



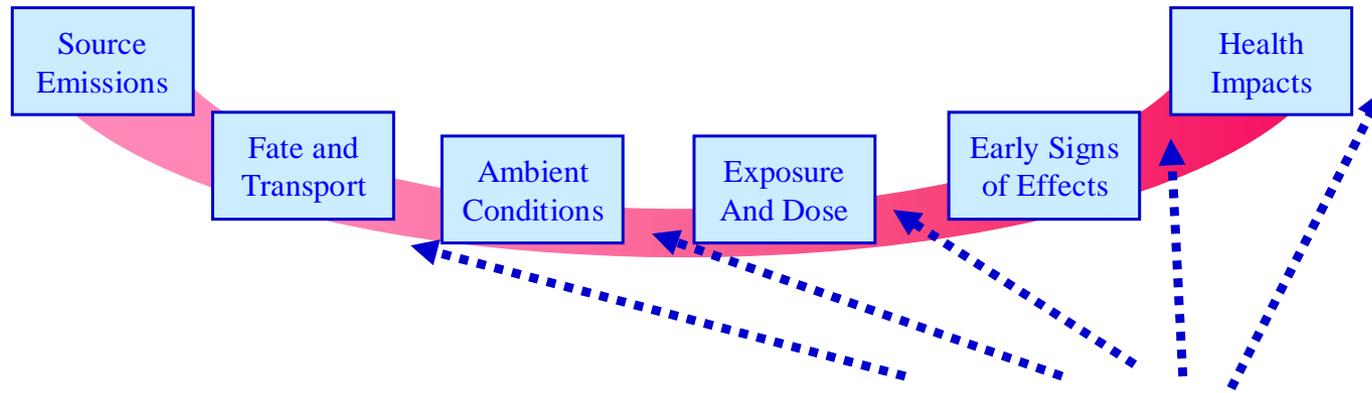
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HUMAN HEALTH RESEARCH PROGRAM
BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

Human Health Research Program

Sally Darney
National Program Director

Over-Arching Goal: To Help EPA Protect Human Health



- Human health research develops the **methods, models, & data to characterize and reduce uncertainty** in the ‘critical links’ across the exposure-to-effect paradigm;
- and, explores **fundamental determinants of exposure and dose, and the basic biological changes (effects)** that result from exposure to environmental contaminants and lead to adverse health outcomes

4 Inter-related Long Term Goals: Risk assessors and risk managers USE ORD's methods and models to...

- Understand and reduce uncertainty in risk assessment using mechanistic (mode of action) information
- ↕
- Characterize aggregate & cumulative risk in order to manage risks to humans exposed to multiple environmental stressors
- ↕
- Characterize and provide adequate protection for susceptible populations
- ↕
- Evaluate the effectiveness of risk management decisions

Human Health Research Program
Multi-Year Plan
(FY 2006-2013)

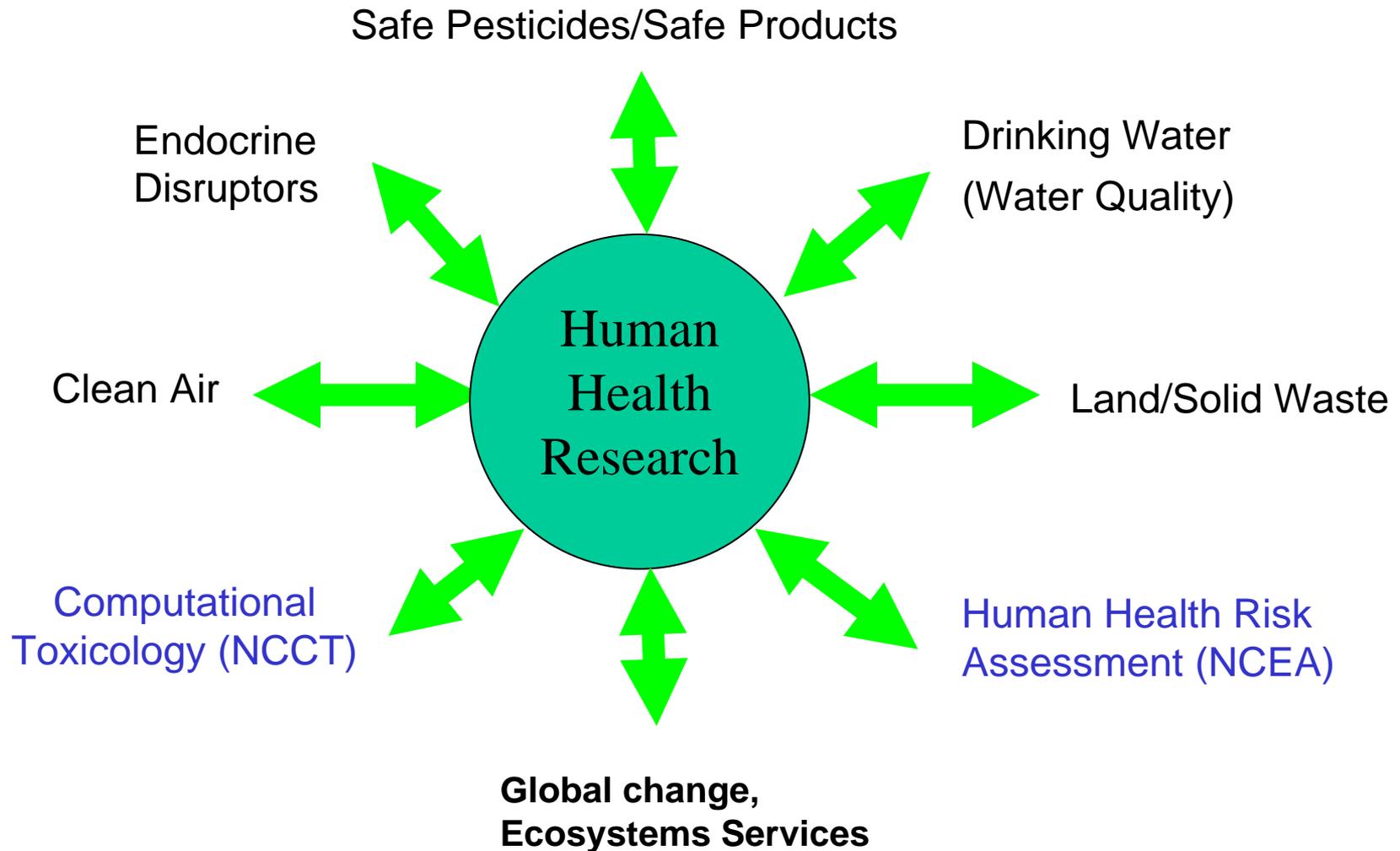


Office of Research and Development
US Environmental Protection Agency

2 June 06

BOSC review January 2009
Fully successful rating

Interdisciplinary, Cross-Program (“Core”) Research



HHRP products are broadly applicable to many partners and stakeholders

- Research informs risk guidance and assessments by NCEA, and computational toxicology modeling in NCCT
- Relevance/utility of research is not program office specific (OAR, OPPTS, OW, OSWER)
- Projects solve problems in Regions (States) and Tribes
- Close ties with Office of Children's Health Protection and Environmental Education (OCHPEE)
- Stress Cooperation with Federal Agencies: NIH, CDC, NIEHS, HUD
- International: WHO, OECD, IPCS

Mode of Action Research Accomplishments and Strategic Directions

- Cancer vs. non-cancer mechanisms:
 - Conazoles– OPPTS SAP & risk assessment (2012),
 - Arsenic forms, PBPK model
 - Neuro-endocrine – novel modes of action (LH, adrenal axis)
 - Stem cell model for developmental pathways
 - Oxidative stress pathways – in vitro system
- Interpretation of Biomarkers using PBPK modeling (STAR RFA issued 2008 for 3-year projects)
- Increasing emphasis on Key Events in Toxicity Pathways; Collaboration with NCCT
- Transition to Systems Biology approaches
- Predictive Toxicology using “virtual organs” (liver, embryo, lung)
- Responsive to NRC’s “Toxicity Testing 21st Century”and EPA’s “Strategic Plan for Evaluating the Toxicity of Chemicals” (2009)
- Integration of these approaches with other programs related to managing chemical risks (Administrator priority)

Cumulative/Community Risk Assessment

- Cumulative risk assessments (OPP SAP)
OPs, Carbamates, Pyrethroids (2012)
- Exposure models: SHEDS, ERDEM, HEDS, CHAD
 - Characterize exposures in specific environments (homes, daycare, playgrounds)
- Community based risk assessment: Regional-ORD workshop
CBRA (2009)
- C-FERST Tool website launched: application for identification of communities at disproportionate risk of exposures
- Strategic Directions:
 - Interpretation & Use of Biomonitoring Data: Reverse dosimetry project (collaboration with CDC);
 - “Understanding the Role of Nonchemical Stressors and Developing Analytic Methods for Cumulative Risk Assessment” (2009 STAR RFA to fund projects 2010-12)
 - STAR RFA on Tribal Communities under development for 2010
 - Next generation of exposure models (e.g. SHEDS multi-media) and user-friendly web based tools for Regions and States (e.g. C-FERST)
 - Collaboration with NCCT on exposure databases

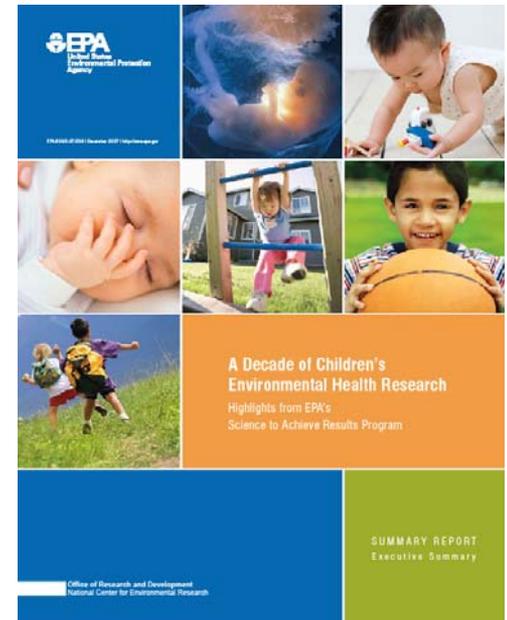
Susceptible Populations – across Life Stages

EPA-NIEHS Children’s Environmental Health & Disease Prevention Center Grants

- 10 years of Progress: Asthma, Autism, Gene-Environment, Rural vs Urban, Socio-Economic-Cultural Factors
- Examples of 2009 Findings:
 - **PON-1 as a marker of children’s susceptibility to organophosphate pesticides (UC Berkeley Center)**
 - **Mother’s exposure to urban air pollution may lower child’s IQ (Columbia Center)**
 - **PM in indoor air increase asthma symptoms (Hopkins Center)**

■ New Children’s Center RFAs 2009

- Full Centers 2010-14
- Formative Centers 2010-12



NCER 2007 Report
1998-2007

Susceptible Populations – across Life Stages

Methods: Breast milk storage & analysis of contaminants;
 Biomarkers of exposure in children

Child-specific exposure factor handbook (NCEA, 2008)
 all age groups

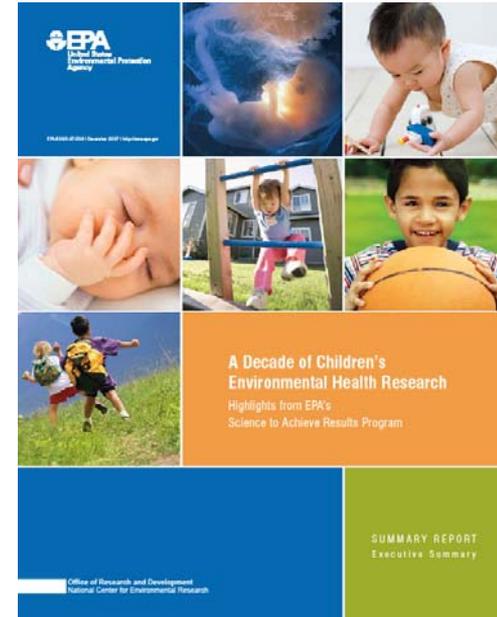
2010 Exposure Factors research (observational studies):
 very young children (NERL); school aged children
 (STAR RFA), 2010-13

Environmental stressors and developmental origins of
 childhood chronic diseases

- **International Conference: December 2009**
- **In utero exposures associated with premature hypertension in a rodent model**

National Children’s Study

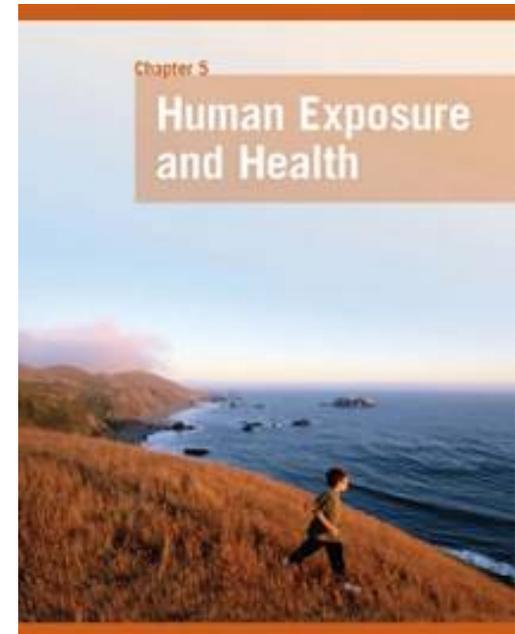
- Interagency Coordinating Committee & Workgroup contributions
- Exposure methods & sampling strategies for NCS
 - **Workshop 2010**
 - **Research on sampling methods**



N CER 2007 Report

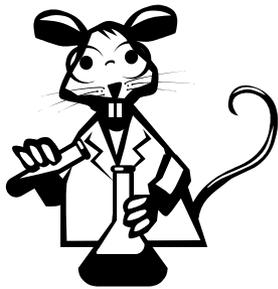
Evaluate Effectiveness of Risk Management Decisions (“Closing the Loop”)

- Framework & workshop 2008
- Public Health Early Indicators 2005 STAR grants yielding results
- Demonstration Projects (“Accountability”) yielding results 2009-10:
 - Health benefits of water plant upgrade in Massachusetts (Region 1);
 - Improvements in air quality after State and voluntary actions in New Haven CT (Region 1)
- 2009 RFA: Exploring Linkages between Health Outcomes and Environmental Hazards, Exposures, and Interventions for Public Health Tracking and Risk Management (2010-12)



EPA Report on the Environment 2008

Managing Risks of Environmental Chemicals



Mode of Action

Susceptibility Vulnerability



Cumulative Risk



Address uncertainty and characterize variability to improve risk assessment

Assess the public health impacts of risk management decisions

To help EPA protect human health

Human Health Risk Assessment Research Program: Strategic Directions

Lynn Flowers
Acting Associate Director for Health
National Center for Environmental Assessment



Human Health Risk Assessment

Recent Performance Accomplishments

■ **LTG 1: IRIS and other priority health hazard assessments**

- Initiated interagency or external peer review for 20 IRIS assessments and posted 7 completed assessments in 2009.
- Completed 69 new or renewed provisional peer reviewed toxicity values (PPRTV's) in 2009 to support OSWER, EPA regions and states' decision-making.
- Upcoming release of several major assessments for external peer review (methanol, TCE, formaldehyde) and posting on the IRIS database (acrylamide, carbon tetrachloride).

■ **LTG 2: State-of-the-science risk assessment guidance, models, and methods**

- Final Children's Exposure Factor Handbook for use by Agency and external risk assessors.
- Final report on PBPK methods for assessing internal doses of mixtures of trihalomethanes in drinking water for use by OW.
- Report on the 2007 workshop on "State of the Science on Low-Dose Extrapolation – Issues and Practice" which will support all EPA Programs.
- Report on analysis of 2-stage clonal growth models for formaldehyde with relevance to other biologically-based dose response models.
- Final report on Inhalation Reference Value arrays for use by OSWER, OAR, and Homeland Security.

■ **LTG 3: Integrated Science Assessments (ISAs)**

- Nitrogen Oxides and Sulfur Oxides – final ISAs for health and environmental effects are being used to support court-ordered decisions on the primary (health-based) and secondary (environmental effects-based) National Ambient Air Quality Standards (NAAQS).
- Particulate Matter – final ISA is being used in review of the primary and secondary NAAQS.
- Carbon Monoxide – final ISA will be used to support court-ordered NAAQS decisions.
- Ozone – provisional assessment is being used to support reconsideration of the primary and secondary NAAQS.
- Significant scientific support provided for NAAQS decision-making.



Human Health Risk Assessment 2010 – 2014 Strategic Directions

■ IRIS and risk assessment methodology

- Accelerate IRIS and incorporate new data and methods for improved assessments.
- Move towards *Next Generation Risk Assessment*.
 - ❖ *Develop methods for the use of new data (e.g., comp tox) in risk assessment.*
 - ❖ *Integrate methods into chemical assessment development to increase quantity of toxicity values available for decision-making.*
 - ❖ *Collaborate across EPA (e.g., NHEERL, NCCT, OPPT).*
 - ❖ *Implement NAS Report “Toxicity Testing in the 21st Century: A Vision and a Strategy” (2007) and EPA’s “Strategic Plan for Evaluating the Toxicity of Chemicals” (2009).*
- Increase collaboration with CalEPA and ATSDR to develop health assessments.
- Advance cumulative risk assessment (phthalates, PAH mixtures) – implement NAS report “Phthalates and Cumulative Risk Assessment” (2008) – collaborate with OPPTS and OW.
- Evaluate and implement recommendations of NAS Report “Science and Decisions: Advancing Risk Assessment” (2008) – cross-Agency effort.

■ Integrated Science Assessments

- ISA process revised by L. Jackson in 2009: “All NAAQS All the Time.”
- Implement Health and Environmental Research Online (HERO) database.

Human Health Risk Assessment

Significant Anticipated Products (2010-2014)

- **LTG1: IRIS and other priority health hazard assessments**
 - Deliver a substantially increased number of IRIS assessments for interagency or external peer review and posting to database to support decision-making.
 - Increase program and regional collaboration in nomination and prioritization processes.
 - Complete 50 new or renewed PPRTV's to support OSWER, EPA regions and states' decision-making each year. This will result in about 400 PPRTV's being completed during FY09-15.
 - Implement HERO to support more efficient and transparent assessments (IRIS and ISAs).
- **LTG2: State-of-the-science risk assessment guidance, models, and methods**
 - Develop guidance and methods for the use of new data in risk assessment.
 - Evaluate approaches for unifying cancer and noncancer dose-response assessment including moving away from the reference dose to a probabilistic approach.
 - Develop methods for incorporating population background risk into dose-response assessment.
 - Improve cumulative risk methods by considering vulnerability, nonchemical stressors, and background risk factors.
 - Update reference concentration methods and provide exposure-response arrays for evaluation of risks from varying exposure-time scenarios.
- **LTG3: Integrated Science Assessments**
 - Fully implement revised NAAQS process and develop new ISAs for the six criteria air pollutants on a 5-year review cycle meeting Clean Air Act mandates.
 - Sustain scientific support to OAR and Administrator for NAAQS decision-making.



ENDOCRINE **DISRUPTORS** RESEARCH PROGRAM
BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

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Endocrine Disruptors and Safe Pesticides / Safe Products Research Programs: Strategic Directions

Elaine Francis
National Program Director
Pesticides and Toxics Research Program

Strategic Directions (2)

- Consistent with Administrator's priority areas:
 - Managing chemical risks. Protecting America's waters. Vulnerable subpopulations, specifically children
- Leveraging with other research partners
- Addressing SAB Recommendations:
 - Apply newer molecular tools to develop subsequent generations of screening assays, increase efforts on cumulative risk, incorporate newer "computational" approaches to CAFOs research
- **Major Changes**
 - Acceleration/augmentation of certain research areas as a result of FY09 Omnibus Bill increase of \$1.5 M more than FY08 enacted budget
 - Competitive internal RFPs with emphasis on integrated multi-disciplinary research
 - FY08 Appropriations requested a proposal and budget for extramural grants program – not known whether this will be considered in future

Major recent program accomplishments

- Completed research in developing assays for Tier 1 of the Agency's EDSP
- Began integrated multi-disciplinary effort across all of ORD's Laboratories in collaboration with grantees, scientists from Programs/Regions and other Agencies to characterize the environmental impact of hormones (natural and synthetic) from CAFOs; held workshops in '07 and '08
- Completed project with GWRC where assays, including one developed by EPA, were used to determine estrogenicity of WWTP effluents from around the world
- Summary report on 10 years of accomplishments
- Research on prenatal effects of phthalates (individual and mixtures of) considered in NAS report, PL 110-314, assessments in US, Canada, Europe
- Report on whole lake study dosed with EE2 (one of *Discover's* top 100 papers of '07)

Major program accomplishments anticipated in the near-term

- Completion of last 2 assays for Tier 2 of EDSP using fish and amphibian models
- Short term screen to predict developmental neurotoxicity of thyrotoxic agents
- STAR grantee reports on characterization of low dose effects
- Characterization of predictive value of *in vitro* aromatase assays
- Improved biomarkers of exposure and development of other novel approaches for monitoring endocrine activity in complex environmental media
- Analytic methods to quantify EDCs and determine treatability of selected EDCs
- Approach for utilizing genomics data in EPA risk assessments
- Completion of 5 epidemiology studies on developmental/reproductive effects

Significant Anticipated Products and their Intended Use by Partners

- Comprehensive battery of “next generation” assays using several classes of vertebrates
 - *Used by OPPTS and others for chemical prioritization and screening*
- Cross-Lab/Center/Program/Office/grantees/interagency/state/city efforts to develop/apply new analytical & *in vitro* methods & other tools to evaluate environmental samples for endocrine activity & determine potential impact on fish & human health using lab & field studies; determining efficacy of operations to reduce endocrine activity
 - *Used by Program/Regional Offices, States, municipalities, and industry to assess and mitigate environmental impact of endocrine activity*
- Frameworks for: cross-species models of TH and aromatase disruption; improved linkages between TH alternations in short term screens and adverse outcomes; cumulative risk assessments; characterization of impact of EDCs on toxicity pathways associated with neuroendocrine regulation of puberty and epigenetic mechanisms of transgenerationally induced reproductive effects
 - *Used by EPA and others to improve risk assessments of EDCs*
- Training of Programs/Regions, States, Tribes on molecular assays and exposure methods for environmental assessment; further application of methods, e.g., characterize impact of CAFOs, endocrine active pharmaceuticals in WWTPs on fish populations
 - *Used by Programs/Regions, States, Tribes for environmental assessment*

Strategic Directions (1)

OPPTS and/or other organizations use the results of ORD's research on methods, models, and data as scientific foundation for:

- 1) prioritization of testing requirements, 2) enhanced interpretation of data to improve their human health and ecological risk assessments, and 3) decisionmaking regarding specific individual or classes of pesticides and toxic substances that are of high priority.
- probabilistic risk assessments to protect natural populations of birds, fish, other wildlife, and non-target plants.
- decisionmaking related to products of biotechnology.



Strategic Directions (2)

- Consistent with Administrator's priorities:
 - Managing chemical risks. Protecting American's waters. Vulnerable subpopulations, specifically children.
- Leveraging with other research partners
- Addresses SAB Recommendations: extension of program to develop ecological risk assessment tools
- **Major changes**
 - Additional FTEs brought in to develop integrated effects-exposure ecological risk assessment tools
 - Determine feasibility of having a viable biotechnology program with resources that are now <50% of the original initiative; Can expertise be applied to biofuels program? Can unmet priorities be addressed through/leveraged with biofuels program?



- **Major recent program accomplishments**

- Compendium of AHS Pesticide Exposure Study results for use in exposure classification
- Support to Agency assessment of potential risks in Decatur from PFCs
- Collectively with NIAID funded 16 grantees on factors contributing to food allergenicity; session at SOT; workshop & state of the science publication
- Developed novel methods to detect pest resistance to GM crops: 1) Partnered w/NASA & developed remote sensing capability; 2) developed/applied methods for genetic characterization; 3) developed & evaluated exposure monitoring protocol
- Brought together 180 scientists and managers for international workshop on PFCs where ORD's multidisciplinary research was showcased
- Developed novel method to screen chemicals using HTPS and whole zebrafish approaches and contributed chemical analysis to ToxCast program
- Developed ecological models Web-ICE and ACE to support pesticide assessments
- Established ORD NMR-based Metabolomic Research Facility

- **Major program accomplishments anticipated in the near-term**

- Additional data on effects, exposure and fate of PFCs
- Tools and data on the fate of pesticides and PFCs following drinking water treatment
- Population-level models for risk assessments for aquatic and avian populations
- Metabolite & degradate simulator model for rapid/efficient identification of chemicals
- Evaluation of the next generation of lead test kits

Significant Anticipated Products and their Intended Use by Partners

- Assays to screen chemicals for their potential toxicity across a number of end points & multiple modeling approaches for prioritizing chemicals
 - *Used by OPPTS and others to prioritize and screen chemicals*
- Advanced methods/modeling approaches for extrapolating integrated toxicological and exposure data across wildlife, media, and individual- and population-level
 - *Used by OPP and others to characterize individual- & spatial population- level exposures & effects in aquatic and other wildlife for use in addressing ESA*
- Multiple models to assess potential allergenicity to GM crops & guidelines/tools to mitigate gene-transfer, non-target effects & development of resistance in targeted pest populations
 - *Used by OPP to improve data requirements for registrants & aid management of potential human and ecological risks from GM crops*
- Completion of multidisciplinary research on the toxicity, environmental pathways and fate of PFCs, including their characterization in environmental and biological species
 - *Used by OPPT and other organizations in their assessments on potential risks of PFCs*

Computational Toxicology Research Program: Strategic Directions

*Robert Kavlock, Director
National Center for Computational Toxicology*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



Computational Toxicology Research Program

Major Accomplishments

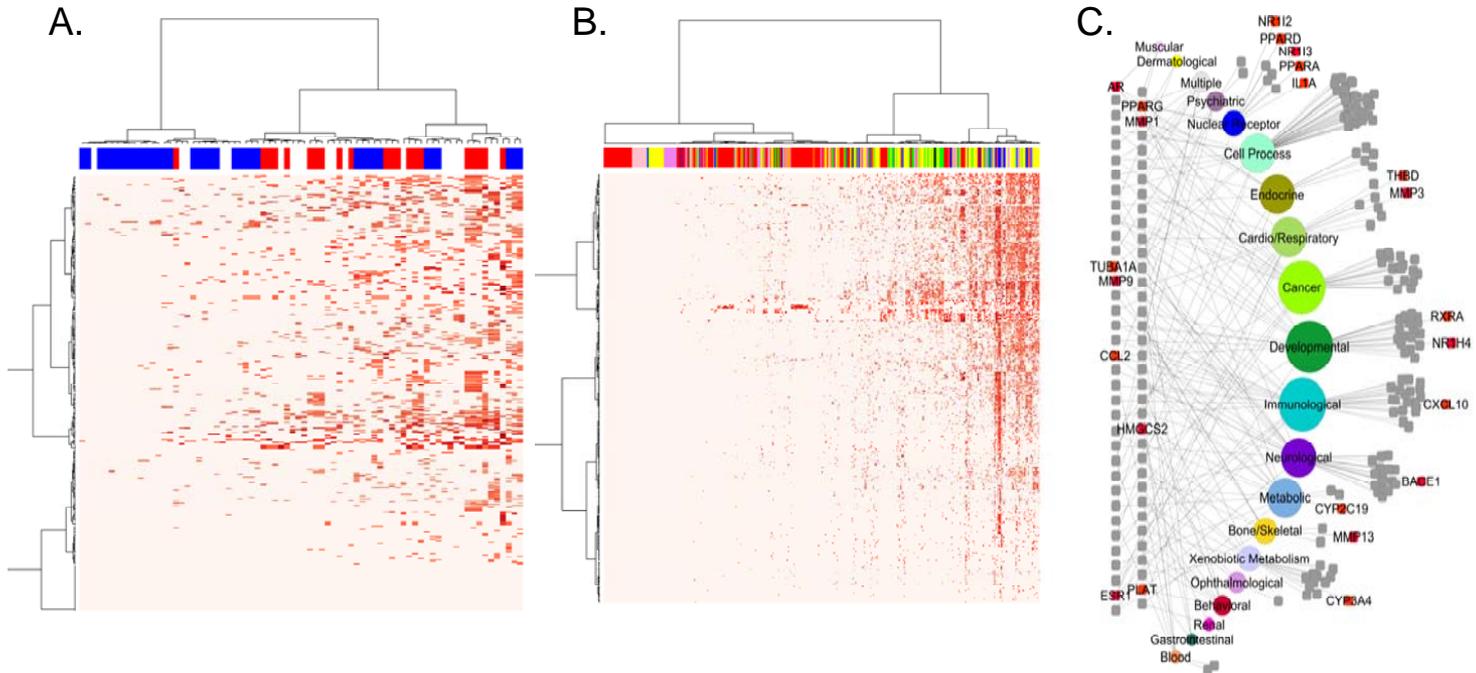
- Major recent program accomplishments
 - Completion of Phase I of ToxCast, international workshop May 2009
 - Expanded ToxCast collaborations with pharmaceutical industry, academia, stakeholders
 - Publications on ToxRefDB and five major data sets in relational format
 - Significant upgrades to ACToR and DSSTox online
 - Launch of v-Liver and v-Embryo, international workshop April 2009
 - Continued development of interagency Tox21 consortium
 - Chair of OECD Working Group on Molecular Screening
 - Ongoing collaborations with STAR Computational Toxicology Centers, and award of 4th Center on Developmental Systems
 - Fourth review of program by the sBOSC – September 29-30, 2009
- Major program accomplishments anticipated in the near-term
 - Publication of series of papers on ToxCast Phase 1 assays and predictions
 - Launch of Phase II of ToxCast; 700 chemicals and pilot for nanomaterials
 - Construction of screening library of 10,000 chemicals at NCGC under Tox21
 - Expand data contained in ToxRefDB: developmental neurotoxicity, potentially EDSP Tier 1 Battery
 - Release of ToxMiner and other Knowledgebases and tools

Computational Toxicology Research Program Significant Products In Use by Partners

- ToxRefDB:** relational database developed in partnership with EPA's Office of Pesticide Programs (OPP) that contains results of over 30 years and \$2B worth of rat and mouse chronic, rat multigenerational, and rat and rabbit developmental studies for over 400 chemicals. This database is being used by OPP and various groups world-wide for research and regulatory use.
- **ToxCast:** Comprehensive bioactivity profiling of over 300 chemicals in over 500 assays for human toxicity pathways completed in FY2009. Profiling of 700 additional chemicals was launched in FY2009, including failed drugs with known human toxicity for translating bioactivity into toxicity pathways and prioritization of environmental chemicals for further testing.
 - **ACToR:** Aggregated Computational Toxicology Resource is a web-based portal of information on chemical structure, bioassay and toxicology data for environmental chemicals from 200 sources of public data for over 500,000 chemicals.
 - **DSSTox:** Distributed Structure-Searchable Toxicity Database Network updated with several high-interest EPA chemical inventories (e.g., HPVs), public genomics inventories, and linkages to NIH's PubChem and the OECD QSAR Toolbox.

Computational Toxicology Research Program

Transforming Toxicity Testing from In Vivo to In Vitro



ToxRefDB is an EPA database digitizing over 30 years and \$2B worth of animal testing data. The “heat-map” in (A) represents results for over 400 chemicals, and hundreds of toxicity endpoints. In (B) the bioactivity of over 300 of the same chemicals has been profiled without animal testing, using over 500 assays for human toxicity pathways as part of EPA’s ToxCast screening program. The bioactivities from ToxCast assays can be mapped to human disease processes (C), indicating potential hazard and a future toxicity testing paradigm that is faster, more efficient, and more relevant to public health.

Computational Toxicology Research Program September 2009 sBOSC Review & 2nd Generation Implementation Plan

- A single new Long-Term Goal: Providing high throughput decision support tools for screening and assessing chemical exposure, hazard and risk
- Strategic Directions:
 1. Expand beyond hazard prioritization
 - Addition of exposure and other data domains
 - Systems approach to modeling toxicity
 2. Support EPA's Strategic Plan for Evaluating the Toxicity of Chemicals
 - Provide databases and analysis tools
 - Expand Tox21 and other partnerships
 - Collaborate and communicate with EPA Programs and Regions
 3. Anticipate EPA's Integrated Multidisciplinary Research on improving chemical risk management



U.S. EPA OFFICE OF RESEARCH AND DEVELOPMENT
COMPUTATIONAL TOXICOLOGY RESEARCH PROGRAM
IMPLEMENTATION PLAN FOR FISCAL YEARS 2009-2012

*Providing High Throughput Decision Support Tools for Screening
and Assessing Chemical Exposure, Hazard and Risk*

BOSC Review Draft- 24 August, 2009

DISCLAIMER:

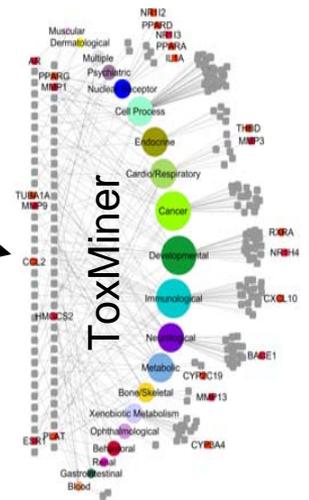
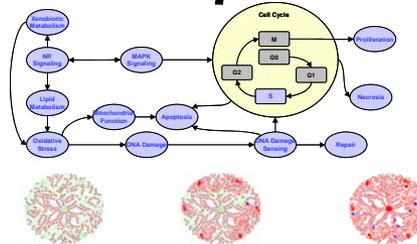
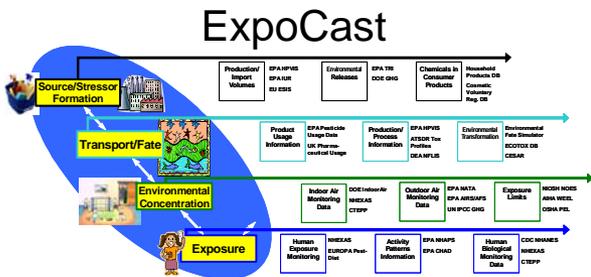
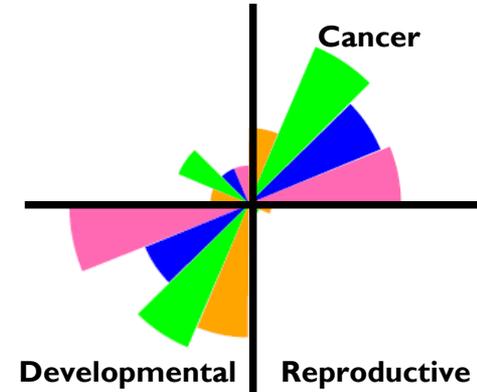
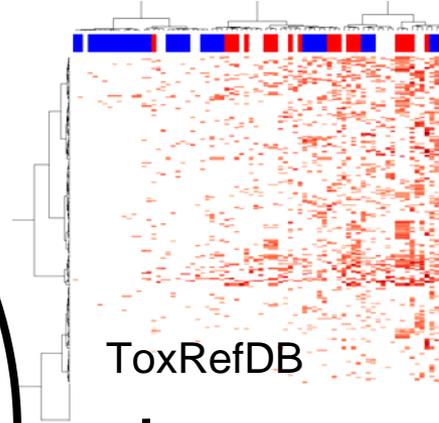
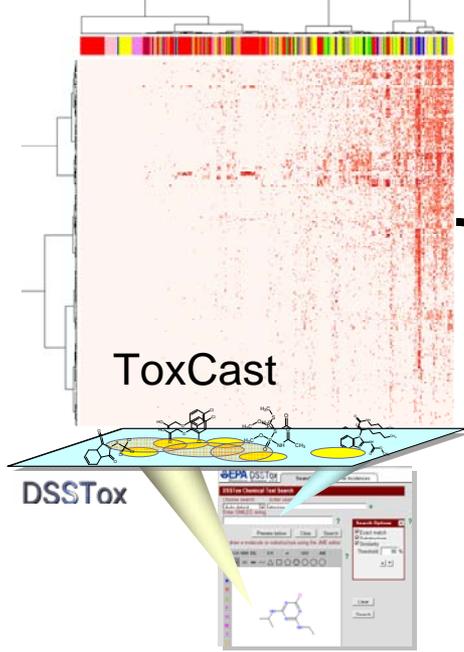
This document has been reviewed by the U.S. EPA Office of Research and Development (ORD) and approved for public release, but does not necessarily constitute official Agency policy. This Plan follows the first generation FY2005-2008 Computational Toxicology Research Program (CTRP) Implementation Plan, and provides a strategic overview of research for FY2009-2012. This Plan was reviewed by ORD senior management and members of the Science Council, as well as the Computational Toxicology Subcommittee of the ORD Board of Scientific Counselors (BOSC) on September 29-30, 2009, in RTP, NC.

http://www.epa.gov/ncct/bosc_review/2009/agenda.html

http://www.epa.gov/ncct/bosc_review/2009/files/CompTox_BOSC_09.pdf

Computational Toxicology Research Program High Throughput Screening of Chemicals

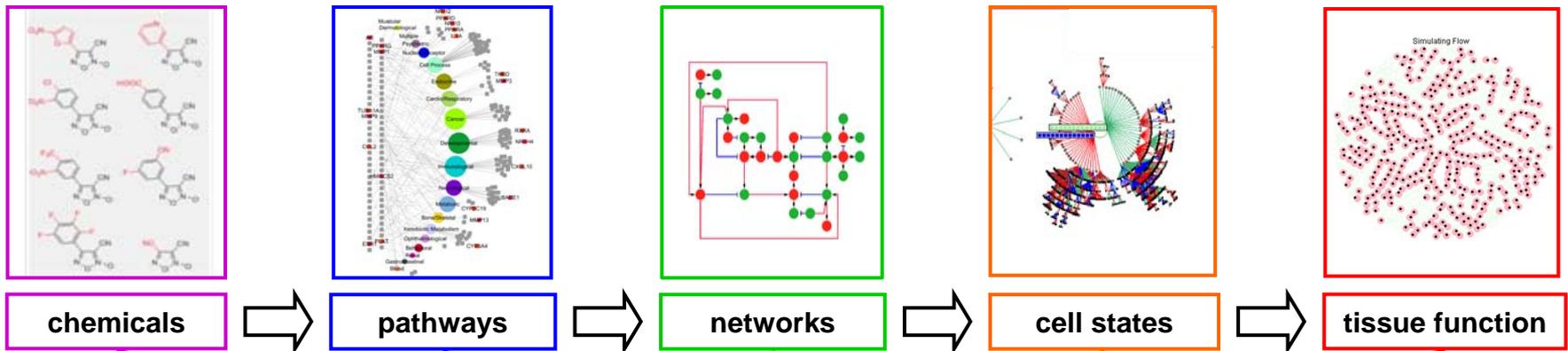
$$\text{Priority} = f(\text{Chemical Descriptors} + \text{ToxCast} + \text{V-Tissues} + \text{Exposure})$$



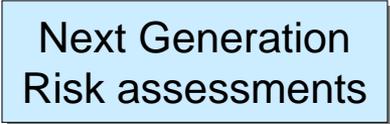
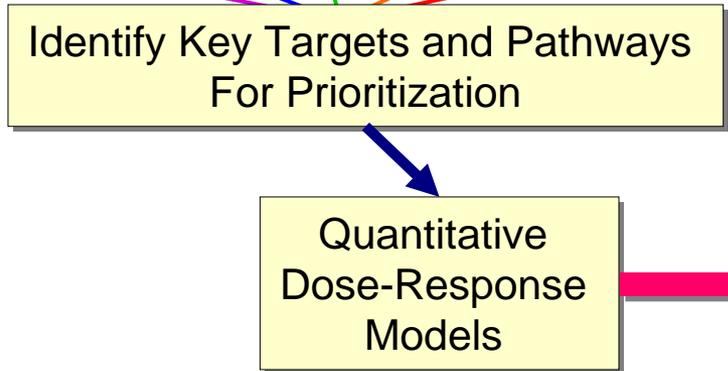
Computational Toxicology Research Program

Systems Approach to Modeling Toxicity

From Pathways to Virtual Tissues

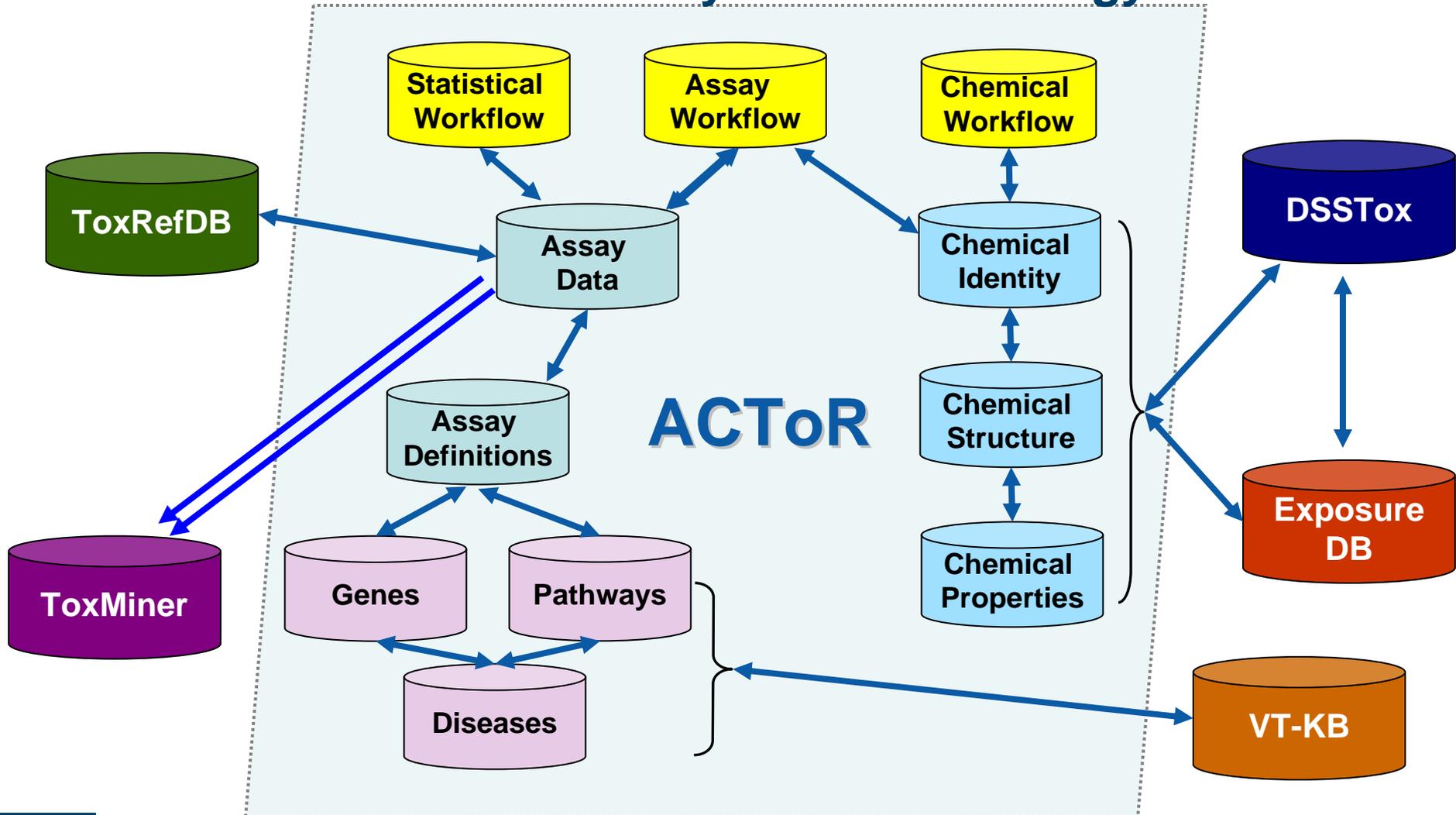


Moving beyond empirical models, to multi-scale models of complex biological systems.

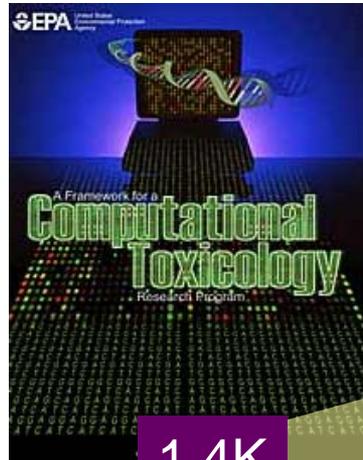
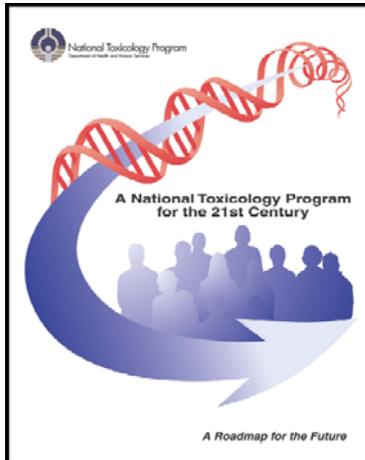


Computational Toxicology Research Program

Foundational Databases and Tools for Predictive and Systems Toxicology



Computational Toxicology Research Program Building the Tox21 Community and Chemical Library



10K

2.8K

1.4K

**Tox21 Chemical
Library**

2004

2006

2008

2010

2005

2007

2009



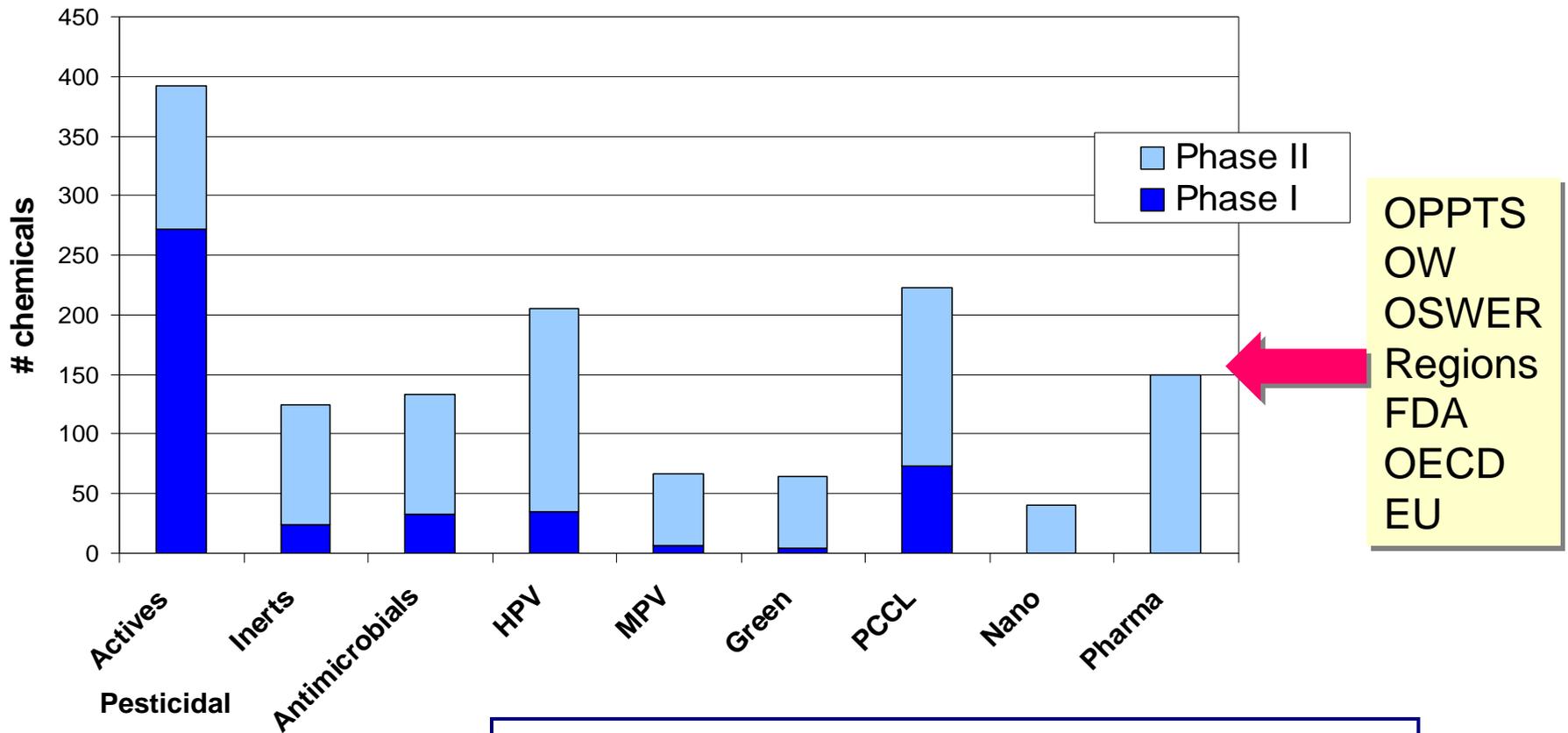
FDA
EU JRC



Office of Research and Development
Computational Toxicology Research Program

Computational Toxicology Research Program

Expanding ToxCast Chemicals for EPA Program Needs



FY2012: thousands of chemicals in Phase III

Computational Toxicology Research Program From Research to Practice ...

Providing High Throughput Decision Support Tools for Screening and Assessing Chemical Exposure, Hazard, and Risk

FY09

FY10

FY11

FY12

FY13

FY14

Informatics: DSSTox, ToxRefDB, ACToR, MetaPath, ExposureDB, VT-KB



Prioritization: ToxCast, Tox21, ExpoCast, V-Tissues, ToxMiner



Risk Assessment...

Nanotechnology Research Program: Strategic Directions

Jeff Morris
National Program Director

Strategic Directions, 2010 - 2014

- Continued focus on 5 material types (Ag, C, CeO, Fe, TiO₂)
- Continued emphasis on exposure, fate & transport – “Source to dose”
 - Continue research in soil, water, biota, and extend research to air medium
 - Develop exposure models
- Increased emphasis on targeted effects, based on source-to-dose findings
- Integration of ToxCast into in-house program
- Increased emphasis on green nanotechnology from a life-cycle perspective
- Continued development of risk assessment methods, including comprehensive environmental assessment and decision analytic approaches.

Program Integration – Multi-walled Carbon Nanotube (MWCNT) Example

Frame the question to focus on the goal: "Are humans or ecosystems likely to be exposed in the environment to MWCNT, and do MWCNT have unique properties that may result in harmful effects? If so, how can we avoid or mitigate potential risks from MWCNT?"

Overarching Goal is **Minimizing Environmental Impacts**

Risk Management Approaches

Property modifications
Process controls
Exposure mitigation
Waste management

Research to Investigate Potential Impacts

Chemists and material scientists detect & characterize materials.
Toxicologists identify properties associated with hazard concerns.
Exposure researchers describe environmental fate, transport & transformation.
Risk Assessors investigate methods to characterize potential impacts.
Modelers predict stressor & receptor activity across life cycle.
Chemists and engineers devise management options.

Key considerations:

- *Information continuously moves between disciplines.*
- *All disciplines look at nanomaterials from a life-cycle perspective.*

Anticipated Products – 2014

- Determine the major processes that govern environmental fate, transport, and transformation of the 5 nanomaterial types.
- Source-to-dose exposure models for the 5 nanomaterial types.
- Approaches to screen, rank, and predict *in vivo* toxicity.
- Identification of key physical-chemical characteristics to inform development of predictive modeling.
- Comprehensive environmental assessments of selected nanomaterials, based on progress in prerequisite areas of research.
- Green nanotechnology and other risk management approaches for priority applications of the 5 nanomaterial types.