Prospective Technology Assessment and Precautionary Design

Symposion GeneTip, Bremen 19./20. 6. 2018

Arnim von Gleich
University of Bremen
Fac. Production Engineering
Dep. Technology Design and Development

TEST
BIOTECH
Testbiotech e. V.
Institute for Independent
Impact Assessment in
Biotechnology

Universität Vechta
University of Vechta

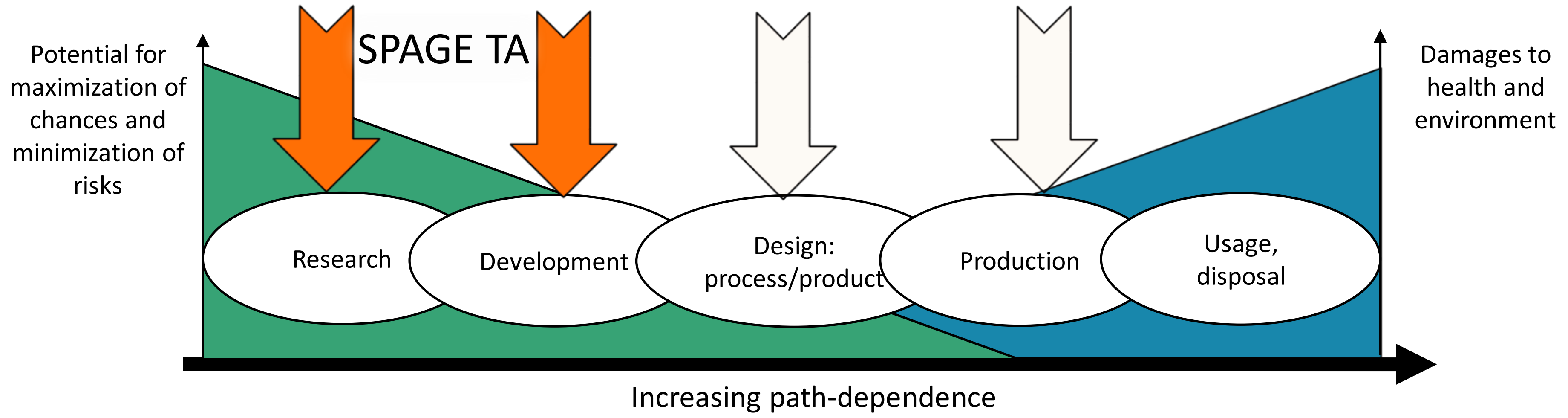
BOKU
I S R
Institut für Sicherheits-
und Risikowissenschaften
Universität für Bodenkultur Wien

Early Indicators in TA and Starting Points for Precautionary Design

Facing the Collingridge Dilemma

1) Paradigms, contributing disciplines
2) Methodology - theoretical and practical abstractions
3) New or improved functionalities?
4) Potentials for opportunities and threats (benefits, hazards, exposure)
5) Recommendations (guiding design principles)
6) Alternative development paths

=> Researchers and developers are addressed - More Science Assessment then TA



Epistemological Aspects

Which conceptions of nature, of genes?

What kind of scientific abstractions? What is regarded as important, as disturbing, as negligible?

- theoretical: in models
- practical: in experiments

Scientific paradigms:

- Bio-chemical
- Informational
- Systemic

Reductionist models and experiments still dominate

=> How is complexity reduced?

=> How is dealt with instability, self-organization, emergence, evolution?

Precaution

Facing extreme uncertainties and lack of knowledge (up to ignorance) in view of
  severe consequences (by trend global and irreversible)
  => probability of surprises

Precautionary action must be based on comprehensible knowledge
  => reasons for concern
    Power: extremely powerful effects and/or severe detrimental effects
    Range: extreme dispersal/proliferation in space and time
      high exposure (half life, persistence, self propagation, …)

=> Are there possibilities for corrective action, in case something goes wrong?

Prospective TA:
Identification of 'reasons for concern' and 'reasons for relief'

Prospective TA

A. Technology characterization (criteria)

- Depth of intervention (power and range)
- Liability – malfunction, side effects, on target, off target
- Possibilities for corrective action facing problems (irretrievability)

B. Vulnerability of target system (criteria)

- Carrying capacities, system services
- Essential elements and structures
- Weak points, tipping points

=> persistent and self propagating contamination =
deep intervention into ecosystems

C. Aims and contexts of application (criteria)

ELSI = Ethical, legal and socio-economical implications incl. misuse

We should not focus too much on 'intentions'

(cases where technological catastrophes are triggered by 'best intentions' are more interesting)

Depth of Intervention

Locating technological intervention at structures that control phenomena provide more power compared to technological interventions at the phenomenological level (genes, molecular structures, elementary particles)

=> Difference between splitting stones and splitting atoms
=> Difference between killing an organism and altering its genes

Depth of intervention leads to
a) high power – new or improved functionalities, character of implemented trait
b) high range of exposure and effects in space and time (unclear fate, irreversibility)

Intensity of intervention (high quantity) leading cumulatively to
a) high power b) high range

Uncertainty and Ignorance

Are not ‚just there‘ but produced by the ‘character of the technology’

High depth of intervention - high power and high range - lead to increase of uncertainty and ignorance (probability of surprises)

⇒ Uncertainty and ignorance can be reduced by choosing technologies with minor depth of intervention (power and range)

Strong focus on exposure – the other half of the risk term

⇒ Exposure oriented (hazard independent) precaution?

1. Approach: Hygiene – we do not want it there – NanoP in the brain
2. Approach: Global exposure – too many unforeseen circumstances

CFCs as an Example

Th. Midgley jr. 1930 introduced CFS for domestic refrigerators at ACS meeting inhaling Freon 12 and blowing out a candle:
Freon 12 is not toxic and incombustible. It is absolutely safe!

- **What kind of arguments could have been raised without knowing the complex ‚impact model‘ of ozone depletion?**

Freon 12 is

- **unnatural**
- **highly persistent / inert - half-life: 111 years and**
- **volatile,**
- **it may occur everywhere**
  => these are ‘reasons for concern’

Precautionary measures – phase specific

Late innovation phase (Regulation)

- Registration, authorization, moratorium

Earlier innovation phase (Risk Management)

- Containment, barriers, reducing exposure by external measures
- Security strains (internal) (e. g. E. coli at Asilomar conference)

Very early innovation phase (R&D)

Precautionary design:

- Reducing exposure by design: shorter half life, limited propagation and mobility, …
- Reducing power and severe effects: toxicity, ecosystem alteration, extinction, … by less problematic traits

Scientists and developers should create technological low risk development paths

Decision makers should identify alternative socio-technological solutions

Scientists are on the way, but not yet sufficient?

Oye, Esvelt:
Localize (degradation)
Immunize
Reverse

Alphey:
Invasiveness, self-limiting, self sustaining

Stringent confinement strategies:
Physical, molecular, ecological, reproductive barriers

Reverse gene drives (1), immunizing reversal gene drives (2)
Daisy chain gene drives (3)

(1): Di Carlo et al 2015, Wu et al 2016; (2): Esvelt et al 2014, Vella et al 2017; (3): Noble et al 2017, Esvelt, Gemell 2017

Conclusion

- Gene drives increase power and range
- Extend non-knowledge incl. unknown unknowns
- Increase intended and unintended effects
- Increase exposure, contaminations and possible misuse

⇒ Enough ‚reasons for concern‘ for application of the precautionary principle

⇒ Scientists and developers should focus on low risk development paths and benign design

⇒ Regulative approach with focus on exposure: Following REACH, vp/vb or Novel Food directive, novelty?

⇒ Up to now there is no procedure for weighing ‚reasons for concern‘ and ‚reasons for expectable benefits‘ – It is the task of parliaments and society

⇒ The procedures must include examination of technical and non-technical alternatives