# *Biodefense implications of Synthetic Biology & Emerging Technologies*

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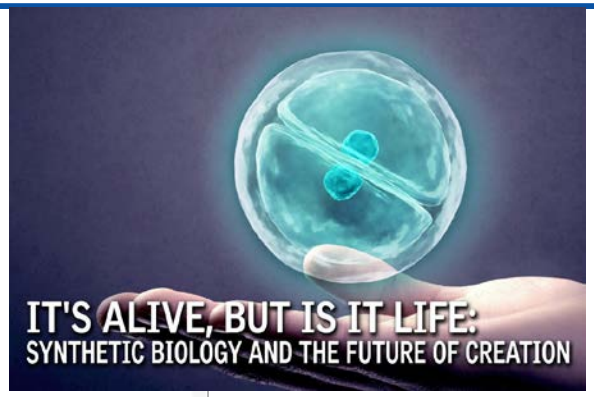
# *Hope for innovative solutions to global problems*

- *Health*: antimicrobial resistance, increasing threat of pandemics; threat of biological weapons
- *Energy*: need for cleaner, safer, renewable sources
- *Climate*: increasing natural disasters and disease outbreaks
- *Resource scarcity*: water, land use/crops, fragile coastal zones, toxins, biodiversity, sustainability;
- *Economic stability and growth:* US competitiveness in the marketplace;
- *National security:* CBRN, WMD defense

# *Hope, and Hype*




**MEDICINE**

## CRISPR Could Turn Viruses Into Unstoppable Bio Weapons

White House science advisers warn of possible risks and ask for faster vaccine development and more vigilance.

The Atlantic

**Hacking the President's DNA**

theguardian

Designer babies: an ethical horror waiting to happen?

**MIT Technology Review**

**The Dangers of Synthetic Biology**

Nobel Prize winner David Baltimore explains why building smallpox from scratch is a key safety concern in synthetic biology.

gp global POLICY

**Synthetic biology - what to expect and fear?**

# *Questions*

- What's changing?
- How does it affect (bio)security and biodefense?
- How do we adjust and gain advantage?

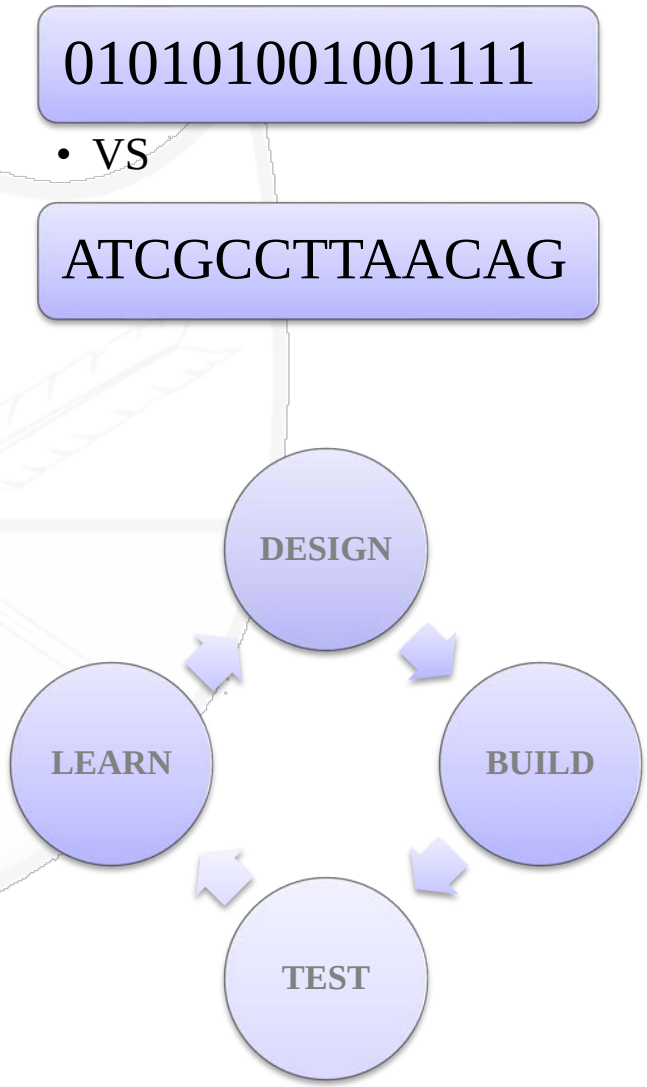
# *What is changing?*

- Biology can be engineered…

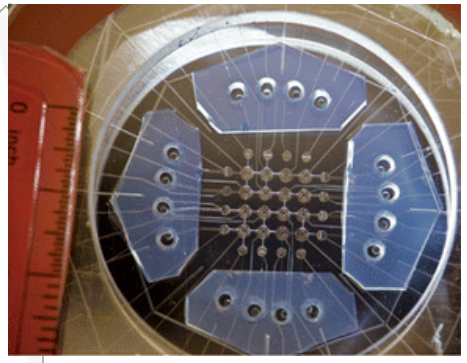
  ...Engineering and other emergent technologies can be applied/converge
- Pace of technology and innovation is FAST.
- Biotechnology is used by, and accessible to, more diverse actors.

# *Biology can be engineered*

- Biology is a sophisticated platform:
  - Programmable; can manipulate matter at nanoscale; scalable (nano to macro);
- Engineering technologies now converge with biology in exciting/potentially disruptive ways.



# *Other rapidly emerging novel technologies enable beneficial applications*



- Automated systems, microfluidics
- Complex computation
- Bioinformatics
- Mass Spec
- 3D printing

# *Biology is highly accessible*

- Growing global industry;
- State Actors developing National synthetic biology strategies, programs, and investments;
- iGEM
- DIY Bio movement

# *What are the implications?*

- Traditional Threats
- Novel Threats
- Capability arising from convergence
- Ineffective policy controls?
- other

**Biosafety**

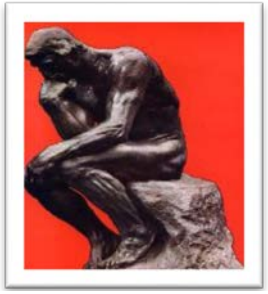
***Accidental exposure to pathogens, toxins, or genetically engineered organisms could adversely affect:***

**Laboratory workers**
**General public**
**Plants and animals**
**Environment**

**Biosecurity**

***Deliberate misuse of technology to cause harm to:***

**Humans**
**Plants**
**Animals**
**Environment**



**Societal Norms**

***Controversial uses and consequences of technology, e.g.,***

**Germline interventions**
**Enhancements**
**Genetically modified organisms**

# *Traditional threats may be easier:*

- Enable a virus to evade a vaccine
- Make an agent resistant to antibiotics or antivirals
- Make an agent more infectious; make a virus more virulent
- Increase the transmissibility of a pathogen
- Alter the host range of a pathogen
- Enable the evasion of diagnosis or detection
- Enable the weaponization of a biological agent or toxin
- Synthesis of pathogenic micro-organisms
- Recreate a past/eradicated pathogen (e.g. 1918 flu)

# *Novel threats may be possible*

- Novel Threats:
  - Gene drives, new pathogens/toxins? Humans, animals, agriculture, materiel, environment
- Bioweapons for strategic use? “mass disruption” rather than “mass destruction”.
- Industrial sabotage (biosafety/security as well as economic risks)
- Detection/attribution will be challenging

# *Convergence acts as a "force multiplier" for synthetic biology's capabilities*

- Gene therapy; Nanotechnology, advances in aerosolization technology
- 3D printing – microbes and human tissues
- Automation, bioinformatics
  - "Precision Medicine vs Precision Malady"
  - Cybersecurity vs. biosecurity?

# *Current biosecurity policies fall short:*

- Rapid pace of biotechnology far *outpaces policy development;*
- The *threat space is widening* from technology advancement/convergences;
- Capabilities are accessible to wider range of actors
  - Innovations in startups/academia - not fully in the hands of government
  - 'democratization' lowers barriers to entry
  - Non-state actors: do they want this capability? (degradation of the norm for CW, captagon?)

# *Additional Observations*

- DOD has not traditionally led this space;
- State actors will invest in biotechnology for
  - Pharmaceutical advances
  - warfighting capabilities (enhanced human performance, adaptive materials, sensors, etc.)
  - 'Legitimate' uses could easily mask illegitimate programs.
- Protection of genomic information is a critical biosecurity issue that is currently unaddressed.

# *How to Adjust and Gain Advantage?*

- The tools of biotechnology itself are the best options for ensuring biodefense against misuse;
- Incentivize and promote "*biosecurity by design*" in academia, industry, government, etc.
  - Safegenes, FELIX
- *Explore convergence*: it reveals likely points of "technological surprise"; educates horizon scanning for barrier points; DOD can excel at these technologies

# *Adjust and Gain Advantage cont.*

- Risk Analysis
  - National Academies' and other studies
  - Red Team exercises
  - Intelligence on adversaries, collecting the right intelligence?
- Build "core competencies"; invest in convergent bioengineering technologies
- Maintain norms - establish new where needed

# *Thank you*

Questions

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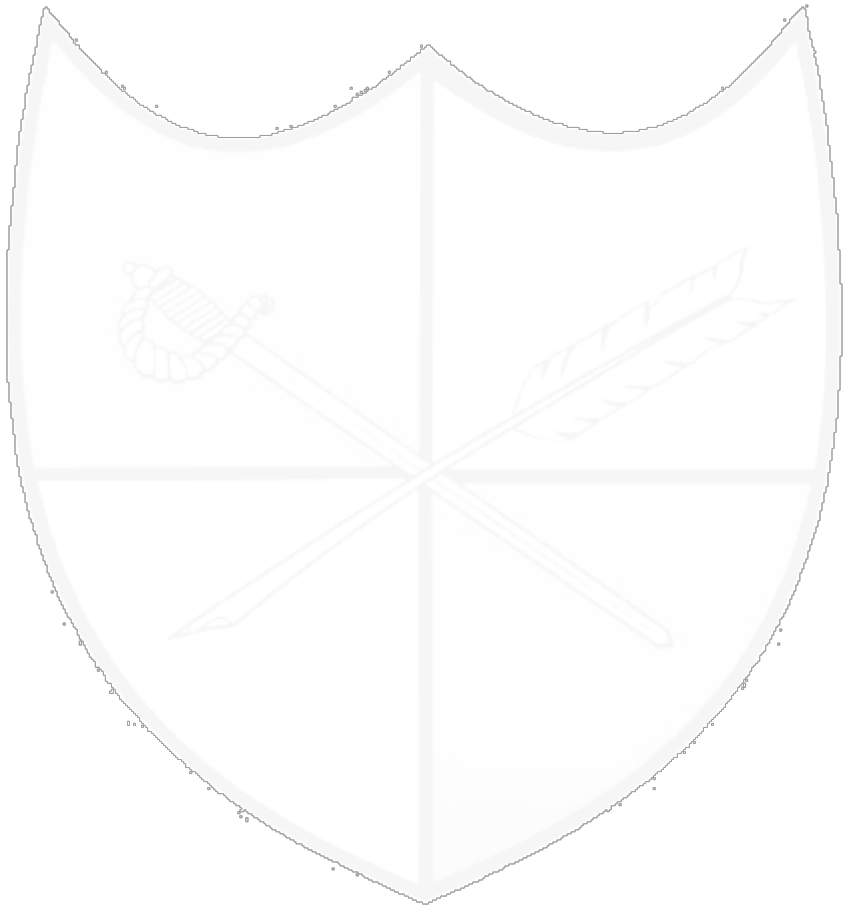
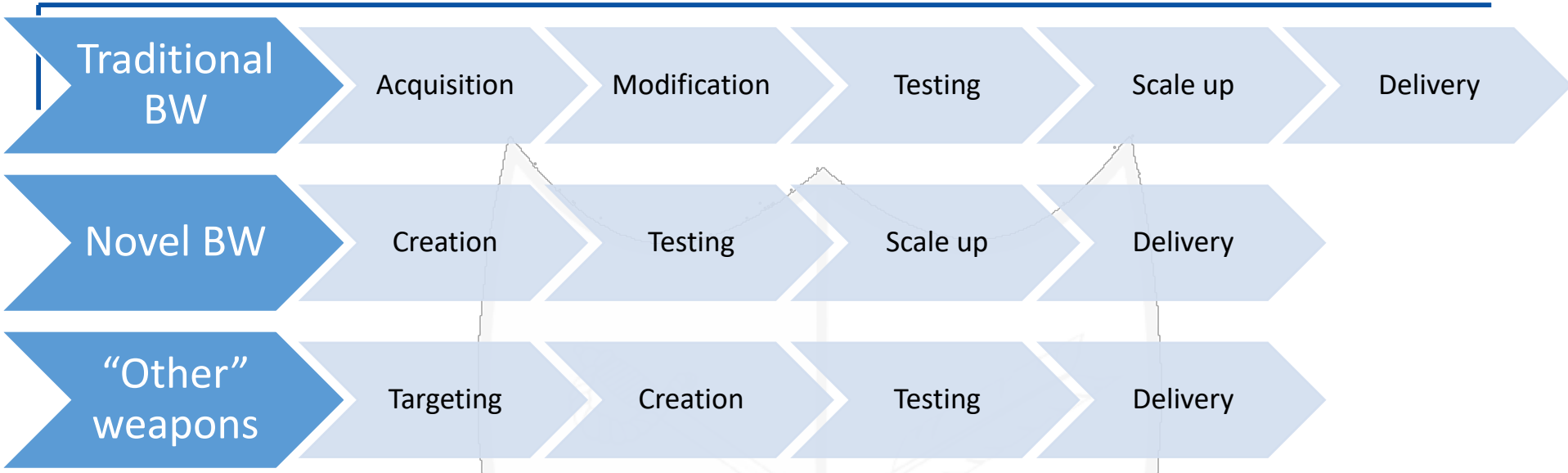
# *Back up slides*






DEFINITIONS:

***Acquisition***: theft from lab or transport, harvest from nature, synthetic recreation

***Creation*** : wet-bench laboratory work

***Testing***: animal models, field testing?

***Scale up***: mass production, freeze drying, encapsulation, storage/stockpiling?

***Delivery***: sprayer, point delivery mechanism, filling

***Targeting***: bioinformatics targeting of specific group

**attribution* will be a potential challenge

★ Significant barrier still exists

★ Lowered barrier with genomic or other tools

★ tacit knowledge has key role

# *What's the market for DOD?*

- Commodity materials:
  - textiles, fuels
- "specialty" materials:
  - Corrosion resistant coatings, high strength polymers, biological computing
- Sensors
  - Organisms which detect magnetic waves ionizing radiation, changes in environments
- Medical Countermeasures
  - Vaccines, antibiotics, pretreatment prophylactics etc.
- Force health protection/human performance modification
  - Skin and gut microbiomes

# *What's the real market?*