science journalists, it is evident based on the test stories produced for this thesis that it is possible to create a model of science journalism which is consistently resistant to critiques of hype, however, the criteria for model E should be amended moving forward based on focus group participant feedback (see 5.3).

5.2 The Impact of Textual Journalism on Audience Opinions of Synthetic Biology

While an analysis of the test stories produced by the recruited journalists is critical to assessing the efficacy of model E criteria in practice, it is equally necessary to explore the results relating to the second research question posed for this thesis, which probed how the deliberate absence of hype impacts audience opinions and perceptions of the synthetic biology field. It is key to note here that the connection between model-types and audience opinions and perceptions was weak in comparison to the connection between hype and audience opinions and perceptions (see 4.3). Here it is especially relevant to reflect on the responses of focus group participants who

received stories 2A and 2B (see Appendix II), as five out of six participants that received these model B stories indicated that they would be interested in reading more print news stories focused on synthetic biology in the future. This result is critical in relation to research question two (see 1.3) for this thesis as it demonstrates that a deliberate absence of hype did not deter participants from being willing or interested in engaging with news stories about synthetic biology moving forward.

In relation to the second research question posed for this thesis it is also key to reflect on participant comments surrounding the use of the "Frankenstein" reference in story 4B (see Appendix II) produced by Journalist 4. As noted earlier in the literature review for this thesis (see Chapter 2) academics have critiqued the use of language and references which connote imagery of monsters in relation to synthetic biology (Kueffer and Larson 2014). Focus group participants identified the use of "Frankenstein" in the title of 4B as problematic, as exemplified by Audrey's comment that she found the use of this term to be sensationalistic. Brittany, another participant who read stories 4A and 4B, reported being confused by the use of the term "Frankenstein science" in the title of story 4B. It is key to regard Audrey's comment as significant to this thesis as it provides evidence that non-expert audiences are capable of recognizing sensationalistic language/metaphors and identifying them as problematic. On the contrary, it also important to regard Brittany's comment as significant to this thesis as it provides evidence that language and references which connote monster imagery can be misleading to non-expert audiences, as critiqued in the academic literature surrounding the communication of synthetic biology by authors Kueffer and Larson (2014) (see Chapter 2). While Caulfield argues that hype in science journalism is not inherently negative, as hype has the potential to bring communities together in support of scientific research (2018), the inclusion of language which

references monsters, such as the headline of story 4B, should be examined in the broader context of misinformation, as this type of reference can lead non-expert audience members to consider the entire field of synthetic biology as bad (Kueffer and Larson 2014).

5.3 Participant Thoughts on Improving the Communication of Synthetic Biology

As a final question during focus group discussions, participants were probed about how the communication of synthetic biology could be improved moving forward. After close examination of the responses from all 29 participants it was evident that major themes were prevalent across all groups, including comments about the use of technical language and remarks related to transparency. These thoughts relating to transparency encompass participant suggestions to include details about the purpose of the synthetic biology innovation being covered and why the research to produce the innovation was necessary. These themes are discussed below in sections 5.3.1 and 5.3.2.

5.3.1 *Use of Technical and/or Scientific Language:*

After careful analysis of focus group participant opinions and perceptions of the test journalism that they received, and how that journalism may have influenced their thoughts about the field of synthetic biology, it is equally critical to reflect on the suggestions participants made for how the communication of synthetic biology could be improved moving forward. While not entirely surprising, it was noteworthy that 14 out of 29 participants stated that the communication of synthetic biology would be improved by including more layman's terms in synthetic biology news coverage. This point deserves reflection as numerous participants mentioned being hesitant prior to joining group discussions about their knowledge level of the synthetic biology field and were concerned that they lacked the appropriate scientific understanding in order to be able to effectively participate. After reading the textual journalism

that they were sent, numerous participants also reported being confused while reading, ultimately leading them to suggest that the use of less technical terms throughout would have made understanding the topic at hand easier. While this seems to be a very reasonable suggestion for the improvement of synthetic biology communication, it is arguably difficult for science journalists to produce a successful story whilst using very few technical terms for non-expert audiences, as many science journalists feel strongly about the importance of science to society or have had scientific training themselves (Caulfield and Condit, 2012). This enthusiasm and educational background may often contribute to the inclusion of an increased amount of technical or scientific terms in their coverage, as those who are regularly reporting on science news may be commonly more familiar with certain fields of science than the general public, however, based on the comments collected as data for this thesis it is necessary that the use of any technical or scientific terms in a science news story are coupled with a detailed explanation of their meaning. Scholars who have published academic findings surrounding hype in science journalism, notably Dr. Timothy Caulfield, have argued that one single entity, including journalists and the mass media, cannot be blamed for hype in science reportage alone (Caulfield and Condit, 2012), however, it could be possible to improve the communication of synthetic biology moving forward through providing criteria which address language in relation to hype. The newly created hype guidelines for this thesis are intended for use amongst the science journalism community, and perhaps should be altered to include criteria which directly address the use of technical or scientific terms. The guidelines in their current state explicitly acknowledge sensationalistic or exaggerated language in addition to inflammatory terms or the use of qualifications in regard to scientific findings, however, the guidelines do not definitively

address the use of scientific language or terms. The guidelines would perhaps best be adjusted to include the following for creating hype resistance:

"Scientific terms or technical language can be included; however, it is important to accompany these terms with clear definitions or explanations that those who do not have formal education or training in scientific fields can easily understand". The inclusion of this criteria in the newly created hype resistance guidelines would perhaps not only mitigate some confusion amongst non-expert audiences, it may aid in educating the general public about the field of synthetic biology as well. When discussing her thoughts about how the communication of synthetic biology could be improved moving forward, Abbie noted that while readers may not be particularly knowledgeable about the field of synthetic biology prior to reading, that does not automatically mean that non-expert readers are uninterested in learning about this field. They may be doing so through their reading of synthetic biology news stories in the media, therefore, it is necessary to tweak the newly created hype resistant criteria used with recruited science journalists for this thesis as deterring non-expert audiences from reading further through the inclusion of unexplained technical terms may discourage them from learning about the synthetic biology field further. If the hype resistance guidelines are adjusted in this manner, it is possible that a portion of non-expert audiences may feel both encouraged to learn more about synthetic biology in addition to being more likely to read synthetic biology news stories moving forward.

5.3.2 *Transparency:*

Aside from adjusting hype resistance guidelines to include criteria that addresses scientific or technical language, it is critical to examine participant comments surrounding how the communication of synthetic biology could be improved moving forward through adjustments to how journalists approach the idea of transparency in their coverage. Despite five out of 29

participants stating that the communication of synthetic biology would be improved through the inclusion of more information which supports multiple perspectives, their thoughts about how this could be done varied. William was the first participant to comment on this need when discussing how communication about synthetic biology could be improved moving forward, followed by Robert, Abbie, Ian and Dylan. This is perhaps another example of how the newly created criteria for hype resistance could be adjusted in an attempt to create more effective science news coverage. Dylan clearly articulated that in addition to thoroughly explaining the positive and negative aspects of a new scientific innovation, it would also be useful for coverage to explain why the research behind the new innovation was necessary to begin with. This comment was especially significant for this thesis, particularly in regards to the smallpox vaccine research utilized as a case study, as numerous participants commented that they were wondering why researchers at the University of Alberta would spend time, effort and money on vaccine studies for a disease that has not posed a public health threat in many years. Perhaps the criteria for hype resistance could be edited to include the following: "Explain in an exhaustive manner the reason(s) for which the research behind the scientific innovation was conducted. In particular, if a current innovation which addresses the problem at hand already exists, discuss any reasons why the new scientific innovation or finding would be more effective than the current one." This adjustment to the newly created hype resistance criteria would enable non-expert audiences to understand why the scientific research needed to be conducted and perhaps in the case of government funding would also explain to non-expert audiences why spending money on this research leading to the scientific finding or innovation was necessary. It is reasonable to suggest that if non-expert audiences understand the pitfalls of a current innovation or technology, such as the severe side effects associated with the smallpox vaccine used a case

study for this project, they will have a clearer understanding of why the new scientific innovation being reported on is significant to humankind.

This adjustment to the newly created hype resistance criteria also directly connects to findings published by academics focused on hype in science journalism, as authors Caulfield and Condit discuss in their 2012 paper "Science and the Sources of Hype" published in the peer-reviewed journal *Public Health Genomics.* Caulfield and Condit state that government funding for scientific research has been rationalized in large part due to the promise of economic growth, ultimately meaning that academics and researchers feel an intense pressure to prove that the research they are doing will become available and relevant in clinical practice (2012). If the hype resistance guidelines for this thesis are altered to include an explanation as to why it was necessary to conduct the research which led to the scientific innovation being reported on, this may provide insight to taxpayers as to what their money is being used for. While it is paramount to acknowledge that taxpayers have a right to understand how their money is being used by the government to conduct scientific research, it is also critical to explain to non-expert audiences that scientific research is not guaranteed to yield any helpful or positive results every time research is conducted, as trial and error is a necessary part the scientific process. This may provide insight to non-expert audiences who are unfamiliar with the scientific process and successfully manage research expectations. This adjustment to journalistic practice can occur in conjunction with efforts made by scientific researchers, as the International Society for Stem Cell Research published new guidelines in 2016, and iterate that researchers have an obligation to interact with those communicating about science to ensure that portrayals of scientific work are as transparent as possible (Caulfield 2018). Much in the same way that scientific researchers are

required to adhere to guidelines, it would arguably be very helpful to non-expert audiences if science journalists were required to adhere to specific hype guidelines consistently as well.

In addition to being thorough in their explanations of why the scientific research was conducted which led to the scientific innovation being covered, it is also necessary for science journalists to make adjustments to the way that they present the intended purposes for a new innovation based on the comments from participants for this project. To rectify this shortcoming, the newly created guidelines for hype resistance criteria should perhaps be revised to include the following: "Thoroughly explain the intended purposes of the scientific innovation being reported on as described by researchers". This revision to the newly created criteria is critical with regards to synthetic biology coverage as four out of 29 participants indicated that including this type of information would be helpful. An example of how this may be done effectively within the context of this thesis would be highlight whether the synthetic biology innovation at hand may be used for medical, military defense or other societal purposes. This modification also clearly fits underneath the transparency theme identified in this thesis as including this type of information would not leave non-expert audiences speculating as to what synthetic biology technology may be used for. Fernando noted that it would be his hope that synthetic biology technology would be used only for helpful or positive reasons that are of aid to humankind moving forward, and explaining the intended purpose of synthetic biology innovations being covered in the media would perhaps ease concerns from non-expert audiences regarding safety and security. While four out of 29 participants indicated that the communication of synthetic biology would be improved moving forward by only focusing on positive or beneficial aspects of synthetic biology innovations, it is necessary to highlight that an emphasis on only the positive aspects of a scientific finding was included in the newly created criteria (model E) for creating

hype in textual journalism for this thesis. Although it is arguably detrimental to scare non-expert audiences, focusing only the positive aspects of a synthetic biology innovation without noting potential risks, as is included in model E, would ultimately portray an incomplete picture of the innovation being covered.

Stanley also noted that the communication of synthetic biology would be improved moving forward through an emphasis on debunking any conspiracy theories surrounding the technology. This comment is significant to the broader theme of transparency as the media can arguably be of great assistance in terms of halting the spread of conspiracy theories by correcting the false information that conspiracy theories may spread. Through the use of expert sources, such as working closely with researchers while covering a synthetic biology news story, journalists may be able to convince non-expert audiences through their reportage that the information including in the conspiracy theory is not to be trusted. It is paramount that the information surrounding synthetic biology innovations is depicted accurately through journalism as a major mode of communication with the public, and does not ultimately fuel the spread of misinformation, as science stories, particularly those which focus on medicine and health information, are recognized as being influential on the behavior of readers ("Spin Cycle" 2014).

Lastly, underneath the umbrella of transparency as a theme for the improvement of synthetic biology communication moving forward, it is crucial to discuss participant comments who highlighted the need for journalists to disclose any conflicts of interest to their audience. Participants who felt that the communication of synthetic biology would be improved moving forward by highlighting conflicts of interest noted that, in their opinions, it would be beneficial for journalists to not only highlight if they themselves have any connections to companies that were involved in producing the synthetic biology innovation being reported on but also including

information regarding where funding came from for necessary research and/or trials. An addendum could further be added to the newly created hype resistance criteria which outlines the need to include this information in synthetic biology reportage, as omitting this information from coverage may impact or influence how readers feel about both synthetic biology companies and synthetic biology innovations at large.

5.4 Study Strengths and Weaknesses:

In light of the journalistic theme of transparency which emerged as a major theme throughout the analysis phase of this thesis, it is necessary to reflect upon the strengths and weaknesses of this study. It is first possible to identify both the number of recruited science journalists for this thesis, as well as the number of recruited focus group participants, as limited. For the purposes of this study, only four science journalists were recruited to incorporate the hype and hype resistant criteria into the journalism stories that they produced for each of the existing four models of science journalism outlined by authors Secko, Amend and Friday (2012). In order to further probe the efficacy of the created hype criteria, it would be helpful to employ a greater number of recruited science journalists for a future study, perhaps assigning two recruited science journalists to each theoretical model.

Aside from addressing the number of recruited science journalists that participated in this thesis, it is also critical to note the imbalance between the number of journalists who chose to follow model E criteria for creating hype versus the number of journalists who chose to follow model E criteria for hype resistance during the production of their second stories. Only Journalist 2 chose to create a hype resistant second story (2B) while Journalist 1, Journalist 3 and Journalist 4 followed model E criteria for creating hype. This imbalance can be identified as a weakness of this study as focus group participants were only exposed to a hype resistant story

(2B) created by a single science journalist. To further examine how hype resistant news stories about synthetic biology may impact public opinions and perceptions of the field, it would helpful to recruit other science journalists to create additional hype resistant model E stories for a future study.

Another limitation of this study can be identified as a lack of information from the recruited science journalists about the processes that they used while producing their stories. Due to limited time and resources, the four recruited science journalists who participated in this study were not interviewed to understand how they chose to approach their tasks. It would be valuable for a future study to include a phase where recruited science journalists are interviewed to gain insight as to why they made the choices that they did while in the story production phase. This insight would provide further understanding as to how recruited science journalists interact with both the existing theoretical models of science journalism (Secko, Amend and Friday 2012) while producing their stories in addition to working with model E criteria.

It is also necessary to take into account the experience of the recruited science journalists, as experience of the science journalists utilized for this study ranged from seven to 22 years. It is arguable that the number of practicing years that each of the four recruited science journalists had played a significant role in the production of their test journalism stories, in addition to the ways in which they incorporated the hype versus hype resistant criteria into their work. Adjusting the years of journalistic experience amongst the recruited science journalists, including the recruitment of science journalists with fewer or more professional experience, would likely yield different test journalism stories. Altering the years of journalistic experience for the recruited science journalists would also ultimately mean it would be necessary to probe the

impact of the produced test stories amongst focus group audiences to explore if this experience variable made any change in audience opinions and perceptions of the field of synthetic biology.

In addition, it would be helpful for a future study of this nature to include a larger number of recruited focus group participants. Unfortunately, due to the coronavirus pandemic, it was not possible to hold focus group meetings in person on Concordia's Loyola campus as originally planned. It was necessary to alter the proposal for this phase of the study to encompass focus groups which were conducted entirely online, and ultimately may have had an influence on the number of recruited participants who were interested in engaging with this study. Ideally, a future study of this same nature would include a larger number of focus group participants, still keeping within the identified demographics which are representative of the island of Montreal based on the most current census data. This increased number of focus group participants would provide the opportunity to further study how the hype versus hype resistant criteria impacts audience opinions and perceptions of the synthetic biology field.

While the above alterations to future study designs would undoubtedly be beneficial to continue exploring the research questions at hand, it is similarly necessary to highlight the strengths of this study. Based on extensive exploration of the academic literature surrounding the field of science journalism, no other studies have aimed to gain an understanding of how audience opinions and perceptions of a specific scientific field can be influenced through the use of test journalism in conjunction with created hype-focused criteria. This study can be regarded as novel based on these factors, and also aims to provide practicing science journalists with tools that can be employed in an effort to more effectively reflect upon and improve their own work in addition to the work of their colleagues. The creation of such tools for professional science journalists to use in their daily practice will ultimately generate more science reportage for the

public, as well as expert audiences alike, which are resistant to scholarly critique of science news.

5.5 Conclusion:

The thesis first sought to investigate whether it was possible to create a new model of science journalism which was resistant to critiques of hype in print. Secondly, this thesis aimed to investigate how hype resistant textual journalism may impact the opinions and perceptions of nonexpert audiences of the field of synthetic biology. This study was designed to build off of the theoretical framework outlined by authors Secko, Amend and Friday in their 2012 paper titled "Four Models of Science Journalism". The new hype focused model created for this thesis, which is referred to throughout as Model E, is not intended to serve as a model alone but rather consists of two sets of theoretical criteria which can be employed in partnership with any of the four existing models. The methods for this thesis (see Chapter 3) which consisted of the use of test journalism amongst focus group audiences, was crafted following similar methods to authors Amend, Capurro and Secko's 2014 paper titled "Grasping Scientific News: The Use of Science Journalism Models to Clarify the Impacts of Alternative Forms of Production". This thesis required three phases, which included the following: 1. Theoretical Creation of Hype Versus Hype-Resistant Criteria (see 3.1) 2. Test Story Creation with Recruited Professional Science Journalists (see 3.2) and 3. Audience Assessment with Focus Groups (see 3.3). The main results are summarized below:

- Model E was created based off of critiques of hype in science journalism from 14 academic publications (Bubela et al. 2009, Caulfield and Condit 2012, Caulfield 2018, Condit 2007, "Don't Feed the Hype" 2003, E.R. 2015, Gilbert and Ovadia 2011,

Kamenova and Caulfield 2015, Molek-Kozakowska 2016, Pyatt 2019, Rachul et al. 2017, "Spin Cycle" 2014, Weingart 2017, Weiss 2017)

- Model E consists of two sets of criteria- one set of criteria designed to create elements of hype in textual journalism and one set for producing hype-resistant print stories
- Model E was distributed to four recruited professional science journalists, who were instructed to write two test journalism (Amend, Capurro and Secko 2014) stories each, one story following criteria for an existing model (Amend, Capurro and Secko 2012) alone and a second story following the same existing theoretical model plus the criteria developed for Model E (see 3.2)
- Despite differing writing styles, it was possible to identify evidence of criteria developed for Model E in each story produced by the four journalists (see 4.2)
- Data collected from focus group discussions with recruited participants was analyzed following qualitative analysis methods outlined by Priest (2010) (see 3.4)
- Theoretical criteria included in Model E (see Appendix I) should be amended moving forward to include additional criteria which address technical language, journalistic explanations of reasoning behind research and the intended uses of synthetic biology innovations

Overall, this study concluded that while it is possible to expand the existing models of science journalism to include a model focused on hype, the criteria which were generated to encompass Model E should be broadened to address additional issues of hype in science journalism than they currently do. In addition, this thesis deemed that the role of model types (Secko, Amend and Friday 2012) was weak in comparison to the role of hype in assessing audience opinions and perceptions of synthetic biology, which was evident through focus group

discussions based on test stories (Amend, Capurro and Secko 2014). It is necessary to further this research moving forward, as public opinion and perceptions of the synthetic biology field will influence both future research, availability of applications to patients and consumers in addition to the creation of policy regulating the field (Ancillotti et al 2016). While hype in science journalism cannot be attributed to a single entity (Caulfield 2018), Model E aims to function as a tool for practicing professional science journalists to mitigate the production of hyped science coverage in text within a broader context of misinformation.

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Appendices:

Appendix I: Supplementary Packet for Recruited Science Journalists

Horsepox and Hype: A Science Journalism Experiment
Researcher: Taylor Kann

Instructions for Recruited Science Journalists:

1. You are asked to write two (2) news stories centered on the topic provided through this case study. This case study involves researchers at the University of Alberta who synthesized a horsepox virus for vaccine study purposes using synthetic biology techniques.

2. You are asked to write one news story based on this case study following the criteria for your assigned theoretical science journalism model as outlined in the *Four Models of Science Journalism* by authors Secko, Amend and Friday. You will be notified of which theoretical model you are assigned by the researcher (either model A, B, C or D) after signing the necessary participant consent form. This first new story must be submitted to the researcher in PDF format via email to tayks11@gmail.com **no later than 7pm on Friday, April 10th, 2020.**

3. You are asked to write a second news story following the same criteria for the assigned theoretical science journalism model in addition to following the provided criteria regarding hype. Your second news story may either follow the criteria provided for hype-resistance or for adding elements of hype into your story. You may choose which set of criteria you follow. Please let the researcher know which option you chose upon submitting your second story. Your second story must be submitted to the researcher in PDF format via email to tayks11@gmail.com **no later than 7pm on Tuesday, April 14th, 2020.**

4. Participants will be provided with a supplementary packet from the researcher (an aid), which will include a copy of the case study, a guide explaining the assigned theoretical model from Secko, Amend and Friday's paper *Four Models of Science Journalism*, as well as a worksheet regarding the criteria for both hype resistance and adding hype to written news stories. This packet will be sent to you via email.

5. Each news story should be approximately 500 words in length, however no less than 400 words or more than 600 words.

6. Participants are asked to please not identify themselves as the writer for the two news stories they produce. To clarify, the name of the journalist who wrote each story should

not appear anywhere on the PDF version that is submitted to the researcher (any direct identifiers will be removed and replaced with a code on the information provided).

7. These stories are only intended for the purposes of this study. Submission of the stories is deemed as consent to include them in the resulting thesis and any subsequent publications by the researcher. Participants are asked to not publish or post their stories publicly.

Horsepox and Hype: A Science Journalism Experiment
Researcher: Taylor Kann
Hype vs. Hype Resistance Criteria

<u>Criteria for Hype Resistance:</u>

- Avoid downplaying the risks associated with a new technology or scientific finding (i.e. placing an emphasis on the positive aspects of an innovation while failing to fully address any potential negative aspects or concerns).

- Diversify sources for your story as much as possible, avoid (if possible) limiting your sources to only the researcher(s) and a few other well-known scientists. As best as possible, demonstrate how widely supported a new scientific finding or tech is supported by experts in the field.

- Evade using press releases (either from private industry or from universities) as the principal source for information for your story, as press releases are commonly designed to attract positive attention.

- Unless specifically stated in a published study or by an expert, avoid either specifically stating or implying cause and effect. Rather, be as clear as possible in explaining that a correlation between two factors and cause/effect are not synonymous.

- When including a timeline in your story, be both as accurate and realistic as possible. Avoid statements which are vague, including but not limited to "in the very near future" or "right around the corner", or other such phrases which allude to inevitable progress in the field.

- Be mindful of the headline which accompanies your story, as headlines initially draw readers in but have been critiqued by academics as being easily inflammatory.

- Abstain from qualifying scientific findings or innovations through the use of sensationalistic language (i.e. using adjectives to describe new scientific tech/discoveries as "groundbreaking" or "revolutionary").

(these criteria were created based on scholarly critique surrounding hype in science journalism)

Criteria for Creating Hype:

- Focus largely on the positive or potentially beneficial aspects of a new technology or scientific finding, place lesser emphasis on negative or potentially harmful aspects.

- Limit the sources for your story to primarily the researcher(s) involved with the study as well as a few other well-known or "celebrity" scientists in the field.

- Utilize press releases from universities or from companies in private industry as a primary source of information for your story, include limited other information in your story aside from what was included in the press release.

- If reporting on a published study which links two factors, do not over-explain the difference between a correlation and cause/effect.

- Include exaggerated or sensationalistic language in your story to describe the scientific findings or innovations, avoid using terms which are neutral.

- Create a headline for your story that is designed solely to attract the reader and peak interest rather than crafting a headline for accuracy.

- Qualify scientific findings or innovations through the use of inflammatory terms and adjectives, describe the finding/innovation as a "cure" or dramatic advance in research that does not indicate to readers that future research is still necessary.

(these criteria were created based on scholarly critique surrounding hype in science journalism)

Appendix II: Test Journalism Produced by Recruited Science Journalists

Journalist 1
Story 1A: Model A (Alone)

A controversial resurrection
Creation of an extinct poxvirus, which could lead to a safer, more effective smallpox vaccine, causes concerns in the scientific community.

Researchers literally brought a poxvirus back from the dead. In doing so, they hope to develop a more effective vaccine against smallpox, a disease that killed an estimated 300 million people in the 20th century alone before it was eradicated in 1979. The study, partly funded by New York City-based Tonix Pharmaceuticals, who has a keen interest in developing a potential vaccine to prevent smallpox infection, was published in PLOS ONE in 2018.

University of Alberta's virologist David Evans, his research associate Ryan Noyce and Seth Lederman, president of the pharmaceutical company, generated an infectious horsepox virus using chemical synthetic DNA and reverse genetics. They then demonstrated that the new poxvirus protected mice from a lethal virus challenge.

A Safer Vaccine

The team constructed the horsepox virus from 10 large fragments of synthetic DNA that were based on the poxvirus genome along with two short vaccinia virus terminal sequences. This molecular clone virus was then introduced in cells infected with Shope fibroma virus, a helper virus. This is the first time a poxvirus was generated using these techniques.

"This application of synthetic DNA technology has the potential to revolutionize how we manufacture complex biologicals including recombinant viruses. These methods advance the capacity to produce next-generation vaccines," state Evans, a professor of microbiology attached to the University of Alberta Faculty of medicine and dentistry, via a press release.

Horsepox is an extinct poxvirus that is related to the variola virus. It is not known to harm humans—researchers believe it no longer exists in nature. More importantly, they think that horsepox virus may provide a safer vaccine alternative to the one isolated by Edward Jenner, 200 years ago. While effective, this "old" smallpox vaccine would sometime trigger adverse reactions such as encephalitis and rashes.

The scientists hypothesize that Jenner's vaccine is in fact derived from a horse-pox virus, explaining why their vaccine alternative could be safer in humans. As of today, modern smallpox vaccines are only administered to protect first responders and military members on rare occasions, because of their toxicity. Canada has long discontinued immunizing whole populations for this reason.

Bioterrorism ?

From a scientific point of view, Evan's and his co-investigator's finding isn't seen as a big breakthrough. Researchers in the virology field had long assumed that it would one day be possible to synthesize poxviruses—the feat had already been accomplished in 2002 with poliovirus. It is nevertheless "an important milestone, a proof of concept of what can be done with viral synthesis," says bioethicists Nicholas Evans of the University of Massachusetts in Lowell to *Science*.

The study, however, alarmed the scientific community because its method could be used to construct other, more dangerous poxviruses. It raised doubts about how malicious organizations or rogue states could use modern biotechnology to cause deliberate harm, a menace known as bioterrorism. "If anyone wants to recreate another poxvirus, they now have the instructions to do that in one place", says Andreas Nitsche of the Robert Koch Institute in Berlin also to *Science*.

The controversy prompted PLOS ONE's ethical committee to defend its decision to publish, saying that "on this occasion, the benefits of publication outweigh the risks." It added that "the study did not provide new information specifically enabling the creation of a smallpox virus, but uses known methods, reagents and knowledge that have previously been used in the synthesis of other viruses."
-30-
585 words

Story 1B: Model A + Hype
A new smallpox vaccine is on his way

Using revolutionary techniques, researchers hope to develop a smallpox vaccine that is safer and more effective than existing ones.

Smallpox is a disease that killed an estimated 300 million people in the 20th century alone. The scourge was eradicated in 1979, thanks to a vaccine isolated some 200 years ago by famed English physician Edward Jenner. While effective, the original smallpox vaccine would nevertheless trigger adverse reactions such as encephalitis, myopericarditis and rashes in some people. This is why Canada has long discontinued immunizing his population, leaving it with no immunity to the deadly virus.

Researchers from University of Alberta and Tonix, a clinical-stage pharmaceutical company based in New York City, think they may have found a safer, more effective alternative to this old vaccine. They generated an infectious horsepox virus using chemical synthetic DNA and reverse genetics, then went on to demonstrate that the new poxvirus provided vaccine protection in mice from a lethal poxvirus challenge. The study was published in PLOS ONE in 2018.

High hopes

"This application of synthetic DNA technology has the potential to revolutionize how we manufacture complex biological including recombinant viruses. These methods advance the

capacity to produce next-generation vaccines and offer special promise as a tool for constructing the complicated synthetic viruses that will likely be needed to treat cancer," state Evans, a professor of microbiology attached to the University of Alberta Faculty of medicine and dentistry, via a press release.

"Tonix's goal is to develop a vaccine that has a better safety than the current vaccines for broader usage and to provide greater protection to the public," says in complete transparency Seth Lederman, president and chief executive office of Tonix, the renowned pharmaceutical company. As a matter of fact, current smallpox vaccines are only administered to protect first responders and military members on rare occasions, because of their high toxicity.

An Important Achievement

The team's finding was saluted by the scientific community. This is, after all, the first time a poxvirus was generated using these revolutionary techniques. The feat is "an important milestone, a proof of concept of what can be done with viral synthesis," says bioethicist Nicholas Evans – who's not related to David Evans – of the University of Massachusetts in Lowell to *Science.*

The original version of the horsepox virus synthesized by University of Alberta researchers is a relative of the variola virus, the cause of smallpox. In fact, it is not known to harm humans – researchers believe it no longer exists in nature and that it isn't a major agricultural threat.
-30-
434 words

Journalist 2:
Story 2A: Model B (Alone)
Synthetic smallpox vaccine shows early promise in mice: study
By Journalist 2

A Canadian-led early-stage investigation of a new smallpox vaccine suggests a synthetic horsepox variant should be investigated for further development, possibly for eventual use in humans.

Researchers synthesized fragments of horsepox DNA in mice, which are animals commonly used to test medicines for humans. Mice tests are performed for newer vaccines that do not have enough research data accumulated yet to evaluate vaccine safety, or effectiveness, in humans.

Mice trials showed the synthetic horsepox vaccine, compared with the usual smallpox vaccine from cows, creates smaller virus structures and less virulence after vaccination, among other positives.

But more studies will be required to confirm the results, even before starting the long road to human testing – a process that typically takes many years under the supervision of several Canadian federal government departments that deal with public health and food safety.

"If the lower virulence in mice reflects better tolerability in humans, it supports further investigation as a vaccine," wrote the study team, led by Ryan Noyce of the University of Alberta's Li Ka Shing Institute of Virology, in the peer-reviewed PLOS One journal published Jan. 19, 2018.

Developing the horsepox virus vaccine was a challenge as horsepox appears to be naturally extinct; moreover, the only available specimen of this virus is not available for investigation, the researchers noted. This prompted the team to develop a synthetic version of horsepox through DNA synthesis, which means artificially linking together the nucleic acids that form DNA, outside of natural processes.

Smallpox is a serious illness generally considered fatal in roughly 30% of cases, although the variola virus that causes it can also come in a less virulent and dangerous form. Smallpox is naturally extinct and the last immunization programs in Canada were halted in 1988. The disease produces a range of flu-like symptoms that vary as the disease progresses, but one key thing doctors look for is a rash that begins in the mouth area and spreads.

Samples of smallpox are kept in a few designated registered research laboratories around the world. Some scientists, however, are concerned that there may be secret smallpox stockpiles that could be used for bioterrorism. That said, there is no evidence yet of such illegal copies of the virus.

The University of Alberta took numerous biosafety and biosecurity precautions associated with the research above the usual ethical standards associated with working with animals, the scientists noted.

The research team complied with the Canadian Biosafety Standard Level 2 containment conditions, which have strict regulations pertaining to a single room as opposed to (for example) an entire facility. Scientists were prohibited with interacting with horses or cattle during the study. The University of Alberta took the further precaution of disclosing its containment plan to the Public Health Agency of Canada, which approved the plan. All efforts were also reported to the World Health Organization.

The researchers acknowledged that further development of synthetic vaccines present "significant challenges for public health authorities" but added that some of their goals in producing the study were to stimulate public health discussions about synthetic biology, and to stimulate the evaluation of possible new synthetic smallpox vaccines.

Story 2B: Model B + Hype Resistance
Synthetic smallpox vaccine raises ethical concerns
By Journalist 2

A Canadian-led early-stage investigation for a new smallpox vaccine suggests closer scrutiny is needed for vaccine development more generally, critics say.

The research team synthesized fragments of horsepox DNA in mice, which are animals commonly used to test vaccines when it is unclear how safe or effective a treatment may be for humans. The treated mice displayed smaller virus structures and less virulence after vaccination, the scientists wrote in PLOS One in January 2018.

It is unclear if the same results would be present in humans, as typical vaccine development can take a decade or more from the preclinical trial stage – a stage that is more advanced than mice trials.

Horsepox and smallpox appear extinct in nature; smallpox is considered fatal to humans in roughly 30% of cases in its most virulent form. As such, some health researchers expressed concern with the new work.

"Bringing back an extinct virus that is related to smallpox, that's a pretty inflammatory situation," said Paul Keim, who has studied anthrax at Northern Arizona University, in a Science Magazine report.
"There is always an experiment or event that triggers closer scrutiny, and this sounds like it should be one of those events where the authorities start thinking about what should be regulated."

Another PLOS One study raised concerns about the health risks associated with vaccine development and pandemics. (The study was written before the unrelated pandemic of naturally occurring novel coronavirus, or COVID-19, in 2020.)

"There should be a new norm related to experiments that increase pandemic risks, and ... there should be more transparency and stronger oversight for biological research and science that increases pandemic risks," wrote Tom Inglesby, who holds affiliations at the Johns Hopkins Center for Health Security and the University of Pittsburgh, in an October 2018 study from PLOS One.

Beyond the Canadian-led study's discussion of the vaccine's efficacy in mice, Inglesby pointed to unexpected side effects of its publication.

One difficulty could be assisting an unethical scientific group "determined to synthesize smallpox"anew, since virologists he interviewed said it was "ill-advised to publish the full prescriptive details of the synthesis in one manuscript." There are only two known repositories of smallpox worldwide that are deliberately difficult to access, due to the dangers associated with the disease.

Inglesby further pointed to the public health issues associated with a new outbreak of smallpox. Almost no one has been immunized since 1980, when smallpox was "declared eradicated" from nature, he said.

The University of Alberta, which led the horsepox study under researcher Ryan Noyce, took numerous biosafety and biosecurity precautions associated with the research above the usual ethical standards associated with working with animals, the scientists noted.

The research team complied with the Canadian Biosafety Standard Level 2 containment conditions, which have strict regulations pertaining to a single room as opposed to (for example) an entire facility. Scientists were prohibited with interacting with horses or cattle during the study. The University of Alberta took the further precaution of disclosing its containment plan to the Public Health Agency of Canada, which approved the plan. All efforts were also reported to the World Health Organization.

The researchers acknowledged that further development of synthetic vaccines present "significant challenges for public health authorities", but added that some of their study goals were to stimulate public health discussions about synthetic biology, and to stimulate the evaluation of possible new synthetic smallpox vaccines.

Journalist 3:
Story 3A: Model C (Alone)
Skirting the scourge: synthetic biology faces its "atom bomb" moment
In a panel discussion entitled "International Research Collaboration in a Polarized World", which was part of the Canadian Science Policy Conference (CSPC) in Ottawa during the fall of 2019, participants outlined challenges facing the scientific enterprise in the face of its potential abuse. Although that enterprise has for centuries been dedicated to the open communication of its work, some observers pointed to looming conflicts of interest posed by that approach. More specifically, researchers in open societies like Canada routinely publish their findings with the aim of contributing to knowledge, which makes those same findings accessible to a closed society like China, which has a clearly stated policy that draws no distinction between the intellectual and military application of science.

"Given this ideological divide, where does the science community ally itself?" asked former MP and party leader Preston Manning. "They are at the risk of being co-opted by one side or the other, as well as being accused of inappropriate collaboration."

This conundrum has dogged a major breakthrough by David Evans and Ryan Noyce, two members of the University of Alberta's Department of Medical Microbiology and Immunology. In 2018 they announced what they described as the first complete synthesis of a virus classified as *poxviridae*, which includes the agents of deadly epidemic diseases such as smallpox. The team worked with fragments of a rare sample of horsepox, a virus that does not threaten human health, and restored it to a complete, active form.

Evans and Noyce published their work in *PLoS One*, where they voiced their desire to demonstrate the viability of synthetic biological techniques, especially with respect to the development of new virus-based vaccines. While this technical accomplishment has been acknowledged by their peers in the scientific community, their paper was earlier rejected for publication in *Science*, where an editor argued that this definitive journal did not want to be responsible for inciting the dual use of the findings.

The term "dual use" refers to the problem being cited by policy analysts at the CSPC more than a year later. Among the more famous instances of this tension have been German chemical

research that introduced mass quantities of chlorine gas to World War I battlefields and American experiments in high energy physics that made it possible to create the first atomic bomb.

In much the same way, some critics have suggested that the synthetic methods Evans and Royce directed toward vaccine production could provide the foundation for a sophisticated viral arsenal, one that might even be tailored in subtle ways such as "tuning" viruses to create a racially focused bioweapon that would be lethal only to classes of people with particular genomic signatures.

While such imagery may smack of science fiction, it is not far removed from a critique posed by Gregory Koblentz, director of the Biodefense Graduate Program at George Mason University. Writing in February for the *Bulletin of the Atomic Scientists*, a journal that has struggled with the dual use concept for more than 70 years, he argues that the risks associated with viral synthesis far outweigh any commercial or medicinal benefits.

"According to a 2019 global survey of biosecurity practices by the Nuclear Threat Initiative, a nonprofit that tracks biosecurity risks and other threats, no country requires the companies that sell synthetic DNA to prevent 'questionable parties' from acquiring materials," he states. The result, he adds, "creates an environment in which a rogue state, unscrupulous company, reckless scientist, or terrorist group could potentially reintroduce one of the worst microbial scourges in human history."

Ω

Story 3B: Model C + Hype
Company recruits another virus to vanquish COVID-19

As countries around the world grapple with the impact of the highly contagious and lethal virus COVID-19, a New York-based firm is using a Canadian innovation to develop the first vaccine against this threat. Tonix Pharmaceuticals has worked with researchers at the University of Alberta over the last few years to learn how the molecular structure of the horsepox virus could be modified to create a new type of vaccine against the closely related and much deadlier smallpox virus. Now the company is adapting this approach to employ horsepox as the foundation of what could the first vaccine for COVID-19.

There are dozens of companies around the world working on such a vaccine, but almost all of them are looking at a traditional model of stimulating the body's immune system to create antibodies by injecting key parts of the virus or an inactivated, "dead" version of it. Tonix, on the other hand, is working with a "live" virus that can still replicate itself, which could provide a much more aggressive immune response in a vaccinated individual. Referring to lessons learned from the outbreak of SARS, a similar virus that created a more limited pandemic in 2003, Tonix CEO Seth Lederman says this strategy generates not just antibodies against COVID but a powerful class of virus-hunting agents known as T-cells.

"We don't know much about COVID-19, but from the work that was done with SARS, it's clear that people who recovered from SARS had strong T cell immunity," he told the definitive news site *Technology Networks*. "T cell immunity lasts years, whereas antibody immunity is relatively short-lived and relatively weak."

Lederman co-authored a 2018 paper in the journal *PLoS One* that described the foundation for this innovative use of the horsepox virus. The work, which was carried out at the University of Alberta, employed sophisticated techniques of synthetic biology to reconstitute an active copy of the virus from just a few of its DNA components. The goal at the time was to examine the possibility of using horsepox to improve the efficiency of smallpox vaccine for the World Health Organization (WHO).

"We were developing it as a vaccine to protect against smallpox and monkeypox," he said. "Smallpox was eradicated by the WHO's accelerated vaccination program, but there is still considerable concern that rogue nations, particularly North Korea, may have smallpox and might use the malicious reintroduction of smallpox as a bioweapon."

In the meantime, COVID has appeared as a more immediate threat. The process pioneered by Tonix is therefore being turned to a vaccine against this new virus.

"As a standalone, our vector is a potential vaccine for smallpox," he said. "But in the case of COVID-19, it's kind of like a pickup truck and we can put into it in a modular way, a new antigen or group of antigens that would potentially protect against other infectious agents."

Ω

Journalist 4:
Story 4A: Model D (Alone)

APRIL 2020 – An extinct horsepox virus was synthesized by University of Alberta (UofA) researchers, a move that may lead to safer smallpox vaccines, as well as new vaccines for other diseases.

But the work triggered debate in the scientific and biodefense communities ranging from critics who claim it is dangerous and could lead to others building smallpox viruses, to those who say the work is part of a larger oeuvre that helps with the understanding and prevention of serious viral diseases, including COVID-19.

Ryan Noyce, PhD, a microbiologist and immunologist at the UofA and colleagues chose to recreate the horsepox virus because of its connection to the smallpox vaccine. It goes back to 1796 when the first vaccine against smallpox was developed by Edward Jenner. Results were published in PLoS.

The story of the smallpox vaccine revolves around milkmaids who were protected against the disease if they had been exposed to cowpox. However, as well as cowpox, cows are also susceptible to a related virus, horsepox, which also causes mild disease in humans.

The question is, also highlighted in an historical review in The Lancet, was Jenner's original vaccinia virus-based vaccine derived from cowpox; cows infected with horsepox; or from horsepox derived from horses? This was difficult to answer because the original horsepox strain is extinct. But more than that, would a vaccine made from horsepox be safer than current ones based on different versions of cowpox?

The modern vaccine may be different from Jenner's version because the vaccinia components likely mutated over 200 years. It is known to sometimes cause myopericarditis and shouldn't be used in immunocompromised people. Plus, there were two modern reports of vaccinia infection caused by exposure to people who had been vaccinated.

Some answers were provided after the UofA researchers successfully used synthetic genetic techniques to build a horsepox virus. Further to recreating horsepox, the researchers replicated it and tested it in mice to see if it provided protection from the vaccinia virus (the active component in the smallpox vaccine). It did.

While the research has many supporters, some are skeptical. A commentary by biodefense researcher Gregory Koblentz, PhD, from the Shar School of Policy and Government in Virginia stated "The combination of questionable benefits and known risks of this research raises serious questions about the propriety of a private company sponsoring such dual use research without appropriate oversight."

Dr. Koblentz suggested the methods used in the study could be used to synthesize or recreate the smallpox virus and present a security risk.

However, according to some experts, no new techniques were revealed. In fact, the PLOS Dual Use Research of Concern Committee, stated "The study did not provide new information specifically enabling the creation of a smallpox virus, but uses known methods, reagents and knowledge that have previously been used in the synthesis of other viruses (such as influenza and polio viruses)."

Volker Thiel, PhD, an infectious diseases researcher at the University of Bern, wrote in PLoS Pathogens and pointed out "the individual experimental steps and methods to generate infectious horsepox virus have been reported before." The paper then described previous works that used similar techniques.

He added "These examples illustrate the fact that synthetic biology has matured towards a powerful
technique that will impact the scientific community and our society in general similar to the advent of recombinant DNA technology in the 1970s."

Tonix Pharmaceuticals, Inc., which funded part of the horsepox research, now reports that the horsepox vaccine vector is being investigated as a platform for a possible vaccine against COVID-19.
-30-

Story 4B: Model D + Hype

Living Virus Related to Smallpox Built Using Frankenstein Science
APRIL 2020— _The once extinct horsepox virus has been recreated by using novel genetic techniques. The groundbreaking work promises to lead to safer vaccines and new cancer treatments or cures.

Researchers at the University of Alberta (UofA) and colleagues recreated a living horsepox virus because of its connection to the smallpox vaccine. Components for the original smallpox vaccine, developed back in 1796 by Edward Jenner, were derived from a version of horsepox which infected horses and sometimes cows, but could cause only mild problems in humans.

However, the form of horsepox (a type of vaccinia virus) in the modern vaccine may be significantly different from Jenner's version. The components of the virus likely mutated over the past 200 years, and the modern vaccine is known to have serious potential side effects. The new work would remedy these problems. Results were published in PLoS.

A goal of the researchers was "to develop a vaccine that has a better safety profile than the current vaccines for broader usage and to provide greater protection to the public" according to a release from the UofA. It is also a virus that can be altered and used to fight cancer.

Due to toxicity issues and smallpox eradication, the modern smallpox vaccine stopped being used to immunize whole populations. Smallpox was declared eradicated in 1980. While the vaccine is available for use in first responders and military service members in case of bioterror uses of smallpox, it occasionally causes serious side effects such as heart issues, which a new vaccine could be designed to avoid.

In order to build the virus, the UofA research team, headed by virologist David Evans, PhD, created chemically synthesized DNA using genetic information from a sample of horsepox that was preserved in 1976 – _the last known date of any known horsepox outbreaks. This synthesized DNA was then used to alter a sample of modern vaccinia virus and combined with another living virus.

The result was a living virus that can be replicated and put to good use in the lab. In further testing, the researchers administered it to mice to see if it provided protection from lethal doses of the vaccinia virus (the active component in the smallpox vaccine). It successfully did.

Impressively, there is potential to work with this modified form of the horsepox virus to treat cancer. "These methods advance the capacity to produce next-generation vaccines and offer special promise as a tool for constructing the complicated synthetic viruses that will likely be needed to treat cancer," said Dr. Evans, in a press release.

The researchers noted it is an oncolytic virus, meaning it is drawn to certain types of cancer cells. In related work, Dr. Evans' team found that in laboratory models of cancer, another version of the vaccinia virus showed promise in terms of infecting and killing cancer cells, while at the same time it promoted an immune response that would prevent the cancer from returning. The work looked specifically at bladder cancer.

The researchers stated that the techniques used to build this virus will be needed to develop future versions of cancer-fighting agents.

The work was done in conjunction with Tonix Pharmaceuticals.

Appendix III: Script for Focus Group Discussions

MODERATOR GUIDE: FOCUS GROUP

Taylor's MA Thesis
Horsepox and Hype: A Science Journalism Experiment

The key to successful focus groups is having questions asked in a conversational manner. Because the focus group is a social experience, conversational questions are essential to create and maintain an informal environment. The research purpose of a focus group is to have the entire group discuss, interact, and present their viewpoints in reaction to others.

Goal: To evoke the viewpoints of participants on test journalism. The test journalism is the research probe that is to be examined as an input whose impact is sought to be understood.

Research Question for Focus Groups:
How does the presence/absence of elements of hype in textual journalism impact audience viewpoints (opinions and perceptions) of synthetic biology?

Note: The research question is phrased in this way as recruited journalists had the choice to either add elements of hype into their second stories or follow guidelines to make their second stories hype resistant

Types of data to be collected:
1) Participant viewpoints on the field of synthetic biology (in general);
2) Participant viewpoints on the journalistic coverage (or other media coverage) of synthetic biology (general);
3) Participant viewpoints on the test stories (specific audience comparison of stories);
4) Participant viewpoints of the hype, tone, language, interest in the test stories (specific).

Role of the moderator:
- To have the discussion go quickly;
- To get through all the questions;
- To evoke different viewpoints among participants;
- To get all participants involved (integrate any shy person);
- To umpire deftly to curb those who 'chat', refocus those that stray or ask you a question (moderators do <u>not</u> answer questions), and handle those that interrupt or 'put down' another's viewpoint.

Note: Only participants who have signed a consent form are able to participate; moderator needs to ensure everyone is aware that the group will be recorded.

Role of the participants:
- To present their viewpoints on the questions;
- To be open to collective, respectful discussion and listen/respond to others.

Role of focus groups:
- Focus group are an informal conversation;
- Focus groups are *unique* experiences that are guided but sought to evolve naturally;

- Focus groups are designed to **evoke** the views of **all** participants;
- Focus groups allow the moderator to probe the group about a research question;
- Focus groups are **not** a space for the researcher to discuss their work;
- Focus groups are influenced by the interactions between participants;
- Focus groups are a data collection activity and are recorded.

SESSION GUIDE FOR EACH FOCUS GROUP (45 TO 60 MINS)

The session begins with everyone logging onto Zoom.
The moderator welcomes everyone as they join and says the session will begin shortly, we are just ensuring everyone is logged on. (2 mins)

Round 1: Introduction to the Focus Group (3 mins)

Moderator: Hi everyone, my name is Taylor Kann and I am the moderator for this group. Cristina Sanza works closely with me in the Department of Journalism at Concordia, and she will assist today in taking notes during our discussion. Today we are going to discuss science journalism and synthetic biology.

The session is expected to take about 45 minutes to an hour total and will be recorded. Regardless, it will end promptly at 5:30pm, 6:30pm, or 11:30am (dependent on day).

We are holding this focus group because as researchers we are studying journalism and we believe we don't know enough yet about how science journalism is viewed by the public. This group is a way for you to voice your viewpoint on one topic and some journalism, so that the field can improve moving forward.

I need to hear from everyone during the group, however, you don't have to answer every question. Differing ideas from one another are encourage and please feel free to speak up to add additional info to another person's answer. Please respectfully respond to one another, not to me; also feel free to ask each other questions for clarification. I am here to keep the discussion on topic. I also will be keeping time, so it is possible that I may need to interrupt you occasionally.

I was not involved in the production of the journalism you read for this group at all, so you won't hurt my feelings if you say anything negative or make me happy if you liked it (*laugh*). There are no wrong or right answers, the point of the group is to get your thoughts and opinions.

Round 2: Get everyone to speak (5 mins)

Moderator: So, let's begin! Starting with X and going round robin, please give your first name so others can talk to you, and tells us quickly, why you got involved in the group today.

{Key elements to end with, very quickly}:

- *Show how to raise your hand on Zoom*
- *Show that you can raise your hand in your screen to talk next*
- *Explain that the chat is used for items we don't have time to fully discuss (a parking lot)*

- *I may call a name to ask them to speak next.*
- *If you have lots of background noise you can mute your mic at the bottom.*
- *If you get disconnected, please just try to re-join. If I get disconnected, I will return asap. The notetaker would take over if need}*

Round 3: Viewpoints on the field of synthetic biology, and then journalism (15 mins)

Moderator: Thank you, everyone. Let's move on.

Think back to before you received an invite to this group. Think of whether you had any opinions about synthetic biology.

In a second, I am going to ask you to write on a piece of paper as many words that come to mind when you think about synthetic biology. These words can be anything.

Please go ahead and do this for 20 seconds. *{Stop everyone after 20 seconds}*

Question 1: Our first question is based on the words you wrote down. **What was your opinion of the field of synthetic biology?**

Let's start with XX.

{Go around to have everyone speak; encourage responses to what others have said.}

- Additional probe : Have you read, seen, or heard anything about synthetic biology in the media?
- Additional probe (if needed): Was the journalism you saw positive or negative?
- Additional probe (if needed): What knowledge did you have of this field?

Round 4: Participant viewpoints on the test stories (15 mins)

That was great. Please hang on to your piece of paper.

Question 2: Let's move onto the journalism you were sent. **After reading these stories, what was your initial reaction?**

{Allow people to speak as they feel, don't let answers get too long.}

Someone else? A different idea…

- Additional probe: Has reading these stories changed your opinions/perceptions of synthetic biology?
- Additional probe (if needed): Can you give an example of how your opinions/thoughts have changed?
- Additional probe: Were the stories different? The same? (If different, how where they different…etc.)

Round 5: Viewpoints on hype, tone, language, interest in the test stories (15 mins)

Very interesting! Let's move on.

Question 3: I'd like to get a little more specific in this final round. **What did you think about the language or tone of the two stories you read?**

Someone else? A new idea…

{Allow people to speak as they feel, don't let answers get too long. Watch your time.}

- Additional probe: Did you find the language to be dramatized or sensational at all?
- Additional probe: Given COVID-19 and what you read, should synthetic biology be utilized to create vaccines for diseases currently threatening global health?
- Additional probe: Do you feel that synthetic biology is a positive or potentially threating area for society?
- Additional probe: Would you be interested in reading print news that is focused on synthetic biology innovations again in the future? If so, explain why? If you wouldn't be interested, why not?

Final Round: Thank you and closure (5 mins)
Thank you for your participation.

Before we end, can we take 10 seconds to re-read your same piece of paper from the start.

Now I am hoping everyone will take 1 minute to type on the chat any words that come to mind about how to improve the communication of synthetic biology, or anything about the topic that you feel is important. *{wait one minute}*

We are done! Your ideas will help the future of science journalism. Thank you for your participation in today's discussion.

{Save the chat from the session and log off. Save the video and audio. Upload all the files to a backup area to ensure it is not lost.

Researcher debrief: Take the time to write 1 page of field notes on your impressions of the focus group, the main themes, the key ideas for improvement, who spoke the most or quotes you remember, differences to other groups, any challenges or problems with the group}

Appendix IV: Key Terms on Synthetic Biology from Focus Group Participants

Key Term:	**Frequency (# of times key term was mentioned by participants):**	**Percentage of Participants Who Shared this Term:**
Artificial Limbs/Hearts	1	3%
Augment	1	3%
Babies	2	7%
Bioengineering	1	3%
Biology	2	7%
Bionics	1	3%
Bioterrorism	2	7%
Cancer Treatment	1	3%
Cells	1	3%
Challenging	1	3%
Chemistry	1	3%
Competitive	1	3%
Complexity	1	3%
Complicated	1	3%
Controversial	1	3%
Cooperation	1	3%
Creation	1	3%
CRISPR	2	7%
Cures	2	7%
Curing	1	3%
Custom	2	7%

Cutting Edge	1	3%
Dangerous	1	3%
Defense	1	3%
Development	1	3%
Discovering	1	3%
Did Not Know Much About SB Field	6	21%
DNA	2	7%
Do Not Know Where SB Could Lead To	1	3%
Economy	1	3%
Fabricated	1	3%
Fake	1	3%
Forced Evolution	1	3%
Frankenstein or “Frankensteining”	2	7%
Future	1	3%
Futuristic	1	3%
Gene Editing	1	3%
Genes	1	3%
GMO	2	7%
Health	2	7%
Healthcare	1	3%
Helpful	5	17%
Human Beings	1	3%
Inequality	1	3%
Innovation	3	10%

Interesting	1	3%
International	1	3%
Jury-Rigging	1	3%
Made to Replace	2	7%
Human-Made	4	14%
Manufactured	1	3%
Medical Field	2	7%
Medication	1	3%
Monsanto	1	3%
Nature	1	3%
Nervous	1	3%
New	1	3%
New Era	1	3%
Novel	1	3%
Pacemaker	1	3%
Pesticide	1	3%
Progress	1	3%
Remapping DNA Structures	1	3%
Research	1	3%
Risky	1	3%
Robots	1	3%
Safety	1	3%
Scary	2	7%
Science	3	14%

Slapping Things Together	1	3%
Systems Different Than Natural Systems	1	3%
Technology	1	3%
Testing	2	7%
Things Inserted Into Body to Help	1	3%
Treating Disease	2	7%
Unclear	1	3%
Unnatural	1	3%
Unreal	1	3%
Vaccination	1	3%
Vaccines	2	7%
Wealth	1	3%