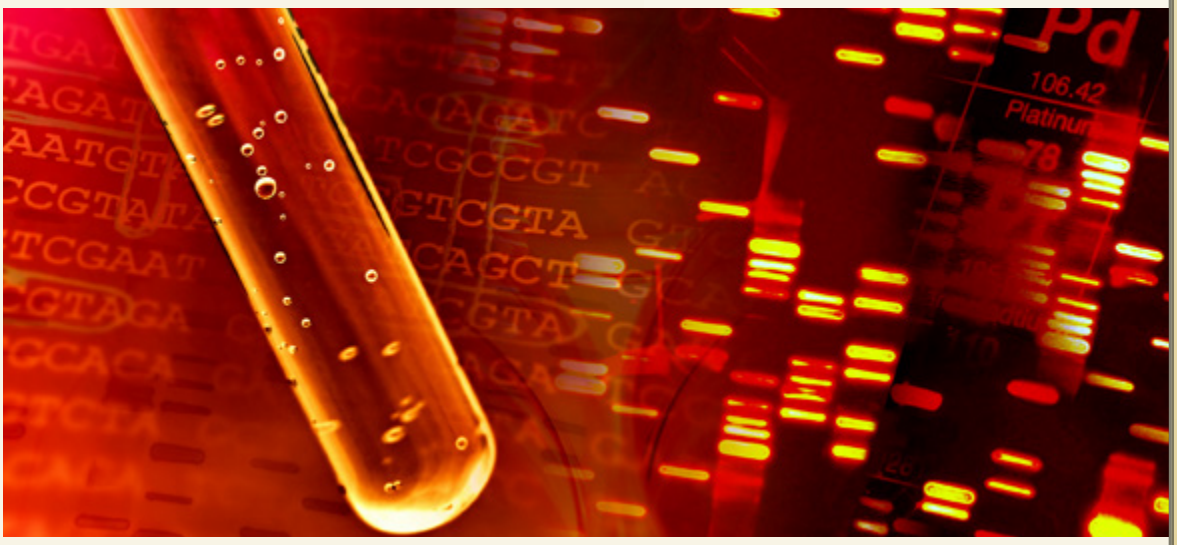
A GUIDE FOR COMMUNICATING SYNTHETIC BIOLOGY



SYNBIO 8

Synthetic BIOLOGY PROJECT

Wilson Center

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EXECUTIVE SUMMARY

"The single biggest problem in communication is the illusion that it has taken place."

- George Bernard Shaw

In recent years, synthetic biology has emerged as a cutting-edge field at the intersection of biology and engineering. This newly developed discipline brings together scientists and concepts from a variety of fields, such as cell and molecular biology, genetic engineering, and computer science.

The ability to modify biological systems means the technology poses unique issues for those trying to communicate about new research and applications. Public perception research to date has revealed that audiences respond differently to synthetic biology compared to other emerging technologies like nanotechnology. Press coverage of this new and growing field is increasing and information surrounding the science is reaching a larger audience. Stories about synthetic biology research are spreading through the news media and generating both hopes and hype about its potential applications.

As the synthetic biology field advances, the need increases for methods to communicate to the public the scientific findings and applications born from synthetic biology.

This document provides a set of guidelines that may help organizations, institutions, journalists, and others discuss synthetic biology with various audiences. The "Communication Process" section incorporates

Defining Synthetic Biology

While there is little consensus around the definition of synthetic biology, the National Science Foundation's Synthetic Biology Engineering Research Center, or Synberc, offers a detailed definition on its website:

Synthetic biology is the design and construction of new biological entities such as enzymes, genetic circuits, and cells, or the redesign of existing biological systems. Synthetic biology builds on the advances in molecular, cell, and systems biology and seeks to transform biology in the same way that synthesis transformed chemistry and integrated circuit design transformed computing. The element that distinguishes synthetic biology from traditional molecular and cellular biology is the focus on the design and construction of core components (parts of enzymes, genetic circuits, metabolic pathways, etc.) that can be modeled, understood, and tuned to meet specific performance criteria…[1]

Further discussion about definitions can be found on page 16 of this report.

key concepts that communicators should keep in mind during message development and delivery, ensuing discussions, and any evaluations that follow. These concepts include:

Audience Matters: While formulating and delivering a message, be mindful of the target audience. Different audiences will have different preconceived notions, leading to different reactions.

Framing is Important: Each message has a "frame" that influences how the message will be perceived. The media will play a role in developing the frame of a message.

Balanced Content is Important: When planning and delivering a message, it is important to present both sides of the issue and prepare for a range of reactions from the audience.

It is also important to consider "Message Content," which is covered in the second section. These recommendations are based on studies focused on the perception of synthetic biology, its potential risks and benefits, and the issues surrounding the science:

Applications and Definitions Matter: Examples of applications are helpful when starting a conversation about synthetic biology, while definitions should be tailored to the needs of the agency or institution.

Messenger Matters: It is important for a trusted source to deliver a message – and that trust must be built and maintained over time.

Language Matters: Try to use clear, concise language to develop messages that accurately portray synthetic biology's risks and benefits and minimize hype.

Organism Matters: Public reaction may very well be negative if the engineered organisms are associated with negative health or environmental effects.

Address Questions Regarding Regulation and Oversight: Despite uncertainty about the governance of synthetic biology, clearly communicating plans about biosafety and biosecurity is essential.

These recommendations are based on public perception research, focus group discussions, and cautionary tales about the hype surrounding the nascent field of synthetic biology. This guide aims to help communicators shape and deliver their messages about synthetic biology in ways that achieve their goals, while still informing the public about the potential benefits and risks of the science in a balanced way.

INTRODUCTION

Guidelines for communicating synthetic biology become more critical as the science advances and moves from the lab to the market, resulting in increased visibility and possible scrutiny by the public and media. A recent analysis of media coverage of the field over the past decade found numerous headlines that were likely to trigger public fears and questions about risk (Pauwels, Lovell, & Rogue, 2012). Underlying both the science and the communications process are deeper questions regarding the public's trust in various institutions to manage emerging risks (Hart Associates, 2013). Traditional risk communication research has demonstrated that maintaining open lines of communication as risks develop will increase the likelihood that the public will remain open minded about the technology (Kasperson Interview, 2013). Presenting balanced information about synthetic biology as the field develops can help control hype about the science and its potential applications and promote more realistic assessments of possible downsides.

Research from the Cultural Cognition Project at Yale University suggests that public perception of synthetic biology is different than other emerging technologies like nanotechnology (Kahan, Braman, & Mandel, 2009; Kahan et al., 2008). Social groups that normally embrace technological advances can have significant concerns about synthetic biology. The researchers suggest that these concerns are due to the moral and ethical implications of creating and engineering living organisms (Kahan et al., 2009).

Abigail Davenport, senior vice president with Peter D. Hart Research Associates and director of focus groups assessing public reaction to technology, also acknowledges that participants react differently to synthetic biology (Davenport Interview, 2013). Since 2006, the Synthetic Biology Project at the Woodrow Wilson International Center for Scholars and Hart Research have collaboratively conducted almost 40 hours of focus groups looking at attitudes towards emerging technologies. Sessions focused on initial impressions of synthetic biology, perceptions of the risk-benefit tradeoff, and reactions to potential applications.

"Even without any knowledge of synthetic biology and what this emerging field of science involves, people make associations based on their understanding of the words 'synthetic' and 'biology,'" Davenport says. "Based on their understanding of this terminology, many participants associate synthetic biology with things that are artificial, fake, or man-made." Researchers have seen these initial negative reactions elsewhere as well. Paul Freemont at the UK Center for Synthetic Biology notes, "Having the word 'synthetic' next to the word 'biology' does provoke a reaction in people that can be negative."

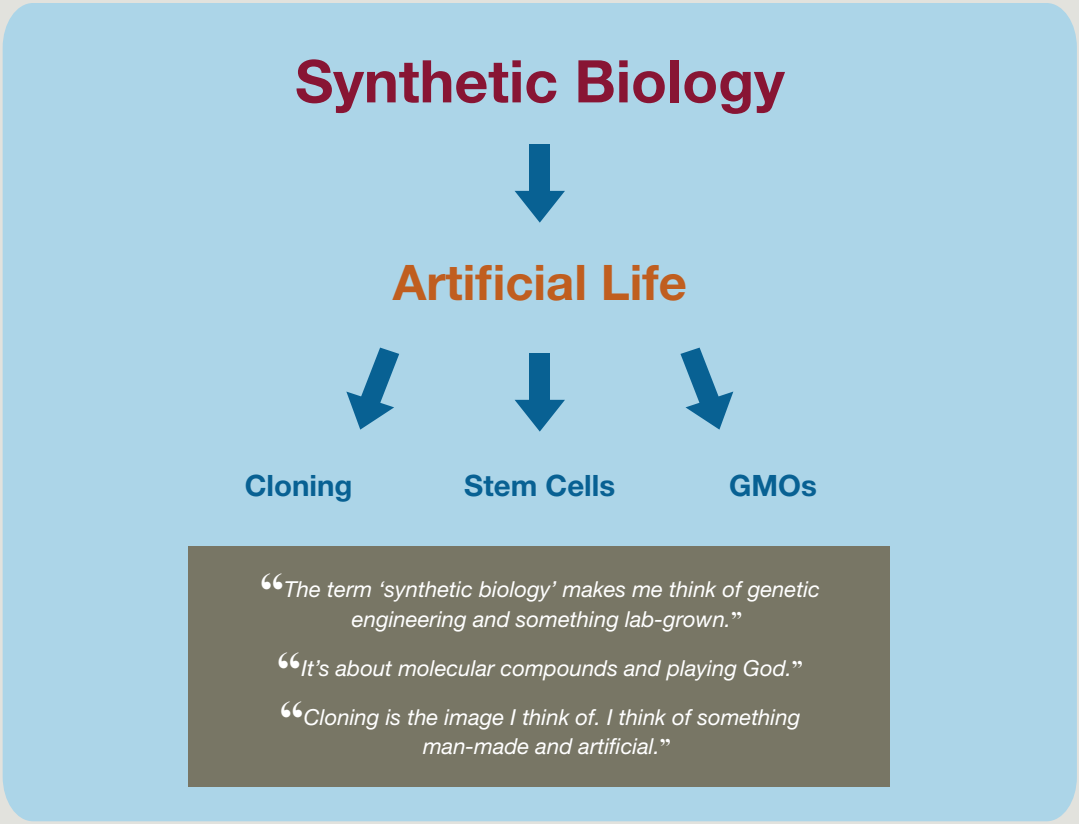


Figure 1: *Quotes from focus group participants describing synthetic biology in their own words (Hart Associates & Wilson Center, 2009, 2011)*

Participants in the focus groups also made a variety of associations with the term "synthetic biology" (Fig. 1). Davenport says while some participants think of prosthetic limbs, artificial medical devices, and synthetic organs, others "imagine scientists manipulating cell life in a laboratory, creating genetically modified plants or animals and altering natural human processes." For example, when asked to describe their initial reactions to the term "synthetic biology" during a 2011 focus group, participants often referenced cloning (Hart Associates & Wilson Center, 2011). In a 2009 focus group, a non-college educated adult described his reaction to the term: "Cloning is the image I think of. I think of something man-made and artificial" (Hart Associates & Wilson Center, 2009).

Meanwhile, information on this developing field is spreading through the mainstream media. Studies from the Synthetic Biology Project show that press coverage in the United States between 2008 and 2011 increased almost three-fold as compared to the period between 2003 and 2008 (Fig. 2) (Pauwels et al., 2012).

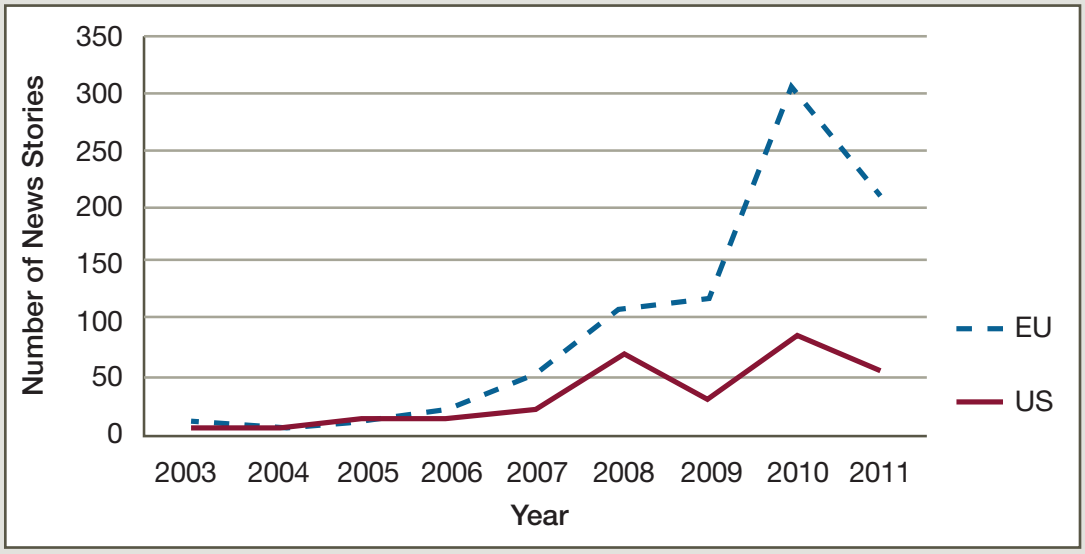


Figure 2: *Number of new stories mentioning synthetic biology in the European Union and United States between 2003 and 2011 (Pauwels et al., 2012)*

Most news articles are driven by key announcements or events. The press also tends to highlight potential applications, but often without any realistic discussion about the major challenges of bringing these products to market. The result is that the public often believes applications are ready for use and perceived risks are imminent. Misunderstandings during the communication process can result in reactions to applications or organisms that do not even exist. Media coverage of the Glowing Plant project in May 2013 highlights overreaction about both the benefits and risks of a novel application that had yet to be produced (Box 1). Furthermore, the incident demonstrates how government agencies were unprepared to deal with questions about first-time applications of synthetic biology – even one not being deployed yet.

In approaching communications about synthetic biology, it is important to consider both the messaging process and the message itself. The messaging process includes identifying an audience and appropriate messenger, planning the message content, delivering the message, and evaluating the audiences' reactions and perceptions. The success of the message delivery hinges on having appropriate content and a reliable communicator. As a message is planned, a trusted, credible messenger should be chosen to deliver a clear and balanced message. (This concept is discussed further in the *Messenger Matters* section.) The taxonomy below may help anticipate and correct errors that lead to mixed messages and negative public perceptions (Fig. 3). Credible messengers do not guarantee better public understanding of synthetic biology if they are delivering poorly crafted or sensationalistic messages. Conversely, even the best message will be viewed skeptically if the communicator lacks credibility with the audience (Kahan et al., 2008).

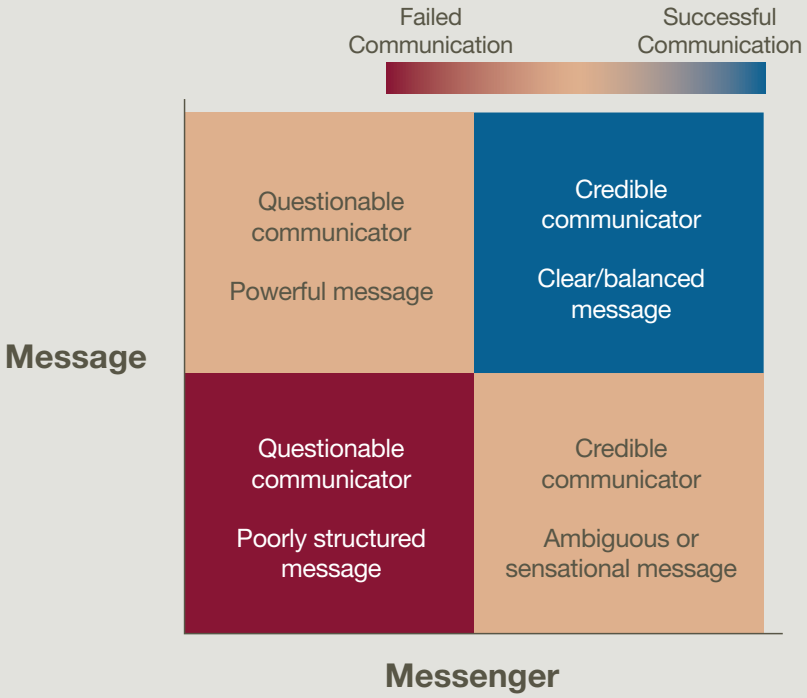
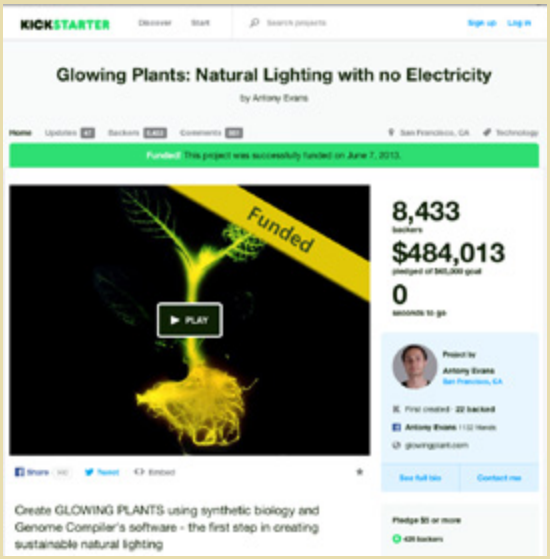


Figure 3: *Communicators must strike a balance between formulating the best message and having a credible messenger deliver it*

BOX 1 A Plant that Glows

The Glowing Plant project is an ongoing saga in the synthetic biology field. Three entrepreneurs— Omri Amirav-Drory, Antony Evans, and Kyle Taylor— launched a campaign on crowdfunding platform Kickstarter to raise money to design a glow-in-the-dark plant. Their initial hope was to raise $65,000, which they easily surpassed with their final take of $484,013[2]. To each backer contributing $40 or more, the project promised to mail a packet of seeds to grow glowing plants. Previous research suggested that engineering plants to glow was not a far-fetched goal, but, at the time of the fundraising, the research project was not complete and no seeds were ready for distribution. While donors were anxiously awaiting their seeds, organizations led by Montreal-based ETC Group actively protested against the design and distribution of the seeds and started their own multi-faceted campaign, called Kickstopper, in an attempt to stop the glowing plant campaign. The U.S. government, meanwhile, indicated there were no regulatory issues with the production or distribution of the seeds, but Kickstarter later banned future campaigns from offering genetically altered organisms as a reward for donations (Callaway, 2013). The Glowing Plant team continues to develop a glow-in-the-dark plant. Although the planned distribution date has been extended several times, the team currently plans to distribute seeds in late 2014.[3]



GUIDELINES FOR THE COMMUNICATION PROCESS

Audience Matters

While formulating and delivering a message, be mindful of the target audience. Different audiences will have varying degrees of background or preconceived knowledge about synthetic biology, which can lead to drastically different responses to the technology.

Scientists in both academic and industry settings are constantly talking with each other about their latest findings. Having these open lines of communication is key to advancing research, as it allows scientists to share ideas and critique interpretations of results. However, it sets up a scenario where most scientists are talking to others who share the same vocabulary. Mathew Nisbet, a researcher in the area of science communication, has argued, "Science and its policy implications need to be communicated in ways that address an intended audience's values, interests, and worldviews" (Nisbet, 2010). This is often difficult for experts in any field. In a new book on communicating complex issues, Frank Pietrucha outlines several reasons that experts may fail to connect with an audience (Pietrucha, 2014):

- Experts were taught to communicate with peers, not to broader audiences
- Experts often live in a bubble
- They are too busy to customize communications for specific audiences
- They are driven by ego and seek to impress their audience

The entire communication process should be tailored according to what an audience already knows and believes, suggests Roger Kasperson, professor at Clark University and expert on the risk communication process (Kasperson Interview, 2013). Before formulating and delivering a message, Kasperson says an understanding of the target audience's perception of synthetic biology is needed. In this regard, understanding existing studies on the public perceptions of synthetic biology may be helpful. For example, the Hart focus groups reveal that many audiences have concerns about the links between synthetic biology and cloning. If not properly addressed during the communication process, fear of cloning might color the perceptions of synthetic biology and prevent the transfer of accurate information. In some cases, an understanding of the audiences' perceptions may not necessarily lead to an accurate portrayal of synthetic biology. Preconceived notions can also be used to propagate hype and sensationalism, as was the case for George Church's tale of "cloning a Neanderthal baby" (See Box 3 on page 20).

It is important to point out that multiple feelings and perceptions might exist within an audience and will likely differ between audiences; therefore, having multiple approaches to the communication process could be beneficial in formulating and delivering a message that will reach a broad number of individuals. This includes recognizing the community's outlook on synthetic biology, as individuals tend to adopt the attitudes and beliefs of their peers and others in their social network.

Framing is Important

A message always has a "frame" that influences how the message is perceived. When framing a message, keep in mind the target audience and the desired outcome of the message. The media plays a major role in developing and propagating the frame of a message.

"Framing" as a communication concept means that one piece of information can be presented in different ways. Depending on the language and visuals used, various representations of this piece of information can lead to different interpretations. All communication has a frame and, once established, it is often difficult to change.

Media outlets play a role in framing messages. David Berube, professor at North Carolina State University, explains that in recent years technology has changed the framing process from "top-down," where traditional media outlets are responsible for framing messages, to more "bottom-up," where audiences participate more fully in the communication process by consuming, producing, and sharing information (Berube Interview, 2013). Messages or information produced by an individual and disseminated over a personal blog, Twitter, or Facebook might eventually influence the overall frame of a topic, especially if the messages go viral.

Messages about new technology like synthetic biology might be framed in terms of their relation to existing technologies (Rodemeyer Interview, 2013). This often means defining what synthetic biology is not. Michael Rodemeyer, of the University of Virginia's School of Engineering and Applied Science and an expert on biotechnology, points out that addressing similarities and differences between synthetic biology and the related fields of genetic engineering might influence an audience's perception of the message and the field as a whole (Rodemeyer, 2009). When developing the message frame, the desired reaction should be considered. For example, framing synthetic biology in terms of its ability to advance medical treatments and benefit public health may be received more positively than a frame that links synthetic biology to genetically modified organisms (GMOs) or calls it an extension of genetic engineering. The Canadian environmental organization ETC Group, which has called for a moratorium on "the release and commercial use of synthetic organisms," describes synthetic biology as "Extreme Genetic Engineering" and "Genetic Engineering on Steroids," creating a potent link between synthetic biology and genetic engineering, an area that raises concerns for many people.[4] Additionally, risk perceptions are socially constructed so one can expect that the GMO frame will elicit different reactions in many European countries as compared with the United States and other parts of the world.

Choosing an appropriate frame for a message is not entirely separate from understanding the preconceived beliefs and feelings of the audience. If the messenger has a sense of how beliefs and knowledge vary within an audience, and the resources to address these preconceived notions, multiple messages can be adjusted and delivered accordingly. Dietram Scheufele, a communications scholar at the University of Wisconsin-Madison, has argued that "tailoring communication efforts to fit with publics from different social and educational backgrounds is not an option, it is a necessity" (Nisbet & Scheufele, 2007).

For instance, a number of potential applications, risks, and benefits might be included in a message, but the order in which they are presented or how they are emphasized may differ based on the audience. Studies conducted by the Cultural

Cognition Project at Yale Law School show that religious audiences are highly concerned about synthetic biology risks, likely because the science often focuses on creating novel life forms (Kahan et al., 2009; Mandel, Braman, & Kahan, 2008). If addressing a religious audience, a frame that focuses on medical advances will evoke a more positive reaction than a message focused on modifying or creating living organisms. Donald Braman, law professor at George Washington University, provides more details on how different groups of people view synthetic biology (Box 2).

However, framing a message for a single audience can be challenging because material often spreads to the masses via the Internet. Stories written with a specific news outlet's audience in mind can be picked up and passed around via Twitter and other social media outlets, reaching various diverse audiences.

Balanced Content is Important

Keep in mind balanced messaging while planning and delivering a message. This means presenting both sides of the story and being prepared for various different reactions from audiences.

As with many emerging technologies, scientists, communicators, and audiences talking about synthetic biology often focus on the extremes. In his 2007 article *A Place for Hype*, Princeton

BOX 2

How Do Ethnic and Religious Groups Respond to Synthetic Biology?

Research by the Cultural Cognition Project at Yale Law School resulted in a typology that is useful in understanding how individuals might respond to information about synthetic biology. Donald Braman, law professor at George Washington University and a part of the Yale project, categorized public reactions using the following typology (Braman Interview 2011):

Secular Humanists are progressive, civil liberty supporters. This group likes synthetic biology but also worries about the impact on workers and the environment.

Secular Conservatives are free-market advocates who fully support most technological advances, including synthetic biology and nanotechnology.

Religious Conservatives are distressed by synthetic biology. Although they often cannot identify a specific problem that will arise from synthetic biology research, they worry about hubris and researchers "playing God" and are convinced that something bad will occur. Interestingly, religious groups that do not worry about GMOs and nanotechnology are still concerned about synthetic biology. Individuals in these groups sometimes have visceral responses, likely because synthetic biology research threatens their views of what humanity should and should not do.

Progressive Religious individuals are highly concerned about synthetic biology. This group often includes African Americans and women. African Americans are often suspicious of new technologies, and may ask, "How has technology benefitted us in the past?"

University scholar Edward Tenner points out that hype can mobilize funding and public support for new technologies (Tenner, 2007). But excitement for potential applications might be accompanied with an exaggeration of risks or benefits that are not necessarily rational or imminently threatening. The tale of the Glowing Plant project exemplifies these ideas (Box 1) and, more broadly, the story of genetically altered organisms. Depak Pental, a professor of genetics at the University of Delhi, recently told *The New Yorker*, "We made a mistake in hyper-propagandizing [genetically modified] products, saying it was a technology that would sort out every problem. . . . The hype has hurt us" (Specter, 2014). Delivering a balanced message is crucial to accurately portraying the field and helping audiences form balanced opinions about synthetic biology.

Working with the media is critical to deliver these balanced messages and prevent hype. Instead of highlighting the extremes, press efforts should focus on covering middle ground, presenting information that does not over-hype applications or under-hype risks (Brainard Interview, 2013). Currently, most applications and associated risks are merely possibilities and should be presented as such to reduce unreasonable hope or fear. When addressing the technology's risks, bland reassurance might evoke panic, so freelance science writer Ann Finkbeiner recommends that communicators "tell the balanced truth in simple and clear words" (Finkbeiner Interview, 2013).

Hype, however, does not come from the media alone. Tim Caulfield, Canada Research Chair in Health Law and Policy at the University of Alberta, and Celeste Condit, Distinguished Research Professor in the Department of Communication Studies at the University of Georgia, emphasize that researchers often feed into hype surrounding new discoveries by succumbing to pressures to publish, generate more research funding, impress their colleagues, climb the tenure ladder, or quickly turn their scientific findings into marketable applications (Caulfield & Condit, 2012). As products come to the market, industry and the public continue to drive hype surrounding science and its applications. They represent these ideas with a "hype pipeline" (Fig. 4) (Caulfield & Condit, 2012).

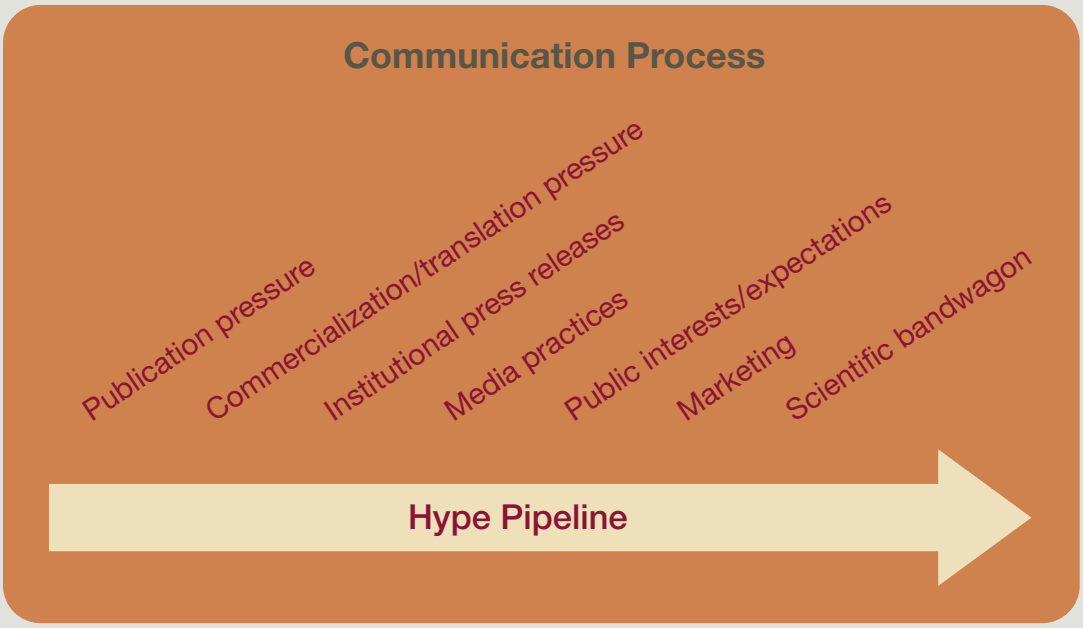
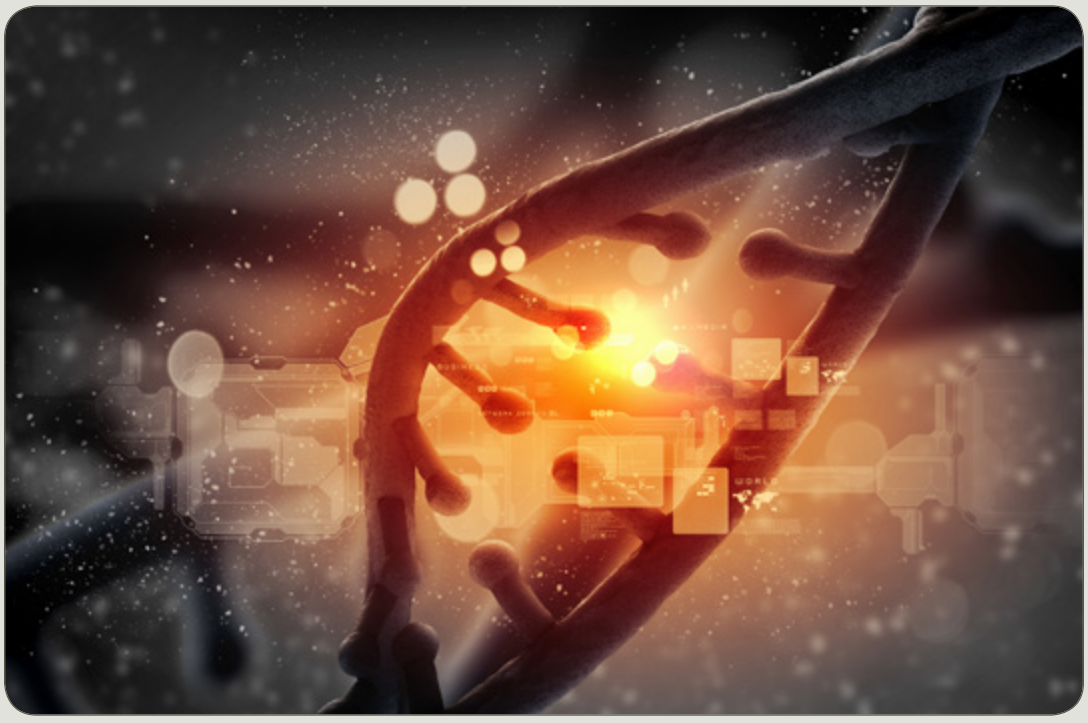


Figure 4: *Hype is derived from multiple sources during the communication process (adapted from Caulfield & Condit, 2012)*

To help audiences contextualize scientific findings, a well-balanced message should include realistic estimates on how long applications will take to bring to market, because news stories and scientific advances happen on fundamentally different timelines. Scientific results published in peer-reviewed journals often take years to collect. When these results are presented to the public as a news story, the time frame associated with the scientific process can be lost in translation (Brainard Interview, 2013). Information about timing can help audiences understand that potential applications and associated risks are often projections that could be years away, and might never even materialize. The same goes for potential benefits of research.

In some cases, the various regulatory processes define the time required to bring an application to market. Many pharmaceutical products fail in clinical trials and never reach the market. Likewise, certain agricultural applications may have to undergo significant and expensive testing to receive approval from the U.S. Department of Agriculture and the Environmental Protection Agency. If an application is several years away from development or use, there is time to address associated risks and develop regulatory guidelines, a key point often excluded from news narratives.

Despite considerations of timing and attempts to address various audiences, there will still be members of the public who do not agree with the message. For example, if the message is framed in support of synthetic biology and members of the audience are unwilling to accept the science, this does not necessarily mean they cannot grasp the research. Anne-Marie Mazza, director of the Committee on Science, Technology and Law at the National Academy of Sciences, suggests that instead they might have other moral, ethical, or personal reasons for disapproving of a particular process or application and their opinions should be respected (Mazza Interview, 2013). The same is true for the opposite scenario: If a message about synthetic biology is meant to cast a negative light on the science, there still may be audience members who approve and support the technological advances.



GUIDELINES FOR MESSAGE CONTENT

Examples and definitions matter

Examples of applications are helpful when starting a conversation about synthetic biology. A definition can be accurately tailored to the needs of an agency or institution and should be used consistently throughout communication efforts.

Defining synthetic biology is not easy. "[P]roviding a single definition for synthetic biology is a challenge even to those active in the field," wrote the Presidential Commission for the Study of Bioethical Issues in its 2010 report on synthetic biology (Presidential Commission, 2010).

The Synberc definition provided on page 3 of this report is one place to begin, but other balanced definitions do exist. The website of the United Kingdom's Royal Society says synthetic biology "involves the design and construction of novel artificial biological pathways, organisms and devices or the redesign of existing natural biological systems." The definition also includes potential applications: "[Synthetic biology] has enormous potential applications and benefits, including the development of cheap anti-malarial drugs, the production of green hydrogen for fuel and the use of programmable cells to treat cancer. There is promise, but also uncertainty about how govern this emerging field."[5]

Starting a conversation about synthetic biology by defining the science may seem obvious, but focusing on potential applications may be a better way to introduce the topic to novices. This approach is applicable to the public and journalists alike. In a study that explored perceptions of synthetic biology, Nicole Kronberger, a researcher at London School of Economics and Political Science, and her colleagues found that reporters prefer press releases that mention applications and illustrate why researchers are working on synthetic biology (Kronberger, Holtz, Kerbe, Strasser, & Wagner, 2009). According to *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks* by Regina Lundgren and Andrea McMakin, when audiences know "why" in addition to "what" and "how," they are more likely to change their behavior (Lundgren & McMakin, 2009). In the case of synthetic biology, a statement might say, "Synthetic biologists are modifying yeast and bacteria (what) by adding novel DNA pieces to or deleting regions from these organisms' DNA sequences (how) in order to create organisms that can produce new therapeutic agents (why)." Knowing "why" can encourage audiences to consider both the possible benefits of the science and associated risks, regardless of whether or not they support the research.

Careful consideration should also be given to which application is discussed. Research done by Hart Research shows the public is more accepting of applications that will benefit human health and well-being, including applications that have potential to provide medical treatments or create renewable energy sources (Hart Associates, 2009, 2013). In her 2013 report in BioScience, Eleonore Pauwels, program associate at the Synthetic Biology Project, summarizes the Hart studies and concludes that participants are also concerned about applications that would require the release of genetically altered organisms into nature (Pauwels, 2013b). The public prefers these organisms stay within a controlled environment. The Hart focus groups also

found audiences are less tolerant of applications surrounding food, such as food additives or fertilizers that speed root growth (Hart Associates, 2009, 2013). Focus groups conducted in April 2014 again found significant support for applications linked to health and the environment (Fig. 5) (Hart Associates & Wilson Center, 2014). Interestingly, there were very negative reactions to the use of synthetic biology to create substitutes for existing chemicals, food ingredients, and other household products.

APPLICATION	Number of Participants that Feel the Application		
	Is Appealing	Raises Concerns	No Response
Treating disease	14	1	4
Creating new drugs	13	1	5
Cleaning up the environment	7	0	12
Sensing harmful contaminants	3	0	16
Creating chemicals or food products	0	11	8

Figure 5: *In two focus groups in 2014, 19 participants indicate whether applications are appealing or raise concerns*

Listing potential applications provides a useful way to break into discussions about the topic, but does not necessarily substitute for supplying a definition of the technology. However, providing one is difficult because different organizations, institutions, and research groups do not always use the same definition. A simple Google search for the words "synthetic biology" reveals that most definitions in news stories, academic articles, and researchers' websites are multi-faceted: They highlight various aspects of the research, but do not provide unifying descriptions. Often definitions include descriptions of technical approaches and overall goals. The best strategy may be to compile an accurate definition tailored to the communicating agency or institution. (One place for government communicators to start is the Synberc definition on page 5 of this report.)

In surveys, people who are initially positive about the field sometimes become worried upon hearing synthetic biology defined as a science that aims to redesign organisms' genetic code or create code that does not exist in nature. As discussed, one natural reaction audiences have is to associate synthetic biology with GMOs. A definition might focus on the fundamental differences between GMOs and synthetic biology. Introductory material on the topic may often include a section devoted to clearly delineating the differences between synthetic biology and genetic engineering.[6] Finally, once a definition is agreed upon within an institution or agency, internal consistency is important.

Messenger Matters

It is important to identify a trusted source to deliver a message. Audiences might trust a messenger with whom they associate culturally, or one they consider to be an expert on the content (Kahan et al., 2008). Trust also needs to be built and maintained over time for successful continued communication (Kasperson Interview 2013; Berube Interview 2013).

Public reaction to a message is based on its source and the audience's trust in that source (Faber et al., 2010). Kasperson, who has researched the role of trust in risk communication, explains that if messengers are not perceived as trustworthy, it will affect the way the public perceives the message (Kasperson Interview, 2013). While trust in the messenger reduces public uncertainty, it is important to note that trust is a fragile commodity – it is not immediate and must be built over time.

A 2013 study by The Edelman Trust Barometer[7] revealed several attributes that help organizations build trust, some of which can also be applied to synthetic biology researchers and communicators. These include:

- Maintaining transparency
- Listening and responding to needs and feedback
- Addressing the needs of society in innovative ways
- Working to protect and improve the environment
- Communicating frequently and often

As trust in a source develops, audiences are less likely to want deep involvement in the process and are more willing to accept the message (Kasperson Interview, 2013). Choosing a trustworthy messenger is not an easy task, and much risk communication research has focused on how to identify trusted individuals.[8] One tactic that may help identify trusted sources is to involve target audience members in the message-planning process (Huntley-Fenner, 2011). Research by the Cultural Cognition Project at Yale University found that, in the case of nanotechnology, audience members trusted messengers to whom they can relate (Kahan et al., 2008). Surveys show that members of the public also have faith in university scientists and academic researchers to maximize benefits and minimize risks (Fig. 6) (Hart Associates, 2013).

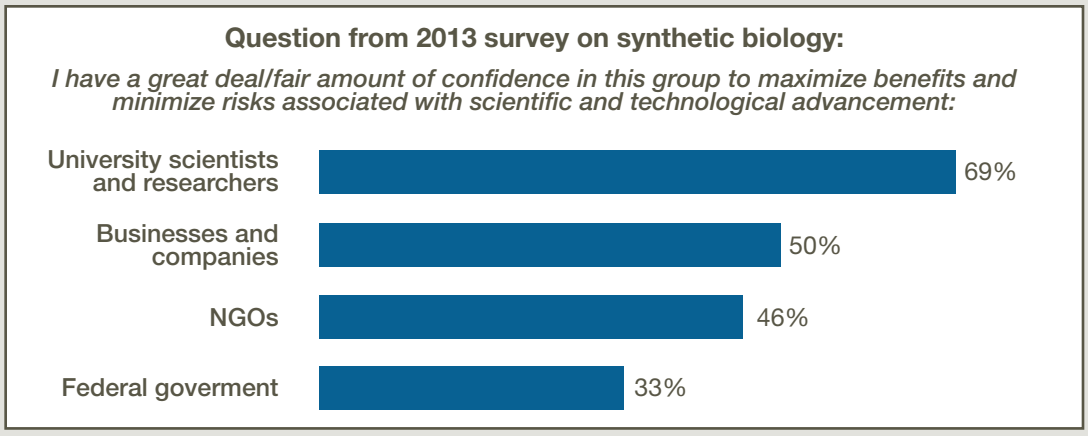


Figure 6: *National survey shows which organizations the public trusts to manage potential risks of synthetic biology (Hart Associates, 2013)*

Media outlets also act as messengers because they are major sources of information for the public and have strong influences on overall perceptions. These outlets increase general social awareness (social amplification) and may also amplify the awareness of risks. The way the media translates the frame of a message from the original source is integral to the communication process, and proper frame and balance in the original message can help prevent sensationalist reporting. The challenge is to create a message that is accurate and balanced yet still interesting and readable.

When journalists interview trusted sources, the public is more likely to receive a balanced, well-framed message. But there are some cases when synthetic biology researchers, even though they are experts on the topic, become the subjects of unbalanced, sensationalized news stories. Consider the media coverage of comments by George Church, a genetics professor at Harvard University, about his 2012 book *Regenesis: How Synthetic Biology Will Reinvent Nature and Ourselves*. During the interview, Church describes in detail the steps that could be taken to clone a Neanderthal. The interviewer then asks if, as his book states, the surrogate mother would be an "extremely adventurous female human," to which Church replies, "Yes…if human cloning is acceptable to society." A timeline of the key press events following the interview provides an object lesson in how scientific information can spin out of control when sensationalized in the press (Box 3).

The evolution of this story provides a cautionary tale for how a combination of both old and new media can propagate a sensationalized, unbalanced message even when a trusted source is involved with the delivery. Cloning has long been a "third rail" in science policy and this sort of sensational yet sensitive topic is attractive to reporters, and a magnet for readers. Having a trusted source ready to talk frankly about sensitive and novel issues, such as cloning, may help mitigate situations and provide much-needed context.

Unlike other technologies, synthetic biology so far lacks a visible and trusted spokesperson. In the past, government and academic experts close to the emerging fields have filled this role. For example, while leading the Human Genome Project, Dr. Francis Collins (currently the Director of the National Institutes of Health) was an excellent communicator for the project. Dr. Mihail Roco, Senior Advisor for Nanotechnology at the National Science Foundation, similarly represented the National Nanotechnology Initiative both at a national and a global level, while Dr. Anthony Fauci, Director of the National Institute of Allergy and Infectious Diseases, not only contributed substantial scientific advances to HIV/AIDS research but was also a champion spokesperson for further research.

Overall, good communicators that are willing to accurately and evenly portray advances in synthetic biology can help build trust in the public eye, reduce false hope, and prevent unnecessary risk amplification. Ultimately, trusted messengers can help build a more realistic perception of synthetic biology and lead to more balanced public awareness of the field.

Language Matters

Carefully crafted messages with simple, clear language could better portray synthetic biology's risks and benefits and minimize hype. Scientific jargon should be eliminated from messages to the greatest extent possible. Metaphors can be good tools for communication but they must be properly chosen and contextualized.

In any communication process, a major challenge is to create content that is easy to understand. As Albert Einstein once noted,

BOX 3

Headlines Responding to George Church's "Neanderthal" Comments

January 15, 2013: The German weekly, *Spiegel*, publishes an interview with Harvard genetics professor George Church about his book with the headline, "Rebirth of the Neanderthals: Maybe they are Smarter than We Are."

SPIEGEL ONLINE

"Wiedergeburt des Neandertalers: 'Vielleicht sind sie intellingenter als wir'"

January 20, 2013: *Spiegel* releases an English translation of the interview on its website.

"Interview with George Church: Can Neanderthals Be Brought Back from the Dead?

In a SPIEGEL interview, synthetic biology expert George Church of Harvard University explains how DNA will become the building material of the future - one that can help create virus-resistant human beings and possibly bring back lost species like the Neanderthal."

The English-language story is picked up the same day by widely read UK news website, *Mail Online*, the online presence of London tabloid *The Daily Mail*. With an attention-grabbing headline, the story goes viral via social media.

Mail Online

"Wanted: 'Adventurous woman' to give birth to Neanderthal man - Harvard professor seeks mother for cloned cave baby

Professor George Church of Harvard Medical School believes he can reconstruct Neanderthal DNA

His ambitious plan requires a human volunteer willing to allow the DNA to be put into stem cells, then a human embryo"

Other media outlets, such as *The Telegraph*, pick up on the story.

The Telegraph

"'I can create neanderthal baby, I just need willing woman'

A scientist has said it would be possible to clone a Neanderthal baby from ancient DNA if he could find a woman willing to act as a surrogate."

January 21, 2013: *The Guardian*'s Comment is Free site builds on the story published in The Telegraph. Pundit Naomi McAuliffe starts by calling for a "young, single and adventurous female human" to provide a womb for the Neanderthal experiment.

theguardian

"Have a Neanderthal baby and save humanity

This is a once-in-a-lifetime opportunity – simply rent your womb out to Prof George Church, Harvard, and a Nobel prize is yours"

January 23, 2013: Church accuses *Spiegel* of mistranslating his remarks and the magazine issues a detailed response. By then, the story has propagated across the web, becoming more distorted and sensationalized along the way.

The story spread on social media outlets like Twitter as well. *The Spiegel Blog* reported that one person tweeted, "My life's new ambition: Mate with a Neanderthal woman." Bioethicist Arthur Caplan wrote a commentary for CNN Opinion, which the outlet announced via Twitter: "Don't clone a Neanderthal baby, says bioethicist Arthur Caplan."

"Everything should be made as simple as possible, but not simpler." But synthetic biology sits at the interface of genetics, engineering, computer science, and biology, making it inherently complicated.

Avoiding scientific jargon, other complicated, field-specific language, and "loaded terms" is important when formulating and delivering messages about synthetic biology. During the Hart focus group discussions, participants had an opportunity to view videos of scientists discussing synthetic biology. After viewing, one participant summed up the experience, noting, "I think that if you're not schooled in what they're talking about, it can be kind of horrifying." Words commonly used in the synthetic biology field also have different connotations for lay audiences than they do for scientists. In focus groups, participants associate positively with some scientific terminology, but find other words negative or confusing (Fig. 7).

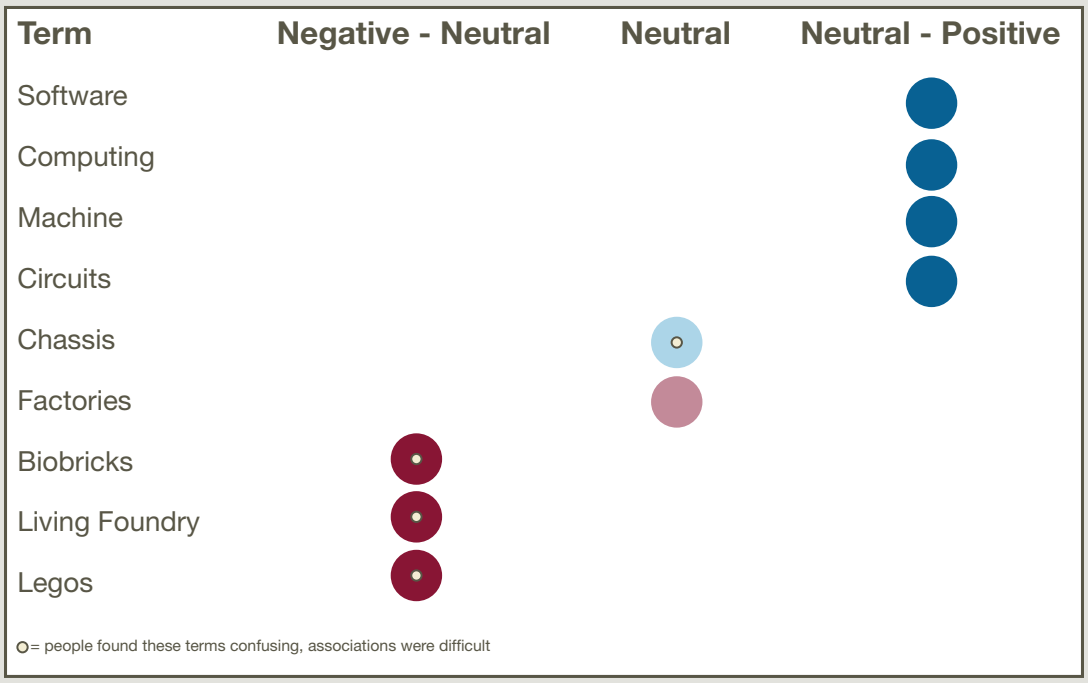


Figure 7: *Focus group participants illustrate which words they find negative (red), positive (blue) or neutral (light blue and pink) when applied to synthetic biology*

Metaphors are frequently used amongst scientists in lab discussions and are prevalent in mainstream journalism. Straightforward and easy to use, metaphors can make complex topics easier to understand. However, it is important to keep in mind that they often eliminate important information in their simplification, but get lengthy when properly explained.

In a field like synthetic biology, metaphors can cause oversimplification or misrepresentation of the science. Pauwels points out in articles in *BioScience* and *Nature* that researchers compare DNA to the "software of life," which equates genetic manipulation to writing and editing computer code. Pauwels regards the use of computing and engineering metaphors as a double-edge

sword because they give the impression that researchers are able to easily engineer controllability into complex biological systems. While the "genetic software" terminology is appropriate, inspiring, and well understood in the lab, Pauwels notes that the analogy might not transfer accurately to the public (Pauwels, 2013a, 2013b).

It is also wise to stay away from flashy language. So far, the media has chased the most dramatic stories about synthetic biology. To prevent this sort of hype, Curtis Brainard, science writer and editor at *Columbia Journalism Review* and the *Scientific American* blogs, says public information officers should avoid starting press releases with "catchy pushes" or hooks that seek to draw in audiences through use of sensational examples or anecdotes. The media may exaggerate these further, leading to misconceptions and miscommunication. Avoiding sensational language and still releasing an exciting story that gets picked up by news outlets is a delicate balance: Providing caveats alongside exciting new discoveries can give the reader perspective and prevent overdramatization.

Further, Brainard says it is important to work directly with scientists when writing press releases about their work. Exchanging drafts with the lead researchers can help ensure that the language describing the science is simple and clear, and the findings, subsequent applications, and risks are properly presented. With a bit of creativity, results can be presented in ways that are exciting, interesting, and accurate.

Organism Matters

Public reaction to synthetic biology depends on the organisms being engineered, especially if the organisms have been connected to negative health or environmental impacts in the press.

Audiences' perceptions of synthetic biology can depend on the type of organism that scientists are modifying. Focus groups show that people can have negative reactions to projects or applications that exploit the bacteria E. coli because these organisms often appear in the press in association with food-borne disease outbreaks. In reality, most E. coli strains are harmless, but some, like O157:H7, can be quite lethal and prompt headlines like these:

- *The Burger that Shattered Her Life*[9] (The New York Times, October 3, 2009)
- *Ewwww -- Poop in Pools More Common than You May Think, CDC Warns*[10] (Los Angeles Times, May 16, 2013)
- *Parents Sue County Fair, Petting Zoo Over Son's* E. Coli *Death*[11] (ABCNews, July 9, 2013)

Focus groups react very differently to synthetic biology that uses engineered yeast instead of *E.Coli*. The use of yeast in bread, beer, and other common foods changes the risk perception. As one person in a 2011 focus group noted, "[W]e put it in our bread. We eat it. We drink it. Yeast is good" (Hart Associates & Wilson Center, 2011).

During the communication process, awareness that the microorganism matters can help shape the message. If the research is focused on organisms that the public feels are benign, misconstrued perceptions are usually not an issue. When communicating about studies using "dangerous" organisms, however, the message might include more nuanced information about the organism being modified, how the organisms will be contained, why the research is necessary, a frank discussion of the potential risks, and an explanation of safety and security precautions that have been taken.

Have Answers to Questions About Regulation and Oversight

How synthetic biology may be governed is a work in progress, but preparing clear messages about biosafety and biosecurity plans and making them available to the public is essential for the communication process.

One common public reaction to potential risks from emerging technologies is to ask the question: "If something goes wrong, who is in charge?" In reality, it may not be clear that anybody is in charge, especially if the technology is novel and oversight responsibilities have not been sorted out among multiple agencies or between local, state, federal, and international entities.

If regulatory responsibilities are undefined, in flux, or untested, clear messages regarding oversight are difficult to craft. Often the public believes that some government agency has tested a product, overseen a process, or is otherwise acting on their behalf. In reality, government oversight can be minimal and enforcement of existing laws can be difficult due to lack of resources. It is important for government agencies to be clear about the extent of their oversight capabilities for synthetic biology applications and, if officials are trying to understand their authority, to say so. This straightforwardness will benefit the public and businesses seeking clarity on regulatory pathways to take scientific products to the market.

Non-governmental policy research organizations tracking issues like synthetic biology often have useful information and analyses about which products are being regulated and how, blind spots in existing regulatory structures, and how these frameworks might be improved. Environmental groups involved with the issue also have data and analyses worth considering, especially groups with well-trained legal and scientific staff.

Scientists working on synthetic biology in university settings should be very clear about their adherence to safety standards. In the United States, biosafety, biosecurity, and ethics regulations for scientific research are put in place by the National Institutes of Health (NIH). Elsewhere, the International Genetically Engineered Machines competition, or iGEM, a global synthetic biology contest for students and entrepreneurs, has developed protocols to increase awareness and understanding about the biosafety, biosecurity, and ethical issues of synthetic biology. Most universities have environmental health and safety departments that enforce the NIH rules, as continued funding is contingent upon compliance. These departments should be integrated into the messaging process.

Corporations or startups involved in synthetic biology are often operating on the frontier of emerging expectations where a social contract is being shaped more by think tanks, non-governmental organizations, and the media than formal law and regulations (Bonini, Mendonca, & Oppenheim, 2006) (Fig. 8). This means companies seeking proactive technology governance can reap benefits, but it is also an area where communications missteps could have significant negative impacts.

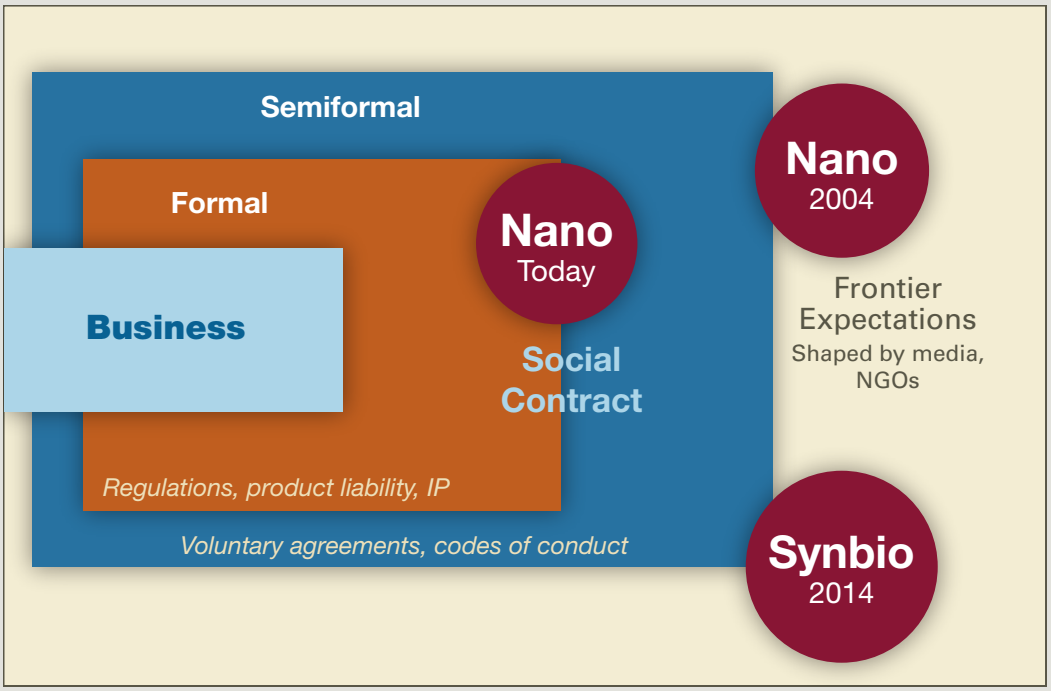


Figure 8: *Policy landscape between formal law and semiformal agreements (adapted from Bonini, Mendonca, & Oppenheim, 2006)*

Lacking clear guidance, companies may fall back on voluntary agreements, codes of conduct, and adherence to international standards (such as ISO14001) or agreed upon environmental management approaches. These measures should be communicated to the public. Rather than wait for government to develop plans for regulation, some businesses will act strategically to head off public concerns. For instance, in 2004, the Dupont chemical company partnered with the Environmental Defense Fund to develop a risk management framework for nanotechnology, the first of its kind, putting in place an approach to managing risks in anticipation of any formal government regulations.[12]

In general, messengers from government, universities or businesses should be ready to address the public's concern about risk and regulation with examples specific to the application under discussion. Citing any precautionary or regulatory steps taken by the researchers or organization will provide a realistic outlook on potential risks and can help reassure audiences.

CONCLUSION

Synthetic biology is still maturing and public perceptions of the field will likely remain in flux for many years. But as the field advances, social science research on public perceptions should continue in order to better understand how the public feels about the science. The information drawn from these investigations should be used to provide timely feedback to scientists, universities, governments, businesses, and others to inform communications about synthetic biology in an effort to maximize potential benefits and reduce potential risk.

ENDNOTES

1. http://www.synberc.org/what-is-synbio
2. https://www.kickstarter.com/projects/antonyevans/glowing-plants-natural-lighting-with-no-electricit
3. http://www.glowingplant.com/
4. http://www.etcgroup.org/fr/node/602
5. https://royalsociety.org/policy/projects/synthetic-biology/
6. https://www.youtube.com/watch?v=7qwNbrvUSxs
7. http://www.edelman.com/insights/intellectual-property/trust-2013/building-trust/
8. Social trust and uncertainty has been extensively studied in risk communication research. While this is not a risk communication document, some of the concepts in this guide have been further elucidated through research in risk communication, a rich field going back decades. Some suggested references include the following:
   - Effective Risk Communication, edited by Joseph Arvai and Louie Rivers III (Arvai & Rivers, 2014)
   - Four Questions for Risk Communication, by Roger Kasperson (Kasperson, 2014)
   - Communicating Risks and Benefits: An Evidence Based User's Guide, edited by Baruch Fischhoff, Noel T. Brewer, and Julie Downs (Fischhoff, Brewer, & Downs, 2011)
   - Thinking, Fast and Slow, by Daniel Kahneman (Kahneman, 2011)
   - National Academy of the Sciences report, Improving Risk Communication (Council, 1989)
9. http://www.nytimes.com/2009/10/04/health/04meat.html?pagewanted=all
10. http://articles.latimes.com/2013/may/16/science/la-sci-sn-contaminated-pools-fecal-matter-20130516
11. http://abcnews.go.com/Health/parents-sue-state-fair-petting-zoo-sons-ecoli/story?id=19609248
12. http://www.nanoriskframework.com/files/2011/11/6496_Nano-Risk-Framework.pdf

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