Winter 2020 Webinar: How to Get to Safer Using Non-Animal Testing Methods

Wednesday, January 29, 2020
9:00 AM - 10:00 AM PT
12:00 PM - 1:00 PM ET

WELCOME!

Today's A4 webinar:

How to get to safer using non-animal testing methods

Goal - to better understand:

- what are new approach methods (NAMs) – why they are of interest and how are they being used
- considerations for using NAMs in the context of conducting alternatives assessments, and
- where we can learn more about NAMs, if interested

Today's facilitator

Dr. Margaret Whittaker

TOXSERVICES
TOXICOLOGY RISK ASSESSMENT CONSULTING

Co-Chair, A4 Program Committee

Today's Speakers and Respondents

Pamela Spencer – *VP Regulatory, Product Stewardship and Quality*

ANGUS® CHEMICAL COMPANY

Lauren Heine – *Director of Safer Materials & Data Integrity*

CHEM FORWARD know better chemistry

Amy Clippinger – *Director*

PETA INTERNATIONAL SCIENCE CONSORTIUM LTD.
Advancing 21st Century Toxicology

Shari Franjevic – *GreenScreen® Program Manager*

CLEAN PRODUCTION ACTION

Webinar Logistics

- Due to the number of participants on the webinar, all lines will be muted
- If you wish to ask a question, please type your question in the Q&A box located in the drop down control panel at the top of the screen
- Questions will be answered at the end of the panel discussion
- The webinar is being recorded and will be posted with the slide deck on the A4 website: www.saferalternatives.org
- At the end of the webinar, we will launch a short evaluation survey to help us with future webinars

Introduction to NAMs and Application of NAMS in New Product Innovation

TOPICS IN
ALTERNATIVES ASSESSMENT

Pamela J. Spencer, Ph.D. D.A.B.T.
VP Regulatory, Product Stewardship & Quality
ANGUS Chemical Company

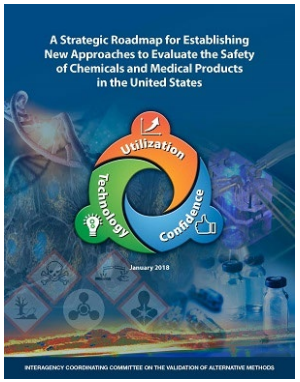
Overview

- What are NAMs
- Types of NAMs
- Are animal tests really the gold standard
- Highlight innovation application strategies

What are NAMs?!

New **A**pproach **M**ethodologies, also known as:

- Predictive Toxicology
- Tox21
- Non-animal alternatives
- Alternative test methods

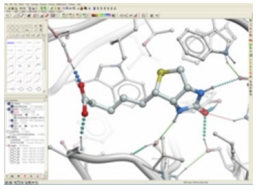


"*adopted as a broadly descriptive reference to any non-animal technology, methodology, approach, or combination thereof that can be used to provide information on chemical hazard and risk assessment.*"[1]

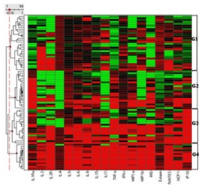
[1]NIEHS A Strategic Roadmap for Establishing New Approaches to Evaluate the Safety of Chemicals and Medical Products in the United States, 2018

Types of NAMs

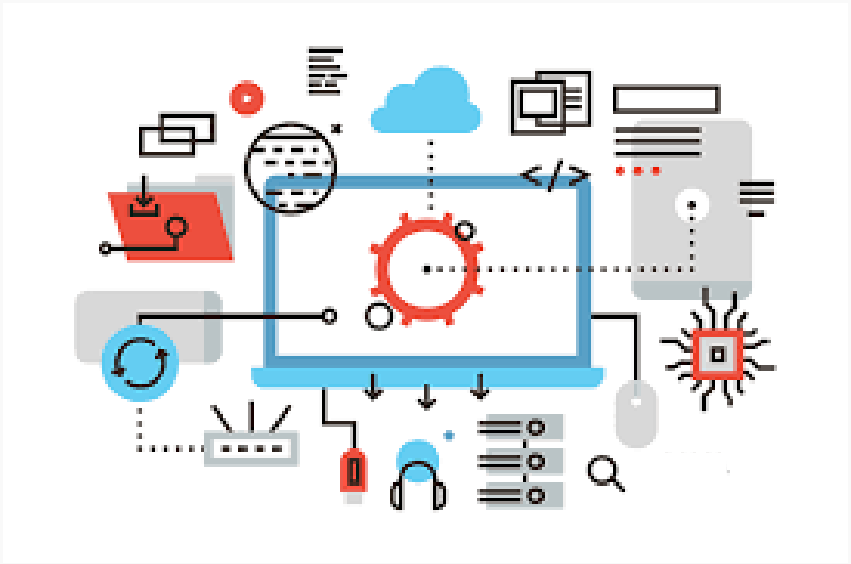
1. In silico/computational tools
   - QSARs
   - Machine learning
   - High throughput exposure modeling



2. In vitro biological profiling
   - Cell cultures
   - 2, 3-D organotypic culture systems
   - Genomics/transcriptomics
   - Organs on a chip



3. Frameworks
   - Adverse Outcome Pathways (AOPs)
   - Defined Approaches (DA)
   - Integrated approaches to testing and assessment (IATA)

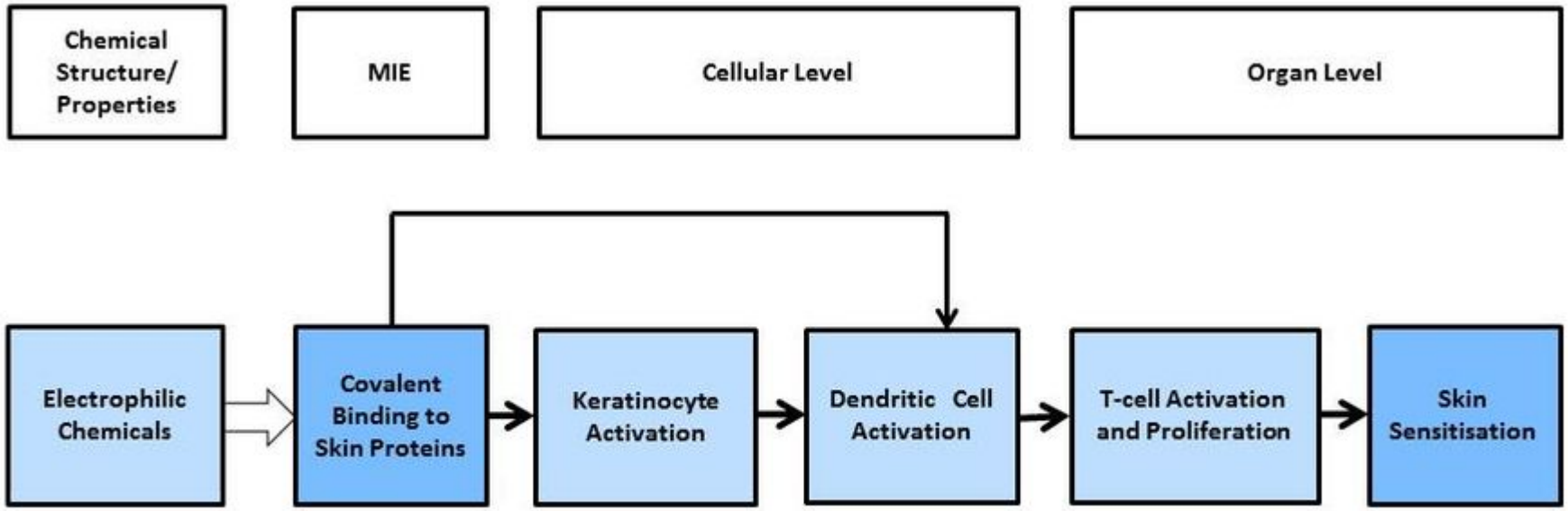


A LITTLE MORE DETAIL ON FRAMEWORKS . . .

Adverse Outcome Pathways (AOPs)

An adverse outcome pathway (AOP) is a model that identifies the sequence of biochemical events required to produce a toxic effect when an organism is exposed to a substance.

Skin Sensitization AOP



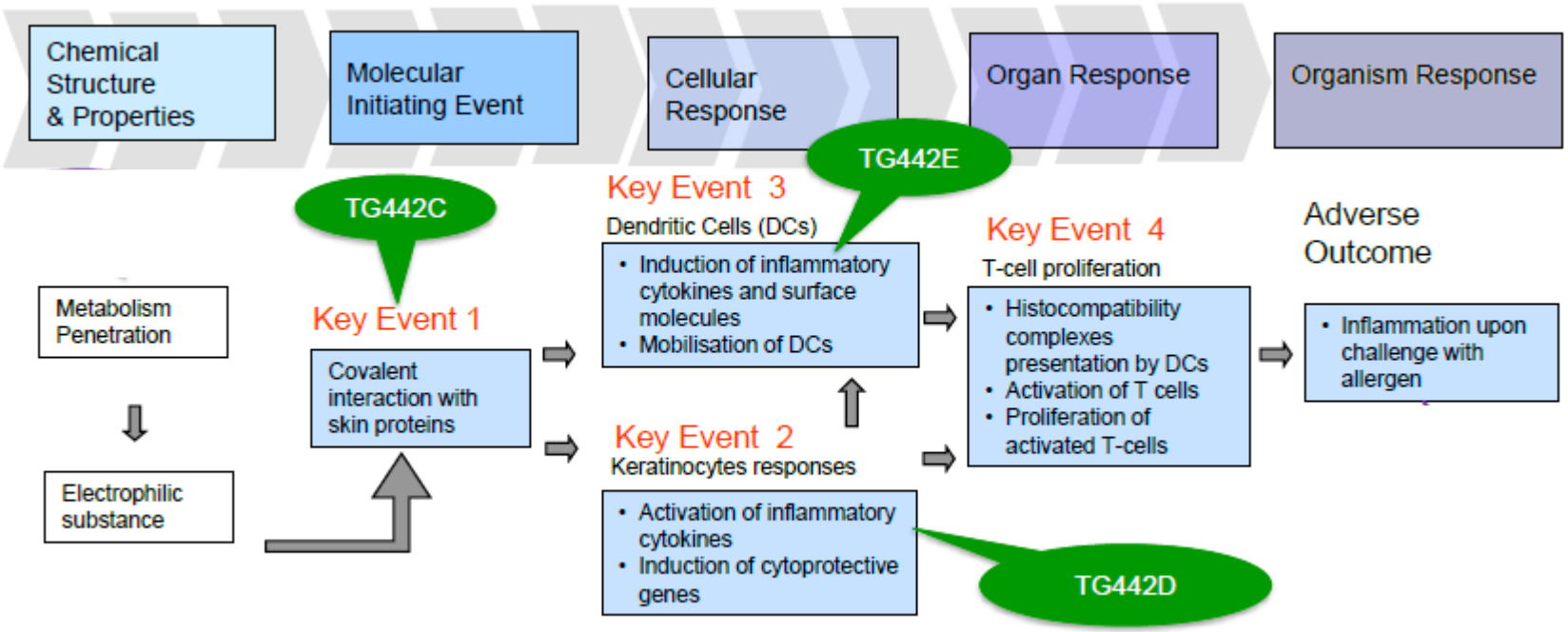
MIE = molecular initiating event

https://aopwiki.org/wiki/index.php/Aop:40

Defined approaches (DAs) to Testing & Assessment

Relies on:

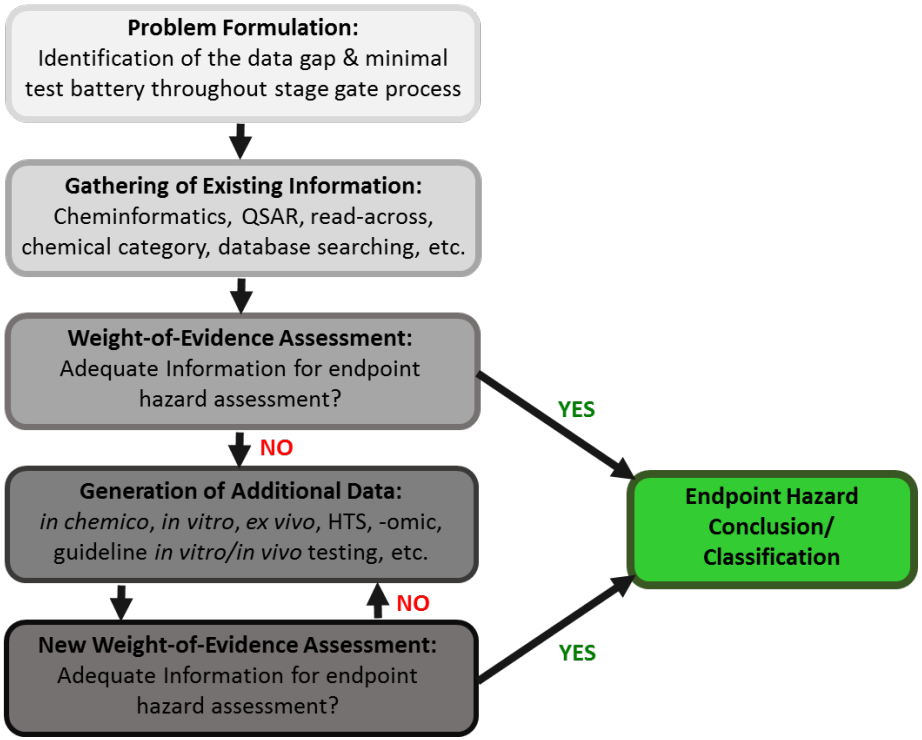
- Input data generated from identified methods
- A data interpretation procedure, such as machine-learning, flowchart, or decision tree, through which data are evaluated
- For skin sensitization 2 out of 3 approach can be applied (i.e. classified



https://ntp.niehs.nih.gov/whatwestudy/niceatm/test-method-evaluations/comptox/ct-its/its.html?utm_source=direct&utm_medium=prod&utm_campaign=ntpgolinks&utm_term=818148

Integrated Approach to Testing & Assessment

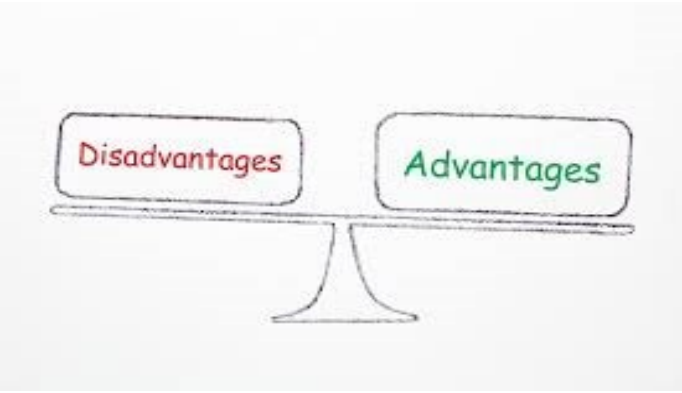
- IATAs – are flexible approaches for chemical safety assessment based on the integration and translation of the data derived from multiple methods and sources



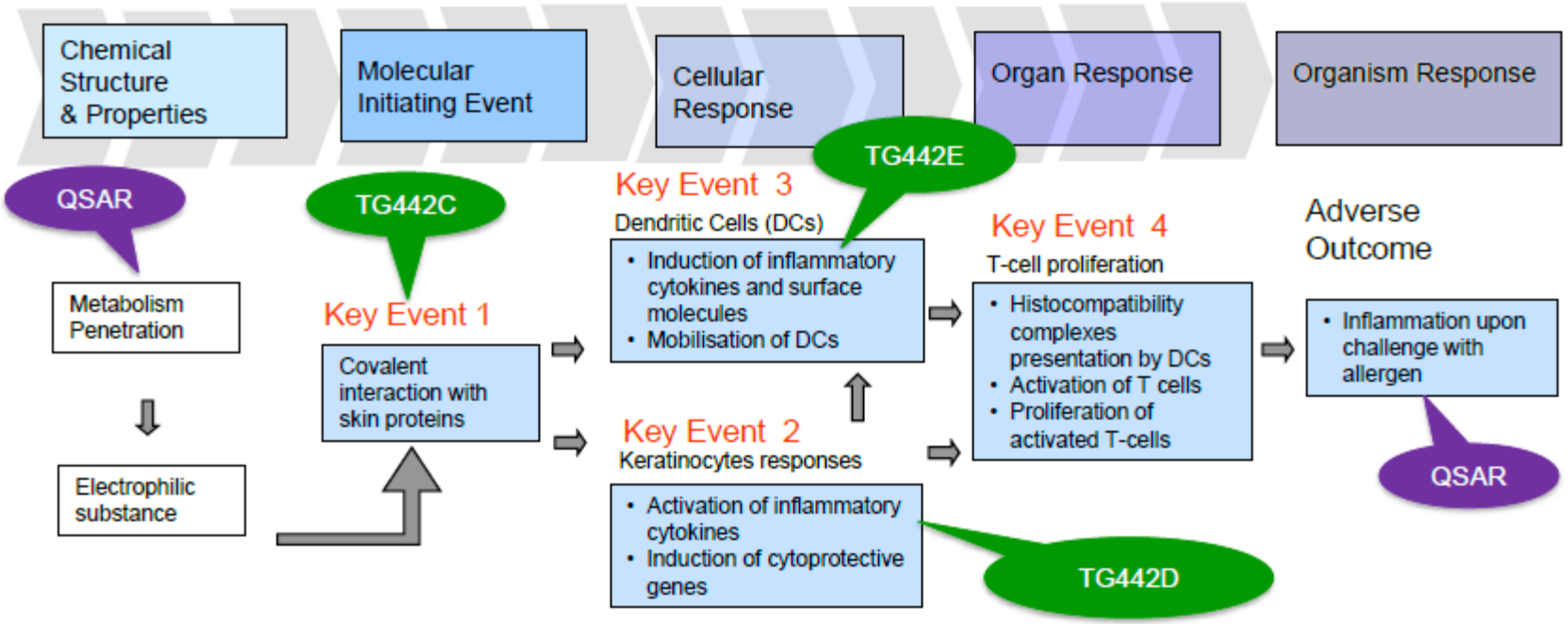
Why NAMs? Aren't the Animal Test Adequate?!

NAMs address important challenges in chemical safety assessments . . .

1. Quicker, lower cost methods (i.e. can evaluate significantly more chemicals for safety than with the current animal tests) – Regulatory aspect addressed in next presentation.
2. Human relevant information
3. Ability to screen chemicals for safety earlier in product development



But Aren't Animal Tests the "Gold Standard"



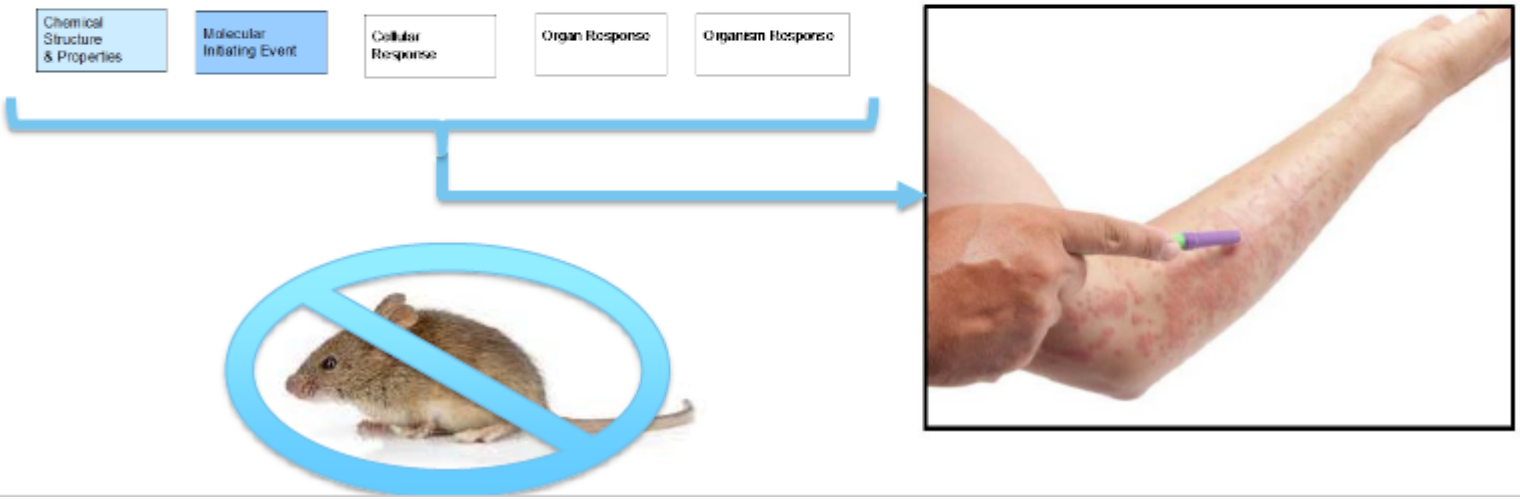
Application of a Defined Approaches (DAs) to combine in vitro and in silico data using sample decisions trees or machine learning algorithms to predict skin sensitization.

NAMs Outperformed Animal Tests for Predicting Skin Sensitization

All non-animal defined approaches evaluated perform as well or **better** than the mouse at predicting human skin sensitization:

Hazard: 74% (mouse) vs. 75-85% (DAs)

3-class Potency: 59% (mouse) vs. 55-69% (DAs)



Kleinstreuer KC, et. al., Non-animal methods to predict skin sensitization (II): an assessment of defined approaches. Crit Rev Toxicol 2018 May;48(5):359-374

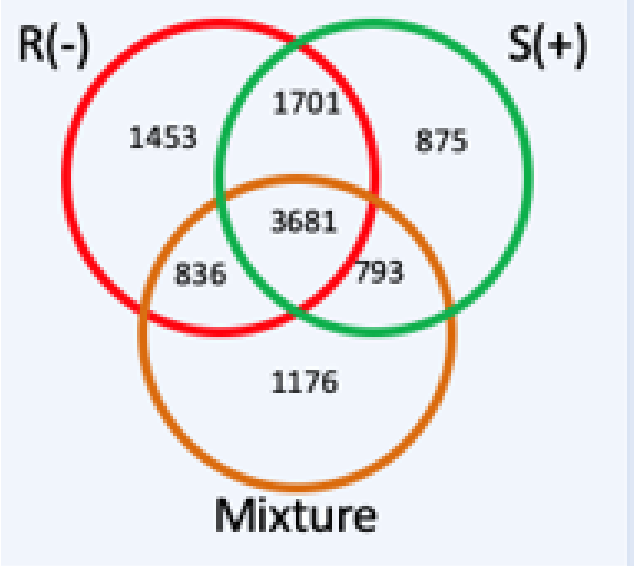
NAMs to Establish Justification for Read-Across to a Chemical Analogue

Background

- Commercial product registered is an isomeric mixture (50:50)
- Want flexibility to vary concentration of individual isomers in product (e.g. 40:60, 80:20)
- *R(-)* isomer is on inventory list, *S(+)* isomer is not and would require registration as new chemical
- Can a transcriptomic approach be used to show similar MOA for individual isomers compared to racemic mixture to justify read-across?

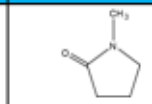
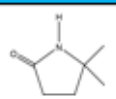
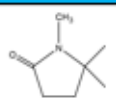
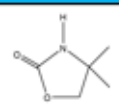
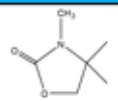
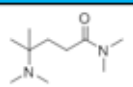
Transcriptomic Approach

- Treat relevant cell line(s) with individual isomers & mixture to compare transcriptomic pathways
- Induction of similar cellular responses indicates consistency in MOA



Application of NAMs in New Product Development

Replacement Candidate Computational Toxicology Screen

Endpoint	A C1(=O)CCCN1C	B C1(=O)CCC(C)(C)N1	C C1(=O)CCC(C)(C)N1C	D C1(C)(C)COC(=O)N1	E C1(C)(C)COC(=O)N1C	F CN(C)C(=O)CCC(C)(C)N(C)C
Chemical Structure						
Oral LD50	L: 3911 mkd[1]	l: 2700 mkd[1]	l: 2017 mkd[1,2]	vl/l: 5083 mkd[1]	l: 2709 mkd[1]	m: 835 mkd[1]
Inhalation LC50	l: nonhaz[2]	m: haz[2]	m: haz[2]	m: haz[2]	m: haz[2]	l: nonhaz[2]
Dermal LD50	vL: >5000 mkd	l: nonhaz[2]	l: nonhaz[2]	m: haz[2]	l: nonhaz[2]	l: nonhaz[2]
Skin Irritation	M: Irritating	m/h: haz[2]	m/h: : haz[2]	m/h: : haz[2]	m: haz[2]	m: haz[2]
Eye Irritation	H: Mod irrit.	h/vh: : haz[2]	h/vh: : haz[2]	h/vh: : haz[2]	h/vh: : haz[2]	m: haz[2]
Skin Sensitization	L: Neg	m: : haz[2]	l: Neg[2]	m: : haz[2]	l: Neg[2]	l: Neg[2]
Mutagen	L: Neg[1]	l: Neg[1]	l: Neg[1]	l: Neg[1,2]	l: Neg[1,2]	l: Neg[1]
Cancer	l: Neg[5]	l: Neg[5]	l: Neg[5]	vh: genotoxic car[5]	vh: genotoxic car[5]	l: Neg[5]
Reprotoxicity	Vh: Repro 1B	m: True[1]	m:True[1]	m: True[1]	m: True[1]	m: True[1]
Acute Ecotox	H: 1.2 mg/L[1]	l/m: 73 mg/L[1,2]	l/m: 77 mg/L[1,2]	m/h: 8.7 mg/L[1,2,3]	m/h: 8.4 mg/L[1,2,3]	l/m: 64 mg/L[1,2,3]
Chronic Ecotox	l: nonhaz[2]	l: nonhaz[2]	l: nonhaz[2]	l: nonhaz[2]	l: nonhaz[2]	l: nonhaz[2]
Biodegradation	L: Ready bio	m/h: Not ready bio[3]	m/h: Not ready bio[3]	m/h: Not ready bio[3]	m/h: Not ready bio[3]	m/h: Not ready bio[3]
Cramer Class	Intermediate[5]	Intermediate[5]	Intermediate[5]	High[5]	High[5]	Low[5]

MODEL USED FOR ASSESSMENT

[1] EPA Chem Dashboard, concensus model
[2] UL cheminformatics toolkit model
[3] EPI Suite BIOWIN
[4] EPI Suite ECOSAR
[5] Toxtree: Modifed Cramer Class or Carcinogenicity decision tree

vL = very low; L = low; M = medium; H = high; vH = very high; Uppercase = test data; lowercase = modeled data

Summary of Results:

- F – predicted to have most favorable human health and environment toxicological profile. No significant structural alerts with the exception of reproductive toxicity & slower potential to biodegrade. Both should be followed up with further testing to confirm validity of model predictions.
- B and C – corrosive to eye, reproductive/developmental, not readily biodegradable
- D and E – corrosive to eye, genotoxic carcinogen, reproductive/developmental, acutely toxic to aquatic environment, not readily biodegradable. It is recommended to eliminate both chemicals from further development based on the number of structural alerts.

Food for Thought . . .

- How can NAMs be utilized to advance the field of AA?
- Is there a role for A4 in helping to establish confidence in NAMs?
  - Which NAMs and how?
- Should A4 advocate/offer training in NAMs for our members?
- Other opportunities?
- New SOT specialty section, Sustainable Chemicals through Contemporary Toxicology, offers point of partnership with SOT

Development and Use of Predictive Animal-free Toxicology Testing Approaches

TOPICS IN
ALTERNATIVES ASSESSMENT

Amy J. Clippinger, Ph.D.
PETA International Science Consortium Ltd

www.PISCLtd.org.uk

FUNDING

TRAINING

WORKSHOPS AND WEBINARS

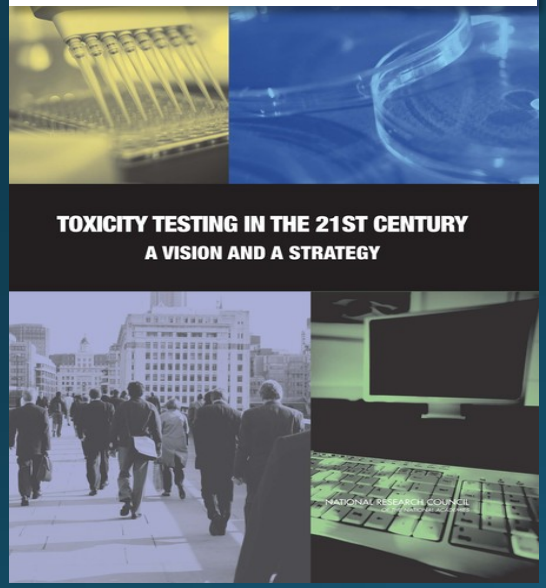
RETROSPECTIVE REVIEWS

PUBLICATIONS AND PRESENTATIONS

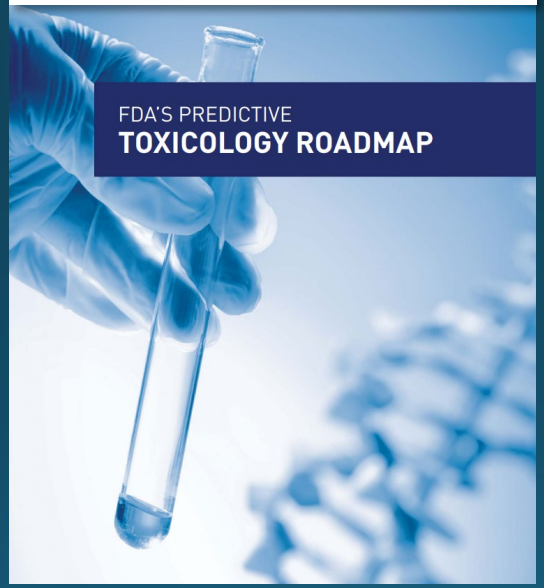
Outline

- NAMs
- Case studies: Inhalation toxicity testing
- Training opportunities

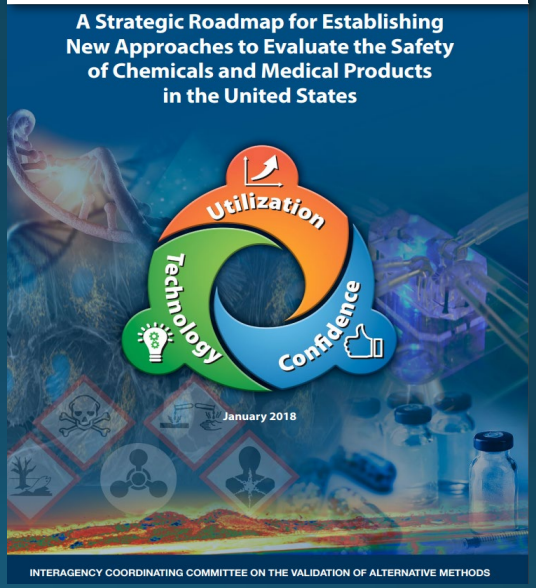
National Academy of Sciences, 2007



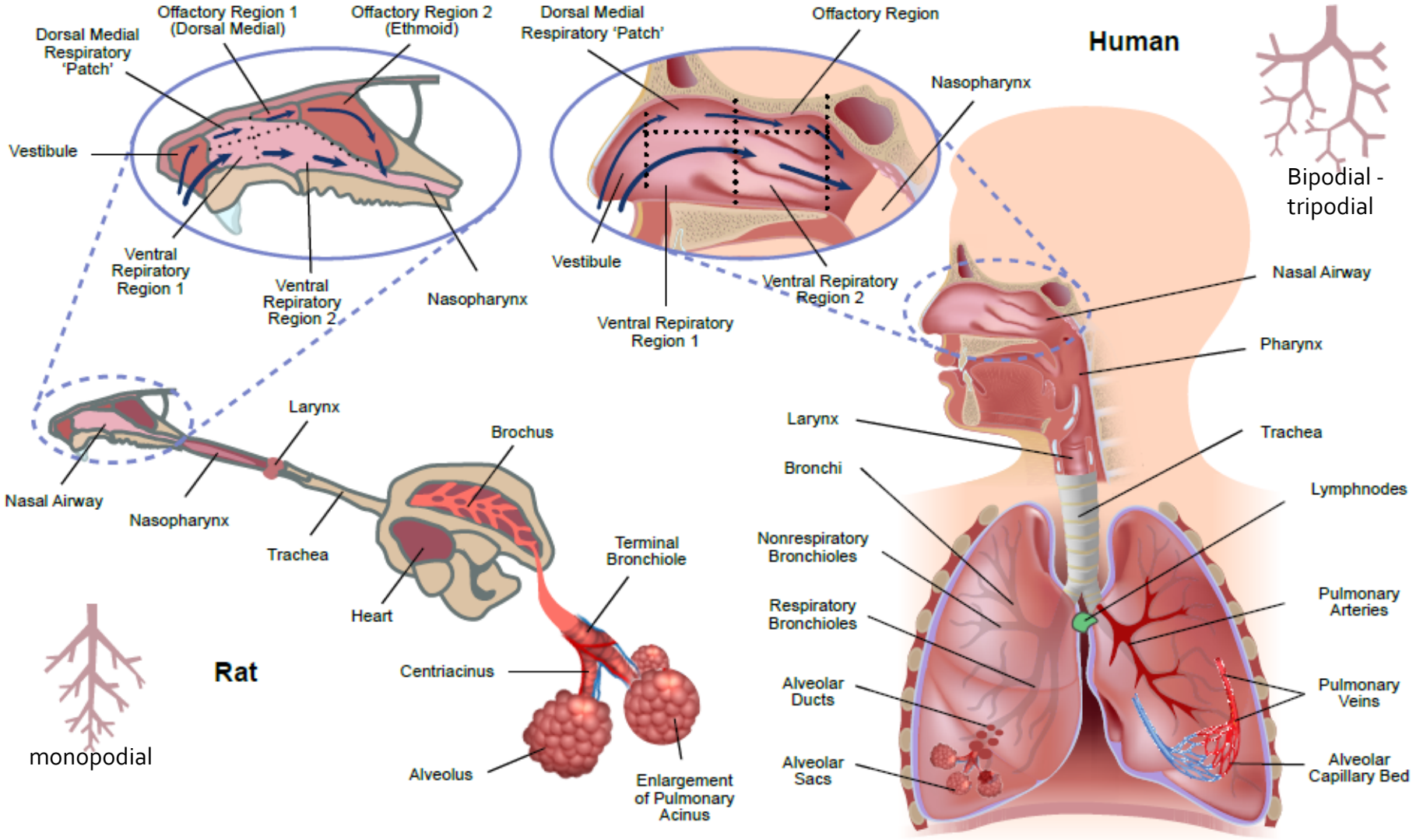
FDA Predictive Toxicology Roadmap, 2017



ICCVAM Strategic Roadmap, 2018



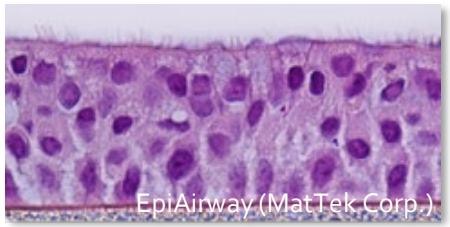
Case Studies:
Inhalation Toxicity Testing



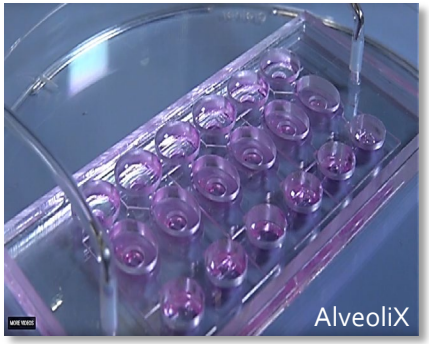
- Ventilation rates and breathing mode
- Airway architecture and branching pattern
- Cell type distribution and mucous composition
- Metabolic activity

Illustration modified from Dr. Jack R. Harkema, Professor of Comparative Pathology, Michigan State University

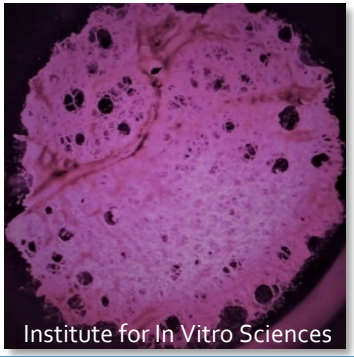
(Co)cultures submerged or grown at the ALI



3D reconstructed human tissues grown at the ALI



Microfluidic human lung-on-a-chip



Human Precision Cut Lung Slices (PCLS)

Case study #1

Toxicology in Vitro 48 (2018) 53–70

Contents lists available at ScienceDirect

Toxicology in Vitro

journal homepage: www.elsevier.com/locate/toxinvit

Alternative approaches for acute inhalation toxicity testing to address global regulatory and non-regulatory data requirements: An international workshop report

Amy J. Clippinger[a,*], David Allen[b], Annie M. Jarabek[c], Marco Corvaro[d], Marianna Gaça[e], Sean Gehen[f], Jon A. Hotchkiss[g], Grace Patlewicz[h], Jodie Melbourne[a], Paul Hinderliter[i], Miyoung Yoon[j], Dan Huh[k], Anna Lowit[l], Barbara Buckley[c], Michael Bartels[m], Kelly BéruBé[n], Daniel M. Wilson[g], Ian Indans[o], Mathieu Vinken[p]

Toxicology in Vitro 52 (2018) 131–145

Contents lists available at ScienceDirect

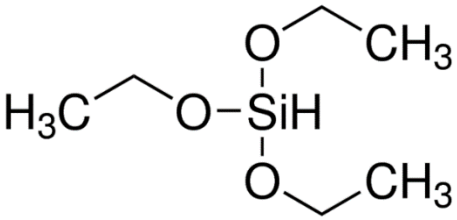
Toxicology in Vitro

journal homepage: www.elsevier.com/locate/toxinvit

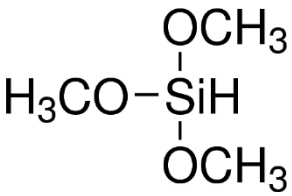
Review

Pathway-based predictive approaches for non-animal assessment of acute inhalation toxicity

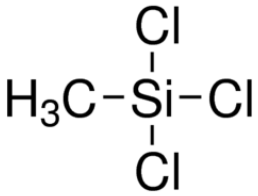
Amy J. Clippinger[a,*], David Allen[b], Holger Behrsing[c], Kelly A. BéruBé[d], Michael B. Bolger[e], Warren Casey[f], Michael DeLorme[g], Marianna Gaça[h], Sean C. Gehen[i], Kyle Glover[j], Patrick Hayden[k], Paul Hinderliter[l], Jon A. Hotchkiss[m], Anita Iskandar[n], Brian Keyser[o], Karsta Luettich[n], Lan Ma-Hock[p], Anna G. Maione[k], Patrudu Makena[o], Jodie Melbourne[a], Lawrence Milchak[g], Sheung P. Ng[q], Alicia Paini[r], Kathryn Page[s], Grace Patlewicz[t], Pilar Prieto[r], Hans Raabe[c], Emily N. Reinke[u], Clive Roper[v], Jane Rose[w], Monita Sharma[a], Wayne Spoo[o], Peter S. Thorne[x], Daniel M. Wilson[m], Annie M. Jarabek[y]



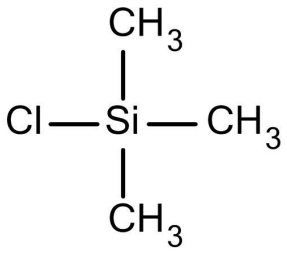
Triethoxysilane
(GHS 2, CAS # 998-30-1)



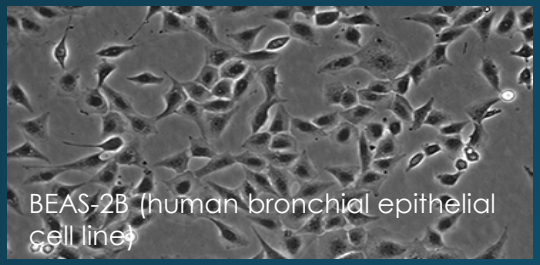
Trimethoxysilane
(GHS 1, CAS# 2487-90-3),

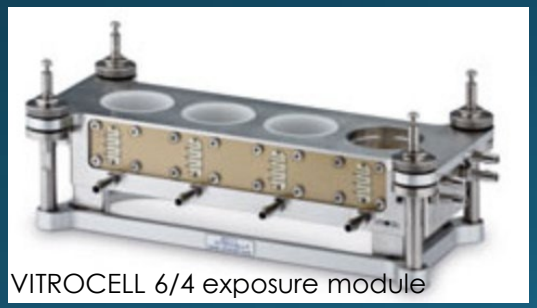


Methyltrichlorosilane
(GHS 3, CAS# 75-79-6),

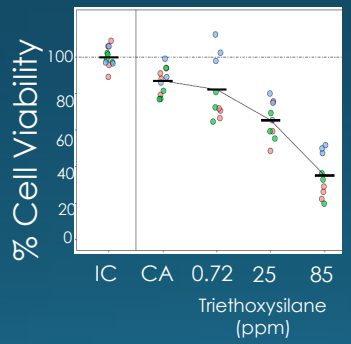


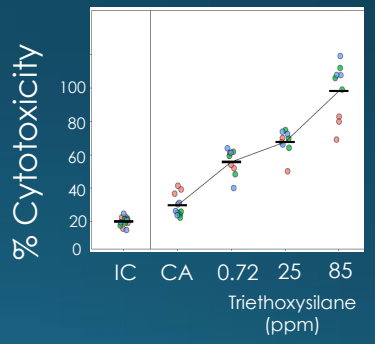
Trimethylchlorosilane
(GHS 3, CAS# 75-77-4)





- Lactate dehydrogenase (LDH) release
- Resazurin metabolism (PrestoBlue®)
- Expression of inflammatory markers





vito

PETA INTERNATIONAL SCIENCE CONSORTIUM LTD.

Case Study #2

EPA Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel

December 2018

OVS tube:
particle size distribution

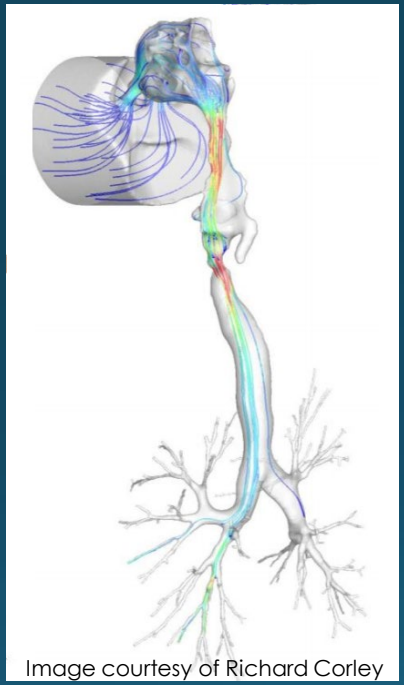
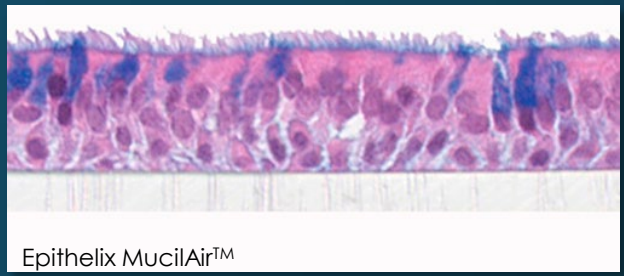


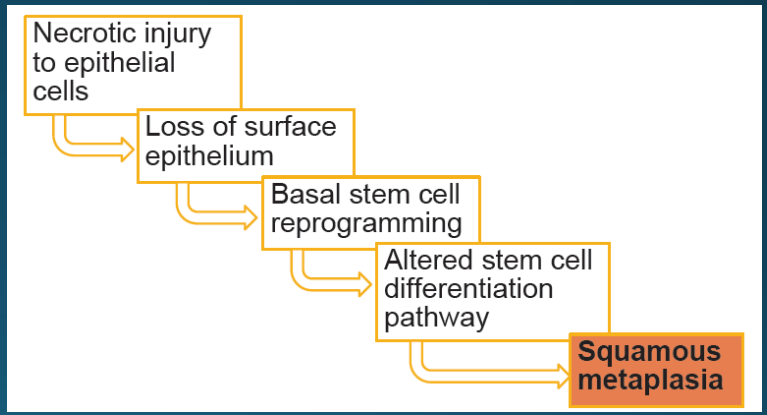
Image courtesy of Richard Corley

CFD modeling



Epithelix MucilAir™

- Lactate dehydrogenase (LDH) release
- Resazurin metabolism
- Transepithelial electrical resistance



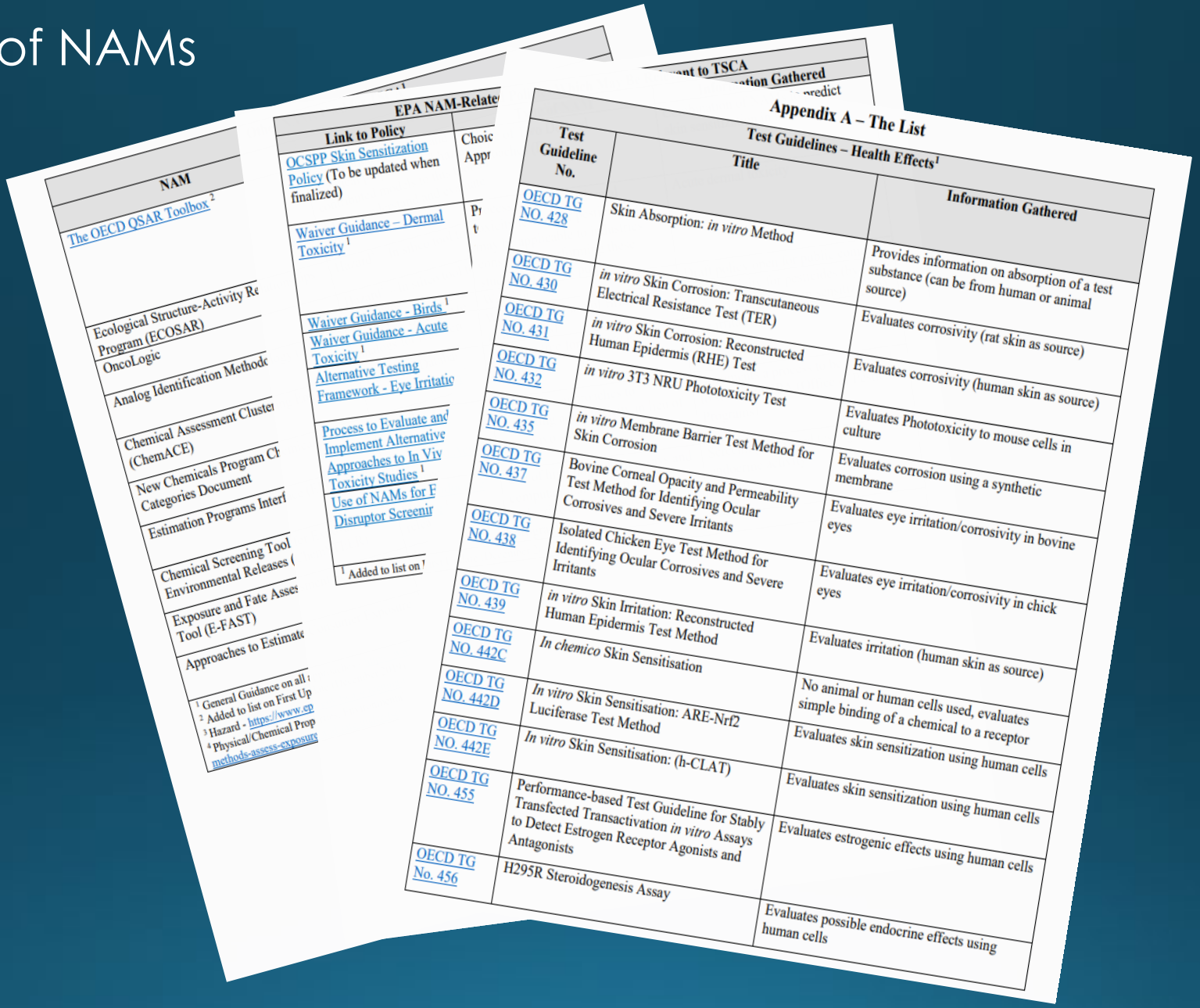
Adverse outcome pathway

- Multiple computational and *in vitro* approaches will be needed to assess the various mechanisms of toxicity following inhalation exposure

- Multi-stakeholder collaborations on data sharing and validation efforts foster the development of non-animal approaches that can be used to protect human health without using animals

Training Resources

EPA's List of NAMs



NAM
The OECD QSAR Toolbox [2]
Ecological Structure-Activity Re Program (ECOSAR)
OncoLogic
Analog Identification Methodc
Chemical Assessment Cluste (ChemACE)
New Chemicals Program Ch Categories Document
Estimation Programs Interf
Chemical Screening Tool Environmental Releases (
Exposure and Fate Asses Tool (E-FAST)
Approaches to Estimate

[1] General Guidance on all
[2] Added to list on First Up
[3] Hazard - https://www.ep methods-assess-exposure
[4] Physical/Chemical Prop

Link to Policy	Choic Appr
OCSPP Skin Sensitization Policy (To be updated when finalized)	
Waiver Guidance – Dermal Toxicity [1]	Pr t
Waiver Guidance - Birds [1]	
Waiver Guidance - Acute Toxicity [1]	
Alternative Testing Framework - Eye Irritatic	
Process to Evaluate and Implement Alternative Approaches to In Viv Toxicity Studies [1]	
Use of NAMs for E Disruptor Screenir	

[1] Added to list on

Appendix A – The List		
Test Guideline No.	Test Guidelines – Health Effects[1] Title	Information Gathered
OECD TG NO. 428	Skin Absorption: *in vitro* Method	Provides information on absorption of a test substance (can be from human or animal source)
OECD TG NO. 430	*in vitro* Skin Corrosion: Transcutaneous Electrical Resistance Test (TER)	Evaluates corrosivity (rat skin as source)
OECD TG NO. 431	*in vitro* Skin Corrosion: Reconstructed Human Epidermis (RHE) Test	Evaluates corrosivity (human skin as source)
OECD TG NO. 432	*in vitro* 3T3 NRU Phototoxicity Test	Evaluates Phototoxicity to mouse cells in culture
OECD TG NO. 435	*in vitro* Membrane Barrier Test Method for Skin Corrosion	Evaluates corrosion using a synthetic membrane
OECD TG NO. 437	Bovine Corneal Opacity and Permeability Test Method for Identifying Ocular Corrosives and Severe Irritants	Evaluates eye irritation/corrosivity in bovine eyes
OECD TG NO. 438	Isolated Chicken Eye Test Method for Identifying Ocular Corrosives and Severe Irritants	Evaluates eye irritation/corrosivity in chick eyes
OECD TG NO. 439	*in vitro* Skin Irritation: Reconstructed Human Epidermis Test Method	Evaluates irritation (human skin as source)
OECD TG NO. 442C	*In chemico* Skin Sensitisation	No animal or human cells used, evaluates simple binding of a chemical to a receptor
OECD TG NO. 442D	*In vitro* Skin Sensitisation: ARE-Nrf2 Luciferase Test Method	Evaluates skin sensitization using human cells
OECD TG NO. 442E	*In vitro* Skin Sensitisation: (h-CLAT)	Evaluates skin sensitization using human cells
OECD TG NO. 455	Performance-based Test Guideline for Stably Transfected Transactivation *in vitro* Assays to Detect Estrogen Receptor Agonists and Antagonists	Evaluates estrogenic effects using human cells
OECD TG No. 456	H295R Steroidogenesis Assay	Evaluates possible endocrine effects using human cells

https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/alternative-test-methods-and-strategies-reduce

NICEATM: Alternative Methods

- U.S. Strategic Roadmap
- Accepted Alternative Methods
- ICCVAM
- Test Method Evaluations
- Integrated Approaches to Testing and Assessment
- Tox21 Support
- 3Rs Meetings and Workshops
- Publications and Presentations
- Resources for Test Method Developers
- Testing Regulations and Guidelines
- Contact NICEATM

Alternative Methods Accepted by US Agencies

The table below includes:

- Methods for chemical safety testing that are accepted by U.S. and international regulatory authorities as replacement, reduction, or refinement alternatives to required animal tests
- Guidances to support replacement, reduction, or refinement alternatives to animal use for required testing: these documents are recommendations that do not necessarily establish legally enforceable responsibilities

An overview of non-animal methods that have been proposed for regulatory safety or efficacy testing of chemicals or biological agents can be found in the Tracking System for Alternative Methods (TSAR) resource, provided by the European Union Reference Laboratory for Alternatives to Animal Testing (EURL ECVAM). TSAR tracks progress of an alternative method from submission for validation through to its final adoption by inclusion into the regulatory framework.

NICEATM and ICCVAM interact with EURL ECVAM through the International Cooperation on Alternative Test Methods.

Show 25 entries Alternative Methods

Toxicity Area	Method	ICCVAM or ICCVAM Agency Contributions	Regulatory Acceptance/ Endorsement and Applicable Regulations
Filter by **Toxicity Area:** None			
Acute Dermal Systemic Toxicity	Acute dermal toxicity (includes provisions for waiving test and reducing or refining animal use)	NICEATM and ICCVAM scientists participated in drafting and editing the revised test guideline	• U.S.: Accepted via OECD Test Guideline 402 (1987, revised 2017) • EU: Accepted via OECD Test Guideline 402 (1987, revised 2017)

https://ntp.niehs.nih.gov/go/regaccept

IN VITRO METHODS FOR PREDICTING SERIOUS EYE DAMAGE AND IRRITATION

Note: If the substance is not classified as GHS Cat 1 or GHS No Cat, it is likely to be GHS Cat 2. To avoid *in vivo* testing, additional testing may be conducted with *in vitro* methods that allow classification of Cat 2 chemicals in a weight-of-evidence approach. *In vitro* methods, such as the EVEIT, ParCORA, or similar ones, which address persistence in the absence of severity, may be suitable. For more information on tiered testing strategies for serious eye damage and eye irritation, please see: Organisation for Economic Co-operation and Development. 2017. Guidance document on an integrated approach on testing and assessment (IATA) for serious eye damage and eye irritation. No 263. Series on Testing and Assessment.

METHOD	PRINCIPLE OF THE TEST	APPLICABILITY DOMAIN	GHS CATEGORISATION
OECD TG 437: Bovine Corneal Opacity and Permeability (BCOP) Test Method for Identifying i) Chemicals Inducing Serious Eye Damage and ii) Chemicals Not Requiring Classification for Eye Irritation or Serious Eye Damage	Test substance is directly applied to cow eyes obtained as by-products from abattoirs. Corneal opacity (measured quantitatively as the amount of light transmission through the cornea) and permeability (measured quantitatively as the amount of sodium fluorescein dye that passes across the full thickness of the cornea) are measured. Optional histopathology can be conducted for additional information.	Applicable to solids, liquids (including semi-solids, creams, and waxes), and mixtures	For the identification of substances causing serious eye damage (GHS Cat 1) and substances not requiring classification for eye irritation or serious eye damage OECD TG 437 training video available at www.youtube.com/watch?v=-TiZbp5KDHI8
OECD TG 438: Isolated Chicken Eye (ICE) Test Method for Identifying i) Chemicals Inducing Serious Eye Damage and ii) Chemicals Not Requiring Classification for Eye Irritation or Serious Eye Damage	Test substance is directly applied to chicken eyes obtained as by-products from abattoirs. Corneal swelling, opacity, and fluorescein retention are assessed.	Applicable to solids (may be soluble or insoluble in water), liquids, emulsions, and gels	For the identification of substances causing serious eye damage (GHS Cat 1) and substances not requiring classification for eye irritation or serious eye damage
OECD TG 460: Fluorescein Leakage (FL) Test Method for Identifying Ocular Corrosives and Severe Irritants	Epithelial monolayer Madin-Darby canine kidney (MDCK) cells are cultured on permeable inserts. The test chemical is applied for 1 minute and then removed; next, the non-toxic highly fluorescent sodium-fluorescein dye is added, and the amount of dye that passes through the cell layer is measured spectrofluorometrically and used to predict toxicity.	Applicable to water-soluble chemicals or mixtures Limitations for coloured or highly viscous substances (predictivity is improved by increasing the number of wash steps) Not applicable to strong acids and bases, cell fixatives, or highly volatile substances	For the identification of substances causing serious eye damage (GHS Cat 1)
OECD TG 491: Short Time Exposure In Vitro Test Method for Identifying i) Chemicals Inducing Serious Eye Damage and ii) Chemicals Not Requiring Classification for Eye Irritation or Serious Eye Damage	Measures cell viability (MTT assay) of SIRC (Statens Seruminstitut Rabbit Cornea) corneal epithelial cells in 96 well plates. As compounds are generally cleared from human eyes in 1 to 2 minutes or rabbit eyes in 3 to 4 minutes, this test requires a 5-minute exposure.	Applicable to test chemicals that are soluble in saline, DMSO, or mineral oil	For the identification of substances causing serious eye damage (GHS Cat 1) and substances not requiring classification for eye irritation or serious eye damage
OECD TG 492: Reconstructed Human Cornea-like Epithelium (RhCE) Test Method for Identifying Chemicals Not Requiring Classification and Labelling for Eye Irritation or Serious Eye Damage (e.g. EpiOcular™)	MatTek's EpiOcular™ tissue is reconstructed from primary human cells, which have been cultured for several days to form a stratified, highly differentiated squamous epithelium morphologically similar to that found in the human cornea. The test substance is exposed to the tissue, and cell viability (MTT assay) is used to predict toxicity.	Applicable to substances and mixtures as well as solids, liquids, semi-solids, and waxes	For the identification of substances not requiring classification for eye irritation or serious eye damage
OECD draft TG: Cytosensor Microphysiometer (CM)	A sub-confluent monolayer of mouse L929 cells is exposed to increasing concentrations of the test chemical. The cellular metabolic rate – measured by pH change in the medium (acidification) – is used to predict toxicity.	Applicable to water-soluble chemicals (substances and mixtures) as well as non-soluble solids, viscous chemicals, and suspensions that maintain uniformity during the analysis time	For the identification of substances causing serious eye damage (GHS Cat 1) and substances that are not classified

+44 (0) 20 7837 6327
PISC@piscltd.org.uk - PISCLtd.org.uk
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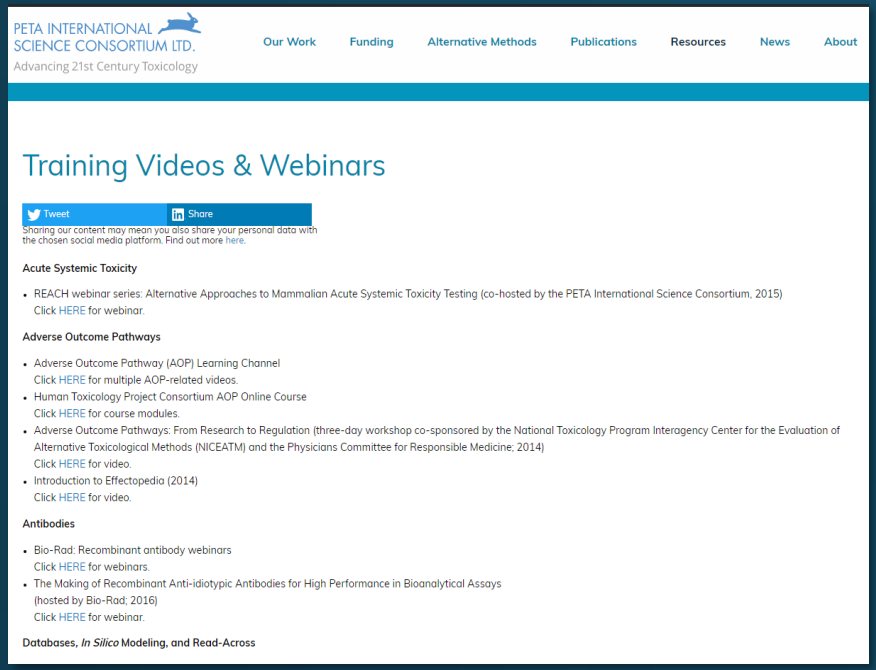

www.piscltd.org.uk/webinars

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Amy J. Clippinger, PhD

AmyJC@PISCLtd.org.uk

www.piscltd.org.uk

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Respondents – Reflections and Insights

Shari Franjevic, *GreenScreen®*
Program Manager

CLEAN PRODUCTION ACTION

Lauren Heine, *Director of Safer Materials & Data Integrity*

CHEM FORWARD
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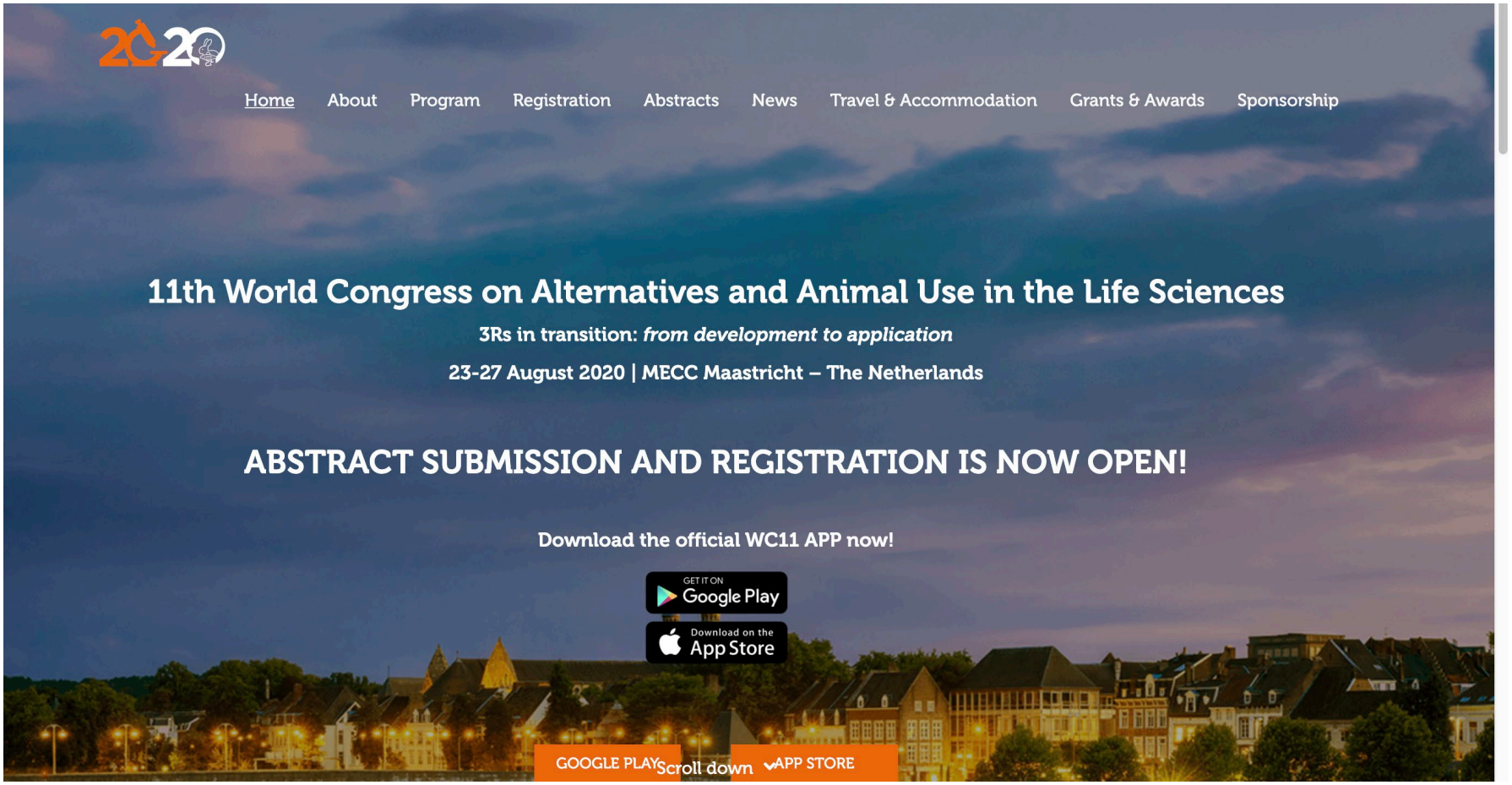
Questions?

Announcements



Announcements

Stay tuned for our official announcement

2020 International Symposium on Alternatives Assessment

- Fall 2020
- California

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