

# **Awareness & Impressions Of Synthetic Biology**

## **A Report Of Findings**

Based On A National Survey Among Adults

Conducted On Behalf Of:

**Synthetic Biology Project**

**The Woodrow Wilson International Center For Scholars**

**By Hart Research Associates**

September 9, 2010

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## Hart Research Associates

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*From August 16 to August 22, 2010, Hart Research Associates conducted a nationwide survey among 1,000 adults about attitudes toward the entities involved in the oversight of new scientific and technological advances, awareness of nanotechnology, and awareness of and attitudes toward synthetic biology and two potential applications of the science. This is the fifth consecutive year that questions have been asked about nanotechnology and the third year that questions have been asked about synthetic biology. At the 95% confidence level, the data's margin of error is  $\pm 3.1$  percentage points.*

### Overview

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- While the American public continues to report a higher level of awareness of nanotechnology (34%) than of synthetic biology (26%), awareness of the latter has grown notably in the past three years. Awareness of synthetic biology is up from 22% last year and 9% in 2008.
- Among the nearly seven in 10 Americans who have an opinion about the risk-benefit tradeoff for synthetic biology, the largest proportion continue to believe the risks of synthetic biology will be about equal to the benefits (33%). The rest are split between its benefits (19%) and risks (16%).
- After being provided with some balanced information about the science, a plurality of Americans still believe the benefits and risks will be about equal, but the movement is more toward risk than benefit. A third of the informed public believe that the risks will outweigh the benefits (up from 16% initially), and one-quarter believes that the benefits will outweigh the risks (up from 19% initially).
- By two to one, Americans believe synthetic biology should be allowed to move forward with a focus on uncovering possible effects on humans and the environment (63%) rather than banning it (33%). Opposition to further research is reported by a majority of African Americans (52%). Higher than average support for a ban also comes from Hispanics (43%), evangelicals (43%), and women (40%), especially women over age 50 (46%).
- The majority also believes that further research should be regulated by the federal government (52%) rather than relying on voluntary guidelines developed jointly by industry and government (36%).
- While most Americans feel the science should move forward, they still have concerns, which include the fear that synthetic biology could be used to create harmful things such as biological weapons, concern for the moral implications of synthetic biology and its use in creating artificial life, potential negative health effects for humans, and to a lesser extent, fears that it could damage the environment.

## Hart Research Associates

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- Americans' familiarity with federal regulatory agencies that might oversee nanotechnology and synthetic biology remains high. Confidence in the Department of Agriculture (USDA) and Food and Drug Administration (FDA) has remained relatively unchanged in recent years, while confidence in the Environmental Protection Agency (EPA) has dropped, earning it the lowest confidence level of the four agencies. Confidence in the Department of Energy (DOE), a research agency, has dropped only slightly since last year.
- Nonetheless, confidence in the four government agencies exceeds confidence in businesses and companies to maximize benefits and minimize risks associated with scientific and technological advancements. In fact, the proportion who say they have very little confidence (25%) is at the highest level measured since the first poll Hart Research Associates conducted for The Wilson Center in 2006.
- Support for synthetic biology is heavily influenced by the application of the science. The public feels significantly more positive about using synthetic biology to expedite the creation of a flu vaccine (59% view it as a positive development) than they are to feel positive about using the science to accelerate the growth of livestock (74% view it as a negative development). Among those who cite moral considerations as a main concern about synthetic biology, the majority views *both* applications in a negative light.

## Key Findings

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**A**wareness of nanotechnology is at its highest measured level in five years. Today, one in three (34%) Americans reports hearing a lot or some about nanotechnology, which is a slight increase over the previous year. The proportion who report having heard nothing at all about nanotechnology (33%) also has declined to its lowest measured level.

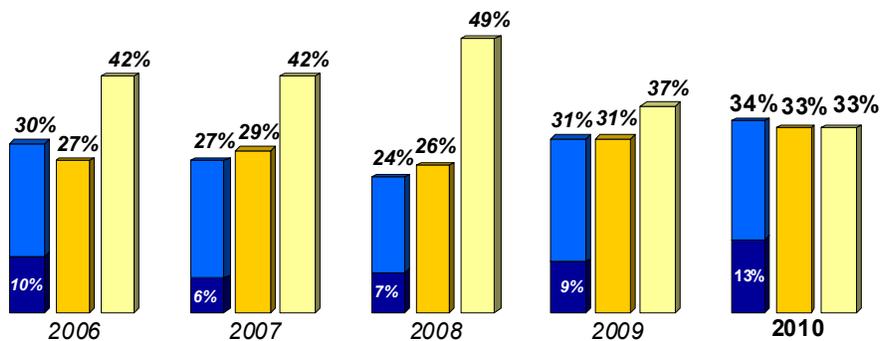
Levels of self-reported awareness vary most by gender, income, and education. Men (46%), especially men under age 50 (54%), are more likely than are women (23%) to say they have heard a lot or some about nanotechnology. Individuals with household incomes of more than \$75,000 (50%) and college graduates (47%) continue to report among the highest levels of awareness about nanotechnology.

### Slight Increase In Public Awareness Of Nanotechnology

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*How much have you heard about nanotechnology?*

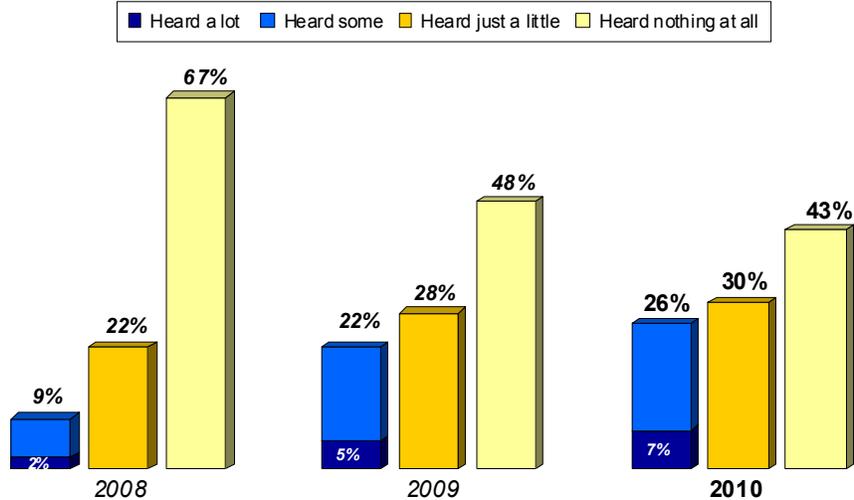
■ Heard a lot ■ Heard some ■ Heard just a little ■ Heard nothing at all



**A**wareness of synthetic biology has nearly tripled over the past three years, with 26% of Americans today saying they have heard a lot or some about it. This is up from 22% last year and nearly three times the proportion (9%) who said they heard a lot or some about synthetic biology in 2008. Just 43% of the public say they have heard nothing at all about it, down from 67% two years ago.

## Public Awareness Of Synthetic Biology Continues To Increase

*How much have you heard about synthetic biology?*



Awareness of synthetic biology is highest among the same groups who report high levels of awareness of nanotechnology: men (32%), especially men under age 50 (35%), college graduates (37%), and those with household incomes more than \$75,000 (40%). Among those who have heard a lot about nanotechnology, nearly seven in 10 (69%) say they have heard a lot or a fair amount about synthetic biology.

When asked about the recent announcement by the J.C. Venter Institute of its creation of a synthetic life form based on DNA produced in a laboratory, nearly one in four (24%) adults says they recall hearing about it. While recall is slightly higher among men than women, seniors and men over age 50 report higher levels of awareness than do younger Americans. Unlike awareness of nanotechnology and synthetic biology, there is no difference in recall by education or household income. Fully 57% of those who report the greatest awareness of synthetic biology say they recall hearing about this recent development.

**S**even in 10 adults report some sense or idea about what they think synthetic biology involves, and their top-of-mind perceptions focus mainly on the concept that it is man-made and artificial.

Respondents were asked to describe what they think synthetic biology is, and the most often volunteered responses relate to something that is man-made, artificial, or fake (30%). Fully 12% say that it has something to do with genetic engineering, modifying, or altering plants, crops, and cells. Smaller proportions of adults mention science or biology (6%), cloning (6%),

medicines, drugs, or advancements in medical research (5%), or synthetic materials and chemicals (5%). Nearly a third (29%) of adults have no sense of synthetic biology or do not offer a response.

### What Do You Think Synthetic Biology Is?

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#### *Volunteered Comments*

Something man-made, artificial, fake, not natural, not real	30%
Has to do with genetic engineering, altering the biological makeup	12%
Has to do with science, biology, the study of living organisms	6%
Cloning	6%
Used in medical research to develop new medicines, treatments	5%
Some kind of synthetic material or chemical	5%
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Don't know; no response	29%

**W**hen initially asked to characterize their feelings about the risk-benefit trade-off of synthetic biology without any information, 68% of Americans express a point of view, while 32% say they are not sure. The plurality of adults believe that the risks and benefits will be about equal (33%), while 19% think the benefits will outweigh the risks, and a comparable 16% think the risks will outweigh the benefits.

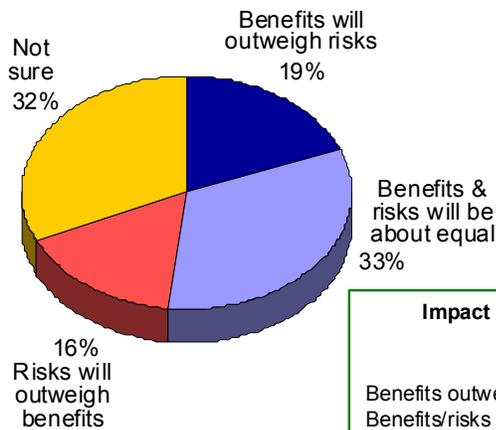
Those with the highest levels of awareness of synthetic biology are the most optimistic about its potential. Among those who have heard a lot about it, more than twice as many think the benefits will outweigh the risks (46%) than believe the risks will outweigh the benefits (20%), while 30% think they will be about equal. Among those who have heard nothing about synthetic biology, half do not express an opinion, while 11% anticipate that the benefits will outweigh the risks, 14% think the risks will outweigh the benefits, and 25% think they will be about equal. A 42% plurality of those who report having heard some or just a little about synthetic biology believe that the risks and benefits will be nearly equal.

The demographic groups with the most positive assessment of the benefits versus the risks also are the groups that report higher levels of awareness of synthetic biology—men, college graduates, and those with household incomes of more than \$75,000.

Additionally, religion plays a role in the risk-benefit analysis of synthetic biology in the minds of many Americans. Adults with no religious affiliation are optimistic about the potential impact of synthetic biology, with 34% believing that the benefits outweigh the risks, 8% who say the risks will outweigh the benefits, and 31% think the risks and benefits will be about equal. Those who identify with a specific religion are more cautious in their assessment, with 16% thinking the benefits will outweigh risks, 17% thinking the risks will outweigh benefits, and 35% thinking the risks and benefits will be about equal.

### Initial Impression Of Risks And Benefits Of Synthetic Biology

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	Heard a lot	Heard some	Heard a little	Heard nothing
Benefits outweigh	<b>46%</b>	<b>31%</b>	16%	11%
Benefits/risks equal	30%	<b>42%</b>	<b>42%</b>	25%
Risks outweigh	20%	16%	18%	14%
Not sure	4%	11%	24%	<b>50%</b>

**A**fter hearing a balanced description of synthetic biology, including some of its potential benefits and risks, a greater proportion of respondents believe that the risks of synthetic biology outweigh the benefits than believe the benefits outweigh the risks.

**Brief Description Of Synthetic Biology Read To Respondents:**

**Synthetic biology is the use of advanced science and engineering to make or re-design living organisms, such as bacteria, so that they can carry out specific functions. Synthetic biology involves making new genetic code, also known as DNA, that does not already exist in nature.**

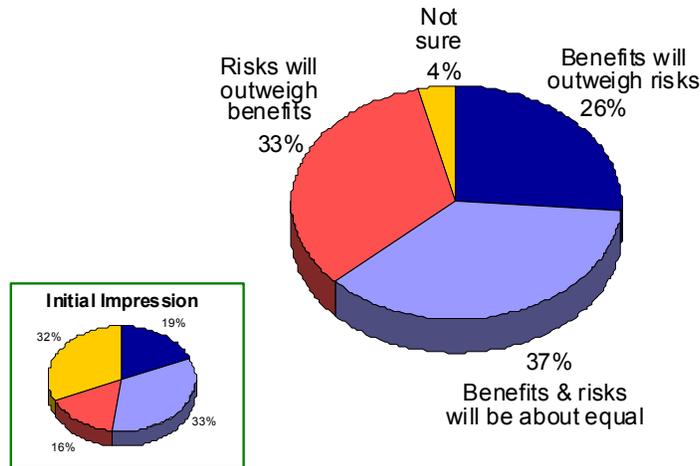
**I would like to read your statements about the potential benefits and potential risks of synthetic biology and get your reaction.**

**The potential BENEFITS of synthetic biology include developing new micro-organisms to treat disease, including cancer, more effectively and to create new and less expensive medications. It also could be used to make new organisms that could provide cheaper and cleaner sources of energy than today's oil-based fuels, and to detect and break down environmental pollutants in the soil, air, and water.**

**While the potential RISKS of synthetic biology are not known, there are concerns that man-made organisms might behave in unexpected and possibly harmful ways and that they could cause harm to the environment. There also are concerns that, if these organisms fall into the wrong hands, they could be used as weapons. Additionally, the ability to create artificial life has raised moral and ethical questions about how life is defined.**

After hearing this description, a 37% plurality say they believe the risks and benefits will be about equal (up four points from 33% initially), while 33% believe that the risks will outweigh the benefits—double the initial assessment (16%). The proportion of adults who believe the benefits will outweigh the risks (26%) also increased (up seven points from 19%).

## Informed Impression Of Risks And Benefits Of Synthetic Biology



As the following table illustrates, groups who report low awareness of synthetic biology also show the greatest movement toward risk, after being presented with information about the potential risks and benefits. Women, especially women over age 50, report elevated concerns about the risks of synthetic biology. Individuals with less than a college education also demonstrate large shifts toward risk. Overall, Americans who reported hearing a little or nothing about synthetic biology show greater movement toward risk than those who say they have heard a lot or some about the science.

### Initial And Informed Impressions Of Synthetic Biology

	Initial Impressions			Informed Impressions		
	Benefits Outweigh Risks	Risks Outweigh Benefits	Risks And Benefits About Equal	Benefits Outweigh Risks	Risks Outweigh Benefits	Risks And Benefits About Equal
	%	%	%	%	%	%
<b>All adults</b>	<b>19</b>	<b>16</b>	<b>33</b>	<b>26</b>	<b>33</b>	<b>37</b>
Men	26	13	33	32	25	40
<b>Women</b>	<b>11</b>	<b>19</b>	<b>34</b>	<b>21</b>	<b>39</b>	<b>35</b>
Age: 18 to 34	21	18	30	29	31	39
Age: 35 to 49	22	14	34	32	30	31
Age: 50 to 64	18	17	37	24	36	37
Age: 65 and over	13	14	32	20	33	42
Men: 18 to 49	32	12	32	36	23	37
Men: 50 and over	22	13	34	29	26	41
Women: 18 to 49	12	20	33	25	37	34

## Initial And Informed Impressions Of Synthetic Biology

Cont'd.	Initial Impressions			Informed Impressions		
	Benefits Outweigh Risks	Risks Outweigh Benefits	Risks And Benefits About Equal	Benefits Outweigh Risks	Risks Outweigh Benefits	Risks And Benefits About Equal
	%	%	%	%	%	%
<b>All adults</b>	<b>19</b>	<b>16</b>	<b>33</b>	<b>26</b>	<b>33</b>	<b>37</b>
<b>Women: 50 and over</b>	<b>11</b>	<b>17</b>	<b>36</b>	<b>17</b>	<b>42</b>	<b>37</b>
High school or less	11	15	37	18	31	46
<b>Some college/tech</b>	<b>18</b>	<b>17</b>	<b>33</b>	<b>23</b>	<b>40</b>	<b>35</b>
College grad or more	26	16	33	35	27	33
Less than \$30,000	12	19	34	19	36	42
\$30,000-50,000	15	15	38	19	36	43
\$50,000-\$75,000	24	16	34	28	33	36
More than \$75,000	28	13	33	38	24	34
Whites	20	15	33	28	31	37
African Americans	11	19	36	19	35	39
Hispanics	14	17	38	21	36	36
<b>Attend religious services weekly</b>	<b>16</b>	<b>17</b>	<b>34</b>	<b>21</b>	<b>36</b>	<b>40</b>
Attend religious services less often	16	17	35	26	33	37
Rarely/never attend religious services	28	12	32	37	27	33
Protestants	17	18	33	22	38	38
Catholics	13	15	36	27	31	37
Other religion	23	12	40	31	30	36
No religion	34	8	31	40	17	40
<b>Evangelicals</b>	<b>14</b>	<b>24</b>	<b>33</b>	<b>15</b>	<b>45</b>	<b>37</b>
Heard a lot/some	35	17	39	37	25	34
Heard just a little	16	18	42	25	31	40
<b>Heard nothing</b>	<b>11</b>	<b>14</b>	<b>25</b>	<b>20</b>	<b>39</b>	<b>37</b>

**F**amiliarity with selected federal regulatory agencies that may potentially play a role in the oversight of synthetic biology remains high, and confidence in their abilities to maximize benefits and minimize risks associated with new scientific advancements continues to exceed confidence in business. Among the four agencies tested, the EPA has suffered the only notable erosion in public confidence over the past year.

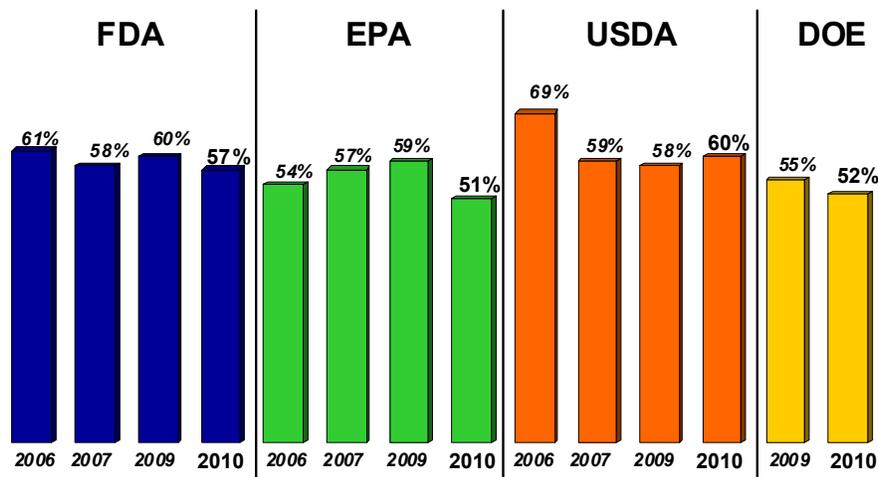
The American public's confidence in the USDA and FDA to manage the risk-benefit trade-offs associated with scientific and technological advancements in the industries they monitor has remained relatively unchanged in recent

years, with the public expressing the greatest confidence in the USDA (60% have a great deal or a fair amount of confidence). Of the three regulatory agencies and one research agency for which confidence was measured, the only notable decline occurred in the confidence the public has in the EPA. Today, 51% express a great deal or a fair amount of confidence in the EPA, compared with 59% just one year ago. This is the lowest level of confidence for the EPA measured since 2006, and putting it behind the USDA, FDA, and DOE.

### Only Slight Shifts In Public Confidence In Federal Agencies

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*% great deal/fair amount of confidence that they maximize benefits/minimize risks of scientific/technological advancements in the industry they are associated with*



Confidence in businesses and companies to maximize benefits and minimize risks associated with scientific and technological advancements in their industries lags behind that of all four government agencies—44% have a great deal or a fair amount of confidence in businesses and companies. The majority of the public has just some or no confidence in business, and the proportion who say they have very little confidence (25%) is at the highest level measured since the first poll Hart Research Associates conducted for The Wilson Center in 2006.

**The American public approaches synthetic biology with a sense of tentative support and guarded optimism. While most do not want to stand in the way of this research, they also do not want to let it proceed without government oversight.**

**The large majority of Americans believe that rather than banning synthetic biology, research and development should move forward with a focus on uncovering possible effects on humans and the**

**environment (63%).** Only one in three (33%) supports a ban on synthetic biology research until its implications and risks are better understood.

## By Two To One, Public Supports Continued Work In Synbio Over Ban

*Which comes closer to your point of view?*

Synthetic biology should move forward, but more research must be done to study its possible effects on humans and the environment



A ban should be placed on synthetic biology research until we better understand its implications and risks



### View By Awareness of Synbio

	Move forward	Ban
Heard a lot	80%	15%
Heard some	76%	20%
Heard a little	66%	29%
Heard nothing	52%	44%

### View By Informed Impression of Synbio

	Move forward	Ban
Benefits outweigh	90%	8%
Benefits/risks equal	72%	24%
Risks outweigh	31%	64%

Those who have heard a lot about synthetic biology are much more supportive of forging ahead (80%) than are those who have heard nothing (52%). As one would expect, those who think the benefits will outweigh the risks are very supportive of moving forward (90%). A look at attitudes by informed perceptions shows that while two-thirds (64%) of those who think the risks will outweigh the benefits favor a ban, one in three (31%) thinks that synthetic biology should move forward with more research on possible effects. Among those who think the risks and benefits are equal, fully 72% favor moving forward with research, while only 24% favor a ban.

The demographic groups most supportive of moving forward with the study and development of synthetic biology are those who are most aware of and optimistic about the science. Men, college graduates, and members of upper-income households report the highest levels of support for and optimism about synthetic biology.

Those who regularly attend religious services are more supportive of a ban than are those who rarely or never attend services. Evangelicals register one of the highest levels of support for a ban (43%), but half favor continuing with the research.

Whites are notably more supportive of moving forward than are Hispanics and African Americans. Indeed, African Americans are the single demographic group among which a majority supports a ban on synthetic biology until more research is done on potential effects and risks.

## Support For Continued Work Vs Ban, Among Key Subgroups

*Which comes closer to your point of view?*

	Move forward	Ban		Move forward	Ban
<b>All adults</b>	<b>63%</b>	<b>33%</b>	Income:		
Men	<b>72%</b>	25%	Under \$30K	50%	<b>47%</b>
Women	55%	<b>40%</b>	\$30K to \$50K	57%	<b>38%</b>
High school/less	51%	<b>45%</b>	\$50K to \$75K	<b>71%</b>	25%
Some college/tech ed	61%	34%	Over \$75K	<b>80%</b>	16%
College graduate	<b>74%</b>	22%	Attend religious services weekly	56%	<b>39%</b>
Whites	<b>68%</b>	29%	Evangelicals	51%	<b>43%</b>
African Americans	41%	<b>52%</b>			
Hispanics	53%	<b>43%</b>			

While the public does not wish to stand in the way of progress in synthetic biology, the majority of Americans feel that when it comes to this research, voluntary guidelines do not provide adequate oversight. More than half (52%) of the public think synthetic biology should be regulated by the federal government, while 36% think that voluntary guidelines developed jointly by industry and government can provide adequate oversight.

## Majority Wants Government Regulation

*Which comes closer to your point of view on regulation of synthetic biology research?*

Synthetic biology research should be regulated by the federal government because voluntary research guidelines developed jointly by industry and government cannot provide adequate oversight



Voluntary research guidelines developed jointly by industry and government can provide adequate oversight of synthetic biology research



Not sure



The groups most supportive of federal government regulation include women, individuals with a high school education or less, and members of low-income households. African Americans and Hispanics are notably more supportive of regulation than are whites.

## **Government Regulation Vs Voluntary Guidelines, Among Key Subgroups**

*Which comes closer to your point of view on regulation of synthetic biology research?*

	Need Gov't Reg.	Voluntary Guidelines		Need Gov't Reg.	Voluntary Guidelines
<b>All Adults</b>	<b>52%</b>	<b>36%</b>	Income:		
Men	49%	40%	Under \$30K	62%	25%
Women	54%	32%	\$30K - \$50K	54%	34%
High school/less ed	56%	31%	\$50K - \$75K	48%	38%
Some college	53%	33%	Over \$75K	49%	43%
College graduates	49%	41%	Democrats	64%	28%
Whites	47%	40%	Independents	49%	37%
African Americans	63%	25%	Republicans	42%	44%
Hispanics	59%	26%			

Unsurprisingly, opinions about the role of government in regulating synthetic biology vary by political affiliation. Democrats favor federal government regulation by a wide margin (64% favor federal government regulation versus 28% who favor voluntary guidelines) and independents do so by a smaller margin (49% favor federal government regulation versus 37% who favor voluntary guidelines). Republicans are divided on the question of regulation, with 42% in favor of federal government regulation and 44% supporting voluntary guidelines.

Among informed voters who think the benefits of synthetic biology outweigh the risks, the majority favors voluntary guidelines (54%) over federal government regulation (40%), whereas those who think the risks outweigh the benefits are more likely to favor regulation (59%) than voluntary guidelines (21%). Interestingly, those who think the risks and benefits are about equal fall along the same lines as the latter group: 55% favor federal regulation and 36% favor voluntary guidelines.

## Government Regulation Vs Voluntary Guidelines, Among Key Subgroups

*Which comes closer to your point of view on regulation of synthetic biology research?*

	Need Gov't Reg.	Voluntary Guide-lines		Need Gov't Reg.	Voluntary Guide-lines
Awareness of Synbio:			Confidence in USDA:		
Heard a lot	39%	50%	Great deal/fair amt	53%	39%
Heard some	42%	47%	Just some/little	48%	36%
Heard a little	57%	32%	Confidence in FDA:		
Heard nothing	55%	31%	Great deal/fair amt	54%	37%
Informed Impression of Synbio:			Just some/little	47%	37%
Benefits outweigh	40%	54%	Confidence in Business:		
Benefits/risks equal	55%	36%	Great deal/fair amt	46%	44%
Risks outweigh	59%	21%	Just some/little	58%	29%

**No single concern about synthetic biology stands out. The public expresses equal levels of concern about synthetic biology being used to create harmful things such as biological weapons (27%), that it is morally wrong to create artificial life (25%), and concern for negative health effects for humans (23%). A lesser 13% say the possibility that it could damage the environment is their biggest concern.**

When presented with four concerns that have been raised about synthetic biology and asked to select which one concerns them most, concern that it is morally wrong to create artificial life is the top concern of evangelicals (45%). It also is the criticism selected most often by those who have heard nothing about synthetic biology (32%), those whose informed impressions are that the risks will outweigh the benefits (36%), and those who support a ban until the risks are better understood (44%).

## Top Concerns About Synthetic Biology

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*Which ONE of these concerns you most?*

It could be used to create harmful things such as biological weapons



It is morally wrong to create artificial life



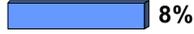
It could cause negative health effects for humans



It could damage the environment



None of these is a concern



**Moral implications are the top concern among adults who:**

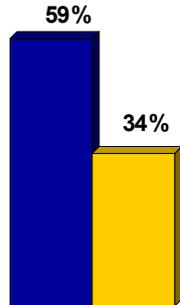
Have heard nothing about synbio	32%
Think risks outweigh benefits after hearing information	36%
Move to thinking risks outweigh	37%
Support ban until we know more	44%

**The public makes different value judgments about synthetic biology depending on the specific applications in question. Some generate greater hope and optimism among most Americans, while others generate a great deal of concern.**

Respondents were presented with two potential applications for synthetic biology: (1) using it to dramatically expedite the creation of an influenza vaccine and (2) using it to accelerate growth in animals. Americans react in very different ways to these applications. A majority (59%) of adults are positive and hopeful about the vaccine application. In contrast, nearly three in four (74%) adults view the use of synthetic biology to accelerate the growth of cows and pigs as a negative development that causes them concern.

## Majority See Developing Flu Vaccine With Synbio As Positive Development

■ Positive development/I would be hopeful    ■ Negative development/concerns me



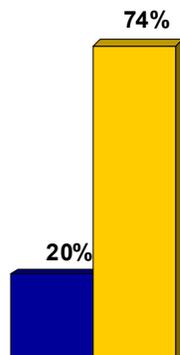
Current flu vaccine manufacturing requires the replication of the flu virus in chicken eggs. This is a lengthy and time-consuming process often taking four to five months to make vaccines available for use. Using synthetic biology, an influenza vaccine could be designed in a few hours on a computer and biologically manufactured in weeks instead of months.

### Seen as negative development by majorities of:

Adults who support ban	64%
Adults who believe risks outweigh benefits	61%
African Americans	57%
Adults who say moral issues are greatest concern	54%

## Large Majority Concerned About Using Synbio To Accelerate Animals Growth

■ Positive development/I would be hopeful    ■ Negative development/concerns me



Using synthetic biology, researchers could insert a synthetic chromosome designed on a computer into cows or pigs that would allow the animals to mature in four months instead of eight months. Other than the acceleration of growth, the animals would look and act exactly like regular pigs and cows, but it would mean that farmers could produce meat for consumers more quickly.

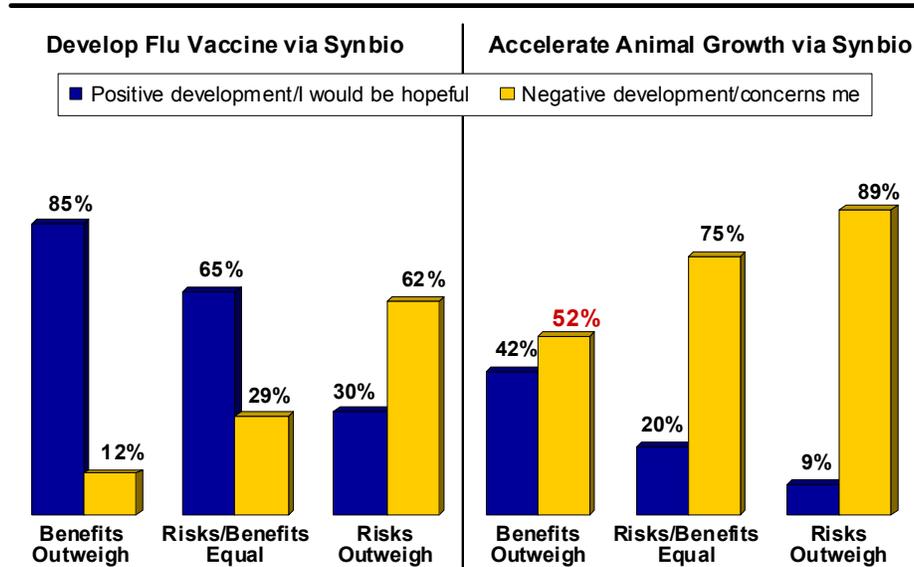
Only 33% of those who feel positive about the flu vaccine application also feel positive about using synbio to accelerate animal growth.

There are NO groups among whom a majority feel positive about this application.

Even among those who feel positive about using synthetic biology to make vaccines more quickly, just 33% feel positive about using it to accelerate the growth of cows and pigs. A solid 61% think this application would be a negative development about which they would be concerned.

Again, perhaps not surprisingly, those who are more likely to be optimistic about synthetic biology and feel that the benefits will outweigh the risks are more likely to feel positive about both applications. Yet still, among this group, concern about using synthetic biology to accelerate the growth of livestock outweighs positive opinions about it by 52% to 42%.

## Views Of Flu Vaccine/Growth Of Livestock, By Initial View Of Synbio



Those whose main concerns about synthetic biology are the moral implications express concern about both the flu vaccine application and the use of synthetic biology to accelerate the growth of livestock at high rates. In fact, across all four areas of greatest concern, the only group among whom a majority feel negative about the flu vaccine are those for whom the moral implications present the greatest concern. This group also reports the highest levels of opposition toward the use of synthetic biology to accelerate the growth of animals, with 90% viewing it as a negative development. Majorities of respondents who select the other three criticisms as their greatest concern express hope and optimism about the vaccine application.

## Views Developing Of Flu Vaccine, By Greatest Concern About Synbio

### Developing Flu Vaccine via Synbio

■ Positive development/I would be hopeful   ■ Negative development/concerns me

Voters whose biggest concern about synbio is:

