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Promise and Ontological Ambiguity in the *In vitro* Meat Imagescape: From Laboratory Myotubes to the Cultured Burger

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ABSTRACT In vitro *meat (IVM), also known as cultured meat, involves growing cells into muscle tissue to be eaten as food. The technology had its most high-profile moment in 2013 when a cultured burger was cooked and tasted in a press conference. Images of the burger featured in the international media and were circulated across the Internet. These images—literally marks on a two-dimensional surface—do important work in establishing what IVM is and what it can do. A combination of visual semiotics and narrative analysis shows that images of IVM afford readings of their story that are co-created by the viewer. Before the cultured burger, during 2011, images of IVM fell into four distinct categories: cell images, tissue images, flowcharts, and meat in a dish images. The narrative infrastructure of each image type affords different interpretations of what IVM can accomplish and what it is. The 2013 cultured burger images both draw upon and depart from these image types in an attempt to present IVM as a normal food stuff, and as 'matter in place' when placed on the plate. The analysis of individual images and the collection of images about a certain object or subject—known as the imagescape—is a productive approach to understanding the ontology and promise of IVM and is applicable to other areas of social life.*

KEYWORDS: *In vitro* meat, cultured meat, images, imagescape, promise, ambiguity

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Introduction

In vitro meat (IVM), also known as cultured meat, involves tissue engineering muscle that could potentially be eaten as meat. Research in the field has been slowly progressing over the last 15 years, although little in the way of edible tissue has been made. In August 2013, the technology achieved a new height in public profile when a €300,000 cultured burger was cooked and tasted in a press conference in London. Branded as a proof of concept, the tasting was a deliberate attempt to communicate the vision for a hitherto little known scientific development as widely as possible. In doing so, the event attracted media attention from across the world, as televisions, print media, and websites displayed images of the world's first laboratory-grown burger.

This event was planned to present IVM to the world and allow many of us to see IVM for the first time. This visual component of seeing the burger—a burger that had been grown in the laboratory—formed a core element of both the press conference and how it was reported in the global media. In this paper, we explore what we can learn from depictions of IVM by comparing these 2013 cultured beef images to images of IVM from 2011 when funding for the burger was first announced. Importantly, the focus is on the images themselves more so than how they are framed in any supporting text, as we analyse what messages these images convey and what remains ambiguous. In particular, we ask: (i) how do these images suggest what IVM can accomplish? And (ii) how do these images suggest we should understand what IVM *is*?

Let us begin with an introduction to IVM, before developing our empirical focus on images. The technology is essentially the application of biomedical techniques developed in stem cell science and tissue engineering to food production. Many of the scientists working to develop IVM have a background in biomedical research and apply techniques used there to this new context. The two earliest projects were conducted by a group funded by NASA (Benjaminson *et al*., 2002) and the bioarts group now known as SymbioticA (Zurr and Catts, 2003): much more on these later. Around 2005 the research was taken up most seriously by a Dutch consortium that today has links to the cultured burger described above. Other laboratories exist in the USA, UK, Canada, Russia, and Sweden. None have produced anything more than small quantities of tissue, and until recently none have acquired substantial or sustained funding for their work. Some had circulated images of the tissue they had engineered by 2011, and these will be drawn upon in our empirical work.

IVM technology is associated with a diversity of reasons for why IVM could benefit individuals, collectives, or societies (if it could be produced successfully) (cf. Chiles, 2013a). We call these 'promissory narratives'. Frequent examples discussed in texts include potential environmental benefit of meat production with significantly reduced land, water, and energy use and greenhouse gas emissions (Tuomisto and Teixeira de Mattos, 2011); animal welfare benefits of killing

fewer animals to produce meat (Hopkins and Dacey, 2008); health benefits of a meat that could (i) be engineered to contain specific nutrients, and (ii) be produced away from harmful farming environments in which animal-borne diseases and medical interventions such as antibiotic or hormone injections are considered a possible threat to the human consumer (Bhat and Bhat, 2011); potential to help address global food poverty (Haagsman *et al*., 2011); potential for food technology innovation, allowing meat to take different shapes, textures, and colours, and use cells from animals not usually farmed (Datar and Betti, 2010); potential to produce meat in space (Benjaminson *et al*., 2002); and the potential to generate profit.

The dominant mode of communication for these promissory narratives is textual; they are discussed, written down, and recorded in YouTube videos. Images that show us 'the meat', however, demonstrate a disconnect from these frequent textual narratives. Instead, images of IVM suggest narrative themes including muscleness, meatness, and deliverability. In this paper, we take these images seriously to explore the promissory work they achieve, and assess the understandings of what IVM *is* that they afford. These images have ramifications for how and if the technology is taken forward, in what form this happens, and how diverse groups of experts and publics respond.

Analytical Perspectives

We draw upon, and synthesise, two clusters of analytical perspectives from Science and Technology Studies, Cultural Studies, sociology, and anthropology in answering our key questions. The first cluster relates to how we understand images, and the second relates to how we understand the classification of what IVM *is*.

Analytical Perspective 1: Images and the Imagescape

Images are important. They impact our understandings across a range of cultural spheres, of which science is only one. This importance only increases in virtual environments where they are moved from website to website and across social media frequently detached from the original textual context in which they were published, and can flow across restraints of genre and language in ways often impossible for textual forms.

Images of IVM show us 'the meat', although this happens in a diversity of ways. Some reveal how it looks today, some reveal how it is envisioned it will look one day in the future, and others reveal commentaries on the associations of the tissue. We term the collectively of these images the 'imagescape'; the expanse of images relating to a distinct object or subject.

The imagescape that emerges will enable and constrain the uptake and use (and easy recognition) of IVM images; it both shapes and is shaped by the images within. In a promissory technological domain like IVM, images are used to 'tell

oneself forward' (Deuten and Rip, 2000) in that they suggest narratives for us to interpret pasts, presents, and futures. Furthermore, images can contribute to 'credibility pressures' (van Lente, 1993) on those producing new technologies as the story the images tell can spark expectations of delivery for the viewer.

Our notion of imagescape builds upon Appadurai's notion of 'mediascapes', which 'refer both to the distribution of the electronic capabilities to produce and disseminate information (newspapers, magazines, television stations, film production studios, etc.) [. . .]; and to the images of the world created by these media' (Appadurai, 1990, p. 298). While mediascapes are image-centred, and an infrastructure is needed for images to circulate, we emphasise that through their circulation images also shape the infrastructure through which they circulate (cf. Ruivenkamp, 2011). Therefore, we prefer 'imagescape' to capture this transformative potential.[1]

We use the term image to mean 'visual representations' with a material basis on a two-dimensional surface—be that on paper, walls, or computer monitors[2]—in which representation means 'standing for' and/or 'acting for', as in political representation (cf. Brown, 2009).[3] To answer our key questions—by focusing on what images do—we employ a theoretical framework that draws upon elements of visual semiotics and narrative analysis.[4]

We draw upon visual semiotics through the work of Kress and Van Leeuwen (2006) and their recognition of images as 'signs'. Visual semiotics offer ways to study and understand how images confer meaning, including the effects of the material configuration on the image's two-dimensional surface. Kress and Van Leeuwen develop De Saussure's (1959) dyadic model of the signifier—the form a sign takes—and the signified—a mental construct of the thing rather than the thing itself—for the study of images. Specifically, we share Kress and Van Leeuwen's view on the relationship between an image and the text that often accompanies it, in that we recognise an image as an 'independently organized and structured message, connected to the verbal text, but in no way depend[ing] on it' (ibid, p. 18). As such, we move away from Barthes' (1966/77) argument that the meaning of an image is always related to image–text relations.

Developing this theme further, our analysis is influenced by narrative analysis, and in particular the application of 'narrative infrastructure' (Deuten and Rip, 2000) to images. This allows us to recognise how images enable and constrain how an image is read. The story that is taken from the reading of a material configuration on a two-dimensional surface is co-created by an image and the reader, as opposed to being exclusively located in the reader's interpretation. We use the notion of affordance to capture this capacity of the image to suggest some readings more easily than others. As Rip and Ruivenkamp (2012) explain:

> Affordances of images differ from those of common artifacts (say, a door handle) in that the gaze of the 'reader' is drawn into a world contained in the image. The gaze, and by implication, the reader, can move around in

> the scenery that is offered, but its movement is guided by the visual semiotics of the image. This is how a story starts being told to the reader. (Rip and Ruivenkamp, 2012, p. 9)

By focusing upon affordance, we can assess the range of meanings most easily communicated by an image while retaining a recognition of the importance of individual viewers to their own sense-making practices.

Visual semiotics and narrative analysis point us towards the specific readings that an image affords. In this framework, these images (1) can circulate as entities in their own right, (2) carry meaning that is independently organised, but (3) convey messages in combination with the frame in which they are presented, and (4) allow for the co-creation of messages through the interpretation of the reader. We explore these four issues with our own theoretical development—the imagescape—to understand what images of IVM do.

Analytical Perspective 2: Categorisation and Ontology

The empirical examination of 'meatness' as a theme holds a central role in our analysis. Elsewhere, one of us has described IVM as an 'as-yet undefined ontological object' (Stephens, 2010, p. 400; cf. Driessen and Korthals, 2012; Chiles, 2013b; Stephens, 2013; van der Weele and Driessen, 2013; O'Riordan *et al.*, 2016). Stephens argues that IVM does not easily fit existing ontologies around meat and animal kinship, as prominent markers of 'meatness' in meat production as traditionally recognised have significantly reduced prominence. Certainly in the 2000s, no culturally prevalent account that clearly defined what IVM *is*, and could do, existed. While both *in vitro* and traditional meat come from the same animal source, it is clear that conception, pregnancy, birth, growth, or slaughter do not feature in IVM as they do with traditionally produced meat. The process is so different that it is possible to question whether IVM is meat at all, which in turn leads to questions about what IVM is if it is not meat. In the absence of any culturally available definition, the tissue can all too easily be perceived as uncomfortably straddling boundaries between the present and the future, tissue engineering and animal rearing, the laboratory and the kitchen, and the routinely slaughtered and the never-born.[5] This notion of ontological ambiguity points to ambiguities around both what IVM *is* and how it relates to existing classifications around food, science, and technology.

For the purposes of this analysis, it is useful to expand this characterisation using the work of Mary Douglas (1966 [2002], 1972). In her classic study of pollution beliefs, she built upon Durkheim and Mauss (1903) to argue that classification is key to rational behaviour and necessary for human coordination. Her analysis presupposed that everyone finds dirt offensive, and defines dirt as 'that which must not be included if a pattern is to be maintained' (p. 50, Douglas

1966 [2002]). Subsequently, from Douglas' perspective, understandings of dirt are an issue of classification.

It is important for our application of this to IVM that we do not understand the term dirt in too simplistic or literal a way. Douglas famously described dirt as 'matter out of place', which 'implies two conditions: a set of ordered relations and a contravention of that order' (Douglas 1966 [2002], p. 44). Matter out of place can include mud on the carpet, but can also include a handkerchief in the cutlery draw, or a clown's hat on a labouring miner. Carpets, cutlery draws, and mining exist within ordered relations and their contravention produces symbolic dirt. Using this framework allows us to understand the potential for IVM to be seen as anomalous or ambiguous as it falls outside accepted ordered relations around both meat and tissue engineering, allowing it to be understood as matter out of place or asserted as matter in place. Here we investigate how IVM is depicted as matter both in and out of place by articulating what matter is depicted, the place in which it is situated, and the affordances for being in or out of place. This allows us to comment on the ontological status of the tissue within a classificatory order in each depiction.

Research Methods

We have two elements to our data set: the 2011 imagescape and the 2013 cultured beef images. To compile the 2011 imagescape, we collected the variety of images observable between May and July 2011, sourcing images through three searching mechanisms: (i) Google searches of the web, (ii) various searches of academic publications, and (iii) searches of science stock photo databases. We collected images that show us 'the meat', either as it is or as it is imagined. We use the phrase 'the meat' because the status of the tissue as meat is an analytical category and, as we will show, some images that depict IVM laboratory work do not afford readings of meatness. We found 310 distinct images, many of which were found multiple times on different websites as linking and downloading facilitated reproduction. We make these patterns of circulation explicit in our analysis. We studied English- and Dutch-language contexts. The analysis and data collection strategy are informed by Stephens' ongoing interview study with the scientists, funders, and supporters of IVM research (43 interviews to date). These interview data are not reported directly in this paper as they do not relate to the theoretical framework used or our focus on the circulation of images.

Google Searches

We used Google and Google Image searches to find images on a variety of blogs, online newspapers, academic web pages, and forums. Search terms used included '*in vitro* meat' and 'cultured meat', and '*in vitro* Vlees' and Kweekvlees' in Dutch. We snowballed out from the initial search results to find links to other

images and web pages. Google searches and the subsequent following of links produce seemingly endless amounts of web pages and ongoing multiple re-presentations of the same image and text. We searched until we believed we had saturated the image set. While some images may have remained uncollected somewhere on the Internet, we are confident we have all those that were on high-profile sites or were frequently used in the summer of 2011.

Academic Publication Searches

Google Scholar and PubMed were used to search for academic publications, as well as the online IVM resource www.new-harvest.org. In practice, Stephens already had copies of the majority of published accounts via meetings with scientists in the field. Identification of articles was problematised by many outputs from the IVM research not mentioning meat at all, either by researcher's choice or editor's direction. Given this, Stephens' ethnographic embeddedness within the field provided a much better confirmation that all appropriate publications were found than the database searches were able.

Science Stock Photo Database Searches

Two online Stock Photography Databases, the 'Science Photo Library' (SPL) and 'Alamy', and the 'Dutch Press Agency' (ANP) (translated from Dutch: Algemeen Nederlands Persbureau) were searched with the same search terms. We did not find any IVM images in these databases.[6]

The 2013 data have a distinct data collection strategy as we focus on the specific intervention of the cultured beef event. The organisers of the London press conference in which the cultured beef burger was cooked and consumed enforced a strict 'no photography' policy on the journalists and other attendees invited to witness the spectacle. All the visual images, still or moving, of the event were taken by the photographers and film crew coordinated by the cultured beef team. Photos were disseminated via their culturedbeef.net website. Subsequently, we collated the 24 still images hosted on this site and narrowed these down to 19 images of 'the meat' for further analysis. As the live filming of the press conference was transmitted in broadcast quality to the global media, it has also been possible for still images to be taken from the cultured beef team's footage. Google and Google Image searches found a set of images of this type capturing two burger tasters sniffing or close to biting the IVM. These images have also been analysed.

An Analysis of the IVM Imagescape

Our analysis found a striking consistency within the 2011 data in the form images take and the types of images found in certain locations. It is also clear that the 2013 data break from this consistency in important ways. This findings section is

divided into six subsections. The first four focus upon the categories of images found within the 2011 data: cell images, tissue images, flowcharts, and 'meat in a dish' images. The fifth focuses upon a limited number of 2011 exceptions, and the sixth subsection considers the 2013 cultured beef data. The characteristics marking each category as distinct will be identified as well as areas of overlap between them. Our application of visual semiotic and narrative-based approaches allows us to describe the meaning that is afforded in each image type, while acknowledging the flexibility of message possible through co-creation with the reader. We do so to illuminate the presence of promissory narratives and engagement with ontology in the images collected. Examples of each image type are reproduced in each section, and a table linking to further examples closes this paper (Appendix).

Cell Images: Muscleness More than Meatness

The first category collates images found in 2011 that are based on photographs of cells produced by scientists making IVM (see Figure 1). These images are produced with imaging techniques—mediated by a microscope lens and possibly some form of image manipulation software—showing the cell structure. The cell images were found almost exclusively in peer-reviewed papers in scientific journals - locations with restricted access that are intended as a site of

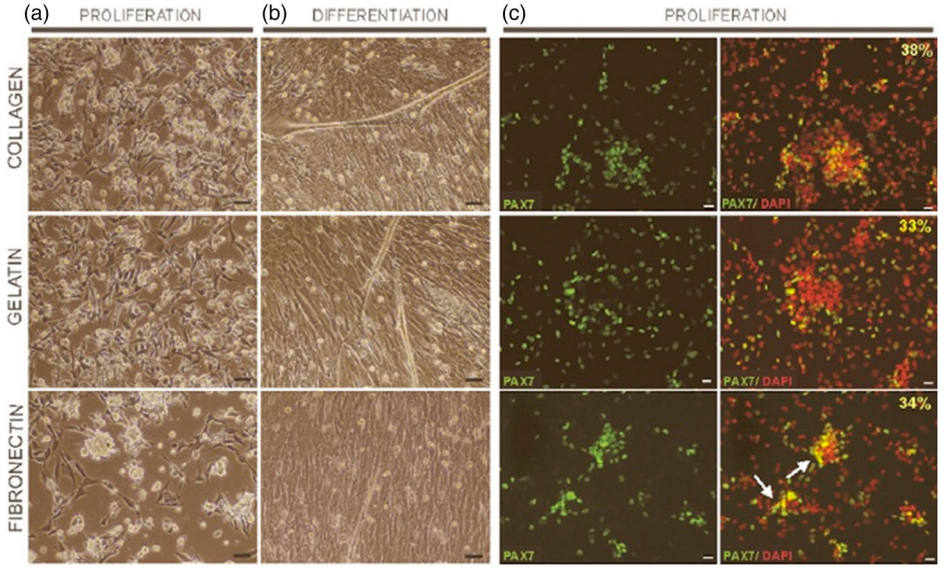

Figure 1. Cell images: note long thin cell shape in the second column that suggests muscle formation. Reproduced with permission from copyright holder © Elsevier 2011.

communication between discipline-specific science professionals - and were not circulated more widely across the imagescape.

We were able to track 10 peer-reviewed journal articles reporting on work funded to develop IVM. The first, published in 2002, authored by the NASA-funded group, the remaining 10 between 2007 and 2011 authored by members of the government-funded Dutch IVM Consortium.[7] Of the 272 photographs in these papers, all but four were magnified images of cell cultures used to present differing states of cell morphology. Scientific equipment is visible in these images, but as background or mediating elements as opposed to the primary content. Authorship is explicit.

These images afford promissory narratives, but rely upon specific expertise and labour on behalf of the reader to co-create them. The typical readership of these peer-reviewed journals is experts in tissue engineering with the expertise to read these images differently compared to most other people. To a tissue engineer, the 'muscleness' of the tissue in many of these images is clear as the shapes in the image run long and thin becoming pointed in the same direction, a growth formation specific to the differentiation of myotubes, the basis of muscle tissue. The promise is the achievability of growing muscle, but is only visible, or co-creatable, to a select audience.

However, while to experts these images may suggest 'muscleness', the narrative infrastructure does not suggest 'meatness' or animal husbandry. Cell culturing is a familiar element of tissue engineering work and growing myotubes fits comfortably within the ordered relations of medical research. Subsequently, the objects shown in these images do not provoke ontological ambiguity; they show engineered tissue on scientific equipment in tissue engineering journals, a wholly normal location for such images to be. In Douglas' terms, this is matter in place. Without invocation of edibility, these images do not challenge the categories that define the journals they are published in and the readers who view them, so no contravention of order is afforded. Promising muscle growth alone is different from promising to grow meat.

To a large extent this continues into the textual framing of the images. The 2002 NASA-funded paper is quite explicit that the work was funded to develop potential protein sources for human consumption, including discussing the impact on astronaut morale of eating the food, and assembling a 'taster panel' to smell and look at the tissue to judge how appetising it was. The Dutch papers approach this differently. Of the 10 papers, only 3 mention meat at all, never more than twice, and within introductory lists of potential applications of their research including transplantation studies, physiological model systems, and gene therapy. 'Meatness' is either downplayed or totally absent.

Cell images are explicitly authored and feature promissory narratives, although the promissory narrative is only accessible to those with specific training. They were not circulated widely, and do not provoke ontological ambiguity.

Tissue Images: Muscular Science, Meaty Art

The tissue images category collates images based upon photographs of small lumps of tissue produced by people making IVM. We found 11 of these images in 2011, 4 featured in peer-reviewed journals and the remaining 7 as part of the Tissue Culture and Art project.

The four images found in peer-reviewed journals feature a petri dish containing muscle cells that are clamped to the bottom of the petri dish with Velcro and pins (see Figure 2).[8] The aim of the experiments is to test techniques to 'exercise' the muscle tissue by fixing it at either end and subjecting it to specific mechanical and electrical stimuli to see if the tissue tries to contract, pulling on its fixings, mimicking a human muscle lifting a weight to develop a fibrous texture familiar to meat eaters. Tissue, dish, medium, clamps, and laboratory bench are all visible. These images were produced to inform the reader about the methodological approach to understanding muscle cell growth. Unlike the cell images, here the scientific equipment is the central message of the image, not the backdrop against which cells are studied. The inclusion of scientific instrumentation is intended to convey information about laboratory methodology.

The images share some of the characteristics of the cell images: they afford promissory narratives that are only recognisable to experts. They are explicitly authored and are not widely circulated. There is perhaps more ontological ambiguity for those experts in these images as the stretching technique is explicitly there to produce a specific texture reminiscent of meat. These three papers include two of the Dutch three that explicitly reference meat in the text. However, this is still largely matter in place. It does not challenge the normalcy of tissue engineering journals to feature this type of image.

The remaining seven images feature tissue grown by artists and tissue engineers Oron Catts and Ionat Zurr who formed the Tissue Culture and Art project in 1996 to explore how artistic expression can be realised through tissue culturing techniques (see Figure 3). In 2002 they began pursuing two IVM-related projects. The first—titled 'semi living steak'—grew cells taken from a sheep foetus onto

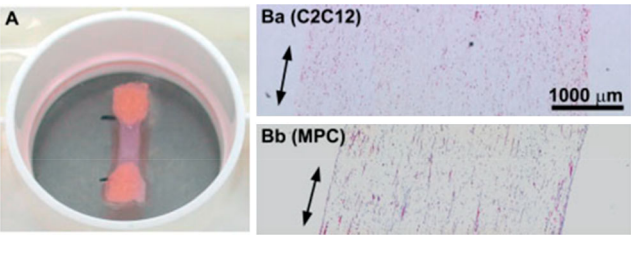

Figure 2. The part of this image marked 'A' on the left-hand side is a typical example of a tissue image as found in scientific journals. It shows a vertically running strip of muscle secured with Velcro at either end. Reproduced with permission from copyright holder © John Wiley and Sons 2011.

Figure 3. Arts tissue image: note small tissue sample on the dinner plate being cut with a scalpel as if a knife and fork. Image credit: Jens Hauser.

a 3 cm scaffold to produce a small morsel of meat. The second—titled 'Disembodied cuisine'—established an installation in a Nantes art gallery where tissue from frogs was cultured into a larger quantity and served in a honey sauce to a dinner party watched by both a public audience and the still living frogs whose tissue was being eaten (Zurr and Catts, 2003; cf. van der Weele, 2007; McHugh, 2011).

The first project resulted in four images showing the meat; photos of some tissue being cut with a scalpel in a petri dish, of a pink blob in medium in a dish, of the tissue once cooked, and an edited image that combines the early steak polymer structure with the grown muscle in the same image. The second project resulted in three images of 'the meat', one on a dinner plate being cut with a scalpel, one of the tissue on a plate on the dinner table in the background, and one of the tissue cooked in a sauce. The central image of the tissue has been cropped from the original image and used widely elsewhere across the IVM imagescape. In the original contexts, the authorship of these images is clear as they are presented on the artist's web pages.

In their original context, ontological ambiguity is the central theme of the art works. Here 'meatness' and the reconfiguration of existing ideas of animal kinship are explicit in the narrative infrastructure, particularly disembodied cuisine where the tissue is placed on a plate in close proximity to the frog from which the cells were taken. The surrounding eating-related paraphernalia of plates, guests, and wine locates the tissue physically and ontologically alongside food-based categories. The ontological ambiguity results in part from the affordances of matter—the tissue-engineered construct—being deliberately put out of place, or into a new place—a dining environment—to provoke speculative imagination.

The images afford a promissory narrative: the eating of the frog which is still alive aligns with animal welfare narratives. Yet this promise is also the basis of the ontological ambiguity. The images also afford the promise that making IVM is possible and has, in a limited capacity, been achieved. Some versions of the images used in these projects have circulated through the online imagescape beyond the artists' web pages, sometimes been used to illustrate discussions about the work of the project, and other times been used as representations of IVM with no reference to their origin. In these later cases, linkages of authorship to the Tissue Culture and Art project are lost.

Tissue images are often explicitly authored and afford promissory narratives, although the form of this promise varies with context. Those restricted within peer-reviewed journals portray similar promissory and ontological narratives to the cell images. This stands in stark contrast to those developed by Zurr and Catts (cf. Zurr and Catts, 2003) who target a different audience and deliberately provoke ontological ambiguity through the depicted promissory narrative.

Flowcharts: Making Meat and Making Meatness

The flowcharts category, as found in 2011, collates images produced by artists using arrows to indicate processes passing over time, or decisions, or options and groupings of variables (see Figure 4).[9] We found 13 of them. Of these, eight originated in peer-reviewed scientific review articles, three were in unpublished online articles written in an academic style by individuals associated with the field, one from a review discussion in Nature, and the remaining image was found on a blog. Nine of the 13 detail imagined processes for producing IVM, starting from the cell or the cell donor animal, using arrows to represent progress through the intermittent production stages resulting in muscle tissue or a food product.

Of these nine process images, five have a pig or farm animal as the originating point of the flow. Three others have 'starter cells', 'myoblast soup', or 'cell isolation' at the origin. The placement of an illustration of a pig or farm animal at the origin makes both animalness and the intervention of the technology into established forms of animal kinship and food provenance explicit. Typically, the flowcharts show a process of cell division in an industrial looking machine labelled a bioreactor and in some instances involve additional processes such as exercising the meat. The endpoints vary between terms such as 'mature myotube', 'edible product', '*in vitro* meat', and 'processing' through to artists' impressions of sausages, and, in two instances, burgers in a bun with salad. This flow forms a strong linearity in the visual semiotics of the images as the reader's gaze is guided from start to finish through the imagined process.

Many of these flowcharts afford clear promissory narratives about the envisioned production process of IVM within their narrative structure. Eight of these originate in academic or popular science review articles mostly written by

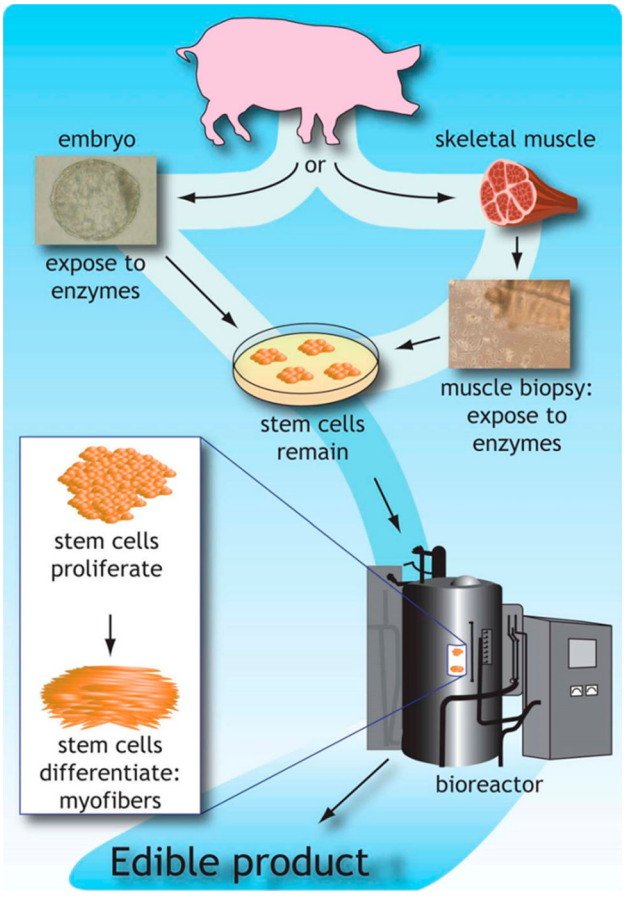

Figure 4. Flowchart. This depiction shows two routes from pig to stem cells, via either an embryonic stem cell line or a muscle biopsy from skeletal muscle. Image credit: Henk Haagsman.

advocates associated with the field, or science journalists looking to explain the technology. Some of these flowcharts have 'escaped' these restricted academic origins; once cut and pasted into new domains within the imagescape, they become ripe for further circulation through linking and down/uploading.

The presence of animalness, scientific instruments, and meatness is an intervention into the ontological uncertainty of IVM. The linkages represented by the arrowed flow are an attempt to redefine the boundaries typically used to categorise meat production systems to include *in vitro* methods as a legitimate form of meat provenance. These flowchart images relate to the issue of matter in and out of place in a nuanced manner. They work to map the processes of IVM production, and as such do present IVM in place: they afford an interpretation of the normalcy, or ontological appropriateness, of meat grown in a bioreactor. At the same time, they show meat produced by means other than those typical of the ontology of meat. As such they are an intervention into existing ontologies: an attempt to

reconfigure ontology in such a way that eating IVM is a normal, ordered, and ontologically defined activity. Some flowcharts do this in a playful way, as in the cartoon Nature flowchart in which animalhood remains present until the muscle tissue is ground through the continual motif of a pig's face on the cells as they run through the *in vitro* process, and the 1960s Batman-style star shape surrounding the sausages on a plate (Jones, 2010). Others use formal lines invoking seriousness (Datar and Betti, 2010).

All these images afford a central promissory narrative: that these techniques can lead to the production of IVM. The focus is upon achievability. The flowcharts do not—apart from one exception—afford the promises present in textual narratives about IVM such as the environmental, animal welfare, or health benefits of the technology.

The remaining two flowcharts do not represent an imagined industrial process. They do boundary work in other ways; for example, one image links IVM research to existing mainstream ontological categories of biomedical tissue engineering by placing IVM research under the same conceptual umbrella as tissue-engineered transplants and biomedical modelling systems (Langelaan *et al*., 2010). It presents IVM research not as a marginal, distant, technological development, but one that shares kinship with successful and credible existing biomedical practices and promissory narratives. As part of this, it also affords an expansion of what constitutes tissue engineering to include food-based applications and highlights the potential for IVM to intervene in the ontologies of science as well as meat.

Flowcharts usually have explicit authorship, but do circulate beyond the original site of publication. The images explicitly bound the ontology into clear frames of reference, engaging with ambiguity through investigating new frameworks of meaning. The promise is that IVM can be delivered.

Meat in a Dish Images: Food/science Juxtapositions

The meat in a dish images collected in 2011 all include two defining features: (i) a meat product recognisable to the contemporary consumer, be it a whole beef burger with bun, uncooked mincemeat, or a steak; and (ii) laboratory scientific equipment often featured in seemingly sterile conditions (see Figures 5 and 6).[10] The central piece of laboratory scientific equipment is usually a petri dish, conical flask, or less frequently a test tube. Often the image includes supporting background scientific features such as rows of test tubes and culturing wells, or the gloved hand of the assumed scientist working on the cells. During the data collection period, we found 18 separate images that conformed to this type. Many of them featured on multiple websites as they are appropriated and circulated widely across the imagescape by other Internet users, further increasing their prominence. These were by some distance the most frequently encountered type in the imagescape.

Figure 5. Meat in a dish image 1. Image credit: Eugene Sim.

These images place the ontological ambiguity of IVM at the forefront, although it remains a specific type of ontological ambiguity represented in a nuanced way. The co-presence of recognisable food products and laboratory equipment highlights the contrasting categories of meat and science. This easily affords interpretations of matter, in this case recognisable meat products, being out of place, in this instance, laboratory containers. This contrast can be read to inspire both 'wow' and 'yuck' responses that encapsulate wonderment or disgust with the category redefining activity (van der Weele, 2010). These contrasting responses also reflect an ambiguous promissory narrative. The images suggest that science could soon make IVM, and allow scope for both celebration of science's mastery and fear of uncomfortable as yet uncharted territory.

Figure 6. Meat in a dish image 2. Image credit: Anya Ivanova.

However, these images do not raise questions about what form meat products take. The narrative infrastructure uniformly presents recognisable existing meat products as found in contemporary supermarkets. The end product presented fits clearly within existing categories of 'meatness' and do not raise questions about whether IVM products may adopt a different form, becoming alternative competitor products for traditional meat foodstuffs. So while these images do engage with the category crossing the nature of IVM technology, the core categories being crossed—laboratory science meat production—remain stable starting and ending reference points.

Meat in a dish images rarely have explicit authorship, and circulate on the Internet being appropriated on various blogs and forums. They suggest a diversity in the graphic design competence used to produce them, from very crude cropping of mincemeat photos into petri dish photos to quite sophisticated professional graphic artistry. This reflects their distribution across private blogs and professional science journalism. What attracted our attention most clearly is the striking consistency across these locations of the visual semiotics, contrasting recognisable referencing points of scientific instrumentation and traditional meatstuffs to engender ontological ambiguity.

Miscellaneous Images: The Minority of Others

We found very few 2011 images that show us 'the meat' that do not fit the above categories, and the limited number helps establish the empirical robustness of our above findings. These exceptions included a cartoon of a young girl holding a plate of beef stake in the shape of a question mark. Another, published by CNN in 2002, shows two NASA astronauts watering recognisable fish growing from plant pots (Stenger, 2002). The third set was developed by designer James King's project to imagine innovative forms that IVM could take (King, 2007). The fourth, Rickard Hederstierna's winning design in the Electolux Design Lab award, features the Cocoon, a home meat-maker similar to a bread machine (Electrolux, 2009). The first three show ontological ambiguity, and the second shows a promissory object relating to a promise that no longer resonates within the field. The third comprises the only images that imagine meat looking in a different form from that recognisable today. The forth image straddles ontological ambiguity and certainty by presenting an unusual way of normalising and domesticating IVM production. However, the most important insight from these miscellaneous images is their scarcity.

2013 Cultured Burger Event Images: A New Ontological Intervention

On 5th August 2013, a press conference was held in London, in which a cultured beef burger was cooked and eaten. This is a defining moment in the emergence of IVM technology and remains the most high-profile instance within the field

(O'Riordan *et al.*, 2016). The press conference had an associated web page (culturedbeef.net) containing images associated with the launch. The organising team—led by Prof Mark Post of Maastricht University—employed a strict 'no photography' rule during the press conference as all images showing the cultured burger were circulated exclusively by them. This occurred in two forms: (i) a live video stream filmed by the team made available online and (ii) a set of 24 photographs of the team and the burger. From the openly available video stream, a small cluster of images have been cropped and circulated through the imagescape. These show the two tasters sniffing the cultured burger and holding it close to their mouths in preparation for eating it.

The footage of the full one-hour press conference, available on culturedbeef.net, includes an introductory video, the unveiling, cooking, and tasting of the burger, and an animation presenting the method used to produce the burger. The press conference was conceived as a deliberate communicative strategy intended to raise the profile, and financial support, bestowed upon IVM. Filmed in a London arts centre, and attended by around 70 journalists, interested parties, and Stephens—co-author of this paper—the press conference succeeded in attracting global media attention. The images within the video show IVM in two distinct ways: (i) two instances of computer-generated animations of muscle cells dividing and (ii) the revealing, cooking, and eating of Mark Post's cultured beef itself.

The longer of the two animations, just under two minutes, features a version of the technical process used to make the burger from start to finish. It starts with an image of a cow from which muscle tissue is removed via a syringe. This strip is depicted separating into muscle fibres and cells of white fat and orangey-red muscle. The muscle is shown separating and dissected. The cells then divide as one single muscle cell results in one trillion other cells, which merge into short pink myotubes of 0.3 mm. These are placed in a petri dish and squeeze around a gel ring, causing them to bulk up, making a small piece of muscle tissue. This one strip is replicated into one trillion strands, which are shown layered together in a circular form, quickly changing colour once more into the striped dark brown and black of a chargrilled burger, on a plate, in a bun, with lettuce and tomato.

The narrative infrastructure in this video shares much with the flowcharts found in the 2011 data. Like most of the flowcharts, the video starts with a farm animal, making animalness explicit, and finishes with a recognisable meat product, denoting foodness. In both cases, the processes of cell division are depicted. The promissory narrative relates to the achievability of IVM technology by showing in a readily understandable form the mechanisms that underlie the production process. The video, like the flowcharts, also represents a direct intervention into the ontology of IVM, asserting cell-culturing techniques as a legitimate approach to meat production and a new ordering of meat-making relations.

The reveal, cooking, and eating of the cultured burger produce promise and intervene in ontology in a similar way. The moment of reveal—when the cultured

burger is first shown—combines key elements of both foodness and scienceness. Before its reveal, the burger is brought onto stage by Mark Post on a white tray underneath a large domed metal lid as may be used to cover a turkey or beef joint. When the lid is removed, it reveals the burger. It appears pinkish red, with the many small strands of tissue from which it is made remaining visible. Perhaps most strikingly, the burger is contained in a transparent petri dish, echoing the key elements of the 'meat in a dish' images found in the 2011 data. The recognisable meat product, an uncooked burger, is sited within a container usually associated with tissue culture laboratories.

Over the course of 20 minutes, the cultured burger is removed from the petri dish by chef Richard McGeown and placed within a frying pan, doused in oil and butter, and cooked. Richard, dressed in chefs' whites, stands in the studio kitchen with food-related paraphernalia such as a chopping board and knife. As time passes, the cultured burger changes colour from pink to a crispy brown (see Figure 7). The burger is then placed on a plate next to a bun, lettuce, and tomato slices. Once the burger has been removed from the petri dish, there is nothing to suggest anything other than the normal practices of burger frying,

Figure 7. Cultured burger image: Chef Richard McGeown frying the cultured burger. While this image has similar content to the press conference images, it was most likely photographed the day before with the practice burger. Image credit: David Parry/PA Wire.

except perhaps for a slightly larger quantity of cooking oil. The burger is then passed to the two food authors who volunteered to taste the cultured burger; Hanni Rützler and Josh Schonwald. First Hanni, then Josh, use knife and fork to cut the burger, wave quizzically in front of their noses to smell, and then eat. Hanni prods it with her cutlery, affording a level of suspicion and exploration not usually granted a typical burger.

As a series of images, this reveal, cook, and eat narrative infrastructure is a further intervention into the ontology of IVM that asserts foodness, through consumption, cooking, and supportive props, while acknowledging a level of unusualness, through the initial siting of the burger in a petri dish, and Hanni's quizzical fork prods. Perhaps the dominant narrative is the promissory, premised upon achievability, of showing real people eating real IVM sitting alongside the real scientist who oversaw the cultured burger's development. While the ontological work of the 2011 meat in a dish images was premised upon the posed photo shoot or the Photoshop edit, the 2013 cultured burger event was premised upon the actualness of the tissue-engineered material presented. Affording less opportunity for IVM to be an unreachable future uncertainty, the cultured burger press conference images showed expensive and small quantities of IVM to be here and now, and to be meat that can be cooked and consumed in an almost normal way.

During 2013, culturedbeef.net also hosted 24 still images that divide into four distinct groups. The first five were headshots of key people involved in the event, Mark Post, the two tasters, the chef and the food technologist. We focus upon the remaining nineteen images that show 'the meat', and fall into three types. Of these, the first group of five images shows Mark Post wearing a blue shirt against a black background, with a serious expression and holding or looking at the cultured beef. In the first four, the burger is in the petri dish, while in the fifth it appears cooked in a bun (see Figure 8). These images have many of the same affordances found in the video, as juxtaposition of raw meat and a petri dish becomes normalised once cooked and housed in bread.

The second group of five images from culturedbeef.net shows the cooking process, and again carries similar affordances to those in the video. In fact, while this is not revealed in the images or the text that accompanies it, the burger featured in these two sets of images is a second (or perhaps a first) cultured burger cooked for practice and to provide these photo opportunities on the day before the streamed press conference occurred.

The final set of nine images has a distinct visual semiotics. They feature Mark Post and food technician Peter Verstrate working in the laboratory environment (see Figure 9). Both wear white laboratory coats, and in most cases blue hairnets and gloves. These images seem more informal than the previous 2013 examples, with little attention to the lighting, and are backgrounded by a working laboratory environment busy with the clutter of cell-culturing well plates, notepads, electrical devices, and safety warning signs. All but one image features tissue, although the

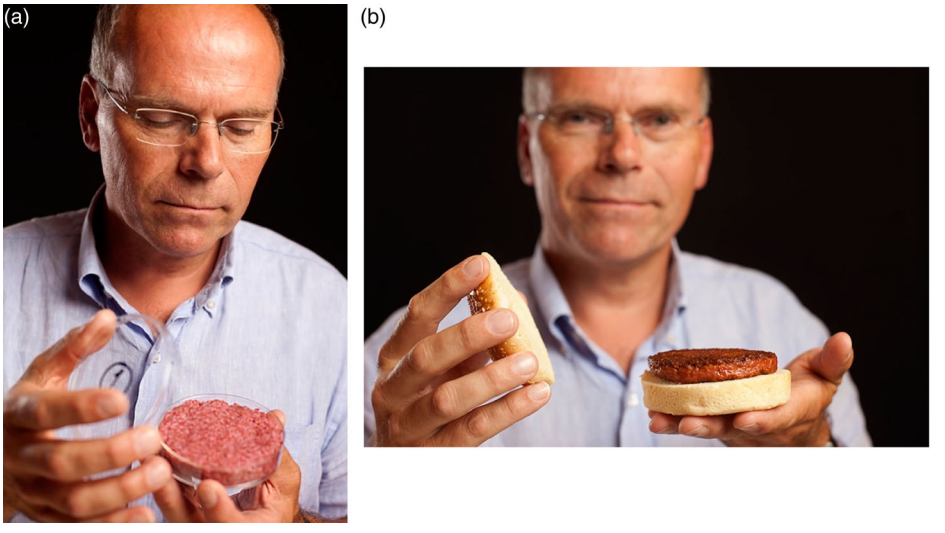

Figure. 8. Cultured burger images: Mark Post holds the uncooked cultured burger in a petri dish (a) and later holds the cooked cultured burger in a bun (b). Image credit: David Parry/PA Wire.

Figure 9. Cultured burger image: Mark Post and food technician Peter Verstrate working on assembling the cultured burger. Image credit: culturedbeef.net.

tissue is small and often not easy to see. The first four show the tissue in a small tube, while the second three show it being mushed in a cell culture well plate and mixed with beetroot juice to give colour. The final image shows the tissue most clearly, with Mark Post holding a laboratory beaker containing a cream-coloured blob.

This set of tissue images does not easily afford an interpretation of food, or meat, in any recognisable form. It appears rather small and gooey. The images contain elements of both versions of the tissue images found in 2011: the tissue and scientific equipment of the journal publications demonstrating laboratory techniques, and the co-presence of the tissue engineers and the tissue found in Oron Catt's and Yonat Zurr's 'Disembodied Cuisine'. Like Zurr and Catts (2003), the tissue would subsequently be eaten; but in Mark Post's case, this would happen in a separate series of images with the ontological intervention taking a different form.

Conclusion: Analysis of the IVM Imagescape

In this paper we have asked two questions: (i) how do images that show us IVM suggest what it can accomplish? And (ii) how do these images suggest we should understand what IVM is? The answer is that images afford readings that are co-created with the viewer, although different types of image do this work through different narrative infrastructures. Images confer meaning through signs that can be analysed through visual semiotics. They offer a scenery that draws the gaze of the viewer and affords some interpretations more easily than others. We term the collectivity of images on a specific object or subject the imagescape, and through the IVM example demonstrate how an imagescape can include multiple distinct image types.

We have articulated the key features of these image types both in terms of their markings on a two-dimension surface and how they do promissory and ontological work. Our investigation of IVM images in summer 2011 identified four categories of images that show us 'the meat': cell, tissue, flowchart, and meat in a dish images. The different image types afford different accounts of what IVM can accomplish and what it is. We also found that IVM images do different promissory work from the textual narratives that often accompany them. These textual forms, found in both 2011 and 2013, assert the environmental, health, and innovation benefits of IVM technology. In contrast, the promise most easily afforded in the images is that IVM can be produced with the suggestion that it will resemble familiar forms of meat known today. That given, we have made clear the potential for interpretative flexibility as image readings are co-created by the viewer, for example in the potential for both 'wow' and 'yuck' responses to meat in a dish images, and the scientific expertise required to read the muscleness of cell images.

The 2013 press conference data also feature meat in a dish images, as Mark Post's cultured burger was revealed in a petri dish. However, the burger was

then positioned among standard eating paraphernalia before being eaten in an attempt to reconfigure the ontological status of the tissue. A further ontological intervention is afforded in the 2013 animation of the IVM production process that, like the 2011 flowchart images, affords an achievability and normalcy for IVM as meat. In so doing, the 2013 images both draw upon and depart from the robust forms found in 2011 and form part of ongoing considerations about how IVM should be classified and what it can accomplish.

Our analysis of how images suggest what IVM is has drawn upon Douglas' (1966 [2002]) account of classifications and matter out of place. In this work, she argued there are several ways to respond to ambiguities in classification systems: to ignore, to condemn, or try to create a new pattern of reality in which they have a place. By making IVM visible, none of the image types we discuss ignore it. The meat in a dish images afford both condemnation, via 'yuck', and celebration, through the 'wow' of ordering new patterns of reality in a technically innovative and promising formation. Flowcharts and the 2013 IVM production animation and burger consumption most explicitly afford new patterns of reality by binding the tissue into novel but acceptable forms of deliverable meat production. Of these, it is perhaps the burger consumption images that Douglas would suggest are most likely to achieve successful reclassification of IVM simply as meat by embedding its consumption within the routine rituals of eating and the press conference as a site of announcement. As Douglas noted, '[s]ocial rituals create a reality which would be nothing without them' (p. 77). The depiction of IVM as meat shown in the context of the ritualistic activities of food gives greater affordance to this mode of reclassification.

Douglas' approach allows us to ask whether IVM is a special case or another example of the ordinary. We believe it has elements of both. The case study is ordinary in that it is an analysis of ontological positioning and classification: activities that remain ongoing in all aspects of social life. Within relatively stable cultural classifications, the making and remaking of meaning continues, and can be challenged by moments of rupture. Meat itself is an example of this. On the one hand, generations of people have lived quite happily mobilising a concept of meat without routine ontological ambivalences or crises inhibiting their lives. On the other hand, we can easily point to the cultural specificity of meatness in national variations in which species are eaten, or moments of classificatory rupture—such as the 2013 European horse meat scandal during which products labelled as beef were found to contain horse—and we can also point to moments where the boundaries and definitions of meatness are reconfigured, such as long-running debates over whether desinewed meat should be legally recognised as 'meat' or 'mechanically recovered meat'. In this regard, ongoing ontological positioning is part of routine social life.

Yet in another way the IVM example is a special, or at least rare, case. This is because of both the lack of historical ontological definition and the chasm in the ontological boundaries it straddles: tissue engineering and meat. IVM has little in

the way of a history beyond science fiction accounts and an often referenced Winston Churchill (1931) quotation. As a potential practicable technology, it has appeared in our shared cultural space—including the imagescape—almost from nowhere, and its classification crossing status necessitates an unusually laboursome task if it is to acquire a communally held status as meat. This lack of history is evident in the IVM imagescape as the scenes depicted exist within and across existing classifications.

The development of IVM technology is set to continue. Mark Post has secured new funding to improve the cultured burger production process, and seeks further funds to expand the project's remit. Meanwhile, other researchers in North America and Europe also pursue research programmes in the area. The increasing financial weight and visibility supporting the research are buoyed by the intervention into the IVM imagescape made by the 2013 cultured burger event. When successful, the affordances of the promise and ontological status of IVM as meat in these images have social and material impacts. They make IVM reputable and attract money, which in turn shapes innovation practices, which in turn will reshape the imagescape once again as new IVM technologies and new ideas become depicted and circulated in visual environments.

The 2013 cultured burger images associate with a defining moment in the history of IVM, framing both what it *is* and what it can do. Because of this, IVM is perhaps no longer an as-yet undefined ontological object in the purest sense. A culturally visible definition now exists: that of Post's cultured burger. This does not mean the ontological ambiguity is resolved, only that it is now played out in a different way, with the cultured burger as a referencing point for support, ambivalence, and contestment: IVM remains without a culturally accepted ontological definition, but there is now a culturally available definition vying for broader acceptance and prominently placed within the imagescape. Yet we anticipate the cultured burger images will not be the final set of images, and final ontological intervention, with the potential to afford new processes of sense-making. It remains plausible that new image types, and new definitional accounts, will emerge that contest and support IVM in potentially novel ways. It seems likely it will be sometime before the imagescape shows a stabilised communicative form associated with a stabilised set of classifications for IVM.

Our theoretical approach draws together visual semiotics and narrative analysis to facilitate an analysis of images that recognises the capacity for images to circulate as entities in their own right—carrying meaning that is independently organised—while also conveying messages in combination with the frame in which they are presented, and allowing for the co-creation of message through interpretation by the reader. We have emphasised the communicative form of the images we studied, and balanced the agency of image and reader through the notion of affordance. We develop the notion of the imagescape to capture the expanse of images relating to a distinct object or subject at a particular moment that recognises their capacity for change over time.

Through the IVM case study, we provide a worked example of how imagescapes from different moments can be analysed and compared to reveal aspects of how communicative strategies change over time, using previous imagescapes both as resources to draw upon and as histories from which to deviate. We have also shown how images can have a narrative and promissory character distinct from textual forms. We offer our methodology as a potentially valuable resource for researching images in other contexts through which other narratives—beyond promise and ontology—can also be explored.

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Notes

[1]See also Schafer (1994) on the 'Soundscape' and the terms development in Sound Studies (Pinch and Bijsterveld, 2012; Sterne, 2012).

[2]This obvious point also implies some of the mystery of seeing/reading images. Compare Sonesson (2006, Lecture 1: 55): 'To perceive a picture is very different from the perception of the real, three-dimension world, already because the former is actually a surface, masquerading as part of the world of our experience.'

[3]By restricting the meaning of 'images' to 'visual representation', we will not use the term in phrases like 'the image of In Vitro Meat with the public'. This also implies that the investigation of public reactions to IVM is a different type of study than an investigation of images and their role in the construction of meaning of IVM. Thus, while images may provoke certain reactions, this paper does not investigate the reception of images by a variety of publics.

[4]Cf. Ruivenkamp and Rip (2011) who apply a similar approach to study images of nanotechnology.

[5]For empirical work on responses to this ambiguity, see Chiles (2013b), Laestadius (2015), Laestadius and Caldwell (2015), Marcu *et al.* (2015), Verbeker *et al.* (2014, 2015), Vinnari and Tapio (2009), and van der Weele and Driessen (2013).

[6]Stock Photography Databases are a main source of images for newspapers. For example, all Dutch quality newspapers (except for the NRC Handelsblad) get their images from the ANP. Therefore, we did not use the Lexus Nexus database to search for images presented in newspapers.

[7]Boonen *et al*. (2010), du Puy *et al*. (2010, 2011), Gawlitta *et al*. (2008), Kuijk *et al*. (2007, 2008), Langelaan *et al*. (2011), Wilschut *et al*. (2008, 2010, 2011).

[8]Cf. Boonen *et al*. (2010), Gawlitta *et al*. (2008), Langelaan *et al*. (2011).

[9]See Haran *et al*. (2008), pp. 27–29 and pp. 102–104 for a similar analysis of equivalent flowcharts detailing stem cell and human cloning practices.

[10]The actual images in Figures 5 and 6 did not feature in the 2011 data set as both were produced more recently. They are included here as representations of the form Meat in a Dish images take. We use these particular images because we could not track ownership for any of the 2011 images and thus could not reproduce them while remaining in accordance with the journal's image reproduction policy.

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Appendix

Table A1. Additional example images for each image type

Image type	Location	URL	Notes
Cell image	*Journal of Visualised Experiments*	http://www.jove.com/files/ftp_upload/4267/4267fig4large.jpg	
Tissue image	*Journal of Visualised Experiments*	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3639551/	Figure 3
Tissue image	Tissue Culture and Arts project	http://www.tca.uwa.edu.au/disembodied/dis.html	This is the artists gallery of images, follow the left-hand menu to access
Flowchart	Nature	http://www.nature.com/news/2010/101208/full/468752a/box/1.html	
Flowchart	The Cultured Meat Blog	http://4.bp.blogspot.com/_qN1c7I5d5Jc/S8UHTlHux9I/AAAAAAAAAB4/47IEWOb0oaE/s1600/Creating+Cultured+Meat.jpg	
Flowchart	OpenWetWare	http://openwetware.org/wiki/CH391L/S13/Synthetic_Meats_and_Organs	
Meat in a dish	Institute for Ethics and Emerging technologies	http://ieet.org/index.php/IEET/more/leland20120507	This and the meat in a dish image below were the two most visible images of their type in 2011
Meat in a dish	VegNews	http://vegnews.com/articles/page.do?pageId=782&catId=8	
Meat in a dish	Marks Daily Apple	http://www.marksdailyapple.com/in-vitro-meat/#axzz3qSuptzpn	
Meat in a dish	James McWilliams	http://james-mcwilliams.com/?tag=in-vitro-meat	
Miscellaneous	Scientific American	http://blogs.scientificamerican.com/guest-blog/dressing-the-meat-of-tomorrow/	Blog post written by the images designer James King
Miscellaneous	Electrolux	http://newsroom.electrolux.com/uk/2009/09/25/swedish-design-student-wins-electrolux-design-lab-2009-with-his-concept-%e2%80%9ccocoon%e2%80%9d24-september-2009/	Electrolux Design Lab winner 2009 'Cocoon' by Rickard Hederstierna

(*Continued*)

Table A1. Continued

Image type	Location	URL	Notes
2013 Cultured burger images	Culturedbeef.net	http://culturedbeef.net/event/	Website of the cultured burger organising team
2013 Cultured burger images	The Blaze	http://www.theblaze.com/stories/2013/08/05/lab-grown-hamburger-meat-gets-taste-test-whats-the-verdict/	YouTube screenshot of the burger being sniffed
2013 Cultured burger images	Sina	http://english.sina.com/world/2013/0805/615710.html	YouTube screenshot of the burger being tasted

Note: Images circulate across the web and it is not always possible to identify original authorship. We do not claim that the below URLs are the original producers or hosts of these images. The images included in the table are illustrative of our analytical categories. However, the *Journal of Visualised Experiments* images were published after 2011 and were not included in our original data collection. All websites accessed 3/11/15.