Emerging S&T: New Challenges to Strategic Stability

Image blatantly stolen from Bioshock, http://www.gamespot.com/pc/action/bioshock

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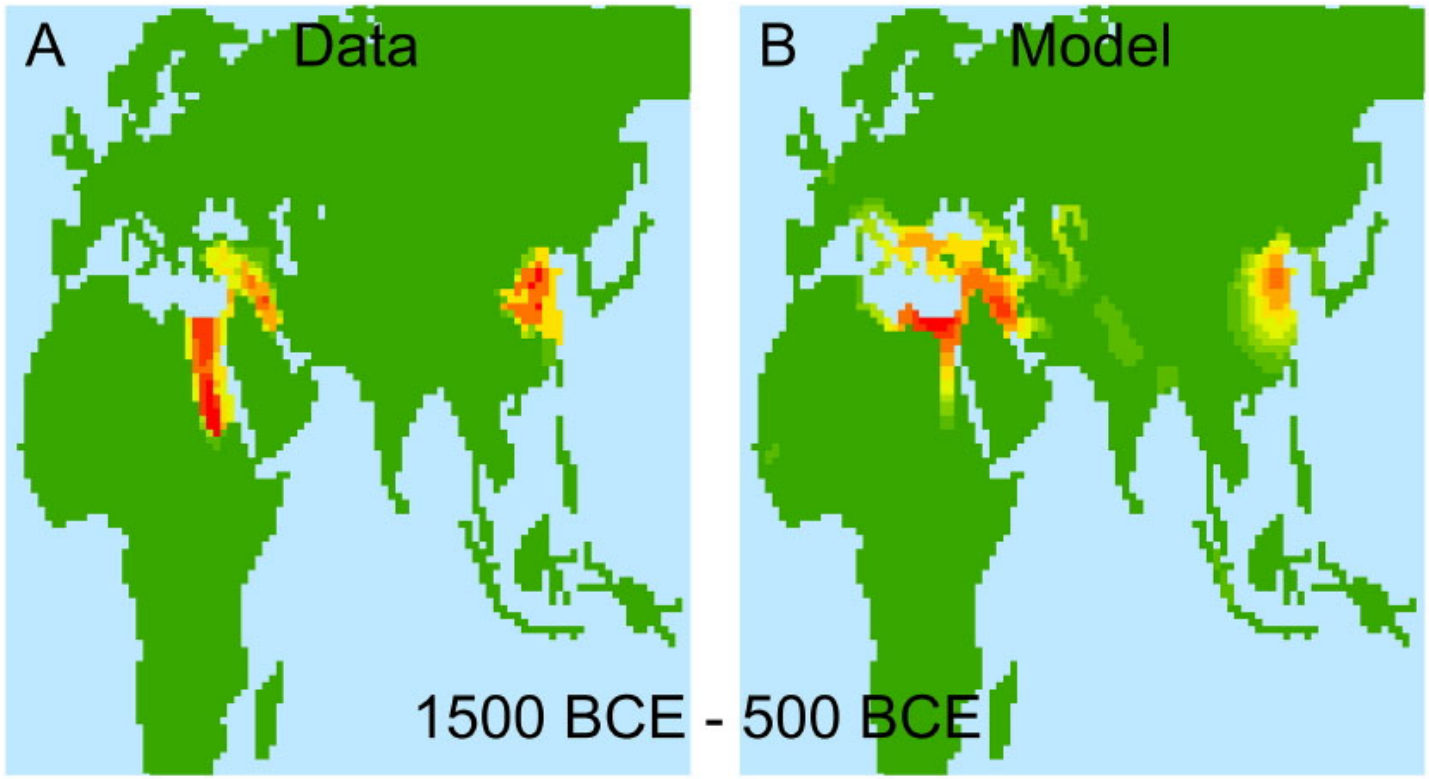
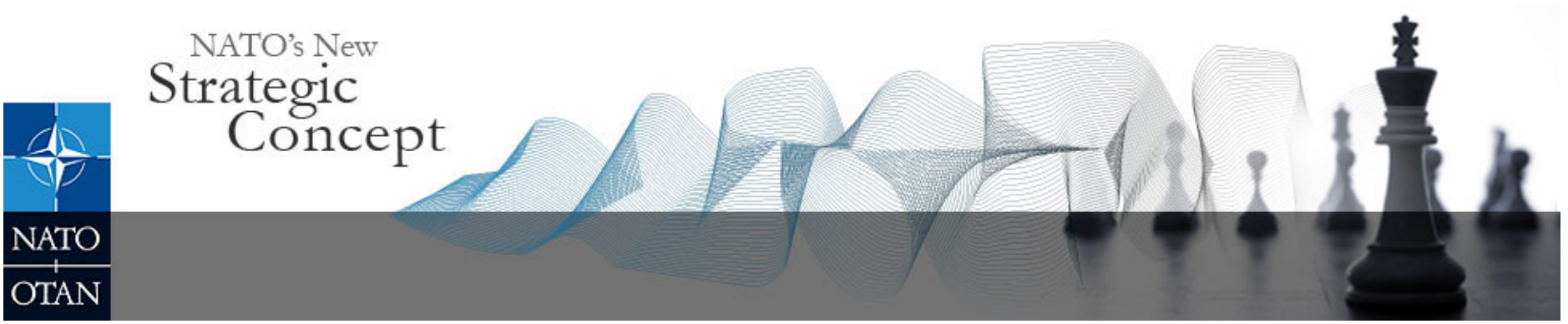
Technology's Role in Politics & War

… & the Role of Politics & War in Technology

Peter Turchina, et al., **War, Space, and the Evolution of Old World Complex Societies,** *Proceedings of the National Academy of Sciences (PNAS)*, published online 23 September 2013.



"Comparison between data and model predictions for three historical eras *[one shown]*. Red indicates regions that were more frequently inhabited by large-scale polities, yellow shows where large polities were less common, and green indicates the absence of large polities."



"Less predictable is the possibility that research breakthroughs will transform the technological battlefield. Allies and partners should be alert for potentially disruptive developments in such dynamic areas as information and communications technology, **cognitive** and **biological sciences**, **robotics**, and **nanotechnology**.

The most destructive periods of history tend to be those when the means of aggression have gained the upper hand in the art of waging war."

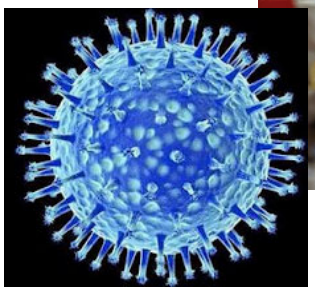
May 2010

http://www.nato.int/strategic-concept/index.html

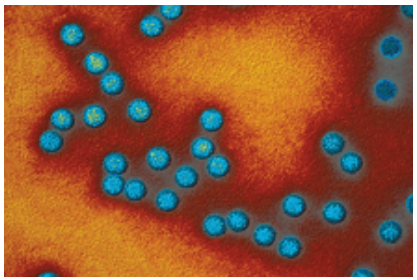
Contentious Research

- Manipulation of microbes
  - circumventing countermeasures
  - increased virulence or lethality
  - antibiotic resistance
  - novel H_5N_1
- Synthesized viruses
  - polio
  - ϕX174 bacteriophage
  - Reconstructed H_1N_1
- Delivery and dispersal
  - novel drug delivery
  - aerosols
  - micro- & nano-encapsulation
- Synthetic genomics & DIY biology

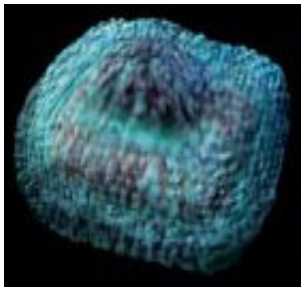
Dr Ron Fouchier



H5N1



Synthetic Polio



Mousepox

Dual-Use Conundrum:

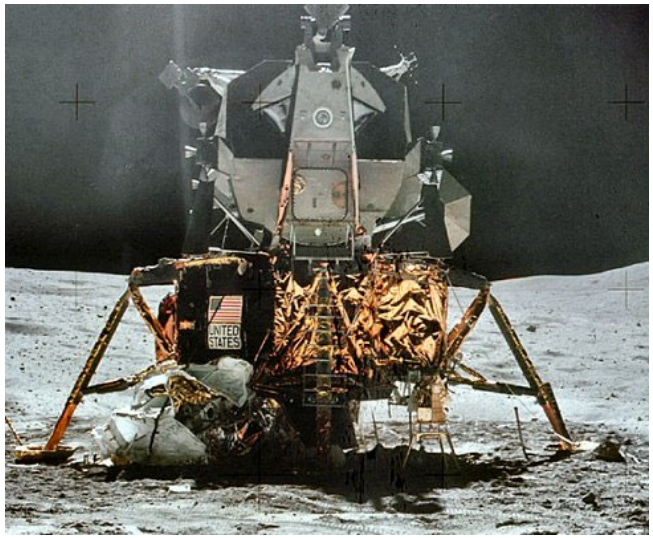
Almost all the equipment and materials needed to develop dangerous biological agents have legitimate uses in a wide range of scientific research and industrial activity

International Studies Review

"Examples of such technologies [at risk for terrorist appropriation] nanotech, proteinacious [sic] microspheres; bioinformatics; single nucleotide polymorphisms (SNPs); and Bose-Einstein condensates."*

* "WMD Terrorism Research: Where to From Here?"
International Studies Review, March 2005, vol. 7, p. 140

What is Revolutionary?



~$490 Billion* Apollo program makes 6 landings on the moon over a 3-year period and stimulates development of many spin-off technologies including integrated circuits and fuel cells. Journey has not been repeated in over 40 years.

* Adjusted to 2016 dollars

Automatic rifle designed by Mikhail Kalashnikov and introduced in 1947 is revered for its simplicity and reliability. Produced worldwide and used by 55 national armies, it has become a cultural icon.

Security Puzzles

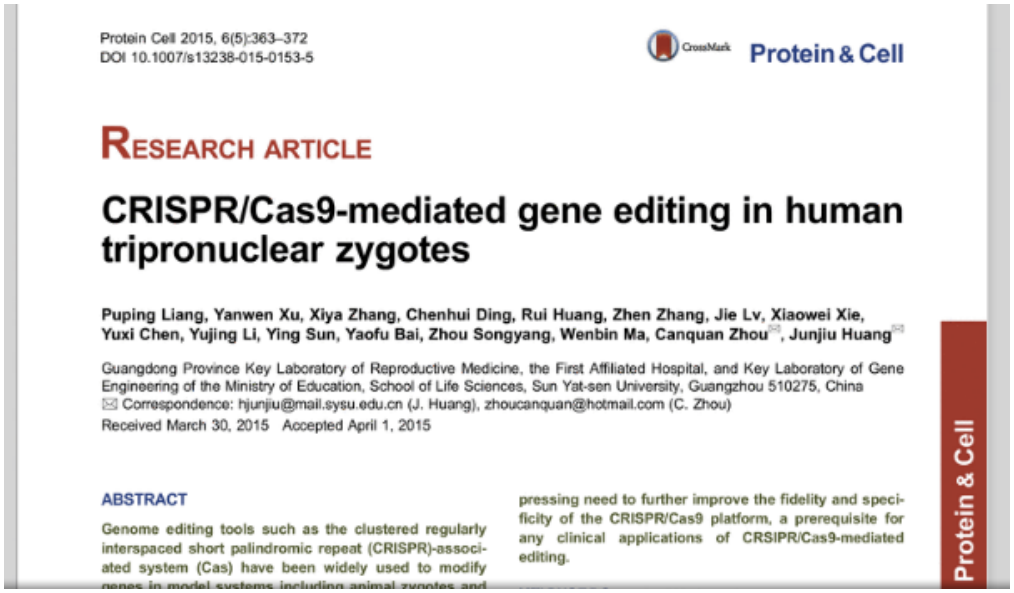
- Do emerging technologies – *biotechnology, meta-materials, robotics/AI, additive manufacturing, nanotechnology, cognitive neurosciences* – have unique strategic value?
- How do these technologies affect conflict and cooperation?
- What are the identifiable technical (material & knowledge), structural (organizational), & political (ideational) factors? And how do they interact?
- Interactions among politics & technology
  - "Hope" & "Horror" hype / rhetoric.
  - [Nanotech is …] "the key to developing new, modern and effective military systems"
  - *"New technologies (at risk for terrorist appropriation) include* ***biotechnology, nanotechnology, single nucleotide polymorphisms*** *(SNPs), and* ***Bose-Einstein condensates****."*
- Best approaches to governance – domestically & internationally – of dual use technologies and contentious research

What technologies or technological scenarios could compete with nuclear weapons to on strategic stability?

What conditions – geopolitical, ideational, technological, organizational – could lead to such be realized?

Chinese Team Reports Gene-Editing Human Embryos

- Used CRISPR-Cas9 system to edit the HBB gene, which encodes the human β-globin protein
- 86 injected, 71 survived, 28 were successfully spliced
- "Off-target" mutations



Protein Cell 2015, 6(5):363–372
DOI 10.1007/s13238-015-0153-5

Protein & Cell

RESEARCH ARTICLE

CRISPR/Cas9-mediated gene editing in human tripronuclear zygotes

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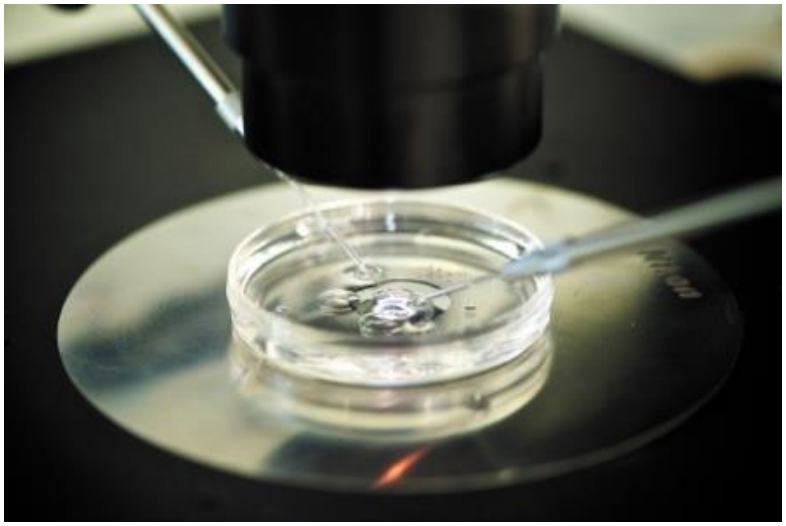
ABSTRACT

Genome editing tools such as the clustered regularly interspaced short palindromic repeat (CRISPR)-associated system (Cas) have been widely used to modify genes in model systems including animal zygotes and

pressing need to further improve the fidelity and specificity of the CRISPR/Cas9 platform, a prerequisite for any clinical applications of CRSIPR/Cas9-mediated editing.

Protein & Cell



Other Metrics

- Dual Use Nature: *Offensive vs. Defensive Capabilities*
- Disruptive (Revolutionary) vs. Sustaining (Evolutionary) Technology
- Program Stability: *Institutionalized vs. Transitory Programs*
- Origin of Technology: *Private vs. Public Investment*
- Capacity: *Higher Education & Research Institutes*
- Distinguishability: *Overt vs. Covert*
- Technological Imperative: *Tech Driven vs. Requirements Pull*
- Regulation: *National & International Frameworks, Implementation, and Execution*

International Security Regimes

- Geneva Protocol
- Biological Weapons Convention (BWC)
- Chemical Weapons Convention (CWC)
- Australia Group
- Proliferation Security Initiative

State-level Policies

- Germline editing prohibited in 40 states
  - Most strictly in western Europe, where 15 of 22 nations prohibit modification of the germ line
  - Germany strictly limits experimentation on human embryos
- No explicit prohibition on genome-editing in US
  - 1996 US law bans *government funding* for work destroys fertilized human embryos or creates them for research purposes
  - Later rules addressed research in human embryonic stem-cell lines
  - Wording interpreted to prohibit funding for work in a non-viable human embryo
  - Undergoing WH-initiated review now: NIH → NIH → NSABB & NAS
- Many countries do not have explicit legislation in place permitting or forbidding genetic engineering in humans
  - In China, Japan, Ireland, and India, guidelines restrict genome editing in human embryos

- *Gain-of-Function work not necessarily at State-level*

*Image adapted from M. Araki & T. Ishii Reprod. Biol. Endocrinol. **12**, 108 (2014*

Current USG Efforts

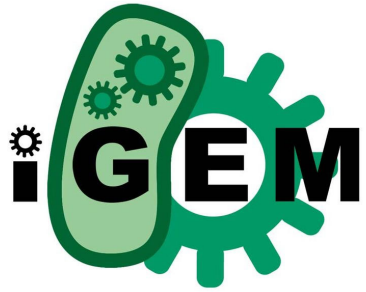
- WH → NIH → NSABB & NAS
- Establish a model regulatory framework that could be adopted internationally

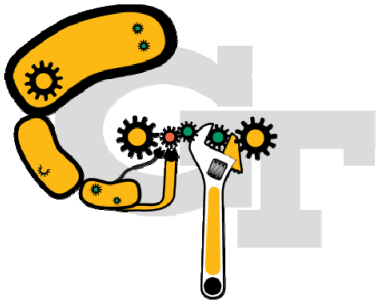
  "Key to all discussion and future research is making a clear distinction between genome editing in somatic cells and in germ cells." I.e., don't edit the human germ line

- Influence policy and design tools & methods to enable inclusive and meaningful deliberation

Governance Forms

- Informal
  - International Genetically Engineered Machine (iGEM) competition
    - Participants from 165 universities from NA, Latin America, EU, ME, & Asia-Pacific
  - 'Grass-roots' initiatives
    - Industry – Blackwatch shared gene database
    - Academia
- Meta-formal
  - AAAS CSTSP
  - FBI-DIYbio Workshop @Genspace
  - FBI WMD Coordinators
- Formal
  - USG Statutes & Policies:
    - NIH/Commerce Synthetic Nucleic Acid Scre
  - Advisory: NSABB
  - NIH Policy on Oversight of DURC
  - International Law





Tensions Between Security & Science

Responses of a "security conscious" person

1. There is a problem of bioterrorism and biological weapons.
2. Developments in the life sciences could contribute to the problem in a variety of ways.
3. An effective pre-project review on biosecurity grounds should and could be introduced at a local level.
4. Given the possibility of unexpected results, an effective prepublication review should and could be implemented.
5. An effective national system of review should and could also be implemented.
6. An effective international review system to help standardise national review systems should and could be introduced.

Responses of a "classic open science" person

1. There is little evidence of a problem of bioterrorism and biological weapons.
2. Neither is there evidence that developments in the life sciences could contribute to the problem.
3. An effective pre-project review on biosecurity grounds should not and could not be introduced at a local level.
4. An effective prepublication review should not and could not be implemented.
5. An effective national system of review should not and could not be implemented.
6. An effective international review system to help standardise national review systems should not and could not be introduced.

Derived from Malcolm Dando, "Education for life scientists after the 2008 BTWC meetings."

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