PROMISES OF IN VITRO MEAT SCIENTISTS AND THE CRITICISMS OF REFLECTIVE SCHOLARS

A Discourse Analysis of Recent Promises and Concerns in the Academic In Vitro Meat Discourse

A 20EC thesis submitted in the partial fulfilment of the requirements for the degree of Master of Science in Philosophy of Science, Technology, & Society

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I. Introduction

A. Promises of Emerging Techno-Science

Contemporary society is saturated with scientific and technological innovations and continuously New and Emerging Science and Technologies (NEST) surface with promises of a better tomorrow. That NEST hold societal promises is nowadays common-sense in policymaking. European Union policies heavily emphasize the importance of NEST. It is even claimed that successful techno-scientific innovation is a key driver of economic and social welfare (Horizon2020, 2011; Juncker, 2016; Moedas, 2016). With other influential institutions such as the United States Department of State, the World Economic Forum and the Dutch advisory body for Science, Technology and Innovation, one finds similar optimism (Schwab, 2016; Rosenthal, & Bovens, 2017; U.S. department of state, 2018).

The potential of NEST is typically first highlighted by enactors of NEST – often scientists (Swierstra, 2016; Konrad, Van Lente, Groves, & Selin, 2017). That NEST-scientists posit promissory arguments for their work is prompted by the need to acquire support, such as research funding (Swierstra, 2016). More critical of the potential of NEST are professional ethicists and other reflective scholars such as sociologists and philosophers. Their collective efforts to scrutinize NEST-promises can nuance the dominant promissory image of NEST, though reflective scholars have been criticised for being too easy on promissory NEST-rhetoric (Hedgecoe, 2010).

The Sociology of Expectations (SoE) is a sociological research domain that is engaged with NEST-promises and how they are contested. The SoE has demonstrated that NEST inherently embody promises of new opportunities and capabilities (Borup, Brown, Konrad, & van Lente, 2006). With these NEST-promises, positive expectations are posited that accentuate the potential of techno-scientific change. NEST-promises embody the urge to realise something that was hitherto not possible or foreseeable. As mentioned, this resonates well with policy makers. Important is that promises impact how a NEST-phenomenon develops, and impacts society (Konrad et al., 2017).

Although optimism for NEST is widely shared between scientists and policy makers, the future of NEST is fundamentally uncertain and unstable (Swierstra, 2016). This uncertainty enables promissory rhetoric by NEST scientists, but at the same time casts doubts on the accuracy of these utterances. The fundamental uncertainty of NEST-futures urges investigation into how NEST-promises materialise and the extent to which they are contested. Fascination for NEST-promises of NEST and how they are contested prompt this thesis in which the role of academic NEST expectations is inquired via a case study.

B. Expectations in case of In Vitro Meat

To inquire the promises of NEST, insights from the SoE are key. The SoE has demonstrated that expectations are typically value-laden. An expectation tends to be framed either positive (promise) or negative (concern) (Te Kulve, Konrad, Alvial Palavicino, & Walhout, 2013; Konrad., et al. 2017). Exchange of value-laden expectations contributes to ongoing assessment of science and technology or 'de facto assessment', implying the importance of the relationship between promises and concerns (Te Kulve, et al., 2013). In addition, the SoE has shown that expectations impact the further development of NEST as well as influence (public) sense-making processes (Konrad, et al., 2017). Insights from the SoE thus highlight that NEST-promises matter as they impact further development and sense-making of a NEST-development and constitute ongoing assessment.

By studying the academic discourse of a NEST-development that is relatively new, it is aimed to access the primary source of NEST expectation-rhetoric before large-scale discussions have emerged and while the NEST is relatively malleable. In addition, by studying a case in which discussions are largely centred around discussions between academic actors such as scientists and reflective scholars, it is possible to study a case relatively comprehensively as most academic materials are widely available.

A NEST-development in which academic expectations are dominant is efforts to create what is known under labels such as 'cultured meat', 'lab-grown meat', 'test-tube meat', 'artificial meat', 'clean meat', 'guilt-free meat', 'shmeat', or the common term that is used in this thesis: 'In Vitro Meat'[1] (IVM). IVM is a collective term for attempts to employ insights and techniques from tissue engineering to grow meat or meat-like products from animal cells in laboratory setting (Stephens, 2013). It encompasses different techniques for the accomplishment of this goal (Bhat, & Fayaz, 2011).

For IVM, numerous promises and concerns have been raised. Proponents of IVM tend to present IVM as *the* future (partial) substitute of meat. To bolster this claim, proponents have pointed to different promises of IVM. These promises are raised in reference to meat, its production processes and related patterns of consumption. Promises range from improved animal welfare, environmental benefits, world food poverty reduction and health benefits to the possibility of meat in space (Bhat, & Fayaz, 2011; Miller, 2012). Sceptics have pointed out potential downsides of IVM and have criticized IVM's promises. For example, concerns are raised about the technical and

[1]the term IVM is used in this thesis as it has a rather neutral connotation. The most common alternative for IVM is 'cultured meat'. This term has been strategically proposed by IVM proponents to associate IVM with established cultured food stuffs such as yoghurt (see Ferrari, & Lösch, 2017).

economic viability of IVM (Bhat, & Fayaz, 2011; Hocquette, 2016). In addition, ethical concerns have been raised, amongst others about labelling of IVM as meat, how to categorize and understand living animal cells in the lab and concerning IVM's tendency to view animals instrumentally (Dilworth, & McGregor, 2015; Hocquette, 2016).

Though IVM's promises and concerns are contested, problems of the meat industry are shared between IVM-proponents and IVM-sceptics almost without contention. The meat industry is responsible for about 14.5% of all greenhouse gas emissions, while beef alone contributes close to 6% of all emissions (Gerber et al., 2013). In addition, for meat and dairy production - including grazing and crops - 70% of all agricultural land is used (Jönsson, 2016). It is predicted, meanwhile, that the demand for meat will increase with over 70% by 2050 compared to 2010, while some see no way beyond production by conventional methods, which is close to its maximum (FAO, 2011). Additional concerns regarding the meat industry include worries over animal welfare, animal borne diseases and use of antibiotics and pesticides in meat production. Discussions over the potential of IVM as an alternative for meat thus concern a significant issue.

The severity of problems of the meat industry and the tension resulting from the opposition between proponents and sceptics of IVM as a future meat substitute makes IVM a societally relevant case[2]. From the perspective of the SoE and this thesis' interest in the valuation and contention of NEST-expectations, the tension between promissory and concerning expectations makes that IVM is of interest. For these reasons, IVM sparked the interest of the author. Additionally, IVM is a relatively new development that has produced a modest amount of academic literature starting in 2005. This makes that the topic fits the scope of this thesis.

C. Argumentative Discourse Analysis of Academic IVM Expectations

To pursue the interests of the thesis, in line with many SoE studies, Discourse Analysis (DA) is employed. DA is a common approach in academia covering a range of theoretical sublines and research methods. Most often, DA is employed in the context of political problems, policy issues and media analysis. To pursue questions regarding academic actors' valuation of IVM it is sensible to focus in on the value-laden arguments that they provide in their works. Such arguments can be found in different scientific arenas, such as in publications, conferences, press releases and on websites. Fitting with such a micro-level analysis of academic arguments as language in use is

[2] This is not to say that IVM is unique in raising a manifold of promises and concerns that contest each other, this is something rather typical for NEST in general.

Hajer's Argumentative Discourse Analysis (ADA) (Hajer, 1993; 1995; 2006). Although ADA is developed specifically for political issues like many other DA approaches, ADA fits the objectives of this thesis as it focuses on arguments as site of analysis with emphasis on inter-personal communication, which is common to academia. ADA understands discourse as: *"an ensemble of ideas, concepts, and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices"* (Hajer, & Versteeg, 2005, p. 175). A relevant feature of ADA is that it advocates examination of the contexts in and positions against which arguments are positioned. Such an examination opens up the possibility to investigate argumentative meaning (Hajer, 1993; 1995).

An example will give indication how IVM's academic valuation dynamics can be understood from the perspective of ADA. Under ADA's conception of discourses - with its understanding that ensembles of concepts, ideas and categories give meaning - one expects a reciprocal relationship between valuation of IVM and the way in which IVM is conceptualized and understood. This is exemplified in the following. For some IVM proponents, such as prominent IVM-researcher Mark Post, IVM is simply meat. His positive valuation of IVM aligns with the conceptualisation of IVM as meat. This is in turn related to Post's research aim to make possible large-scale uptake of IVM as an alternative to meat. By these intertwined positions, a perspective is enabled which holds that IVM can sensibly replace traditional meat. For some sceptics, however, IVM is rather different from traditional meat. For some, it is unnatural and unsafe compared to meat, while for others IVM is a different way in which the problematic dominance of the meat industry can continue. In these sceptical cases, too, understanding and conceptualisation of IVM aligns with valuation of IVM. Drawing on insights of ADA, then, it is presupposed that there is a close relation between the conceptualisation and understanding of IVM on the one hand and the valuation of IVM on the other hand.

D. Problem Statement

This thesis is not the first work to engage in analysis of the wide range expectations raised in case of IVM. Drawing on the sociology of expectations and related fields, analysts have met the need for critical assessment of IVM-related claims. These works, and their foci, will be reviewed in the theoretical framework in more detail in section B-3 starting on page 24. Here, a brief overview of salient issues is provided.

What is clear from the perspective of academic valuation of IVM is that the reflective IVM-literature is largely oriented at understanding what IVM is, how it is interpreted by different actors,

how discursive patterns have emerged and how IVM-proponents conceptualize, market and idealize IVM. In these reflective works concerns have emerged but received relatively little attention compared to promises. Merely concerns from those that object to IVM on ideological grounds have had some attention (Chiles, 2013b; Dilworth, & McGregor, 2015), while Dilworth and McGregor's (2015) topology of ethical IVM discourses and Jönsson's (2016) critical paper that produces new concerns are notable exceptions.

In case of IVM, and in the SoE in general, the relationship between promises and concerns has received little attention thus far (Te Kulve, et al., 2013; Konrad, et al., 2017). For understanding promise-concern relationships in case of IVM, only a study by Chiles (2013b) was relevant as it highlighted the importance of ideologies for valuating IVM.

For IVM, it is hitherto unclear how academic valuation is produced. Moreover, how IVM is assessed de facto and, in turn, how this impacts IVM discussions at large is underemphasized in the discourse. This thesis is an effort to shed some light on these questions marks by focusing on valuation of expectations in the recent (from 2015) academic IVM discourse.

Relying on the SoE, ADA and general sociological principles, it is aimed to be critical to the assumptions behind IVM-related claims and to be sensitive to contextual and historical developments. This allows for the identification of underexposed ideas and assumptions, as well as the possibility to reflect more deeply on the valuation-work of scientists.

In sum, the envisioned thesis has three goals. First, the relation between promises and concerns in the academic IVM discourse is studied, thereby shedding further light on the way in which expectations are valuated in case of IVM. Specifically, in-depth attention for promises and concerns, and the contexts from which they are posited, makes possible to deconstruct how: the positions of optimists and sceptics are grounded, the way in which their positions relate, and how they contribute to de facto assessment of IVM. The thesis, thereby, contributes to the SoE in general in which analysis into the relation between promises and concerns has not yet been carried out often (Te Kulve, et al., 2013). Second, in this thesis it is aimed to further contextualize IVM debates by highlighting underexposed issues and by pointing out relevant historical and discursive details Third, the thesis reflects on the way in which IVM's promises are contested by highlighting how authors from reflective discourses analyse the work of IVM proponents.

The purposes of the thesis are tackled by way of the following research question:

"How is In Vitro Meat valuated in the academic In Vitro Meat discourse and how are promises and concerns contextualised?"

The following sub-questions will be answered to divide the research in manageable parts that, taken together, should lead to an answer for the overarching research question.

"Which promises and concerns are voiced in the academic In Vitro Meat discourse and which expectations are dominant?"

"How do promises and concerns relate in the academic In Vitro Meat discourse and thus constitute academic de facto assessment of In Vitro Meat?"

"From which discursive positionings is valuation of In Vitro Meat produced and contested in academia?"

Having presented this thesis' research interests and objectives, the next chapter (II) describes the case of IVM by discussing its history and current IVM production possibilities. Chapter III constitutes the theoretical framework which introduces the SoE in more detail, with specific attention for the valuation and contention of expectations. Additionally, it presents works that have reflected on how IVM is valuated and it presents this thesis' discourse analytical approach in depth. Following the theoretical framework, chapter IV presents the methodology, outlining how the sample of the thesis is selected and discussing its general make-up. The analysis (chapter V) first presents a descriptive analysis including which discourses and value-laden expectations are identified. The second part of the analysis discusses arguments and rhetoric within discourses, including different promise-concern relationships. The final part of the analysis discusses how IVM scientists and reflective scholars build and present their arguments in interaction with each other. Chapter VI, which presents the discussion, provides a deeper level of reflection by offering observations beyond discursive dynamics. It explores issues that relate to assessment of IVM's expectations, the role of early promissory NEST rhetoric, and related challenges for reflective discourses. Furthermore, chapter VI reflects on the methodology and main findings of the thesis, including implications, limitations and strengths of the thesis and recommendations for further research. Chapter VII concludes that IVM is largely valuated positively from a dominant meat substitution frame where imagined benefits of IVM refer to precisely those issues that are deemed problematic about the current meat industry. While critics nuance IVM's promises and provide additional concerns, they largely remain within meat substitution frame. Despite some methodological shortcomings and limitations due to the scope of the thesis, this thesis contributes to reflection on IVM and provides routes for more nuanced reflection and further research.

II. Case Description

A. The Emergence of Academic IVM Expectations

A-1. Introduction to the emergence of IVM

This chapter starts off with a historical section, integrating discussion of recent IVM developments with how IVM's expectations have changed over time and incorporating information based on how IVM proponents present the history of IVM. This is important for two reasons. First, it provides background and sets the stage for the recent cross-sectional analysis of expectations of in case of IVM. Second, the value-saturated claims that are featured in the analysis are interrelated with (different readings of) the history of IVM. Providing a history of IVM in this section, thus prepares thus a discussion of the linkages between the history of IVM and value-laden claims later in the thesis.

From the perspective of value-laden expectations in IVM's academic discourse, it is viable to demarcate between developments before academic IVM research took off (pre-academic developments) and developments from the emergence of academic IVM inquiries. Naturally, when scientific research on IVM substantiated expectation-dynamics started to emerge in academic setting.

To give an indication of how the academic IVM discourse has developed, appendix A features a plot of Elsevier's Scopus' search results for "in vitro meat" OR "cultured meat" over time. The image shows the emergence and the gradual growth of an academic IVM discourse, starting from one publication in 2008 to a peak of 20 publications in the 2015, averaging just over ten publications a year in the period 2008-2017. It must be noted that Scopus is a database with strict criteria for search results. Via Google Scholar more publications were found (1750 documents, excluding patents and citations), going back to 2005. Unfortunately, Google Scholar has no feature to map search results over time. The image must thus be taken as a rough indication of development of the academic discourse. In sum, the image shows that IVM is a young field of research which attracts rising attention. The typical 'NEST-hype', however, has not materialised (yet) as a spike of 20 publications is modest. Similarly, attention in the popular media has not been hype-like (see Appendix B). Likely, then, is that IVM is in a form of pre-hype stage. This means that there have been relevant developments and discussions, but not to the degree that development of IVM is crystallised nor are IVM discussions saturated. This is a meaningful moment for analysis. To consider IVM's promises and concerns before hype has materialised is to reflect on a development which will still change considerable and thus can be sensitive to critical reflection.

A-2. IVM's Pre-Academic Developments

Along two lines, the emergence of IVM can be traced back from the early 20th-century to the first years of the 21st-century. A first historical thread concerns early IVM-like imaginaries. Conservative politician and writer Frederick Edwin Smith wrote in 1930: "*It will no longer be necessary to go to the extravagant length of rearing a bullock in order to eat its steak. From one 'parent' steak of choice tenderness it will be possible to grow as large and as juicy a steak as can be desired"* (Ford, 2009, p. 2). Two years later, Winston Churchill wrote in his essay 'Fifty Years Hence': *"Fifty years hence we shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium" (*Ford, 2009, p.1-2*).* While there is no evidence that these quotes contributed to the development of IVM, they are often pointed out as conceptual anchor points (e.g. Edelman, et al., 2005; Post, 2012; Arshad et al., 2017). Reflective authors have pointed out that IVM proponents especially reiterate Churchill's quote often. This tendency has been identified as following from strategical considerations to associate IVM with one of the defining figures of the 20th-century (Jönsson, 2016).

In the mid-1990s, Dutch entrepreneur and researcher Willem van Eelen was the first to ponder the idea to grow meat in laboratory setting from animal cells (Bhat, & Fayaz, 2010; Cohen, 2011). As such, he is hailed as the ideological founder of IVM by IVM proponents, in the popular media and in the Dutch IVM-context in particular (Van Mensfoort, 2015). Van Eelen conceived of IVM primarily as a means to combat global food poverty issues, which he had encountered personally during WWII (Van Eelen, Van Kooten, Westerhof, & Lindsay, 2005; Specter, 2011;). Later, Van Eelen became a pioneer in IVM-research. He pursued his IVM imaginary actively from the mid-1990s onwards and while initially unsuccessful, Van Eelen co-filed the first IVM-patent in 1999 (c.f. Van Eelen, et al., 1999; Jönsson, 2016;) and acquired the first substantial funding for IVM research as head of a Dutch research consortium in 2004 (Datar, 2015). The consortium received two million euros from the Dutch Ministry of Economic affairs' funding agency SenterNovem to produce an IVM product to realise van Eelen's vision (Jönsson, 2006). Allegedly, Jason Matheny[3], founder of IVM-promoting NGO New Harvest, played a role in the process by lobbying for subsidy for IVM research to the Dutch minister of Agriculture (New Harvest, 2017).

[3] Matheny was also involved in the first academic publication on IVM in 2005 (see New Harvest, 2017).

A second historical thread concerns development in stem cell and tissue engineering research, regenerative medicine, and related fields[4]. Development in these fields grounded insights and techniques that enable recent IVM-research. Furthermore, several researchers from these fields got involved in IVM research, which accommodated transfer of relevant expertise. For example, the most prominent IVM researcher currently, Mark Post, is a professor of vascular physiology, while Evgeny Mironov, who was involved in early IVM research, is a tissue engineer by trade.

Scientists often identify work of Alexis Carrel in 1912 as a historical starting point for IVM research (Benjaminson, Gilchriest, Lorenz, 2002). Carrel successfully kept a piece of embryonic chick heart muscle alive in a Petri dish (Benjaminson, et al, 2002). Scientists note that a further step was taken when embryonic stem cells were effectively cultured in vitro (Martin, 1981). The first research that approximates contemporary IVM research efforts was initiated by the National Aeronautics and Space Administration (NASA) in the mid nineteen-nineties. The goal was to investigate the possibility for meat in space and thus IVM's expectations shifted away from food poverty issues (Benjaminson, et al., 2002). NASA researchers grew in vitro goldfish tissue successfully, seasoned and fried it, and presented the product to a taste panel (Bejaminson, et al., 2002). Around the same time, two Harvard tissue engineers where involved in a project with art and tissue engineering components. Their goal was artistic, practical and philosophical at the same time: *"to explore questions arising from the use of living tissues to create/grow semi-living objects/sculptures and to research the technologies involved in such a task"* (Catts, & Zurr, 2002, p. 365). For this project, Catts and Zurr grew three centimetres of muscle tissue from pre-natal sheep cells (Stephens, 2010). These first IVM research projects show how IVM served as vehicle for different expectations with different actors over time, from combatting food poverty to the possibility for meat in space and exploration of practical and artistic-philosophical questions.

A-3. Academic IVM Developments

Following the Dutch ministry of economic affairs' two-million-euro investment in a Dutch research consortium in 2004, gradually, an academic IVM discourse developed and reactions in the media emerged. That is not to say that the ministry's investment was the sole cause of the emergence of an IVM discourse - indeed the previous section already pointed to the importance of the work of artists, NGO's, actors in IVM-related academic fields and others. Rather, the funding initiated the

[4] These fields refer roughly to biomedical sciences that aim to replace damaged tissue in the human body and/or to stimulate the human body's regenerative processes.

first large scale academic IVM research effort and, by extension, made possible that the consortium's researchers had the means to reach out to colleagues and others of interest, such as industry, NGO and media actors. Those actors, in turn, found in the research consortium a material, financial and conceptual assembly to anchor their different IVM-related interests.

The consortium was not able to produce an IVM product when it ran out of funding in 2009 (Haagsman, Hellingwerf, & Roelen, 2009), though Maastricht-based researcher Mark Post, who had become part of the consortium in 2008, attracted private funding from Google co-founder Sergey Brin (Ferrari, & Lösch, 2017). With Brin's $330.000 contribution[5] (Chiles, 2013a), Post worked with a small team of colleagues to produce an IVM burger (O'Riordan, Fotopoulou, & Stephens, 2017). For Post IVM can serve to meet the rising worldwide demand for meat and reduce environmental and animal harm. The goal of producing an IVM burger was not to develop a product that could be mass-produced and serve as to fulfil IVM's promises. Rather, it was aimed to 'prove the concept' of IVM and for the burger to serve as an anchor for (media) attention and to attract further funding (O'Riordan et al., 2017). The plan that the to-be-produced burger should be presented in a live tasting event echoes its strategic motivation. This event was organised in 2013 for a live crowd of media actors, researchers, journalists and others of interest, and efforts were made to ensure social media uptake (O'Riordan et al., 2017). An illustrative quote from Mark Post shows the strategical reasons for the event and how it communicated a tangible view of IVM:

> *"One idea that we had, maybe about a year ago, was that we are at the very fundamental level [of IVM research] at the moment and we need to get to a level where the real big money can physically see that it's possible to produce a meat analogue this way. Why don't we use what we have where we are today, which is we can grow in a petri dish very small muscle from satellite stem cells [...] Why don't we do this, say, 2000 [times], which takes a bit of time, and get someone to pick out all these little bits, put them in a mixer, and make a sausage out of it. A very expensive sausage; it'll set you back somewhere between 300,000 and ½ million Euros, but with this sausage, we can go to Sky News, we can go to CNN, whatever and say, 'Look guys, this is a sausage and this is the first one in human history. It's made from real meat and we did not need to kill an animal to produce it'. A lot of questions attached [...] but this is it. It's physically on the table so it is possible. This might trigger people with money because it's, well that's what*

[5] Some Dutch sources note that the total investment was 700.000 euros (e.g. Van der Weele, 2013).

we need, it's money and I don't care who it is, if it's Bill Gates or Paul McCartney or whatever but someone to really see, literally see, that there's a future behind this process"

(O'Riordan, et al., 2017, p. 153, emphasis added).

Brin's private funding impacted the progress of the research. He demanded that Post worked alone with his team (Jönsson, 2016) and while Post's and the Dutch research consortium's efforts had focused on producing an IVM sausage, focus was shifted to production of an IVM burger (O'Riordan et al., 2017). Reason for this change was that a burger was deemed more symbolic for meat consumption and thus should resonate with a larger audience (Post, 2013).

With Post's efforts IVM research took off in one particular direction. The emergence and development of multi-sited international research efforts and exchanges is exemplified in the materialisation of IVM workshops, symposia and conferences. The first IVM conference was held in 2008 in Norway and was organised by an In Vitro Meat Consortium founded a year earlier. Stig William Omholt, at the time director of the Centre for Integrative Genetics in Norway, founded the consortium (Pincock, 2007; New Harvest, 2017). The consortium consisted of thirteen researchers from different countries in Europe and the United States but was discontinued due the lack of funding shortly after the first conference took place (New Harvest, 2017). In 2011, an IVM workshop took place in Gothenburg, Sweden. A multidisciplinary group of twenty-five researchers participated, highlighting the multidisciplinary challenges to develop IVM. Research interests of the participants ranged from tissue engineering and food technology to ethics, consumer perception and public sense-making (Gold, Wallin, & Borg, 2011). Starting in 2015, the University of Maastricht, together with a changing group of partners such NGO New Harvest, organised yearly IVM conferences – exemplifying Mark Post as the main player of contemporary IVM research (University of Maastricht, 2017a). Notably, the agenda of the 2017 conference showed that the event ended with a discussion, led by Mark Post, on how to manage expectations, indicating awareness of the importance of expectation management.

Several small groups of researchers have been working on IVM. Stephens (2010) reports on research clusters in Sweden, the US, Canada and the Netherlands. Later, also efforts in South Korea (Pandurangan, & Kim, 2015), Russia, Israel, Japan (Gunnarsdóttir, 2015; Sjoinmeat, 2018) and the UK have emerged (Stephens, & Ruivenkamp, 2016; Kowitt, 2017). With exception of the work of Mark Post, these sites have not reported on continuous IVM research efforts, nor have they claims success in production of an IVM product (Stephens, 2013).

Partly, IVM developments take place outside of academia. As mentioned earlier, artists have been of importance for the development of IVM by experimenting with animal cells out of animal bodies (c.f. Cats, & Zurr, 2002; Joachim, & Tandon 2014; van Mensvoort, & Grievink 2014). In addition, start-ups such as Mosameat, run by Mark Post (Mosameat, 2017) and Silician Valley-based MemphisMeats (MemphisMeats, 2017) play a role as they aim to produce to IVM products. Mosameat aims to bring IVM-minced meat products to the market for competitive prices in 6-8 years (Rodríguez Fernández, 2017), while it has claimed to have produced the first 'clean' lab-grown meatball in 2016 and poultry products in 2017 (Valeti, 2017). Unfortunately, no detailed information is available on MemphisMeats' production processes and products – other than the company makes revolutionary claims. More recently, start-ups such as Super Meat, Finless Foods and Shojinmeat have emerged (Finless Foods, 2018; Shojinmeat, 2018; Super Meat, 2018).

Finally, NGO's have played a role in promoting IVM by raising medio attention, attracting funding and lobbying for the value of IVM (-related) agricultural or biotechnologies to policy actors and commercial parties (O'Riordan, et al., 2017). Examples of relevant actors are amongst others: Next Nature, Modern Meadow and the Good Food Institute, while New Harvest, with Jason Matheny, has been particularly influential. Matheny for example reviewed a prominent Mark Post paper before publication (c.f. Post, 2012).

The substantiation of IVM research was echoed in the popular media. Two events in particular raised media attention. First, in 2008, People for the Ethical Treatment of Animals (PETA) offered a $1 million prize to the first company to bring affordable lab-grown chicken meat to consumers by 2014 (PETA, 2017). The product should be 'indistinguishable' from real chicken (PETA, 2017). Second, the presentation of the IVM burger by Mark Post in a media event gained attention. Though the burger was not the first IVM-product created nor the first eaten and the event was postponed multiple times, the presentation attracted media attention worldwide: on social media, other online media and print media (Catts, & Zurr, 2002; O'Riordan, et al., 2017) (see appendix B for an indication on the course of IVM's media attention, which shows the importance of the two events).

From early conceptual imaginaries to Van Eelen's patent and the first substantial research funding, and from transfer from different academic fields to substantial IVM research, the emergence of an academic discourse and worldwide media uptake, IVM has a diverse history over many sites and with different actors involved. It shows a hint of the dynamics of an emerging NEST, and its complexity. Now that the emergence of IVM has been outlined, an overview of current IVM production possibilities will be provided to show more concretely what is currently (not) possible.

B. Overview of Current IVM Production Possibilities

B-1. Basic IVM Production

IVM is a collective term for attempts to employ tissue engineering techniques[6] to create meat(-like) products from animal cells in laboratories (Edelman, Farland, Mironov, & Matheny, 2005; Bhat, & Fayaz, 2011; Stephens, 2013). Different methods exist to create IVM, while IVM is very much under scrutiny: technically and conceptually (Post, 2012; Stephens, 2013; Jönsson, 2016;). This section presents IVM's current production processes.

The basic idea of IVM is to acquire a sample of muscle stem cells from a living animal and to grow these cells in laboratory setting to an IVM-product. *Figure 1* provides an overview of the most important aspects of IVM production. To acquire animal material, most IVM production methods make use of a biopsy under local anaesthesia[7] (Kadim et al., 2015). The biopsy procedure is deemed 'harmless' (Chen, & Zang, 2015; Mosameat, 2017). For IVM purposes, myosatellite cells (or 'skeletal muscle stem cells') are the basic materials from which IVM is built in the lab. From the biopsy material, these myosatellite cells are isolated from other tissue acquired in biopsy, such as nerve and fat cells. In living animals, myosattelite cells have the function to repair damaged muscle tissue (Post. 2013). Accordingly, these cells have a set of characteristics, which can be exploited in IVM production (Post, 2013; Arshad, 2017;). Key characteristics of myosatellite cells[8] are that they can divide,

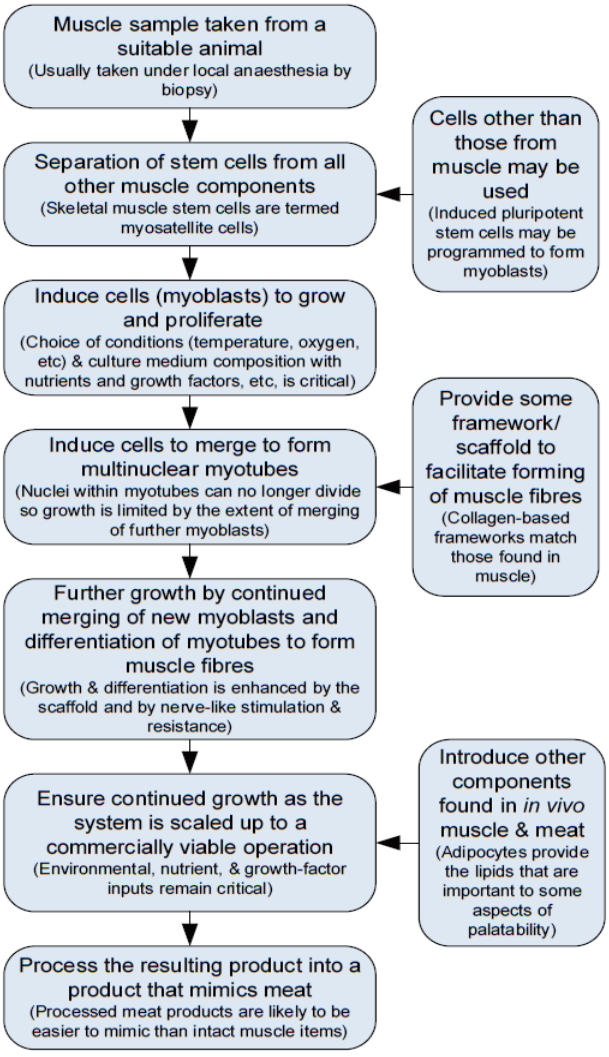

Figure 1: Overview of IVM production basics. An overview of the most important steps to produce IVM (Image from: Kadim et al., 2015, p. 223).

[6] For simplicity's sake 'tissue engineering techniques' is used here to cover all relevant techniques involved.
[7] The alternative is to acquire cells from a freshly killed animal, which is not in line with IVM's purposes.
[8] The potential of other cells, such as pluripotent stem cells, is under investigation, but has received relatively little attention thus far (see Post, 2012 and Kadim et al., 2015).

multiply and merge. In IVM production, myosatellite cells can be stimulated to proliferate by putting them in the right culturing conditions (Post, 2012). When the cells have grown to sufficient size, they are starved and given that the right surface is provided, cells merge so that they form strands of muscle cells, resembling an ordinary muscle (Edelman et al., 2005*)*. By way of proliferating and merging cells, it has been claimed that, theoretically, one cell can result in 10.000 kg of meat (Post, 2013). The processes of proliferation and differentiation phases are key in IVM production. Below, they will be described in more detail.

B-2. Proliferation and Differentiation of Myosattelite cells

The proliferation phase starts when myosatellite cells are isolated and placed in a so-called 'medium' in the lab. The medium is a bath of nutrients which has the purpose to induce proliferation of the cells (Post, 2012). While the composition of the medium is still under scrutiny, it typically contains carbohydrates, lipids, vitamins, foetal bovine serum, antibiotics, growth factors such as IGF and FGF, and hormones such as insulin (Hocquette, 2016; Jönsson, 2017). Of note is that media currently contain an animal product: foetal bovine serum, a by-product of the bio industry (Post, 2012; Dilworth, & McGregor, 2015; Jönsson, 2016). The possibilities for animal-free nutrient media are under investigation but hitherto not achievable (Post, 2012; Post, 2013; Stephens, 2013). In addition, because of the laboratory setting in which cells are grown, chemicals are needed to keep production sterile and free from contamination risk (Bonny, et al., 2015).

When cells have proliferated to sufficient size, the differentiation phase starts. By starving the cells, they stop to proliferate (Post, 2013). When placed on a scaffold with strategically placed anchor points, cells attach themselves to the anchor points (Post, 2013). This process facilitates the merger required to grow a muscle, which is essentially a strand of merged muscle cells (Post, 2012). In addition, cells will start to contract and produce extra protein (Bhat, & Fayaz, 2011; Post, 2013). In the context of IVM as a foodstuff and meat substitute, protein is a key nutrient.

With the completion of the differentiation phase, in vitro muscles are grown. These are glued together and, with some additives, an IVM product is created. The burger presented at the 2013 burger tasting event was created by this process (Post, 2013). The process involves a lot of repetitive small-scale work as 20.000 muscle fibres were grown and glued together. The entire process took between seven and eight weeks (Hocquette, 2016; Post, 2013).

B-3. Possibilities and Limitations of Current Production Methods

While IVM products can be produced with the methods described above, some aspects of these products are different and/or unfavourable compared to meat. This section will provide an overview

of the (in)possibilities of current IVM production in order to provide a starting point for reflection on IVM's promises and concerns.

IVM products are yellow as there is no blood circulation in the in vitro grown cells, so haemoglobin cannot provide for the typical meat-colour. In production of the 2013 IVM burger, therefore, beet juice and saffron were added for the product to look more meat-like. In addition, valuable nutrients of meat, like vitamin B12 or iron are lacking in IVM products as they are made solely from cell material. Vitamin B12 or iron stem from gut bacteria and the blood of livestock (Jönsson, 2016). Fat tissue, which co-produces meat's flavour, is missing in IVM products as well (Hocquette, 2016). Furthermore, some biological processes which impact the sensory appeal of meat, are hitherto poorly understood. When an animal dies, for example, circulation of oxygen stops which relaxes the muscles (Hocquette, 2016). This process is possibly related to tendering of the meat, but is insufficiently understood (Hocquette, 2016). In principle, all that is unknown about meat is unfavourable for IVM production as it hinders the aim to imitate meat as closely as possible.

To date, most IVM production efforts have revolved around the production of processed meat products such as sausages or hamburgers. Because of the scattered structure of processed meats, they are easier to recreate as for instance a T-bone steak. Other cells, such as pluripotent stem cells[9] could potentially be used to grow non-processed meat, but IVM-research with those cells is rare and its prospects uncertain at best (Kadim, et al., 2015; Moritz, Verburggen, & Post, 2015). There are other insufficiencies before IVM can resemble meat. Current production techniques are relatively inefficient and expensive (Post, 2012; Post, 2013; Post; 2014a; Hocquette, 2016). Not only are expensive materials needed, also a lot of labour-intensive laboratory work is required. Therefore, the single IVM burger presented in 2013 costed around $330.00.- (BBC, 2013). IVM researchers, though, are generally hopeful about costs reductions as large-scale production is associated with a severe reduction in price (Bhat, & Bhat, 2011).

Upscaling of production is necessary in order to produce IVM products more quickly, more efficiently and to start to fulfil IVM's promise as a meat substitute (Mortiz, Verbruggen, & Post, 2015). Large scale production faces a number of challenges, for example in relation to the insufficiencies raised above, but also particular technical challenges such as how to best incorporate fat tissue for taste (Kadim, et al., 2015). Furthermore, current production relies too heavily on manual labour for large scale production to be possible (Post, 2013; Mortiz, et al., 2015). Different

[9] Pluripotent stem cells can be 'engineered' to differentiate into different types of cells.

methods to guide IVM towards large scale production have been envisioned but have only been tested on a small scale (Kadim, et al., 2015). Three different systems are envisioned that could enable large scale production of IVM, each with its own challenges and prospects (c.f. Mortiz, et al., 2015). The three options are (1) microcarriers in suspension (2), cell aggregates and (3) packed bed bioreactors. These options are compatible with different types of cells, while for each option there are challenges with regards to: the density with which cells should be concentrated on the surface, costs of materials and general uncertainty and not yet researched aspects (Mortiz, et al., 2015). It is hard to reflect on the prospects of these large-scale production systems as their possibilities are merely discussed from a promissory perspective. For the purposes of reflection, it can merely be noted that, from this promissory perspective, the prospects are for large scale productions systems are hopeful (c.f. Moritz, et al., 2015).

With current IVM production possibilities the case description is concluded. The theoretical framework of the thesis will be provided in chapter III, which features a discussion of the SoE in section A, valuation of IVM in section B and ADA in section C.

III. Theoretical Framework

A. The Sociology of Expectations

A-1. Introduction to the Sociology of Expectations

The sociology of expectations (SoE) is a research domain that is, amongst others, related to Science and Technology Studies (STS), future studies and the sociology of time, and is frequently concerned with NEST. As the name suggests, the SoE focuses on expectations as a site of analysis. SoE studies of NEST claim that expectations play important roles in the emergence and materialisation of NEST which therefore requires that expectations are critically analysed (Borup, et al., 2006; Konrad, et al., 2017).

The SoE has demonstrated that expectations are performative, meaning that they have agency and so co-shape how NEST-futures materialise (Konrad, et al., 2017). The manifestation of a SoE is in line with a general interest in the future as constitutive of the present (Konrad, et al., 2017). The logic of the claim that the future is constitutive of the present works roughly as follows. When an expectation is uttered, a claim is made about the composition of the future. By extension, envisioning a future has implications the present (Konrad, et al., 2017). For governance questions for instance, envisioning a future which a problem occurs warrants action in the present.

Central to the SoE is that the future is a contested terrain, meaning that it holds a variety of interests which are contested and negotiated in the present (Brown, Rappert, & Webster, 2000). This implies that expectations and how they contested co-constitutes present debates and governance issues. In the SoE, 'expectations' are defined as *"statements about future conditions or developments that imply assumptions about how likely these are supposed to be and that travel in a community or public space"* (Konrad, et al, 2017, p.466). By outlining five key characteristics the following paragraph delves deeper into this definition and the nature of expectations in the context of the SoE.

A-2. Five Key Characteristics of Expectations

Fist, of note is that the SoE is interested in collective expectations, meaning that it is concerned with expectations that are shared in the social repertoire of stakeholders (Konrad, et al., 2017). By focussing on collective expectations, the SoE traces their collective effects – beyond a blurry web of singular utterances. In line, the SoE claims that collective expectations have the main performative effects: "*the main performative roles of expectations in mobilizing, guiding, and coordinating diverse sets of actors involved in techno-scientific fields require expectations which are to some degree*

common, shared reference points" (Konrad et al, 2017, p. 466). To acknowledge the agency of collective expectations, however, is not to downplay the agency of individuals.

Second, though the aforementioned definition speaks of expectations as 'statements', the SoE recognizes that expectations can materialise in different forms. Most intuitively, expectations can be written statements or spoken words. Expectations, however, can also manifest themselves in other forms such as images[10], graphs or even material assets such as government investments (Konrad et al., 2017).

Third, the SoE highlights that expectations are not merely techno-scientific, but that they are typically heterogeneous in that they can refer to economic, social and/or cultural trajectories as well (Konrad., et al 2017). The heterogeneity of expectations highlights that expectations are fundamentally linked-up with extra-technoscientific dynamics such as cultural reflections, governance questions or socio-economic issues. For example, when one claimes that IVM can substitute meat when it can be produced for competitive prices, this implicitly assumed that IVM will be culturally accepted as a foodstuff and that its production will not clash with government regulations.

Forth, SoE studies typically focus in on language and rhetoric and metaphors specifically *"to show how, through discourses, meaning is constructed and interpretive social repertoires are formed, be they media, policy, or scientific"* (Konrad et al., 2017, p. 468). A paper by Väliverronen (2004), for instance, concludes that scientists can rely on positive metaphors to evoke emotions for purposes such as popularising complex research results.

Finally, the SoE generally acknowledges that one of the processes by which collective expectations emerge is *"as the result of strategic voicing and dedicated promotional efforts of actors"* (Konrad et al., 2017, p. 467). This is an indication that the manifestation of expectations can be intrinsically linked up with strategical efforts to promote certain interests, such researchers' interests (c.f. Swierstra, 2016). Having presented a basic understanding of expectations in the SoE, valuation dynamics of expectations are discussed next.

A-3. Valuation Dynamics

Of central importance for this thesis is that expectations generally imply positive or negative valuation as they point to the desirability and/or likelihood of a future (Konrad et al., 2017). As a

[10] Stephens and Ruivenkamp (2016) have studied how images of IVM have changed after the 2013 burger presentation and how they enable different readings of what IVM is and can accomplish.

result, expectations manifest themselves as promise, a positive expectation, or concern, a negative expectation (Te Kulve, et al., 2013; Konrad., et al. 2017). Whereas promises highlight the potential and assumed benefits of a development, concerns refer to risks or potential problems (Te Kulve, et al., 2013). This is particularly interesting in light of the strategical reasons for positing expectations as it indicates a possible relation between strategic action and valuation of NEST.

Most valuation-related SoE research has focused on promissory rhetoric, which has yielded that promises are characterized by embedding a positive future scenario under condition that additional work, investments and/or alliances are required (Konrad et al., 2017). Nerlich and Halliday (2007), among the few researchers that have focused on concerns (Konrad et al., 2017), have shown that negative expectations can have the performative effect of *"demoralising individuals and society, neutralising urgency, producing cynicism and indifference and stifling sustained investment"* (Nerlich, & Halliday, 2007, p. 48). Generally, it is assumed that concerns fulfil similar roles as promises, but this has hitherto not been subject to much scrutiny (Te Kulve, et al., 2013).

An important function of promises and concerns is that their aggregated relation makes up for de facto assessments of NEST, as part of ongoing informal assessment (te Kulve et al., 2013). Promise-concern relationships indicate how a NEST is valued and are part of the ongoing conversation of what is assessed (Te Kulve et al., 2013). Promise-concern relationships have hitherto received little action, though Te Kulve and colleagues (2013) have laid important groundwork. They found that promises and concerns can relate to each other in different ways in different academic contexts. Te Kulve and colleagues (2013) showed how promises of nanotechnology linked up with discursive patterns in different domains, thereby showing a differentiated picture based on domain characteristics. These divergent meanings were found to impact sense-making and valuation of the technology, and even the notion of 'responsible innovation' itself (te Kulve et al., 2013). Furthermore, the authors highlighted how promises and concerns do not necessarily balance each other out, but that promises and concerns can relate in different ways (te Kulve et al., 2013). To give some examples, promises can be positive for some and problematic for others, while concerns can support promises by calling for specific requirements or for risk-assessment. The valuation of expectations thus takes shape in different discursive contexts in discursive interaction.

It is found that valuation plays a particular role in the early stages of NEST, which is the topic of the next section.

A-4. 'Early' Promises and Promissory Rhetoric

A significant part of NEST-literature regarding valuation is entangled with the notion that NEST tend to require a degree of 'hype' before they can be successful (Brown, 2003). The notion of hype in context of NEST originates from business and Gartner Consultancy's hype cycle model has been especially influential (see figure 2).

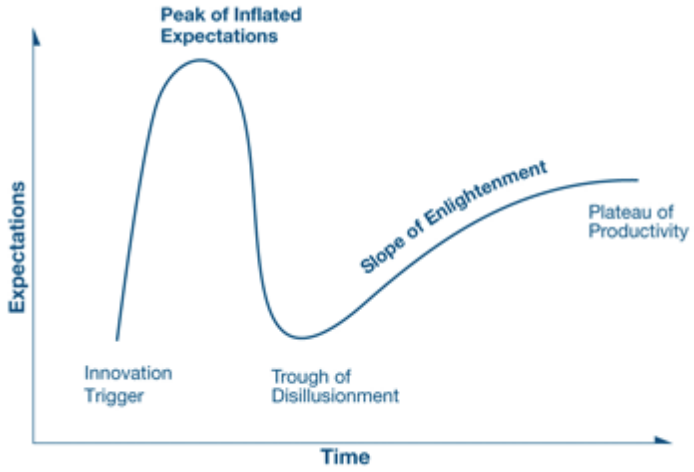

Figure 2: Gartner's Hype cycle. An influential simplified model of the NEST hype-dynamics. Image from: Gartner, 2018.

Put simply, the idea is that NEST require a period of exaggerated promises in which they raise a spike of positive attention, which mobilises necessary support for successful take-off. Gartner's model holds that, following the hype, a sobering period of disillusionment follows, after which the development reaches a state of progression, so it can successfully enter the market - under condition that funding sustains when promises are not met in the disillusionment trough (Gartner, 2018). Though Gartner knows variants of the standard image of hype, the SoE has contested the implied simplicity in the 'need' for NEST to progress through five standardized phases. The idea that some hype is typically required for NEST to be successful, however, is widely shared within the SoE (Brown, 2003; Borup et al., 2006; Konrad et al., 2017).

It is important to note that hype is not something that is produced or encountered outside of academia. Rather, the SoE studies the contribution of scientists to the valuations of NEST, including hype dynamics (Brown, 2003; Konrad, et al., 2017). For example, in case of biotechnology, it is claimed that in *"the journeys or travel that biotechnology expectations make in their passage from laboratory to the news page, it is absolutely clear that it is no longer possible to go on simply blaming the media for hyping things up. Research communities are crucial participants in the production of hype"* (Brown, 2003, p.14, emphasis added). Caulfied and Bubela (2004) have shown that scientific research tends to focus on benefits of research, which is taken over in media reports. Media reports, in turn, typically only slightly exaggerate findings from scientific reports (Caulfied, & Bubela, 2004) In case of climate change, moreover, it has been demonstrated that scientists actively pursued

political acknowledgement. In that case, media tended to reduce uncertainty and make claims that prompt urgent action (Weingart, Engels, & Pansegrau, 2000). Brown (2003) portrays the production of hype as a linear dynamic where expectations grow increasingly as they move from the laboratory to the wider public. While this linear perspective might be overly simplistic, for the purposes of this thesis it is important to note that scientists actively produce positive expectations regarding their work and that they can make efforts to politicize their work.

Different kinds of motives can be distinguished to account for scientists engaging in promissory rhetoric. First, support is needed for NEST to be successful. They require attention and other types of support to be able to develop further, think of financial, political and policy support (Swierstra, 2016). To acquire these resources, scientist and technologist provide ethical arguments in the form of positive expectations. Typically, they take a simplified form*: "if you invest now, tomorrow you will reap the benefits (cure for cancer; solution to hunger; peace through better communication, etc)"* (Swierstra, 2016, p. 13-14). Second, NEST emerge in a world with existing and other emerging techno-scientific options with which they continuously compete (Joly, 2010). Within this competition, promises are key in future-oriented coordination. Delving one step deeper, often a problem needs to be conceptualised for which the to-be-promoted NEST is positioned as an obligatory passage point (Joly, 2010). At the same time, this ensures that alternative solutions are dismissed (Joly, 2010). Fundamental NEST-promises thus tend to emerge against the backdrop of a problem analysis in which existing, and/or emerging techno-scientific options are downplayed. Finally, Swierstra (2016) notes the psychological tendency that positive expectations reflect the pride and enthusiasm of NEST developing scientists and technologists.

The motives described in the above have been reported in empirical research. Brown (2003) recounts a case in which overemphasising potential benefits and downplaying costs was required to acquire funding and permission for painful animal testing. In Brown's (2003) case, the role of a prominent scientists who raised unrealistic expectations was explicitly salient. A study by McGrail (2010) has reinforced the idea that NESTs are sensitive for hype. In his case study of nanotechnologies, a polarized debate took place: one was either a nano-optimist or a nano-pessimist. The polarisation of the debate went hand-in-hand with positions at both ends of the valuation spectrum. McGrail (2010) shows how proponents relied on notions of hype to bolster their positions and to argue against sceptics. Kitzinger and Williams (2005) have shown that in stem cell debates in the media, there too was a polarized debate between proponents and opponents. Their study highlights how both groups relied on their own rhetorical strategy in line with their value-

based position. Amongst others, they drew on hype and anti-hype, read scientific reports differently, used their own metaphors and linguistics webs of meaning, specifically aimed to discredit opposition and selectively and/or differently used words such as 'potential', 'expert', 'hope', 'reason', 'progress' and 'breakthrough' (Kitzinger, & Williams, 2005).

Following insights in the role of NEST hype-dynamics, analysts have pointed out different downsides of the tendencies of actors to co-produce, rely on and bolster hypes – especially proponents. It has been noted how hype-dynamics can inflate promises to become inflexible and exaggerate prospects and risks (Brown, 2003). In line, inflated expectations can provoke strong replies which are not in the interest of those uttering these expectations (Joly, 2010; McGrail, 2010). In addition, the hype of one particular NEST-development can exclude existing or competing viable options (Joly, 2010). Similarly, NEST can take away resources for other options or blackbox (the success of) existing knowledge and procedures (Joly, 2010). A related underlying point comes to the fore in that with-hype-infused NEST can push for techno-scientific solutions while problems might be non-technological in nature, for example socio-economic (Joly, 2010). As promises often point to benefits for the public, inflation of promises can lead to public disappointment, and, as a long-term result, loss of trust in science (Peterson, 2009). In addition, promises might be inflated in the sense that they will not have benefits for the public at large, but for a specific sub-group (Peterson, 2009). For example, a newly developed medical treatment might only be available for the rich because its production costs.

This section has shown that NEST tend to rely on promissory rhetoric for successful development, which has some worrying potential side-effects. Moreover, strategic reasons for uttering promissory rhetoric were highlighted – a phenomenon that manifests itself in and outside of academia. The following section takes a detour to one particularly interesting case study which emphasizes the way in which ethicists dealt with promises of a techno-scientific development. This section concludes the theoretical perspective with which IVM expectations are analysed. An overview of promises and concerns in academic research on IVM follows thereafter.

A-5. A Case of Ethicists Following Scientists' Expectations

The literature above has dealt with scientists' expectations of NEST working on the technology. Academic discourses of NEST, however, are also informed by work of ethicists, philosophers, sociologists and other reflective scholars. One particular analysis of an academic biotechnological discourse has implications for this thesis. Hedgecoe (2010), studied the contribution of bioethicists

to pharmacogenetics[11] debates. Notably, he showed that bioethicists adhered to three tendencies in which they were uncritical to scientists working on the technology. First, they largely followed the expectations raised by scientists without question and tended to neglect ethicists who did. Second, they merely contributed to the debate within the lines set out by scientists, who themselves actively framed ethical issues. Third, they did not bring new issues to the table nor did they offer specific critiques while these were easily imaginable (Hedgecoe, 2010). By these findings Hedgecoe (2010) highlights both the power of scientists working on the technology, as well the shortcomings of ethicists. He further notes how bioethicists have a shared interest with scientists to show a future in which pharmacogenetics plays a significant role. For ethicists, this enables them to continuously debate ethical issues (Hedgecoe, 2010). What Hedgecoe (2010) assesses is that ethicists' tendency to avoid fundamental debates about the construction of pharmacogenetics is problematic and has led them to merely focus on the application of the technology (Hedgecoe, 2010).

As Hedgecoe (2010) provides a single case study, precaution is warranted for drawing implications from his findings to the case of IVM. What is interesting, however, is to take note how and to what extent reflective IVM scholar draw on the expectations, arguments and parameters for debate that IVM scientists have set out. Hedgecoe's analysis is thus used as a frame of reference for the work of reflective scholars in case of IVM.

B. How IVM is Valuated in Academia

B-1 Introduction to Promises and Concerns

Many promises and concerns have been raised concerning IVM. These range from promises that IVM will contribute to combatting food poverty, like van Eelen had envisioned in the 1950s, to concerns that IVM production will be unsustainable. An overview of promises and concerns is given below. Thereafter, the thesis will delve into IVM's valuation-dynamics.

B-2 Overview Promises and Concerns

IVM's promises are usually envisioned in comparison to meat and for a situation where IVM has achieved sizeable market share. A notable exception is IVM's early promise to provide for meat in space. More conventional IVM promises are: reduction of animal suffering and, specifically, eliminating the need for the killing of animals for human food production (Hopkins & Dacey, 2008). In addition, it is envisioned that IVM production might not require medical interventions such as usage of antibiotics or hormone injections and that animal-borne diseases might be avoided (Post,

[11] Pharmacogenomics aims to develop medication that will be tailored one's individual genetic makeup.

2012). IVM might also be better for human health by reducing the saturated and trans- fat contents and increasing poly-unsaturated fat content of meat products (Bhat, & Fayaz, 2011; Miller, 2012). Other promises hold that IVM has environmental benefits: reduction of land, water, and energy usage and lower greenhouse gas emission rates (Tuomisto & Teixeira de Mattos, 2011) and that IVM might help to address global food poverty (Haagsman, et al., 2009). It has also been proposed that IVM could enable the possibility for exotic meat products. More than meat from livestock, cells from other animals could be cultured to exotic meat products such as tiger steak (Laestadius, 2015). In line, IVM could take on different textures, colours, shapes, that meat cannot (Datar & Betti, 2010). Finally, it is proposed that IVM could be quickly produced, and lead to profit (Kadim et al., 2015; Stephens, & Ruivenkamp, 2016).

A wide range of concerns have emerged regarding IVM. Mostly, concerns question the viability of IVM's promises and point to hurdles on the way to large scale production and consumption. Questions regarding IVM's consumer acceptance have been outed in many different forms, they range from concerns over sensory appeal, unnaturalness, 'yuck-responses', the 'chemical' nature of IVM (Marcru, et al., 2015, Mattick, Landis, Allenby, & Genovese, 2015a), claims how IVM is unlike meat (Jönsson, 2016) and the need for a sterile laboratory environment (Bonny, et al., 2015). In line with current IVM production (in)possibilities, concerns have emerged over technical issues before IVM can deliver on its promises (e.g. Hocquette, 2016). Moreover, ethical concerns have been raised, amongst others about labelling of IVM as meat, how to categorize and understand treat living animal cells in the lab and concerning IVM's ascribed tendency to view animals instrumentally (Dilworth, & McGregor, 2015; Hocquette, 2016). Questions are also put to the economic viability of IVM (Chiles, 2013a; Hocquette, 2016). Other remarks have been made regarding the need for IVM. Organisations like the Dutch Vegetarian Organisation claim that meat consumption is not necessary and that meat products can be replaced with vegetarian alternatives instead of IVM (Vegetariërsbond, 2017). In line, it has been pointed out that IVM leaves intact the dominant position of the meat industry (Hopkins, & Dacey, 2008).

Having presented IVM's promises and concerns in academic research, the next section discusses how analysts have made sense of these expectations.

B-3. SoE Studies of IVM

Stephen's (2013) coins the concept "ethical boundary work" in his study of IVM proponents. He dissects how proponents draw ethical boundaries to support an animal liberation-centred narrative of IVM. In this way, IVM-proponents construct a particular promissory narrative, with an

accompanying understanding of what IVM is and what it can achieve (Stephens, 2013). Stephens (2013) demonstrates that to take a position in IVM debates, stakeholders carefully construct narratives in which ethics, materiality, promise and ontology are interrelated and support each other reciprocally. Stephens' (2013) findings are in line with the discourse methodology of this thesis, which will be outlined in the following section.

Studies by Chiles (2013a, & 2013b) focus in on how political stakeholders draw upon ideological frames to make sense of IVM which influences the position of said actors within IVM debates. Chiles' work shows that ideology plays important roles in making sense of IVM and reciprocally, how a techno-scientific development like IVM lends itself for reinforcement of ideological positions. For instance, Chiles (2013a) demonstrates that proponents and sceptics drew on different myths and metaphors to make sense of IVM. Whereas proponents drew on ideologies such as efficiency and progress, sceptics evoked the metaphor of 'Frankenfood' (Chiles, 2013a). He concludes that IVM can be valuated radically different depending on one's ideological viewpoint. Though the discursive approach of this thesis conceptualises ideology as intertwined with, and not a priori to, discourses, Chiles' findings show how ideologies and linguistics tendencies play crucial roles in issues of conceptualisation and valuation of IVM.

Stephens and Ruivenkamp (2016), zoom in on the importance of physical images of IVM. They point to the significance of the highly controlled burger presentation. The researchers show how images of IVM before and after the burger's presentation differ, thereby highlight the importance of the presentation. In addition, they show that physical images can be vehicles for different ways of understanding IVM and as important anchor points expectations. Stephens and Ruivenkamp's work highlights how the burger presentation successfully communicated the vision of proponents.

A study of Jönsson (2016) criticizes proponents of IVM who, on his view, tend to overstate the flexibility and uncertain nature of IVM, leading them to take certain promises and technical possibilities of IVM for granted. Jönsson (2016) argues that the context of the laboratory and ecology have been overemphasized and he points to the larger context of biotechnologies in which IVM-debates take part. In discussions regarding biotechnology, Jönsson (2016) identifies a tendency to narrate stories of biotechnological salvation, which IVM is made to fit by proponents. By his efforts, Jönsson (2016) shows that proponents of IVM build their narratives on ideas that should not been taken for granted and require (more) critical reflection. His critical inquiry is key in broadening promissory IVM-rhetoric.

IVM's proponents have shown awareness of the importance of early promises and have aimed to strategically govern expectations in case of IVM. This is acknowledged by involved IVM-scientists (Chiles, 2013a) as well as noted by analysists (Jönsson, 2016) and exemplified by Mark Post's highly scripted IVM burger presentation in 2013 (O'Riordan, et al., 2017). Stephens (2013) noted how IVM is a form of 'promissory science' that exists more in promise than actual research results. It is against this background that the quote from Mark Post for the reasons behind for the burger presentation (page 10 of this thesis) should be understood. Post was motivated to show a tangible IVM research result to anchor further strategical efforts and to raise funding. That IVM researchers are committed and eager to maintain positive expectations has been echoed in other ways as well, for instance in a case where IVM-researchers publicly criticized colleagues to protect hype-dynamics and prevent perceived undesirable associations (Chiles, 2013a). The quote given below, by Dutch IVM researcher Henk Haagsman, exemplifies the awareness of IVM proponents of the importance of managing expectations:

> *"Coverage by the media has been beneficial for public awareness and initiating discussions about innovative ways to produce animal proteins. On the other hand, media attention raised high expectations by citizens and media alike. If research continues at the present pace and progress remains slow, the present enthusiasm for the technology may dwindle"*
> (Haagsman, et al., 2009, p. 38).

This section's overview of analysists efforts to grasp issues related to the valuation of IVM has given some indications, but not answered the questions that prompts this thesis. Especially, in depth attention for the value-laden arguments of IVM and how these arguments relate is missing. The final section of the theoretical framework introduces the argumentative approach to discourse analysis that this thesis employs.

C. Discourse Analysis

C-1. Introduction to Discourse Analysis

Discourse analysis (DA) is employed to uncover the relationships between promises and concerns in the academic IVM discourse. Employing DA implies that the thesis relies on some fundamental assumptions and insights that come with DA. These will be noted below, followed by an overview of the intricacies of the type of DA that is used in this thesis.

DA stems from the social constructivist tradition and aims to critically analyse the ways in which language is used within a given context (Jørgensen, & Phillips, 2002). DA assumes that language does not copy or mirror the world, but that it actively co-shapes the world and how one understands

it (Hajer, 1993). Its ontology assumes the existence of numerous socially constructed realities instead of a singular universal one (Hajer, & Versteeg, 2005). Of importance from this perspective, then, is not how reality or a part of it *is*, but how meaning is given to it (Hajer, & Versteeg 2005). DA suggest that language, in all its manifestations, plays a central role in this process; it influences how meaning is given to social and physical phenomena, perception and cognition, and it distributes power" (Hajer, 1995; Hajer, 2017). Important to note is that language is not a neutral means through which meaning, perception, cognition and interests are communicated. From the perspective of DA, language is co-constitutive of those (Hajer, 1995). To explicitly note an important aspect, as there is no one reality but multiple socially constructed ones from the perspective of DA, the process by which these realities acquire meaning is political. Discourses give meaning as they provide structures that highlights some aspects while ignoring others (Hajer, 1995). Building on these insights, DA studies linguistic regularities and variations within a given context and related practices (Hajer, 1993; 1995). From the perspective of DA, valuation is part of meaning-giving processes. Valuation concerns the colour of, or the judgment that come with meaning-giving processes.

C-2. An Outline of Argumentative Discourse Analysis

A form of DA that focuses on arguments as the unit of analysis is thus used in the thesis. It is in arguments that valuation of IVM comes to the fore in the academic discourse Developed by Hajer (1993; 1995; 2006), this type of DA is also known as argumentative discourse analysis (ADA). ADA defines discourse as: *"an ensemble of ideas, concepts, and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices"* (Hajer, & Versteeg, 2005, p. 175). ADA is based on Foucauldian discourse analysis and is specifically oriented at interpersonal interaction. This is helpful in analysis of academic IVM discussions as discussion and exchange is key in academia.

Hajer (1995) appreciates Foucault's relational ontology with a study of practices but has criticism as well. He identifies two main sites of improvement of Foucauldian discourse analysis. First, he finds that the possibilities for a subject to produce and transform a discourse are underemphasized. Hajer (1995) claims that actors, within discursive structures, are actively engaged in argumentative struggles where they aim to show others their way of seeing the world and work to position others in specific ways (Hajer, 1995). For analysis of discourse, this means that it is important to investigate not only linguistic expressions, but also the context in which and, possibly, against which position an expression is made - for else argumentative meaning is lost (Hajer, 1993; 1995). Hajer (1995) thus

points to the importance of understanding the social background of specific modes of talking. This is one of the reasons why historical notes on IVM are of importance for the interests of this thesis. Second, Hajer (1995) states that Foucauldian discourse theory does not sufficiently explain how social change and permanence works. Hajer (1995) points to the importance and necessity for discursive rules, conventions and distinctions to be consistently reproduced through speech acts (Hajer, 1995). This means that speech acts, such as documents, that do not contain new information are important in reproducing existing discursive patterns, for without reproduction the discourse would cease to exist. In discursive reproduction or transformation, actors are: *"holders of specific positions, entangled in webs of meaning"* (Hajer, 1995, p.56). This means that agency plays out within in the duality of structure: actors are both constrained and enabled by it. Discourses provide structure that constrain what actors think and say, and at the same time, enables them to out their agency. Here, cognitive routines play important roles in structuring the viewpoints of actors (Hajer, 1995). For IVM, this implies that discursive changes and discursive stability are of importance. Whereas changes emphasise the dynamism, stability points to discursive structure.

Simply put, ADA provides some key concepts that form basic building blocks to grasp the ways in which meaning is given to the world. In addition to 'discourse', the key concepts are 'storyline' and 'discourse coalition'. These concepts are evoked to show how discourses are maintained or altered (Hajer, 1993; 1995). Though this thesis provides a micro-level analysis of a case study and the concepts of story-line and discourse coalition are to be employed for larger scale interdiscursive issues, these concepts will be briefly presented below for sake of comprehensiveness. A story-lines is: *"a generative sort of narrative that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomena"* (Hajer, 1995, p.56). Story-lines are important in creating unity among different discourses and, thereby, reduce complexity and create potential for closure for interdiscursive issues (Hajer, 1995). A further purpose of story-lines is to allow actors to speak about phenomena beyond their own expertise or experience (Hajer, 1995). In this way, story-lines provide actors with a set of symbolic references that suggest a common understanding. ADA suggests that discourse coalitions are formed in the struggle for hegemony in a discourse. Discourse coalitions are defined as: *"an ensemble of storylines, the actors who utter these storylines and the practices in which this discursive activity is based"* (Hajer, 1995, p.65). Story-lines are the basis of the coalition, they form the cement that hold it together. This contrasts with other approaches in which interests provide the ground for coalitions and social constructs in general. In Hajer's approach, interests are not a priori, but *"intersubjectively constituted though discourse"* (Hajer, 1995, p.51). In

line, Hajer argues that interests should not be seen against the background of deeply held beliefs or ideology, but that *"discursive interaction (i.e. language in use) can create new meaning and new identities, i.e. may alter cognitive patterns and create new cognitions and new positionings"* (Hajer 1995, p. 59). In the historical section, for instance, it was shown that IVM held different identities and promises over time.

This section has concluded the theoretical framework, which has provided a sturdy backdrop for the remainder of the thesis. The next chapter outlines the methodology, discussing the make-up and selection of the sample, after which the analysis is presented.

IV. Methodology

A. The Sample

A-1. Sample Selection

A selection of recent academic works that discuss IVM is examined in this thesis. Based on searches with two academic search engines, SCOPUS and Google Scholar, 46 published articles were incorporated in the sample[12]. Searches were done for "In Vitro Meat" and often-used synonyms such as: "Cultured Meat", "Lab-Grown Meat", "Factory Meat", "Synthetic Meat" and "Artificial Meat". To provide an assessment of how IVM is valuated in academia, and because discourses are dynamic in nature and develop over time, articles published before 2015 were not included in the analysis. This means that a cross-sectional analysis of the recent academic IVM discourse is provided. The primary sample was collected in September 2017, meaning that it is comprised of articles from January 2015 to September 2017. It is thus assumed that the discourse has not significantly developed in a period of two and a half years.

The search results were filtered so that only academic IVM-related works remained. Several criteria thought of beforehand were used as a checklist to make sure the sample included enough relevant works. The primary sample was checked for: inclusion of review articles, articles from the most prominent IVM researchers and domain. By this approach, it was ensured that the sample featured overviews of the discourse, incorporated the influence of main players and include articles from a variety of different backgrounds (e.g. tissue engineering, food science, sociological, philosophical).

A-2. Composition of the Primary Sample

The most obvious observation regarding the primary sample was the lack of papers focusing on IVM production technicalities and related tissue engineering developments[13]. In the primary sample, only two out of the forty-six papers had that focus. These two papers, moreover, did not refer to IVM extensively and only briefly mentioned IVM as possible context of application - while discussing tissue engineering developments extensively (cf. Schuster, Wallin, Klose, Gold, & Ström, 2017; Verbruggen, Luining, van Essen, & Post, 2017). The primary sample included eight review papers in which technical developments were discussed. Notably, some of the reviews as well as the

[12] This sample is henceforth referred to as 'primary sample' as an addition to sample was made later.
[13] Tissue engineering is used here as an overarching term for developments of relevance to produce IVM. For brevity's sake, I will refer to papers that concern on IVM production technicalities and related tissue engineering developments as 'technical'.

two technical papers cited technical works in which IVM is not mentioned. Because IVM is historically developed by researchers and artists with backgrounds in tissue engineering, regenerative medicine and fields alike[14], insights relevant for IVM are thus taken from these fields. Whereas the proportion of technical papers in the primary sample is rather small (N=2 + 8 review papers/46), sociological and philosophical works reflecting on IVM on a meta-level are quite prevalent. In total, these works comprised almost a third of the primary sample (N=15/46). The remainder of the primary sample is comprised of works from socio-psychological perspective (N=8/46), meaning articles that report on quantitative and qualitative social science experiments that feature psychological elements or motives. Finally, reviews that focus on more than just IVM (N=4) and a scattered group of other materials (N=8/46) were part of the primary sample.

A second observation concerns the large proportion of sociological and philosophical papers in the primary sample. This is noteworthy since technical papers usually dominate NEST-debates. A nuance is that a significant proportion (N=6/15) of the sociological and philosophical papers was interested in IVM as a case study amongst others, or more comprehensive issues such as food culture or animal welfare. Nevertheless, the large proportion of sociological and philosophical works is salient. Moreover, of 'Ethical Legal, Social Implications' (ELSI)-type of research it is typically claimed that it comes too late; after NEST have stabilised and have become relatively immune to change (as potentially warranted by 'ELSI'-research). The extent to which the sociological and philosophical papers in the primary sample contribute to critical reflection of the technical papers is discussed in section D-4 (p. 55-57) in light of the findings of Hedgecoe (2010). Possible explanations for the large proportion of sociological and philosophical papers in the primary sample lie in that IVM has progressed quite slowly, implying that technical works were more dominant in earlier days of IVM. Some basic Google Scholar searches for IVM in the period 2005-2010 confirmed this suspicion. Moreover, it could be the case that technical developments of IVM have transferred to business via start-ups, as exemplified in the recent emergence of IVM-start-ups which have received substantial funding and media attention[15]. In addition, IVM has emerged against the backdrop of larger trends such as in innovation in bio(medical)technology and tissue engineering, with which analysts have been engaged for longer periods of time. When such analysts are already involved in work on the periphery on IVM, it is foreseeable that they could take

[14] As noted in the case description.
[15] The emergence of IVM starts-up is so recent that it was not foreseen when the design of this thesis.

an early interest in IVM. An example of such an author is Neil Stephens who has frequently published on IVM since 2010. A final possible explanation is the severity of problems of the meat industry which warrens salience for alternatives to meat. An example of a researcher who comes at IVM from that perspective is sociologist Erik Jönsson (Jönsson, 2013), who has recently (2016-2017) published on IVM. In line with the argument for the problems of the meat industry, it could be that IVM is a catchy topic hat is easily introduced and justified from a social science perspective, whereas techno-scientific developments are quite complex and tricky.

A third noteworthy issue is the limited perspectives from the meat industry (c.f. Hopkins, 2015). While IVM potentially has a large impact on the way is which meat is produced and consumed, the primary sample contains a limited number of responses from the meat industry. In the sample, the only clearly visible contribution of the meat industry was found in investments in IVM research projects and start-ups. The Dutch research consortium was sponsored by a large meat company (Chiles, 2013a), while recently, different start-ups have raised venture capital from meat industry actors (e.g. Tyson Foods, 2018). Through work of Jean-François Hocquette, editor of the journal of Integrative Agriculture, who is affiliated with the French National Institute for Agricultural Research and Herbivore Research Unit in France, two contributions have been made to the primary sample that are relevant for the meat industry[16] (Bonny, Gardner, Pethick, Hocquette, 2015; Hocquette, et al., 2015; Hocquette, 2016). It is noteworthy that a powerful industry with large stakes in the future of meat-related food production echo its interests in limited ways in academia. A potential explanation for the limited responses from the meat industry is that it safeguards its interest primarily outside academia such as in politics through lobby organisations, in the public media or professional journals that are not studied in this thesis[17]. Conversely, it is also possible that the meat industry does not think of IVM as much of a threat and therefore has let it be. Recent investments in IVM[18] could be an indication that the meat industry had not, but now is, considering IVM as potentially impactful.

A fourth salient issue in the primary sample is a lack of economic and political perspectives on IVM. In the more promissory IVM papers, these perspectives are practically non-existent, only the need for competing prices and consumer acceptance are widely recognized, while the potential for

[16] One of these publications is co-written with Sarah Bonny, who at the time was affiliated with the French National Institute for Agricultural Research and the French Herbivore Research Unit.
[17] Brief searches for professional journals did not warrant results that indicate discussion of IVM.
[18] As noted in the historical section on IVM start-ups.

profit is seldom noted. More critical papers mention economical/political issues occasionally, but almost never in-depth. Such issues include the consequences of large scale IVM production and consumption for the agricultural sector, the countryside and labour relations. While the promissory IVM discourse makes claims that can seriously impact economic and political arrangements, especially the agricultural sector, very little response has been generated. Jönsson (2016), citing Foucault, has concluded that this silence has become constituent of the discourse and concluded how considering future labour relations would undermine promissory narratives of IVM. It is noteworthy that, besides this observation, no critical views have emerged that engage with IVM-related economic or political issues.

Finally, of note is that 10 works of the primary sample come from a special issue of the Journal of Integrative Agriculture (2015, vol. 14, no. 2). This means that the primary sample possibly relies significantly on the particular criteria and editors of one journal.

A-3. Additional Sample

The expectations that are aimed to identify in this thesis are usually found in works by the researchers that actively contribute to a NEST-development and are thus seen plentiful in technical papers. As there are few technical papers in the sample of this thesis, it makes sense to add materials to the primary sample to enrich its expectation-laden content. Scientists' expectations may also by voiced by other means than academic journal papers. By adding materials that are on the periphery of the academic discourse, but likely at the core of promissory academic rhetoric, such as IVM-related press releases, website of main players, prominent NGO's and start-ups, conference agenda's and TED talks, a valuable expectation-laden addition to the primary sample can be made. Added materials were identified by Google searches for: the names of main players, NGO's, start-ups, conferences and IVM-involved universities. Like for the academic papers in the sample, materials published before 2015 were not included in the additional sample. The existence of influential NGO's, start-ups and other actors largely became clear from close-reading the academic papers in the sample in which their influence is discussed. Additionally, information found in additional sources led to identification of other relevant materials. In total the additional sample comprised of 15 websites, nine video and audio files, and eight documents.

B. Coding

Articles were coded by a combination of open and closed coding in ATLAS.ti 8.0. Coding categories derived from the research questions and theoretical framework helped to structure the reading-process and safeguarded that the focus on main objectives of the analysis was kept. By adding and

scrutinizing codes during and after reading, an ad hoc extension to predefined coding categories was made. In this iterative process called 'evolutionary coding', a finalized operational list of codes evolved from theoretical considerations (Mayring, 2002).

Based on literature review an initial list of codes was assembled. This list was subsequently tailored towards the research (sub-) question(s) that prompt this thesis. Notably, Dilworth and McGregor's (2015) overview of IVM's ethical discourses and Laestadius' (2015) elaborate review of public perceptions of IVM were especially helpful in grounding these codes. The initial list of codes centred around IVM's promises and concerns. The list was pre-tested for workability and applicability and was adjusted accordingly. Materials in the additional sample were coded based on the final list of codes after all academic materials were coded. For a final list of codes, see appendix C.

C. Analysis Procedure

The analysis, although an iterative process, consisted roughly of three rounds. In a first round of preliminary analysis, it was aimed to get an overview of the material and grasp main lines of argumentation. To this end, the summary, introduction and conclusion of materials in the primary sample were read. In the second round, which comprised the main analysis, materials were close-read and coded. In line with the research questions and focus of this thesis, attention was focused on how IMV is valuated, which actors made value-laden claims and in relation to which context IVM was (not) discussed. The third and final round of analysis concerned the close reading of the extra-academic materials that were added to the sample as explained above.

V. Analysis

A. Structure of the chapter

The analysis chapter is carved up into three parts. The first part of descriptive analysis presents discourses, promises and concerns that are identified in the sample, and primary observations regarding those. The second part deals with argumentative analysis. It discusses argumentations and rhetoric within discourses, including promise-concern relations and the way in which valuation is socially shaped. The third and final part of the analysis discusses meta observations regarding the way in which IVM scientists and reflective discourses build and present their arguments in interaction with each other.

B. Descriptive Analysis

B-1. Identification of Discourses

From the materials in the sample, two main IVM discourses can be distinguished and a third discourse that is essentially an extension of the two main discourses. A group of remaining materials did not form a coherent discourse of its own, but also could not be subsumed under the other discourses.

The first main discourse is the promissory discourse which consists of works from IVM researchers and other proponents (N=11/46). The promissory discourse is largely comprised of review papers in which proponents outline and discuss IVM-related developments in a positive way. Pointed out by analysts (e.g. Jönsson, 2016) and confirmed in this thesis is that IVM's promissory discourse is quite prominent in IVM discussions and that it features a fairly stable repertoire of recurring arguments. In addition, it was found that the promissory discourse is featured prominently in the additional sample, and thus in the periphery of academic work as well. Within the promissory discourse, IVM is proposed as a future (partial) substitute of meat with, for instance, identic sensory qualities and some additional benefits. IVM's most prominent benefits concern precisely those issues that are deemed problematic about the meat industry. IVM's promises are thus build on concerns regarding the meat industry. The most prominent promises are: meeting the rising demand for meat, reduced environmental impact and animal harm, reduction of food borne disease and use of antibiotics, and health benefits. A typical argument of the promissory IVM discourse reads:

> *"In vitro meat production is the manufacturing of meat and meat products through tissue-engineering technologies without involving the animal rearing and killing. In vitro meat*

production could have financial, health, animal welfare, and environmental advantages over traditional meat production (Haagsman et al., 2009). The techniques for in vitro meat production are not beyond imagination and the basic methodology involves culturing muscle tissue in a medium in a large bioreactor (Bhat and Bhat, 2011a). Starting cells for meat production could be taken from live animals biopsy or animal embryos and then put into a culture media where they start to proliferate and grow, independently from the animal. Production of in vitro meat for comminuted and processed meat products, such as sausages, burgers, and nuggets will be easier to develop (Datar and Betti, 2010; Bhat and Bhat, 2011a; 2011c); however, for the commercial production of highly structured unprocessed meat, a great body of research is still needed to be done (Bhat and Bhat, 2011c). In the long term, tissue-engineered meat is the inescapable future of humanity; however, in the short term, the extremely high cost of the biofabrication of tissue-engineered meat is the main potential obstacle, although large-scale production and market penetration are usually associated with a dramatic price reduction (Bhat and Bhat, 2011a)"

(Bhat, Kumar, & Bhat, 2017, p. 782).

Noteworthy is how the overall promissory tone of the quote comes boldly to the fore in the conclusion, which regards the more distant future, while the body of the quote has a nuanced and somewhat cautious tone regarding the more proximate future. Furthermore, IVM's benefits are discussed in terms of 'could have' while the overall assessment of IVM is blatantly positive. This typicality of the promissory discourse could be explained by the strategic aim to present IVM as *the* future meat substitute, while framing challenges as concerns to be overcome and in line highlighting to the need for more research funding.

Second, a meta-reflective[19] discourse can be distinguished. The reflective discourse is mainly organized around a group of sociologists and philosophers (N= 15/46). In the works of these authors, claims of IVM proponents are deconstructed and, depending on the nature of the work, contextualized and/or contested[20]. In the reflective discourse, IVM is discussed in a broad range of contexts such as biotechnology, assessment of emerging technologies, problems of the meat industry, private funding of science, animal welfare and the way in which visions and expectations

[19] For brevity's sake, this discourse is referred to as the reflective discourse from here on.

[20] An argument could be made that the sociological papers form a different discourse than the philosophical papers, as they have a different nature. Here, it was chosen to group these works together because of the similar way in which they deal with promissory rhetoric.

play a role in techno-scientific processes. Notably IVM is not always the central object of inquiry, a fair proportion of reflective discourse works discusses IVM as one subject among others. While the promissory discourse is clearly pro-IVM, the reflective discourse is not simply against IVM. Rather, the reflective attitude of the reflective discourse leads to a criticism of IVM in some cases, but more frequently a non-valuating stance is taken. A typical quote of the reflective discourse reads:

> "*The role of the promissory discourse is precisely such selective future-making, to repeat particular expectations and thereby reshape the possibilities for in vitro meat R&D today. The struggle for discursive stability is here a struggle to secure funding for a kind of research entangling universities, capital and publics excited about cultured meat*"
> (Jönsson, 2016, p.741).

The quote is typical for the reflective in the approach of taking an outsider perspective to work of IVM actors - proponents specifically. It is further typical in contextualising efforts of IVM actors thereby broadening promissory IVM rhetoric, in this case in terms of funding opportunities.

A third discourse can be found in papers written from a socio-psychological perspective[21] (N=9/46). This discourse, however, is in many ways a scattered continuation of the two primary IVM discourses. The socio-psychological discourse rarely features new arguments. It tends to reiterate and take over promises and concerns from the promissory and reflective discourse. Notably, socio-psychological works tend not to focus on IVM as the main topic of the research. Rather, IVM is used as a topic fit to study another phenomenon such as consumer attitude, consumer perception or sense-making of new (bio)technologies. A typical quote that reflects how papers in the socio-psychological discourse introduce IVM as a topic to study social science phenomena reads:

> *"Cultured meat has evolved from an idea and concept into a reality with the August 2013 cultured hamburger tasting in London. Still, how consumers conceive cultured meat is largely an open question. This study addresses consumers' reactions and attitude formation towards cultured meat through analyzing focus group discussions and online deliberations"*
> (Verbeke, et al., 2015, p. 49).

A fourth group of papers cannot be subsumed under the three aforementioned discourses, but it does also not form a coherent discourse of its own (N=11/46). This residual group of materials is

[21] This term refers to works that engage in social science experiments, involving psychological elements and motives.

scattered in terms of discipline, analytical focus and the extent to which IVM is central to the work. The residual group entails, amongst others: a reflection on IVM's capability to meet Islamic food laws, a comparison of IVM with consumption of insects and imitation meat, and a reflection on the influence of molecular biology on food practices (respectively: Hamdan, Post, Ramli, & Mustafa, 2017; Alexander, et al., 2017; Wolinsky, & Husted, 2015).

B-2. Overview of Promises and Concerns

In total 25 distinct promissory arguments and 49 distinct concerning arguments were identified in the 46 academic papers in the primary sample. Of note is that, the promises and concerns that the thesis presents are in fact collections of slightly differently phrased instances that essentially make the same argument. Grouping promises and concerns that make the same argument helps to differentiate between distinct arguments and provides insight in the frequency of the occurrence of arguments. A further noteworthy issue is that all expectations mentioned in the sample are taken up in the analysis. This means that when, for example, promise is mentioned and criticized subsequently, the promise and the concerning response are noted in the analysis. This is of importance to assess the degree to which expectations are shared in the social repertoire of promissory and reflective discourse actors.

The following sections present the promises and concern found in the sample[22], with a quote providing an example how those arguments are presented in the sample. To order expectations according to frequency of occurrence - indicating the degree to which they are part of shared social repertoires -expectations were attributed to one of three categories. An expectation is deemed prevalent when it occurred in 15 papers or more. An expectation is deemed regular, but not dominant when it occurred in minimally four and maximally 14 papers. An expectation is deemed incidental when it occurred less than four times in the sample. The divide between the three categories is arbitrary to a degree as it is for example hard to argue that there is a distinct difference between an expectation that is outed 14 times, versus one that is outed 15 times. The purpose of categorising expectations based on frequency of occurrence is twofold: 1) to single out the most prevalent expectations in the sample and to give examples of incidental expectations, leaving a broad rest category of regularly outed but not dominant expectations, 2) to use one standard to be used for categorising and presenting promises and concerns. For sake of comprehension, an

[22] As the additional sample provided no new value-laden arguments to the primary sample, the presentation of promises and concerns is based solely on the primary sample.

overview of all promises and their frequency of occurrence is given in appendix D, while an overview of all concerns and their frequency of occurrence is given in appendix E.

B-3. Promises

Some promises were prevalent in the sample; they occurred in 15 papers or more. Prevalent promises were:

IVM is sustainable, has environmental benefits	*"The production of cultured meat will be environmentally friendly, require less land use and consume less water in comparison with conventional meat production method"* (Hamdan, et al., 2017, p.4).
Reduction of animal harm	*"Producing cultured meat does not involve the killing of animals, as live animals can be used as a source for the initial cells in the bioreactor"* (Kadim, et al., 2015, p.229).
Healthier meat	*"IVM could be engineered to be higher in polyunsaturated fats and lower in saturated fats"* (Laestadius, & Caldwell, 2015, p.2457).
Meeting the increasing demand for meat – reduce world food poverty reduction	*"Many cultured meat proponents champion a food security narrative, suggesting that IVM products may help address devastating food shortages by providing a cheap source of protein that can cater to a rapidly growing demand for meat"* (Dilworth, & McGregor, 2015, p.93).

A second category of promises are those that are outed regularly, but not predominantly. These promises occurred in minimally four and maximally 14 papers. This category comprises, amongst other, the following promises:

Reduction of animal borne diseases and less need for antibiotics and hormones	*"It should also be possible to eliminate its exposure to hazardous products like pesticides, fungicides, heavy metals, aflatoxins, melamine, anabolic agents, and antibiotics"* (Kadim, et al., 2015, p.229).
The possibility for exotic meat products	*"The opportunities are numerous, including the culturing of functional and designer meats, exotic*

	meats, or even human flesh as a "cannibalistic" niche product" (Leroy, & Praet, 2017, p.81).
IVM's safe nature	*"In fact, the producers of artificial meat propose a meat which, because artificial, has potentially an ideal composition and which is technically controlled in order to satisfy the physiological needs of humans without putting health at risk"* (Hocquette, 2016, p.169).
Resource and or cost-effectiveness of IVM	*"It is anticipated that the optimization of large-scale cell culture as performed for other stem cells can be translated into successful protocols for bovine satellite cells resulting in resource and cost efficient cultured beef"* (Moritz, et al., 2015, p.208).
IVM is suitable for vegetarians or vegans	*"Vegetarians might be tempted to return to the flock of animal protein devotees"* (Jönsson, 2016, p.737).
The resemblance of IVM to meat	*"It is a real burger, made of real meat. It's as real as real can be"* (Hopkins, 2015, p.267).

The final category of promises is outed incidentally. The promises in question were outed once, twice, or trice in the sample. Incidentally outed promises are amongst others:

IVM as a meeting religious food laws	*"The in vitro meat would render itself free from social taboos like Halal, Jatka, Jewish, etc., as the production of meat does not involve slaughtering of animals"* (Bhat, et al., 2017, p.787).
The possibility of meat in space	*"There are many situations like space missions, (…) in which it is more economical to produce food in situ and in vitro meat production is one of the prospective options"* (Bhat, et al., 2017, p.787).

B-4. Concerns

Concerns prevalent in the discourse occurred in fifteen papers or more:

Low Consumer acceptance[23]	*"Acceptance of in vitro meat by consumers will be the greatest challenge*" (Hocquette, 2016, p. 174).
Lack of sensory appeal	[IVM] "*fails in mimicking the sensory appeal of animal-derived meat, especially with respect to texture and the incorporation of intramuscular fat."* (Leroy, & Praet, 2017, p. 81).
Technical challenges[24]	*"There is an array of other technical challenges posed"* (Sharma, Thind, Kaur, 2016, p.7606).
IVM is not really meat	*"These examples make evident how little the promissory discourse can claim that in vitro meat <u>is actually</u> just like any other meat"* (Jönsson, 2016, p.737, original emphasis).
High price	*"The extremely high prohibitive cost of the cultured meat is the main potential obstacle"* (Bhat, et al., 2015, p.246).
Animal products are still needed to grow muscle tissue	*"Fetal bovine serum was used in the medium to grow the IVM, indicating a continued reliance on animals at this stage in IVM's development"* (Laestadius, & Caldwell, p.2458).
Unnaturalness	*"One of the serious objections associated with the public acceptance of the in vitro meat is its unnaturalness"* (Bhat, Kumar, & Bhat, 2017, p.787).

The second category of concerns, those that are outed regularly but not predominantly, occurred in minimally four and maximally fourteen papers. This category comprises a large group of concerns, ranging from the more frequent concerns that:

[23] Concerns over consumer acceptance encompass general concerns of how consumers will perceive IVM. Concerns over perceived unnaturalness or lack of sensory appeal, though related to consumer acceptance are taken up as separate issues as they concern distinct arguments.

[24] Many slightly different concerns over technical issues were outed in the primary sample, Here, these concerns are grouped to show the magnitude of their totality.

IVM's large energy requirements	*"Cultured meat will require more industrial energy than is required in livestock production"* (Henchion, Hayes, Mullen, Fenelon, & Tiwari, 2017, p.14).
Better (plant-based) alternatives are available	*"To be candid, I do believe the claims with which I started this paper, and consequently hold that we as individuals should be vegans, and should encourage others to be vegans"* (Milburn, 2016, p.261).

To less frequent concerns that:

IVM might be subject to religious objections	*"Some even foresaw religious groups with extensive rules about meat – like Judaism, Islam, and Hinduism – to playing a role in resistance to in vitro meat"* (Mattick, Wetmore, & Allenby, 2015c, p.59).
IVM has unforeseen consequences	*"Cultured meat will almost certainly be accompanied by unintended consequences as well as unforeseen costs and benefits that accrue disproportionately to different stakeholders"* (Mattick, et al., 2015a, p.249).

The final category of concerns regards those outed incidentally. The concerns in question were outed less than four times in the sample. Incidentally outed concerns are amongst others:

IVM might lead to cannibalism	*"The biotechnological feasibility of culturing animal muscle in the lab leads to the likelihood of culture of human cells in the lab too"* (Sharma, et al., 2015, p.7604).
Animals are still needed for other products like dairy	*"Animals will still be required for dairy and fiber production"* (Hocquette, et al., 2015, p. 282).
IVM might lead to backlash to meat-eaters	*"On the human side I can see a backlash against 'real' meat eaters as savages, which could lower intercultural relations"* (Mattick, et al., 2015c, p.61).

B-5. Descriptive Analysis' Observations

It is noteworthy that the primary sample features considerably more distinct concerning arguments (N=49) than distinct promissory arguments (N=25). This is interesting considering the dominance of the promissory IVM discourse. The dominance of promissory works over sceptical works is

confirmed in this thesis, as is exemplified by the distribution of valuation in the sample (see figure 3). The X-axis indicates the general valuation of the papers in the sample, scored on a 5-point scale by the author. The y-axis indicates the size of the respective category. Criteria for scoring valuation of the papers were: 1) uniformity of valuation, indication the degree to which an author was uniform in expressing a value-laden position, 2) explicitness of valuation, indication the degree to which an author was explicit in expressing a value-laden position, 3) repetitiveness of valuation, indicating the degree to which an author repeatedly expressed a value-laden position. Note that papers that only briefly discussed IVM and had an ambivalent valuation were not taken up in the figure (N=6). One can clearly see that, despite the dominance of concerns over promises, the overall valuation of the discourse is positive (average 3.29 out of 5).

Distribution of the primary sample's general valuation

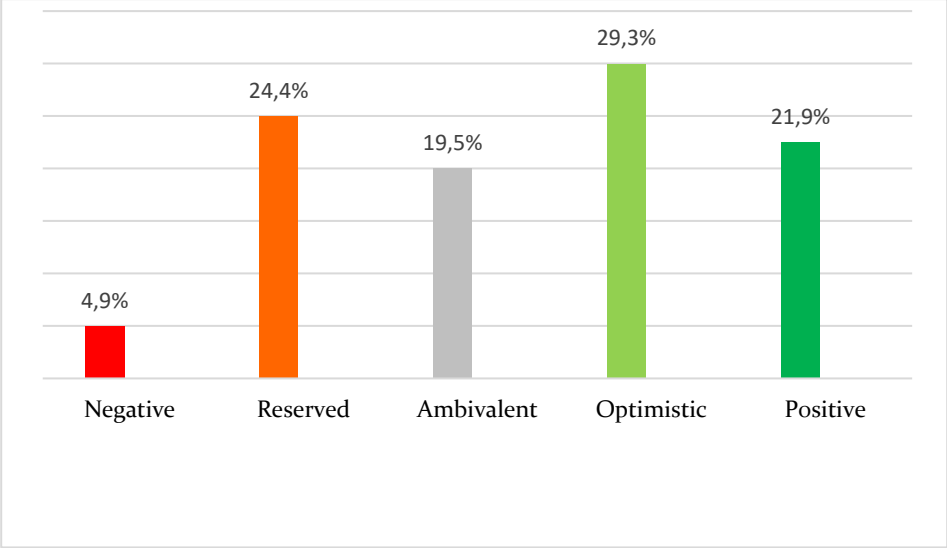

Figure 3: Overview of the sample's general valuation. The figure illustrates that the majority of the works in the primary sample were positively inclined towards IVM.

The most likely explanation for the dominance of promissory works over sceptical works, despite that concerns outnumber promises, is that the promissory discourse, and works following it, frame concerns as challenges to be overcome. By way of this strategic approach, concerns can be mentioned but made to fit a promissory narrative (Bhat, et al., 2017; Ferrari, & Lösch, 2017). A fact that supports this hypothesis is that in the primary sample, concerns were frequently outed in promissory papers. It seems that the promissory discourse is successful in strategically framing the debate towards a positive evaluation (c.f. Chiles, 2013a). Two possible alternative explanations are undermined by the findings in this thesis. First, the content of the promises of IVM could be

deemed more important than that of the concerns and, therefore, weigh more heavily in the eventual judgement. This explanation is undermined by the fact that concerns regularly contest IVM's promises. Virtually no promise of IVM are shared without contention. Second, it could be that promises are reiterated more often on average than the wider range of concerns, balancing out their smaller range. The frequencies with which promises and concerns are stated, however, is rather similar.

A further key observation is that the additional sample features rather similar promissory rhetoric as the promissory papers in the primary sample. Arguments largely overlap, while the promissory is similar. The additional sample differs from the primary sample in that promises are concentrated around a small number of recurring arguments. Arguments regarding the rising demand for meat, environmental benefits and improved animal welfare are the central elements in the additional materials, while other issues are only seldom raised. A further difference between the additional sample and the primary sample is that the additional sample tends to be less nuanced and more optimistic in general. In this regard it was found that new IVM start-ups tended to be most blunt in promissory rhetoric, while established IVM-actors were more cautious. This is exemplified when comparing quotes from the IVM-FAQ's of Israeli IVM start-up SuperMeat and the University of Maastricht. SuperMeat (2018) claims that: *"Clean Meat will require dramatically less resources to produce, hence, Clean Meat will be less costly than conventional meat"* while, the University of Maastricht (2017b, p.3) in response to the question "What is the current price of a hamburger made from cultured beef?" claims:

> *"As production is not at scale yet, it is difficult to say. We expect the price to be in the 10 USD range per hamburger once the production is at scale, using the current technology. With improvements in the technology, which are already foreseeable, the price will come down further to competitive pricing with traditional beef. Eventually it may even become cheaper as less resources are required to culture beef than to produce it through livestock".*

A final key observation is that works in the promissory discourse do not refer to works from the reflective discourse. This is noteworthy as academic publications are supposedly centred around discussion and exchanges, while here a separation is visible. A potential explanation that the proponents of the promissory discourse are fully unaware of the reflective discourse is unlikely, since sociologists have been present at IVM-conferences and sociologists have interviewed promissory actors for research purposes. What is more, a recent book chapter was co-written by

IVM proponent Post and critic Hocquette. Especially since there have been indications of the promissory discourse's awareness of the importance of expectation management, it is likely that the promissory discourse neglects the reflective discourse for strategic reasons.

Having presented the descriptive analysis, the thesis next delves into the arguments and rhetoric of the promissory and the reflective discourse. The section starts off by discussing how promises and concerns are contested which is of importance to understand promise-concern relationships that are presented subsequently. The section continues by concluding how valuation is socially shaped in case of IVM and by considering the structure or 'flow' of typical arguments.

C. Argumentative analysis

C-1. Contesting Promises and Concerns in case of IVM

Intuitively, promises and concerns can contest each other when they refer to similar issues with different valuation. This promise-concern relation is seen frequently in the sample. When focusing more deeply on how promises and concerns relate, it became clear that it is worthwhile to consider promise-promise relationships and concern-concern relationships. This is especially the case when one value-laden discourse is dominant, such as IVM's promissory discourse. Because of the early dominance of promissory rhetoric, more nuanced promises can be a significant contribution to undermining promises of the promissory discourse. Similarly, an issue that is framed as a challenge can be undermined by a bolder statement, a concern[25]. When promises and concerns are contested by statements of the same valuation, the information that had grounded a promise or concern is reiterated, but in a nuanced way or a condition is introduced changing the value-judgement of the claim. Next, an example will be provided.

A straightforward example is the environmental promise of IVM. An often-quoted review from Tuomisto and Teixeira de Mattos (2011) calculated significant environmental benefits of IVM in comparison to meat in terms of land and water use, CO_2 emissions and moderate reductions in energy usage. Tuomisto and Teixeira de Mattos (2011), however, make their calculations based on a set of non-straightforward assumptions. They themselves draw attention to the high uncertainty of their research' results and urge caution for interpretation of the findings (Tuomisto, & Teixeira de

[25] To understand promise-concern relationships, one needs to pay attention to the contention of promises and concerns. It is proposed in this thesis that a semi-optimistic statement that contents a more optimistic statement is better seen as a weakened promise than a concern as its overall valuation is still positive. Overall valuation is thus taken as a criterion of demarcation between promises and concerns. As promises and concerns are not only contested by statements with opposite valuation, it becomes clear that promise-promise and concern-concern relations should be considered.

Mattos, 2011). In numerous papers, the results of this study are taken up as straightforward evidence for the environmental promise of IVM (e.g: Pandurangan, & Kim, 2015; Hamdan, et al., 2017). In turn, some authors have noted the lack of nuance with which this promise is portrayed (e.g. Jönsson, 2016). Interestingly, these critical works provide rather different valuation-laden conclusions about the nuances of Tuomisto and Texeira de Mattos' (2011) review. In some cases, the environmental promise of IVM is upheld, but in a nuanced way (c.f. Sun, Yu, & Lin, 2015). In other instances, the promise is simply discarded or contested as the assumptions are deemed problematic (c.f. Hocquette, 2016.). In a final group of papers, the environmental promise of IVM is deemed ambiguous as it is claimed that it is impossible to verify its environmental status yet (c.f. Ferrari, & Lösch, 2017). The example shows that based on the same information, a promise can be contested by statements of different valuations: by a moderate promise, by a concern and by a claim to ambivalence. This insight will be important in the remainder of the thesis and reappear in various examples in the next section which lists different types of promise-concern relationships.

C-2. Types of Promise-Concern Relations

The example given above showed that promises and concerns may build on the same information that is interpreted differently. It thus shows a particular way in which promises and concerns can relate. Promise-concern relationships show shed light on how valuation is produced through IVM discourses and how IVM is assessed de facto. This section lists four types of promise-concerns relationships and the following section (C-3) presents three routes by way of which these relations can emerge. These findings are summarised in tables 1 and 2(page 48 and 49, respectively). The subsequent section(C-4) discusses the implications of these relationships and routes.

Another example of a case in which the same information leads to different value-laden conclusions results from different readings of the 2013 IVM burger tasting presentation. Whereas the promissory discourse has jubilantly interpreted the burger and the comments from the tasting panel (Cultured Beef, 2013; Post, 2014a), the reflective discourse has interpreted the same information in a more sceptical ways (Jönsson, 2016). The promissory discourse emphasized the edibleness of the burger, its bite and the resemblance to meat (O' Riordan, et al., 2017). Articles in the reflective discourse have responded in different ways to this promissory reading. First, in more ambivalent ways, where the high degree of optimism by the promissory discourse was noted, as well as some characteristics of the burger that were not meat-like (O' Riordan, et al., 2017). Second, more sceptical interpretations claim that the optimistic interpretation of the burger's sensory appeal was unwarranted (e.g. (Jönsson, 2016). Whereas the optimistic readings focus on what is

already achieved and identify this as progress and an accomplishment, the sceptic readings point to how IVM cannot (yet) deliver on its promises of actual meat-likeness.

A striking case, though only once observed, illustrates how uttering a value-statement regarding a matter can lead to a response with opposite value-laden conclusion. Some authors have noted the concern that, were IVM to be employed, this might lead to culturing of human cells and thus to cannibalism (e.g. Sharma, et al., 2015). In response to the concern of IVM-cannibalism a philosophical paper has argued for its legitimacy (Milburn, 2016). Milburn's (2016) work points to the unique context of in vitro cultured cells which, so goes the argument, undermines traditional objections to cannibalism (Milburn, 2016). Though a clearly minor issue in IVM debates, the example shows how considerations from additional points of view can lead to radically different value-laden conclusions. This is exemplified in Milburn's (2016) belief that IVM holds the promise of cannibalism:

> *"I suggest that we should be open not just to the production of in vitro nonhuman flesh, but also in vitro human flesh. This leads to a consideration of the ethics of cannibalism. The paper ultimately defends the position that cannibalism simpliciter is not morally problematic, though a great many practices typically associated with it are. The consumption of in vitro human flesh, however, is able to avoid these problematic practices, and so should be considered permissible"*

(Milburn, 2016, p. 249).

Vice versa, promises can also ground concerns. This type of relation is very prominent in the IVM discourse as it has historically developed as a promissory discourse to which criticism has emerged (Chiles, 2013a; Ferrari, & Lösch, 2017). One example can be found in proponents' optimism regarding improved animal welfare in IVM production. Proponents note that animals do not have to be slaughtered in IVM production and that cells can be acquired by a 'harmless' procedure under local anaesthesia (Kadim et al., 2015). Critics, however, have pointed out that IVM problematically keeps an instrumental view towards animals (e.g. Hopkins, 2015).

A different promise-concern relationship comes to the fore when proponents who work to establish a promise are criticized for downplaying possible alternatives. IVM is proposed as means to relieve the burdens of the meat industry. Criticism has emerged stating that proponents of IVM downplay sensible alternatives such as vegetarianism, veganism, meat substitutes or moderate consumption of meat (e.g. Hocquette, 2016; Alexander et al., 2017). As noted, Mark Post has been quoted as saying that he thinks vegetarianism is in principle the most viable option. Post, however,

has been explicit in saying that it is 'unrealistic' to convince large(r) groups of consumers to lessen their consumption of meat and/or to satisfy them with meat substitutes (Post, 2013; O' Riordan, et al., 2017). Post, in line with other proponents (e.g. Datar, 2013), argues he therefore targets IVM as a solution to those who cannot do without meat. To legitimate IVM as a meat alternative, Post has repeatedly stated how much IVM is like meat, while critical authors have raised different arguments for the differences between meat and IVM (e.g. Jönsson, 2016). In addition, Post has been criticized for providing statistics showing that the percentage of vegetarians have not raised recently, while newer data contrast this finding (Ferrari, & Lösch, 2017). Thereby, according to critics, IVM proponents overemphasize the need for meat (e.g. Laestadius, 2015; Ferrari, & Lösch, 2017). This exchange of arguments thus is concerned with identifying the most sensible solution for a shared problem. Whereas IVM appears as a sensible option when alternatives are discarded, critics, who value these alternatives more, automatically value IVM less strongly.

Table 1.

Overview of different promise-concerns relations in the sample

#	Type of Promise-Concern Relationships
1.	Interpreting information with different value-laden conclusions
2.	Promises ground concerns
3.	Concerns ground promises
4.	Legitimising IVM entails downplaying legitimate alternatives

C-3. Routes to Promise-Concern Relations

Promise-concern relationships can emerge in different ways, via different routes. This section presents three routes that are typical for the sample.

Fist, considering additional contextual information can lead to particular valuation of an issue. In case of the promise that IVM will contribute to animal welfare, for instance, a relevant additional consideration is that in some nations, such as the Netherlands, meat is often a by-product of dairy production (Mattick, et al., 2015a). While animals do not have to be slaughtered per se for dairy production, still a lot of livestock would be needed which, for some, fits a problematic instrumental view towards animals (c.f. Hopkins, 2015). Moreover, in current meat industry practices, animals for dairy productions are slaughtered for meat when they stop providing 'sufficient' milk. One can question what will happen when IVM substitutes meat and such animals stop providing milk. Even though they do not *need* to be slaughtered for meat, it is still possible that they will. Considering additional information in a case can thus evoke responses with different valuation.

A second example shows how valuation is influenced by one's stance on peripheral or encompassing issues. For example, some have found that IVM is suitable for vegetarians, while this is contested by others. Consider the following quote:

> "*Some vegetarians are primarily motivated by consequentialist animal welfare concerns—they can support cultured meat in principle. Some vegetarians are primarily motivated by environmental impact concerns—they can support cultured meat. Some vegetarians are primarily motivated by health concerns—they can support cultured meat. Some vegetarians, however they started, have developed moralizing disgust and purity attitudes toward meat itself—they will not support cultured meat*"
> (Hopkins, 2015, p 273).

The quote indicates that one's positionality on the issue whether IVM is suitable for vegetarians is largely determined by how IVM impacts animal welfare, the environment or other issues that can prompt one to become vegetarian. If one foresees a form of IVM that is completely free from animal harm and has little environmental impact, it makes sense that it could be suitable for some vegetarians. A form of IVM that harms animals and/or significantly impacts the environment, however, is certainly not suitable for most vegetarians[26].

A third and final route towards different promise-concern relations is quite emblematic for IVM discussions. This typical route is expressed in argumentative exchange concerning the need of foetal calf serum as nutrient for serums in current IVM production procedures. The promissory discourse promises an IVM product which is free of animal products and which does not require animal slaughter. It admits that currently cells cannot be proliferated without relying on serums containing animal products. This, however, is phrased as a challenge to be overcome founded by future optimism. The argument relies on the progress of the field of tissue engineering and the availability of directions of future solutions (Post, 2014b). The concern that is raised against this promise is simply that cell-growth is not possible without foetal calf serum yet, which undermines one of IVM's main promises (Ferrari, & Lösch, 2017). By relying on future-based optimism or contemporary-based scepticism, different value-laden argument can be provided.

Table 2.

Overview of three routes towards the promise-concerns relations in the sample

[26] Notable is that IVM proponent Post argues that vegetarianism is preferred over IVM because of IVM's larger expected environmental impact.

#	Type of Promise-Concern Relationships
1.	Considering additional contextual information enables different value-laden interpretations
2.	Positionality towards an encompassing issue impacts valuation
3.	Contemporary-based scepticism critiques future-based optimism

C-3. ADA and the Social Shaping of Valuation

The different (routes to) promise-concern relationships as outlined above shed light on how valuation is produced in case of IVM. It was shown that the same information can be interpreted and valuated differently. This makes clear that valuation is not straightforwardly produced directly from an object or event alone, but that valuation depends on how one is positioned regarding a certain issue and which contextual information is considered. It was demonstrated that positing a promise or concern can elicit a response with opposite valuation by considering additional information or by interpretation from another perspective. Taken together, these findings emphasize the importance of interpretative frames[27] by which information is selected, connected to other information and existing knowledge, aligned with other issues and made sense of generally.

These findings resonate with the ADA approach which highlights that meaning is given to social and physical phenomena through ensembles of concepts and categories that are reproduced in practices so that actors *"hold specific positions, entangled in webs of meaning"* (Hajer, 1995, p. 56). As such ADA offers an account of the intricacy and variety in the social shaping of the valuation of IVM. To illustrate this more concretely in case of IVM: due to different interpretations, the 2013 burger presentation is a success for some and a mere demonstration of researchers' interests for others. This enables that some are optimistic about IVM's future, a future in which current problems are overcome, while others see no way beyond those same problems. It even makes that one can see IVM-cannibalism as a promise.

In terms of ADA it could be said that different promise-concern relationships highlight how valuation can differ based on discursive positionings and correspond with different story lines. From a promissory perspective, for example, the environmental benefits of IVM can be taken up in a storyline that stabilises IVM's environmental potential as a benefit among other IVM-benefits or

[27] I intend to use 'interpretative frame' as a neutral term to emphasise how social shaping accounts for the phenomenon that IVM-related issues are 'placed' in a certain way: in certain contexts, aligned with certain histories, etc. The purpose is to show that the observations in this thesis align well with the ADA approach. I do not want to claim that ADA fully explains these observations, but that it provides a valuable perspective.

as a promise among the potential of biotechnologies in general. From a reflective perspective, IVM's speculative environmental benefits can be taken up in a storyline regarding the strategic efforts of promissory IVM- or biotechnology actors, while critics can establish a storyline which features exaggerated and unfounded IVM or biotechnological promises.

C-4. The Narrative Flow of Arguments

While the rhetorical and linguistic part of the analysis has thus far focused on the contention of and interaction between arguments, the final part of the rhetorical section focuses on the general structure or 'flow' of arguments.

It is noteworthy that the structure of promissory arguments typically contains three characteristics. First, different problems of the meat industry are introduced, thus creating a sense of urgency and setting the stage for a solution. These problems include a rising demand for meat that cannot be met with current production methods, environmental harm and animal welfare issues. Second, IVM is introduced as a (partial) meat substitute that can combat the meat industry's problems. In the primary sample, typically, the promises of IVM are introduced with caution and/or nuance and take the form of: IVM 'has the potential to', 'could contribute to' or 'might have an impact on', while the additional sample features nuanced and less nuanced claims. In any case, the potential of IVM to combat problems of the meat industry is highlighted. Third, when making concluding remarks, IVM is put in promissory light leaving behind many of the nuances, challenges and caution remarks uttered before. This is exemplified in the promissory quote given at the beginning of this chapter (page 35/36). When nuances are kept in the concluding remarks, this is often to argue for further research funding. In either case, thus, the conclusions of promissory papers reinforce the desirability of IVM. In sum, the flow of the typical promissory argument is characterised by movement from the meat industry's problems to IVM as a meat substitute and a potential solution, to IVM as a prominent solution.

The flow of typical arguments in the reflective discourse does not feature the swings that characterise arguments from the promissory discourse. For works in the reflective discourse problems of the meat industry are also frequently the starting point. Thereafter, the reflective discourse typically presents IVM as a substitute of meat as presented by proponents. Whereas the promissory discourse engages with IVM from a first-person perspective, the reflective discourse takes a distancing and reflective perspective. From that distancing perspective, the reflective discourse discusses IVM in particular and detailed contexts such as evocation of 'promotional publics' for the IVM burger presentation, the relevance of a psychoanalytical perspective to

understand 'high-tech foods' or accentuating problematic visions of artists working on IVM. Reflective authors typically end their inquiries by concluding how IVM hitherto has not been recognized in a given context or how the context in question helps to understand IVM or related (larger scale) phenomena. Whereas the aim of IVM proponents is typically to promote IVM, reflective discourse authors focus on contributing critical and coherent arguments to their own research disciplines.

There is a typical flow to the arguments in the socio-psychological discourse as well. Although arguments within the discourse diverge into three directions, their overall composition is similar. Socio-psychological discourse arguments start off by introducing IVM as a relevant development that fits socio-psychological research objectives, such as consumer acceptance or consumer sense-making. In that light, arguments develop in one of either three directions. Socio-psychological works can follow the promissory discourse by outlining the potential of IVM from a first-person perspective or follow the reflective discourse in distancing itself from IVM but observing IVM as an interesting phenomenon. Uncommonly, some socio-psychological authors are critical about IVM and inquire a socio-psychological phenomenon to scrutinize IVM's prospects. In any case, for the socio-psychological discourse, IVM is not the main object of study but a vehicle to study socio-psychological phenomena. Papers typically end with conclusions regarding the investigated socio-psychological phenomena and neglect IVM, or merely mention some implications of the study for IVM.

The typical flow of arguments from the three discourses in the sample reflect their researchers' objectives, as well typical valuation and sense-making of IVM. Moreover, it echoes the disciplinary differentiation between the discourses. Generalising somewhat it can be summarised that the promissory discourse promotes IVM by highlighting the severity of problems of the meat industry and by neglecting nuances and uncertainties when assessing IVM, that the reflective discourse makes critical contextual arguments regarding IVM, mostly within the scope of the author's research domain and that the socio-psychological discourse non-critically use IVM as a case to study socio-psychological phenomena related to new and emerging (bio)-food technology. This section has concluded the argumentative part of the analysis. The next section discusses meta observations regarding the way in which the promissory discourse and the reflective discourse build and present their arguments in interaction with each other.

D. Meta-Analysis

D-1. IVM's Promissory History

At the risk of reading too much into how the promissory discourse present histories of IVM, it can be argued that proponents aim to align IVM with tissue engineering and stem cell research 'breakthroughs' and with scientific 'progress' in general. IVM's promissory discourse frames the history of IVM as one stemming from imaginaries from influential thinkers – especially Churchill's 1932 IVM-related imaginary. IVM-related imaginaries by less famous others or ones that featured in gloomy contexts such as Barjavel's 1943 novel Ravage[28] (Bozetto, & Evans, 1990) are rarely presented by the promissory discourse (Arshad, et al., 2017). Moreover, the promissory discourse emphasizes scientific 'breakthroughs' by Alexis Carrol who kept a piece of chicken heat muscle alive in a petri dish in 1912 and Gail Martin who cultured embryonic stem cells in vitro in 1981. By framing the history of IVM as one starring esteemed figures like Churchill and important scientific developments by Martin and Carrol, not only a simplified picture of the course of scientific research emerges, but a simplified linear narrative is proposed that promotes IVM.

The promissory discourse presents a promissory history of IVM much like how struggles and uncertainties in IVM production are put aside in favour of a rather linear story of potential, progress and success. Leaving aside current concerns and uncertainty, proponents hold on to futures where problems and uncertainties are overcome. Specifically, this comes to the fore in the tendency to transcend current IVM production problems and the wish to anchor IVM as a product and concept in a future where those problems are overcome. Consider the following examples of foetal bovine serum and upscaling of production.

To date no IVM product has been produced without use of foetal bovine serum, an animal by-product of the meat industry[29]. Proponents promise IVM products that do not rely on foetal bovine serum – the importance of which is regularly stressed (c.f. Moritz, et al., 2015). Whereas for critics use of foetal bovine serum is a concern, the promissory discourse deals with it by simple claiming that the problem will be overcome, while sometimes mentioning potential alternatives to foetal bovine serum. From an outsider perspective it is hard to assess the likelihood that an IVM product will be produced without animal products and to reflect upon the time frame that this will require. It is noteworthy, though, that IVM's earliest promises (Edelman, et al., 2005; Post, 2012) have relied on animal-free IVM products, which has hitherto not been achieved. Similar to the case of foetal bovine serum, the promissory discourse envisions upscaling of IVM production with accompanying

[28] Translated into English in 1967 as 'Ashes Ashes'.
[29] Experiments with alternatives were unsuccessful in that they were less productive with non-animal sera (Post, 2012).

cost reductions as something that will naturally occur. While critics have the emphasized high production costs of IVM, including manual labour, costs of materials and the costs needed to build and maintain huge IVM-factories[30], proponents tend to glaze over these issues by emphasising trust in market mechanisms.

By discussing how the promissory discourse presents the history of IVM in line with how it relies on linear narratives of progress and potential to overcome current concerns, a key promissory tendency is highlighted. The following section focuses in more closely on how proponents position IVM in futures where current concerns are overcome.

D-2 Temporal Positionality in Valuating IVM

The general tendency for the promissory discourse is to focus on IVM's great potential once it has gained a proper market share as a meat substitute. It envisions an IVM-dominant future much like contemporary society but with IVM replacing meat. In this future, possible distinct advantages such as no animal slaughter and little environmental output are envisioned, without further constraints. Starting from these promises, proponents frame issues - that are concerns for critics - as challenges to be overcome (Bhath, Kumar, & Bhat, 2017; Ferrari, & Lösch, 2017).

Proponents are willing to go quite a bit beyond IVM's contemporary capabilities as they consider current obstacles as challenges that will be overcome. One can think of technical challenges, consumer acceptance, high energy usage, high costs, and use of animal products and antibiotics in current production. By anchoring IVM as a future success, contemporary issues are blackboxed or underemphasized. In line, promissory papers tend to end their works by emphasizing the need for funding to make IVM (and its benefits) a reality. As Chiles (2013, p. 511) put it, the discourse claims; *"if they (investors) will come, we will build it".* This promissory narrative is built upon the idea of techno-scientific progress if only enough funding is available. Thereby, the promissory discourses points to the responsibility of private funders – or IVM's benefits will not materialise.

More critical voices, contrary to the tendency of proponents, tend to start from a more contemporary starting point from which they see obstacles to realise a situation in which IVM's imagined benefits can reign. Adding up challenges and problems, as well as pointing to alternatives to IVM, critics are sceptical of IVM's future success. Whereas the starting point for the proponents of IVM is more fixed in the future, concerns come from more diverse areas as is signified in the total

[30] Some IVM start-ups aim to establish the term brewery over factory when it comes to IVM production. Whereas there are negative connotations to the word factory, the term brewery is associated with more positive

amount of concerns that outweighs the varieties of arguments found in the sample. Overall, it can be concluded that promissory rhetoric starts in the more distant future, reasoning back to the present where obstacles to a bright future are mere challenges to be overcome. Conversely, critical rhetoric starts from a more proximal temporal starting point, reasoning towards the future and pointing out problems on the way to a scenario of large scale IVM production and consumption. Additionally, reflective discourse actors scrutinize and nuance promises of IVM, in more distant futures as well as in what it is currently possible.

The differentiated temporal dynamics in arguments of IVM proponents and sceptics is exemplified by their attitudes towards consumer acceptance of IVM. Proponents of IVM draw explicit attention to consumer acceptance as precondition for successful adoption of IVM. This is highlighted in quotes from IVM researchers such as Mark Post who has repeatedly stated that IVM should copy the sensory appeal of meat. It is no coincidence that the 2013 burger event tasting featured reports noting how much IVM was like meat (c.f. O' Riordan, et al., 2017). In the arguments of proponents, then, emphasis is put a future for which consumer acceptance of IVM is needed. Critics of IVM tend to see consumer acceptance as an important obstacle of IVM's success. Rather than appealing to need for IVM to mimic the sensory appeal of meat to achieve a desirable future, these authors point to the contemporary difficulty of mimicking the sensory appeal of meat as well as other factors hindering consumer acceptance (e.g. Hocquette, 2016; Leroy, & Praet, 2017). These issues hindering consumer acceptance lead critics to question IVM's potential and thus undermine a promissory IVM future.

D-3. Position of the Reflective Discourse towards the Promissory Discourse

One key question to consider is the extent to which the reflective discourse adds new considerations to the promissory discourse. Hedgecoe (2010) has discussed a case in which reflective (in his case ethical) discourses do not add new considerations to discussions of (bio)technology. Hedgecoe's (2010) study shows that the way in which the bioethicist's discourse of pharmacogenetics developed within the technical and ethical boundaries as laid out by industry scientists, who actively framed ethical issues. Hedgecoe (2010) assesses that this undermines one of the most important aims of bioethics, namely to regulate bioethical debates (Hedgecoe, 2010). In case of IVM, one can pose a similar question: "*to what extent does the reflective discourse add new considerations to IVM's promissory discourse?*" Intuitively, the reflective discourse should at least be suspicious to the dominance of the promissory discourse and be able to come up with critical questions, problems and new considerations.

The reflective discourse found in the sample of this thesis has an atypical make-up in that it largely features sociological papers while there is a relative lack of philosophical perspectives, ethics in particular. The sample of this thesis only features three ethical papers (c.f. Dilworth, & McGregor, 2015; Zwart, 2015; Milburn, 2016). The resulting discourse lacks explicit critical assessments of IVM as the sociological works in the sample tend to refrain from explicit value judgments. This is exemplified in a quote from a sociological paper in which the author explains his non-valuating stance towards valuating IVM:

> *"Innovators' expectations could never be selfcontained but instead clash with more dystopian or authenticity-thirsty discourses questioning the interventions that in vitro meat entails (cf. McHugh, 2010; Metcalf, 2013) and with a vegetarian or vegan discourse questioning the necessity of any meat (Fudge, 2010; Miller, 2012). In acknowledging such clashes, however, my goal is not simply to criticize in vitro meat (in relation to which my stance is one of fascination rather than promotion or opposition). But foregrounding tensions is important for providing openings for further discussions of cultured meat beyond boosterist celebrations and quick dismissals"*
>
> (Jönsson, 2016, p. 728).

The quote illustrates that the author is aware of the dominance of a promissory discourse in case of IVM and that 'clashes' with critical discourses are desirable. Jönsson (2016), though, refrains from engaging in or initiating such clashes. Rather, he is occupied with decontextualizing parts of IVM discussions were proponents have been especially dominant (c.f. Jönsson, 2016). Jönsson's (2016) approach is largely consistent with other sociological papers which make up a large part of the reflective discourse.

The reflective discourse in this thesis brings new considerations to the table meaning that the reflective discourse does not strictly follow the technical and ethical boundaries as set out of IVM scientists. Compared to the case studies by Hedgecoe (2010) this is both due to that IVM-scientists were less involved in framing ethical issues[31] and that the reflective discourse addressees more issues. The reflective discourse reconceptualises proponent's challenges to concerns and brings new concerns to light.

[31] A noteworthy expectation is that IVM proponents such as Mark Post claim that IVM is note preferable for vegetarians.

These considerations emerge primarily when claims of IVM's proponents are considered in a broader societal perspective, when proponents' expectations are considered more extensively and/or in wider contexts that were hitherto unimagined. This is a task for reflective works par excellence. Examples of new considerations by the reflective discourse are concerns over the energy requirements of IVM factories, details of IVM production that indicate that IVM is not exactly meat-like and implications of large scale IVM production for dairy cows and the country side.

As mentioned earlier, the way in which IVM promises are problematised and contested by the reflective discourse is rather tame; explicit value-laden criticism is missing. Typically concerns are presented from the distant perspective that characterises the reflective discourse. Moreover, though new considerations emerge from the reflective discourse, these criticisms are not exhaustive, and, notably, in-depth attention for political and economic issues is lacking. More specifically, concerns remain mostly within a meat substitution frame of IVM, as initiated by proponents.

A case can be made that there are grounds for explicit criticism of promissory arguments, while this is lacking in the sample. Notably, the two papers in the sample that are negative about IVM are non-ethical papers that feature comparisons of IVM to different meat-alternatives such as imitation meat, grass-fed beef and consumption of insects. These papers contest a core presupposition of IVM proponents, namely that vegetarianism and imitation meat have limited potential, and that IVM is *the* option for those who do not want to do without meat (e.g. Post, 2013). This highlights the importance of the promise-concern relationship that promoting IVM entails downplaying alternatives. In general, the content of the works in the reflective discourse itself well for explicit criticism of IVM. Put simply, the contents of these papers could be used as arguments for explicit criticism of IVM, but they are not. Rather, they are offered as observations without value-laden conclusion. Consider for instance how Jönsson (2016, p.737, original emphasis*)* presents his finding that IVM is not much like meat: *"These examples make evident how little the promissory discourse can claim that in vitro meat <u>is actually</u> just like any other meat"*. Jönsson (2016) presents his findings as a counter to a claim by the promissory discourse but phrases the issue such that he does not actively engage with the argument itself. In addition, he chooses a formulation which nuances a positive claim ("how little"), while not positing a negative statement. This tendency is in line with the other sociological papers in the sample.

Therefore, it is concluded that the reflective discourse's tendency to refrain from explicit value-judgement of the promissory discourse is a discursive feature resulting from the discourse's

domain-specific make-up. As Hedgecoe (2010) indicates, ethical papers should to explore ethical consequences of NEST and aim to regulate debate. In the sample, though, little ethical papers are found. It remains unclear why there are so little ethical papers in the sample. One speculative reason could be that, against other new and emerging (bio)technologies, IVM does not seem to threaten many established actors, ideological groups and other shareholders, as in indicated by the relative lack of responses form the meat industry[32]. In principle, one would expect that IVM threatens the meat industry, but realisation of IVM might be too far-fetched yet. This could also explain why the meat industry has not responded to IVM much. Additionally, the lack of ethical papers could be a feature of the relatively small sample and the cross-sectional view that this sample provides, however, additional searches for ethical papers beyond the scope of this thesis did not yield significantly more results. Based on the considerations above it is most intuitive that reflective discourse scholars act according to their disciplinary standards and customs, tough a discursive deficiency as in Hedgecoe's case study cannot be ruled out completely as well.

The following chapter engages in deeper reflection and moves beyond description of discursive particularities. It first explores issues that relate to assessment of IVM's expectations, second the role of early promissory NEST rhetoric is discussed and, third, related challenges for reflective discourses are considered. These reflective discussions are not exhaustive but aim to suggest key routes for further debate by highlighting key implications and problematic assumptions and frames. Subsequently the discussions section considers the strengths, weaknesses and implications of the thesis and makes suggestions for further research.

[32] Consider that an organisation with a strong ideological affinity like PETA, though with internal struggle, endorsees IVM research efforts. Also, Dutch meat producer Stegeman was part of the initial IVM research consortium, indicating that the meat industry could pick up on IVM when it has more potential. In a similar context, recently, small-scale meat imitation producers outed criticism of new subsidies that allow powerful vested meat companies to develop their own imitation meats (c.f. Van Gils, 2017).

VI. Discussion

A. Assessing IVM's Discursive Topography

A-1. Problematic Dominance of the Meat Substitution Frame

In three interrelated ways, the promissory discourse frames IVM as a meat substitute. First, IVM's benefits are imagined in comparison to meat and the meat industry. Second, the promissory discourse claims that IVM products are essentially meat. Third, the promissory discourse holds that IVM products will (partially) replace meat, implying that the emergence of IVM will not bring about any other changes then the imagined benefits of IVM over meat. Additionally, some works in the promissory discourse imply that IVM is *the* solution for problems of the meat industry and, thus, that IVM is a technofix that can overcome all the meat industry's problems. This strong argument, however, is not widely shared.

In response to promissory rhetoric, a reflective discourse emerged. The reflective discourse is critical of promissory rhetoric in several ways: it questions IVM's promises and the substitution frame, it reconceptualises challenges as explicit concerns, and it brings forth new concerns within the substitution frame. These criticisms, however, are not exhaustive and only rarely frames beyond substitution are considered in-depth. Some reflective papers remain entirely within the substitution frame, while when extra-substitution frame issues are discussed, this is typically done in little detail. As a result, various possible issues beyond IVM as a meat substitute are rarely considered.

That IVM is largely discussed in terms of substitution of meat is problematic as insights from STS and Philosophy of Technology (PoT) emphasize that techno-scientific innovation[33] does much more than substitute existing technologies and impacts societies in deeper ways than often imagined by enactors of NEST. Typical examples include how innovation impacts morality (Verbeek, 2005; 2006; 2008), social practices (Shove, 2013), cognition (Aydin, 2015) and maintenance practices (Vinsel, & Russel, 2016). In short, STS and PoT show that science, innovation and society are thoroughly intertwined and co-evolve, implying that innovations deeply impact societies and vice versa. How technology and society might co-evolve in case of IVM is exemplified in two hypothetical examples below.

As shown by co-evolutionary theories of innovation and society, radical innovation typically emerges in niches, rather than that innovations overthrow established socio-technical practice

[33] For brevity's sake' techno-scientific innovation' will be abbreviated to innovation henceforth.

straight away (Kemp, Schot, & Hoogma, 1998; Schot, 1998). In case of IVM, the dominant regime is meat production and consumption. IVM, then, is not likely to simply emerge as a substitute of meat but develop in a particular niche. IVM could emerge as a niche product in several ways. Consider for instance that IVM might co-evolve with meat, instead of simply replacing it as a technofix of sorts. Under a co-evolutionary perspective, for example, IVM could emerge as a niche product for processed foods only or IVM could only satisfy those who now do not eat meat for ethical reasons. Also, IVM could replaces most meats, but meat could remain a luxury product for the rich only. Under the different examples, IVM product might be consumed by vegetarians only or unequally by different socio-economic groups, alternatively IVM might finds its way in the market solely in cheap processed meat products. Such considerations are relevant but hitherto scarce in the reflective discourse.

In addition to niches as sites for IVM to be developed further, different routes of societal uptake of IVM can be envisioned - beyond IVM as a meat substitute. Considering such routes indicates that the promissory discourse conceptualises uptake of IVM too simplistically. One way to highlight the overly simplistic substitution frame is to envision how different social groups might respond when IVM products enters the market. For instance, IMV might attract different responses in different countries with different food cultures.

By way of deconstructing problematic assumptions and implications of the meat substitution frame the following subsections highlights shortcomings in the arguments of IVM proponents. A first example problematizes the technical notion of 'bio conversion rate' of livestock animals, on which IVM-promises rely. This – to the author's knowledge - has hitherto not been subject of scrutiny in IVM discussions. A second example discusses how social groups might respond differently to IVM, resulting in different consumption patterns and framings, thus problematizing overly simplistic considerations about societal uptake of IVM.

A-2. Bioconversion Rate as a Promissory Anchor point

This thesis has noted that the promissory and reflective discourse share an analysis of the problems of the meat industry and that both tend to rely on the framing of IVM as a meat substitute. There is, however, a particular claim that is merely posited in the promissory discourse: that livestock animals are inefficient in producing meat (e.g. Moritz, et al., 2015; Pandurangan, & Kim, 2015). To support this claim, the promissory discourse presents the bioconversion rate of these animals. The bioconversion rate is a measure for the degree to which vegetable proteins in feed are converted

into edible animal proteins[34] (Moritz, et al, 2015). For livestock this is an estimate of 15% (Pimentel, & Pimentel, 2013). In the promissory discourse, this statistical measure is taken up in an arbitrary way that supports a promissory narrative.

In the promissory discourse it is claimed that *because* livestock converts only about 15% of vegetable proteins from feed into edible animal products, these animals are inefficient. Thereby, the 'efficiency' of livestock is equated to how much edible animal products they 'produce' per vegetable protein. This assumes that livestock has merely one function: to produce edible animal products[35]. This is exemplified in the following quote: *"In vitro meat production system will utilize the nutrients and energy required for growth and maintenance of muscle tissue only unlike conventional meat production where nutrients and energy is required for biological structures required for successful living, locomotion and reproduction. These include bones, respiratory system, digestive system, skin, and the nervous system"* (Bhat, et al., 2015, p.244). The next quote by Mark Posts shows what this implies for the potential of IVM for the promissory discourse: *"high efficiency, bioconversion rate, is the basis for a sustainable product that will be able to improve on the carbon footprint of livestock meat production and as a consequence will require less water, land and energy input per kg of meat"* (Post, 2012, p. 298).

Three nuances show how it is arbitrary that IVM's environmental promises are anchored around the bioconversion rate of livestock. Though livestock might not be that efficient in converting feed to edible animal products at a rate of 15%, the remaining 85% is not simply waste(d). The meat industry is very efficient in making use of the non-edible remains of slaughtered animals. Parts of slaughtered animals are used for a wide range of purposes and (non-edible) products. Designer Christien Meindertsma, for example, found that the parts of one slaughtered pig can be traced to 153 different products. She found appliances for the remains of the pig in, amongst others, soaps, toothpaste, frozen pastry products, cellular concrete, bullets, and train breaks (Meinderstma, 2010). Another example that indicates how livestock is part of a machinery beyond producing meat is that livestock's manure can be recycled in various ways (Peterson, et al., 2007).

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[34] Note that there are wider definitions of bioconversion such as *"the conversion of organic materials (such as wastes) into an energy source (such as methane) by processes (such as fermentation) involving living organisms"* (Merriam-Webster, 2018).

[35] In promissory discourse and in the papers that the promissory discourses cite in the context of bioconversion rates, no definition is provided for the term 'edible animal product'. By the context in which this term is used, it seems that it refers to meat and dairy.

A second nuance is that different breeds of livestock are more efficient than others. Consider the Netherlands where over 70% of cattle is held primarily for dairy production (CBS, 2018). Though dairy cows are slaughtered for meat after they stop producing 'sufficient' milk, farmers tend to select the breed of the cow based on the amount of milk they produce (Hakkenes, 2018). To increase productivity for environmental purposes, researchers have urged to select different breeds that produce less milk, but more meat and, thereby, are more efficient on average (Hakkenes, 2018). Efficiency of livestock is thus not a given but can be subject to improvement.

A third relevant nuance is that livestock does more than provide food and useful by-products. It fulfils important cultural roles, for example in visions of the countryside (Mattick, et al., 2015c) and in how humans relate to animals and the environmental overall (Hodges, 2006). In addition, livestock plays crucial roles in ecosystems, by grazing in particular (Milchunas, Laurenroth, & Burke, 1998).

The mentioned nuances were located within current meat industry practices while, additionally, it can be argued that livestock animals have value as living beings which is supressed in the meat industry. Such arguments are regularly found in the societal critiques of animal welfare actors and the like. Regardless of this additional critique, the three outlined nuances show that it is too simplistic to present the bioconversion rate of livestock as a key argument of livestock's inefficiency.

Highlighting the variety of purposes of livestock in (agri-)culture and the meat industry shows that society in many ways relies on livestock – beyond mere edible animal products. Livestock is not an inefficient meat producing machine, as is implied by the promissory IVM discourse. In discussing IVM futures within the substitution frame, moreover, other roles of livestock are blackboxed.

A-3. Differentiation in Social Responses to IVM

To discuss how different social groups might respond to IVM products, this subsection discusses a few hypothetical scenarios. These scenarios introduce conditions under which IVM could reach the market. The point of this section is not to speculate on the plausibility of scenarios, but to point to the variety of ways in which social groups can make sense of IVM under different conditions.

Assume that most IVM promises are fulfilled and that IVM is thus: widely available at compatible prices, with similar sensory quality to meat, while being healthier and having significantly less environmental impact. Under the substitution frame, IVM will function as a substitute for meat; consumers will simply choose IVM products over meat products that they used to purchase. Thereby, they will reduce environmental harm and animal suffering, and make a healthier choice.

This seems appealing at first, but considering how a tasty, healthy, affordable meat product with little environmental output and no animal harm might impact market mechanism changes the issue. One plausible consequence is that IVM products become incredibly popular and thereby raise the demand for meat products[36]. Think of how consumption patterns might change if meat in form of IVM was to become much healthier, environmental and animal friendlier. Diets could become much more meat-heavy to the point that IVM's reduction in environmental harm could be significantly suppressed by higher demands for IVM products. Moreover, the more environmentally friendly option of becoming vegetarian could become much less attractive since some of the key arguments for vegetarianisms are undermined by the emergence of this hypothetical form of IVM (c.f. Hopkins, 2015). In this scenario, the substitution frame is thus unlikely to hold and IVM's overall environmental impact would likely be not nearly as positive as proposed by IVM proponents. IVM's promissory future is thus problematically based on an IVM product that is in some ways better than meat, in some ways the same which does not impact consumption patterns and culinary practices at all.

A similar consideration holds for the claim that the demand for meat will increase with over 70% by 2050 compared to 2010, while production by conventional methods is close to its maximum (FAO, 2011). By emphasising that current production is close to its maximum, proponents highlight how problematic the expected rise of the demand for meat is. The gap between production and demand implies that population growth and demand for meat are dynamic and subject to change, while production techniques for meat are static and will not develop. This implication goes against fundamental economic principles. Consider two basic dynamics under the assumption that the demand for meat will rise as expected. When production techniques do not develop, the price of meat is likely to rise which could make meat unaffordable for some and less frequently affordable for others, thereby lowering the demand for meat. When production techniques develop, there might only be a small or no gap between levels of production and demand for meat thereby largely overcoming the problem. The scenario in which meat becomes less accessible for some would be problematic if there were a priori arguments for the desirability of meat. Even key IVM proponents, however, do not support this claim as they propose IVM because alternatives such as vegetarianism are deemed unattainable.

[36] If IVM products can be considered meat in this scenario. For the sake of clarity, this section assumes so.

In an alternative hypothetical case some of IVM's promises could be fulfilled, while others are not. IVM might be produced more cheaply than meat and be more animal friendly, healthier and similar in environmental impact, but IVM mighty have less sensory quality than meat. In this case, consumers will likely think of IVM as a cheap ersatz to meat. Within nations and food cultures that in principal could embrace IVM, the less affluent might then consume IVM because of the low price, and therefore consume less meat. Consumption of IVM by the less affluent, might also substitute consumption of non-meat products such as vegetables or starch – partly depending on how IVM will impact culinary practices. The more affluent, in turn, might refrain from IVM products and keep to consuming meat, which in turn would mean that meat would acquire a more luxurious status. Additionally, briefly consider the position of religious groups that traditionally keep to food laws. These groups might or might not be see IVM as 'kosher', 'jhatka' or 'halal' and thus potentially would not want to consume IVM products.

The discussion above highlights how it is overly simplistic to envision that IVM will substitute meat. Different social groups will make different sense of IVM depending on the product, with accompanying changes in consumption patterns, culinary practices, food laws, etcetera. By outlining some of the dynamics when social groups respond differently to IVM products, dynamics are opened up beyond IVM as a mere meat substitute. In considering cases beyond the meat substitution frame, moreover, different relevant issues emerge that are hitherto rarely discussed in the IVM discourse. IVM's promises could thus be discussed more thoroughly than is common in the reflective discourse.

A-4. Scientists' Promises, Trust and the Need for Reflection

This thesis has emphasized that scientists need to acquire different forms of support such as research funding to be successful, and that it is against this background that promissory NEST-rhetoric typically first emerges. In the larger scheme of things this raises questions about the trustworthiness of science and the authority of scientists' claims which is potentially undermined when scientists are forced to engaged in promissory rhetoric. This is especially salient against the background that lack of trust in the authority of scientists in public debates and a lack of trust in science in general is increasingly reported as a hindrance to combatting societal problems (Czerski, 2017).

In an article reflecting on the character of the scientist and the way in which scientists are trusted, Shapin (2004) provides a history outlining how being a scientist used perceiving as a divine calling to unravel the mysteries of the universe. This image of the scientist has changed to the point

where it simply considered a profession amongst others. With this shift, Shapin (2004) highlights, morality - what is the right thing to do - used to internal to scientific activity. Nowadays, however, science is seen as morally ordinary or even that science is preferably abstinent with regards to morality. This, in turn, has enabled the rise of professional ethicists and other reflective scholars (Shapin, 2004), which engage in reflection on the work of scientists - as highlighted in this thesis.

When scientists are morally ordinary on the one hand but are forced to provide promissory arguments for their work to highlight its societal significance, scientist are in a crossroads of sorts. As Swierstra (2016) points out, scientists' promises are in fact moral arguments for what to do, at least implicitly. Thus, on the one hand scientists are deemed to move away from moral judgements because of their moral ordinariness, on the other hand they are forced to engage in such rhetoric to be successful in the first place.

In case of NEST, the SoE with its focus on expectations provides a key entry point for reflection upon the rhetoric of scientists - and to make sense of how scientists deal with their position in a cross road. Though assessment of expectations is on the cusp of SoE and ethics (Lucivero, Swierstra, & Boenink, 2011), and assessment is not a main priority for works in the SoE, SoE analyses can help to broaden promissory NEST-rhetoric, as seen in this thesis[37]. A key possibility for cross-pollination between the SoE and scientists to better deal with scientists' moral predicament is to be more actively in conversation in regarding the social and moral implications of scientists' expectations. When scientists are open for critique from reflective scholars, this can help them to formulate more socially sensitive expectations – which should reify trust in science. The latter assumes good intention by scientists and, as this thesis shows, scientists can choose to neglect or otherwise refrain from interaction with reflective discourses. In case of refrainment by scientists, it is to be advocated that reflective discourse scholars take more active responsibility to asses the moral effects of scientists' expectations and that reflective scholars take effort to thoroughly communicate these moral effects to make sure the moral message is heard.

B. Promissory Starting Points to NEST Discussions

A noteworthy observation for the genesis of academic NEST discussions, and their valuation, comes from reflecting upon the genesis of IVM's promises and by considering the typical early promissory rhetoric of NEST. Usually, the first to be engaged in NEST debates are enactors of the technology.

[37] For efforts towards assessment from the SoE, see work of Geels and Smit (2000), and Smart and Martin, (2006).

These actors, quite often scientists, typically set the agenda for further discussion and propose promissory arguments and frames. As a result, the first way in which NEST considerations emerge in academia are when strategically selected issues are put forth in positive light and in a way that omit and/ or positively frame concerns. This is of importance when considering de facto assessments of NEST as well as how reflective discourses engage with promissory discourses.

De facto assessments of NEST are co-shaped by NEST-scientists who actively engage in promissory rhetoric and whose considerations are almost per definition dominant in early NEST literature – before reflective discourses are involved. For the reflective discourses, this means that they typically encounter promise-oriented agenda's, framings and arguments which they deconstruct and scrutinize according to their research interests. Even if reflective discourses are very critical of a given NEST, time and energy needs to be devoted to overcoming promissory agendas, frames and to refute promissory arguments. The case study of Hedgecoe (2010) and to some extent this thesis, demonstrate that a promissory agenda's and frames are not necessarily contested thoroughly by reflective discourses.

The strategic advantage of NEST enactors to first set the agenda and provide early frames and arguments in academic setting is noteworthy as such, but it is especially relevant when NEST scientists are aware of their strategic edge. IVM scientists have shown hints of this awareness and hinted at attempts to actively govern expectations[38]. Such governing attempts can manifest itself in IVM debates by carefully selecting arguments and frames with in mind possible concerning responses. Moreover, promissory discourse actors could strategically choose which concerns to neglect, and which concerns to present as challenges to overcome. In addition, this thesis noted that the promissory discourse neglects the reflective discourse. In light of the strategic awareness of the promissory discourse, this could very well be explained by the promissory discourse consciously neglecting concerns in order to promote a promissory narrative. By way of such strategic actions blackboxes are introduced that obstruct open reflection and conceal concerning issues. One of these black boxes in case of IVM, the bio conversion rate of livestock, was scrutinized earlier.

By highlighting the strategic advantage of IVM scientists to first set the agenda for IVM discussions, to first frame IVM-related issues, to provide first arguments and to the possibility to

[38] See the quote by IVM-researcher Haagsman on page 26 of this thesis.

govern debate, a key dynamic that impacts the valuation and progression of academic NEST discussions was opened up.

C. The Role of The Early Reflective IVM Discourse

This thesis found that a substantial reflective discourse has emerged in response to promissory IVM rhetoric. This reflective discourse engages in critical reflection of IVM, but several promissory arguments and frames were taken over uncritically in a significant proportion of the reflective discourse. It is problematic that promissory arguments and frames are taken over uncritically as this can lead to inflated promises that become inflexible and exaggerated (Brown, 2003). For example, imagined benefits of IVM such as reduction of CO_2 emissions might only play out on very small scale or not at all. In addition, widely shared ill-founded IVM promissory rhetoric can downplay viable alternatives, such vegetarianism (Ferrari, & Lösch, 2017) and consumption of insects (Alexander, et al., 2017). When IVM attracts more attention and eventually fails to deliver on its promises, moreover, this can lead to public disappointment and can bolster loss of trust in science (c.f. Peterson, 2009). Concerns over widely shared problematic promises raise the question whether more can be expected from early reflective discourses in IVM discussions and how they can leave the right mark.

IVM is a relatively new development, which has not (yet) seen far-reaching hype-dynamics characteristic of NEST. Though IVM has attracted some attention and exaggerated claims are made by IVM proponents, IVM has not seen a significant spike of positive attention, nor in popular media, nor in academia. That reflective discourses have already engaged with IVM is a plus, but lack of thorough critical reflection of IVM promises is problematic.

From the perspective of the valuation of expectations most salient it is up to reflective discourses to broaden the promissory rhetoric of IVM proponents. Such broadening efforts can be provided via two routes. The first route is to critically asses IVM's promises by considering their contents, and how they are framed and contextualised. The second route is to come up with additional considerations that provide a more holistic picture of what IVM futures – beyond promissory visions.

It is salient that, reflective discourse authors engage with IVM from analytic points of view based on the research domain of the author and related theoretical considerations. Possibly caused by the methodological limitations of this thesis, noteworthy is that reflections are missing that engage with IVM for the sake of assessing IVM. Regardless whether these reflections would yield results positive or negative for IVM, thorough assessments of IVM would broaden the IVM discourse as

found in the sample of this thesis. A key observation is this regard is that a lot of reflective works in the sample – mostly sociological in nature - describe the strategies and tendencies of IVM proponents, but do not systematically asses those strategies and tendencies. While reflections do emerge by way of this approach, conclusions are often not directed explicitly at the promissory discourse, nor are they formulated in explicit value-laden terms.

Important is to emphasise is the risk when IVM promises are not critically assessed; they can be implicitly or explicitly legitimized and reproduced. Silently legitimizing IVM's promises is not to be taken lightly, as exemplified in the first paragraph of this section. This is not to put the blame on reflective or other scholars. Standard academic practice requires that reflective and social science scholars inquire a phenomenon with distinct theoretical interest in mind and that they organise their narratives within the confinements of those interests. As mentioned earlier, this discussion of what could broaden up IVM discussions could be due to the methodology of this thesis. Two points are particularly of note. First, a fair proportion of reflective discourse works focus on more than IVM, meaning that the depth of analysis and criticism of IVM is less by way of the research' focus. Second, critical assessment of IVM is not something that is confined to the academic publications that dominate the sample of this thesis. To the contrary, an IVM policy report funded by the European Commission and conducted by academic scholars was very critical of IVM's prospects and the work of IVM proponents (Gunnarsdóttir, et al., 2015). These nuances prompt more thorough discussion of the limitations of this thesis.

D. Limitations

The main limitation of this thesis is the relatively narrow cross-sectional sample, which focused primarily on academic works from 2015 onwards. Though materials on the periphery of academic work were included in the sample, significant parts of IVM discussions take place outside of academia and before 2015, which is beyond the scope of the thesis. Whereas the advantage of a narrow recent sample is that the thesis engages with recent states of affairs in a relatively coherent space, it obstructed conclusions about the larger IVM discourse and its development over time.

A second limitation lies in the assumption that the discussion in the sample has not significantly developed in the time span of two and a half years, while discourses are dynamic in nature. Because of this approach this thesis might blackbox actual changes in the discourse during the time span of the sample. Assuming no significant discursive changes, however, was necessary to provide a cross-sectional analysis, without having to study earlier discussions in detail. This limitation is thus one with practical origin.

A third and related limitation lies in the way in which ADA approach was employed. Typically, ADA is used for political and inter-discursive problems while this thesis provided a micro-level study of academic work in relative isolation. Though useful for understanding how social shaping of valuation took place from different discursive positionings and how contention of promises and concerns took place, this thesis was not able to use Hajer's 'higher level' concepts such as discourse coalition and discourse institutionalisation. Whereas the thesis made an in-depth study of the materials in the sample, the thesis is relatively weak in making connections to related discourses such as biotechnology or tissue engineering. Connections to such discourses could have made for better generalisations from the case study, as well as for insight into how IVM-dynamics relate to dynamics in peripheral discourses.

E. Implications & Suggestions for Further Research

The suggestions for further research are discussed separately for IVM (first) and for the SoE (second).

Further research for IVM could focus attention on the relationships between case studies, such as this thesis and related larger scale discourses, such as biotechnology in case of IVM. Though some studies have focused on relations between biotechnology and IVM (e.g. Metcalf, 2013), questions remain to what extent IVM is a typical biotechnology or whether IVM is a unique case with like dynamics.

In case of IVM, there is research lacking from economic and political perspectives. Research from such perspectives could divert into many directions such as, how IVM might clash with regulations, how different social groups might respond to different IVM products, whether and how IVM is to reach non-Western societies, etcetera. Exemplified by the emergence of IVM start-ups, it is of interest to research to what extend the course of IVM research can be traced based on financial motives. This thesis has tacitly mentioned the salience of financial motives with accompanying changes in expectations and research foci, but not traced them in-depth. Recall how IVM moved from funding from NASA and the promise of meat in space to the Dutch ministry of Economic Affairs' effort to realize IVM products for consumers. IVM research of Mark Post then moved to producing a burger, urged by funding from Sergey Brin. In turn Post was motivated to organise the burger tasting event to attract attention and more funding. Finally, the recent emergence of IVM start-ups who are secretive about productions processes and the products for which big promissory claims are made. Tracing financial motives more in-depth could shed more light on the influence of (private) funding in the course of IVM research, and possibly in related discourses.

Related to the former, of interest for the case of IVM is to closely follow how IVM will develop further between academia and business. With the recent emergence of IVM start-ups with big promises and claims to success, it is worthwhile how the (potential) exchange and/or shift between academia and business will progress. It remains currently unclear whether and how academia will play a role in the further development of IVM. Tracing the effort of these start-ups back to academia, moreover, it would be interesting to find out to what extent business efforts rely on and profit from academic developments.

In context of the SoE this thesis argued for the legitimacy and importance of considering promise-promise and concern-concern relations. Following this argument, it would be interesting to study these relations further in two ways. First, to consider such relationships in other cases can provide grip on their general importance. Second, worthwhile is to study promise-promise and concern-concern relations with more sensitivity. In this thesis it was merely demonstrated that such relations are important. Lacking still is insight in whether it is sensible to demarcate between different promise-promise and concern-concern relations and, in general, if there are distinctly different ways in which promises can contest promises and concerns can contest concerns.

From the perspective of the SoE in general, it would be relevant to trace early academic promises in the longer course of NEST development and discussions. Of interest is to consider how and when early promissory arguments, frames and agendas are contested in the development of NEST at large. This could shed more light on the relevance of initial promises in the larger picture of development of NEST.

VII. Conclusions

IVM is an emerging techno-scientific development with big promises. Though IVM has attracted some attention and fostered debate, it remains in a pre-hype stage. By analysing value-laden expectations in the recent academic IVM discourse, key discursive arguments and frames were identified that can be scrutinized before larger scale IVM debates emerge. It was shown that a promissory IVM discourse actively promotes IVM as a meat substitute, which has evoked responses by a reflective discourse. The reflective IVM discourse has scrutinized IVM's promises and raised additional concerns, though these criticisms are relatively implicit and not comprehensive. IVM's promises were further critiqued in this thesis which has argued to move beyond the meat substitution frame that is widely shared between IVM proponents and reflective scholars. Some directions for debate beyond the meat substitution were introduced, as well as reasons for way in which the reflective discourse operates.

This thesis is limited by its relatively narrow sample and limited ability to make connections to related and encompassing discourses. The key strength of the thesis was to analyse academic promise-concern relations in depth which yielded valuable critiques and entry points for further reflection on IVM debates. Key in understanding the intricacies and implicit assumptions of recent academic IVM discussions was to focus attention on the ways in which arguments emerge in response to other arguments, and against which backgrounds. Importantly, this elucidates that which is not said and ill-explained. The founding father of discourse analysis eloquently formulated this importance:

> *"Silence itself–the thing one declines to say, or is forbidden to name, the discretion that is required between different speakers–is less the absolute limit of discourse, the other side from which it is separated by a strict boundary, than an element that functions alongside the things said, with them and in relation to them within over-all strategies. There is no binary division to be made between what one says and what one does not say; we must try to determine the different ways of not saying such things, how those who can and those who cannot speak of them are distributed, which type of discourse is authorized, or which form of discretion is required in either case. There is not one but many silences, and they are an integral part of the strategies that underlie and permeate discourses"*

(Foucault, 1978, p. 27).

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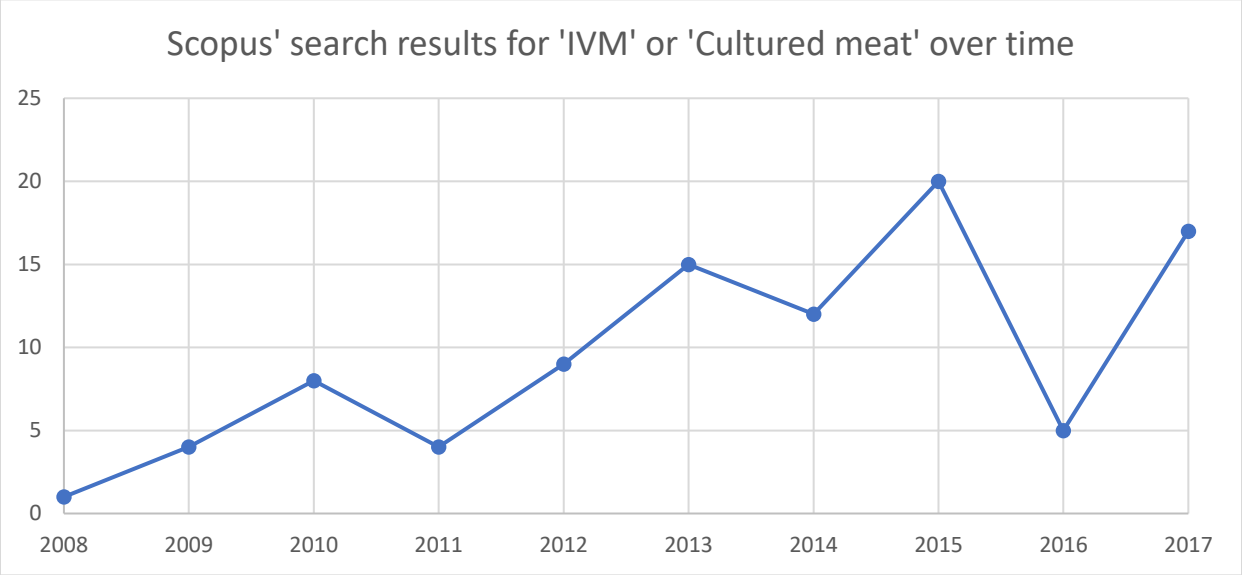
Appendices

Appendix A: Course of the academic In Vitro Meat Discourse

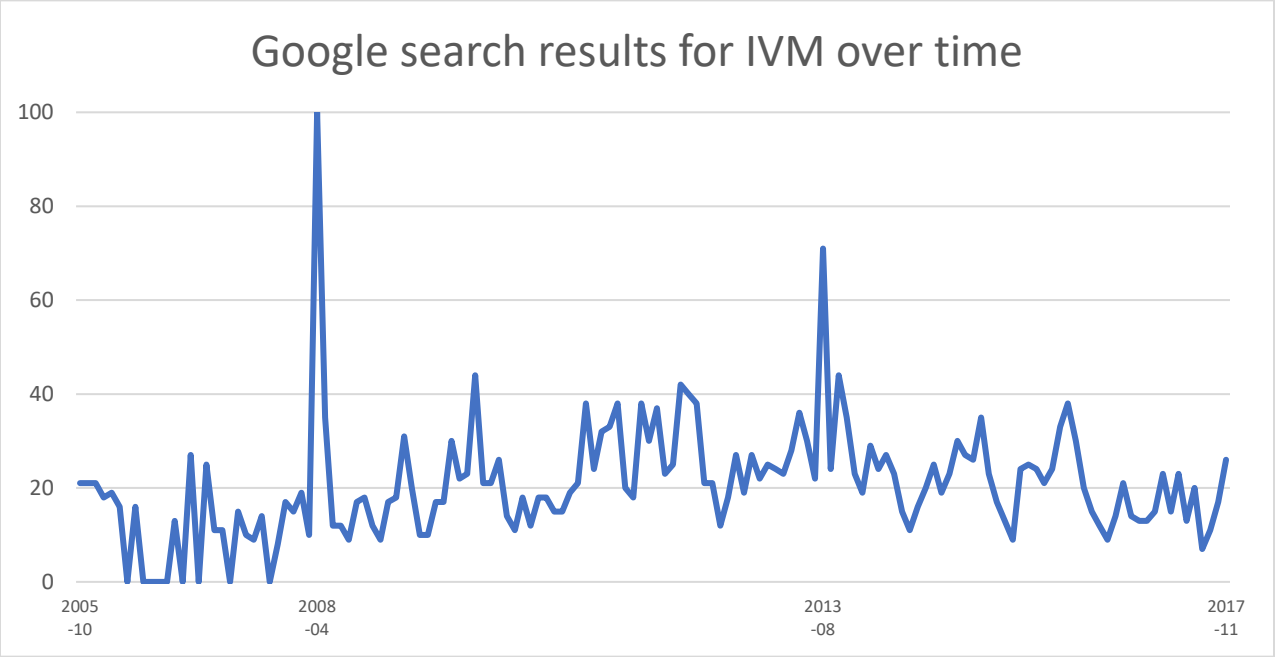
Indication of the development of the academic IVM discourse. The figure illustrates the emergence and course of the academic IVM discourse[39].



[39] The drop in the amount of publications in 2016 compared to previous years - and 2015 especially - is potentially explained by backlash following a special issue from journal of Integrative Agriculture in February 2015 that focused on IVM. Publication of the special issue lead to a spike in publications regarding IVM in 2015. Possibly, researchers involved in IVM worked to meet the deadline for the special issue and hence started new inquires in 2015 that, considering the average lead time for research and revision before publication, did not amount to many publications in 2016. This hypothesis is supported by the finding that authors that publish more regularly on IVM, contributed to the special issue (c.f. Post, Hocquette, Bhat, Verbeke).

Appendix B: Course of the public In Vitro Meat Discourse

Indication of the course of the public IVM discourse. The figure illustrates the two spikes in public attention for IVM, following PETA's one-million-dollar prize for a competitive IVM product by 2014 and Mark Post's burger presentation in 2013.



Appendix C: final list of codes

The final list of code with which the materials in the sample were coded.

1. Chemicals are needed in IVM Production (such as antibiotics, serum, steroids and anti microbials)
2. Availability of IVM will reinforce the demand for meat
3. Beef is partly by-product of daily thus IVM does not make animal harm/slaughter redundant
4. Better (plant-based) alternatives are available (such as: grass-fed beef, meat substitutes, vegetarianism, veganism)
5. Consumers are positive
6. IVM distances victims of meat from consumers
7. IVM does not inherently contain any valuable nutrients
8. Energy recruitments of IVM are possibly high (huge factories/bioreactors high in energy and fossil fuels needed)
9. IVM promises exotic meat products
10. Financial barriers for commercialisation
11. Financial problems for the agricultural supply chain
12. Food equity/Equal access maintains or worsen with IVM
12. Genetic instabilities might occur in IVM production
13. IVM enables healthier meat products
14. High price for consumers/high production costs
15. IVM uses problematic biotechnology salvation narrative
16. Interfering with nature/playing God
17. IVM suggests a false sense of control over cells
18. IVM is not meat (but is a Frankenfood/has a yuck-factor)
19. IVM makes possible better relationships with animals/ reduction of animal slaughter
20. IVM is flexible and quick to address changing consumer demands
21. IVM is unhealthy because of high fat & protein levels
22. IVM enables meat for vegans/vegetarians
23. IVM competes with fair trade trends and thus works against poor world farmers
24. IVM will contribute to a better ecology
25. IVM will worsen relationships with animals
26. IVM alienates from nature
27. IVM cannibalism is a promise
28. IVM creates backlash against real meat eaters
29. IVM is financially effective (low costs, potential for profit)
30. IVM is safe/safer than meat
31. IVM is natural /just like meat, also in sensory quality
32. IVM is sustainable/ has environmental benefits (such as low land, energy and water use)
33. IVM keeps with an instrumental view of animals, just like meat
34. IVM makes it easier to make ethical dietary choices (no behavioural change needed)

35. IVM meets religious laws (such as halal, kosher)
36. IVM research is a waste of resources
37. Success of IVM will still require use of animals for other things like dairy
38. IVM keeps with dominance of the meat industry
39. IVM lacks sensory appeal
40. IVM will produce no/less animal borne diseases
41. less antibiotics/hormones needed for IVM production than for meat production
42. IVM leads to loss of independent farming/ no more need for farm animals, rural livelihood (IVM undermines cultural values associated with meat)
43. Meat in space is possible with IVM
44. Production of meat produces useful by-products that are lost in IVM production
45. IVM helps to meet the increasing demand for meat/ combats world food poverty issues
46. IVM messes with socio-ecological harmony
47. IVM production is vulnerable/ requires a sterile environment
48. IVM will lead to new dining experiences
49. IVM circumvents the burden of unreliable animals as raw materials for meat production
50. IVM is not suitable for vegans/vegetarians
51. IVM enables only processed meat
52. IVM overemphasises that meet is needed - downplays sensible alternatives
53. Possibly low consumer acceptance of IVM
54. IVM enables potential for home-made processed meat products
55. Potential for lot of meat from a small number of cells
56. Problems which IVM aims to combat are not merely scientific in nature
57. Consumption of IVM will evoke religious concerns
58. IVM requires little labour
59. Research is costly and time-consuming
60. Risks for contamination during IVM production
61. Safety concerns (long term) for IVM
62. Slippery slope to cannibalism
63. IVM promises speedy production
64. IVM production requires animal products (such as foetal calf serum)
65. IVM will struggle with government regulations
66. IVM will lead to tastier meat
67. IVM has to overcome technical challenges
68. IVM is a technofix for problems of the meat industry that obstructs veganism and vegetarianism as parts of larger scale critiques of society
69. IVM entails undesirable influence of commercial parties (investors) in scientific processes
70. IVM has unforeseen negative consequences
71. IVM has unforeseen benefits
72. IVM is unnatural
73. IVM produces a lot of tissue engineering waste
74. IVM has unknown long-term effects

Appendix D: Promises and their frequency in the recent academic IVM discourse

#	Promise	Frequency (out of 46)
1	IVM is sustainable/ has environmental benefits (such as low land, energy and water use)	43
2	IVM makes possible better relationships with animals/ reduction of animal slaughter	41
3	IVM enables healthier meat products (e.g. more vitamins, less fat)	27
4	IVM helps to meet the increasing demand for meat/ combats world food poverty issues	17
5	IVM will produce no/less animal borne diseases	15
6	IVM is natural/ just like meat, also in sensory quality	11
7	IVM promises exotic meat products	11
8	IVM is financially effective (low costs, potential for profit)	7
9	Less antibiotics/hormones needed for IVM production than for meat production	6
10	IVM is safe/safer than meat	6
11	IVM promises speedy production	6
12	IVM enables meat for vegans/vegetarians	5
13	Potential for lot of meat from a small number of cells with IVM	4
14	Meat in space is possible with IVM	4
15	IVM has unforeseen benefits	2
16	IVM meets religious laws (such as halal, kosher)	2
17	IVM cannibalism is a promise	2
18	IVM circumvents the burden of unreliable animals as raw materials for meat production	2
19	IVM is flexible and quick to address changing consumer demands	1
20	IVM will lead to tastier meat	1
21	IVM requires little labour	1
22	IVM will contribute to a better ecology	1
23	IVM makes it easier to make ethical dietary choices (no behavioural change needed)	1
24	IVM enables potential for home-made processed meat products	1
25	IVM will lead to new dining experiences	1

Appendix E: Concerns and their frequency in the recent academic IVM discourse

#	Concern	Frequency (out of 46)
1	Possibly low consumer acceptance of IVM	34
2	IVM is unnatural	25
3	IVM has to overcome technical challenges	24
4	IVM lacks sensory appeal	23
5	High price for consumers/High production costs	22
6	IVM is not meat (but is a Frankenfood/has a yuck-factor)	22
7	IVM production requires animal products (such as foetal calf serum)	18
8	Energy recruitments of IVM possibly high (huge factories/bioreactors high in energy and fossil fuels needed)	14
9	Better (plant-based) alternatives are available (such as: grass-fed beef, meat substitutes, vegetarianism, veganism)	12
10	IVM keeps with an instrumental view of animals, just like meat	9
11	Chemicals needed in IVM Production (such as antibiotics, serum, steroids and anti-microbials)	9
12	Safety concerns (long term) for IVM	9
13	IVM leads to loss of independent farming/ no more need for farm animals, rural livelihood (IVM undermines cultural values associated with meat)	8
14	Availability of IVM will reinforce the demand for meat	6
15	Slippery slope to cannibalism	6
16	IVM is not suitable for vegans/vegetarians	6
17	IVM does not inherently contain any valuable nutrients	6
18	IVM messes with socio-ecological harmony	6
19	IVM enables only processed meat products	6
20	IVM needs to overcome financial barriers for commercialisation	6
21	IVM will struggle with government regulations	5
22	IVM research is a waste of resources	5
23	IVM has unknown long-term effects	5
24	IVM overemphasises that meet is needed - downplays sensible alternatives	4
25	IVM alienates humans from nature	4
26	Genetic instabilities might occur in IVM production	4
27	Food equity/Equal access maintains with IVM	4
28	IVM will evoke religious concerns	4
29	Financial problems for agricultural supply chain	4
30	IVM keeps with dominance of the meat industry	4
31	IVM is unhealthy because of high fat & protein levels	2

32	IVM production is vulnerable/ requires a sterile environment	2
33	IVM suggest a false sense of control over cells.	2
34	Interfering with nature/playing God	2
35	IVM has unforeseen negative consequences	2
36	Success of IVM will still require use of animals for other things like dairy	2
37	Risks for contamination during IVM production	1
38	IVM produces a lot of tissue engineering waste	1
39	IVM will worsen relationships with animals	1
40	Research is costly and time-consuming	1
41	Beef is partly by-product of daily thus IVM does not make animal harm/slaughter redundant	1
42	IVM uses problematic biotechnology salvation narrative	1
43	Production of meat produces useful by-products that are lost in IVM production	1
44	IVM creates backlash against real meat eaters	1
45	IVM competes with fair trade trends and thus works against poor world farmers	1
46	IVM is a technofix for problems of the meat industry that obstructs veganism and vegetarianism as parts of larger scale critiques of society	1
47	IVM distances victims of meat from consumers	1
48	Problems which IVM aims to combat are not merely scientific in nature	1
49	IVM entails undesirable influence of commercial parties (investors) in scientific processes	1