A Risk Forecasting Framework for Nanomaterials

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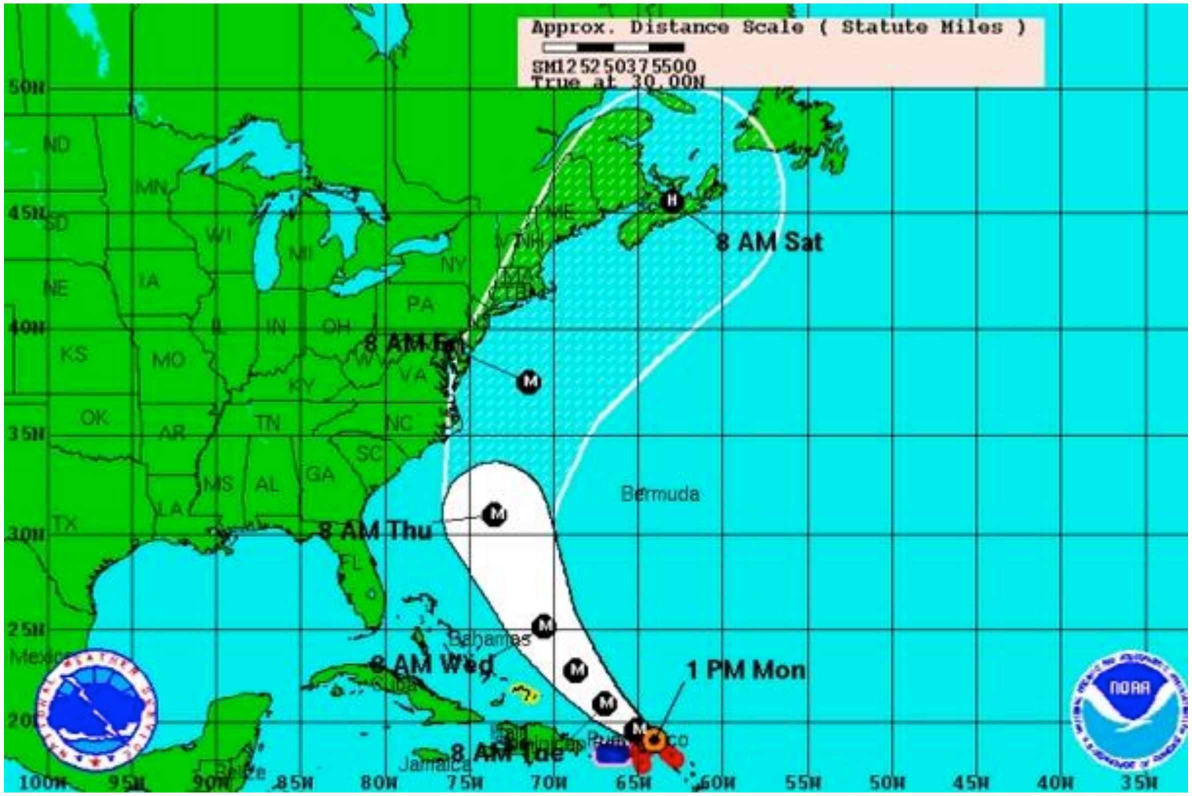
Center for the Environmental Implications of NanoTechnology

Development of methods for risk forecasting



judgment, high uncertainty → *mechanisms, less uncertainty*

Precautionary *Risk-based decision making*

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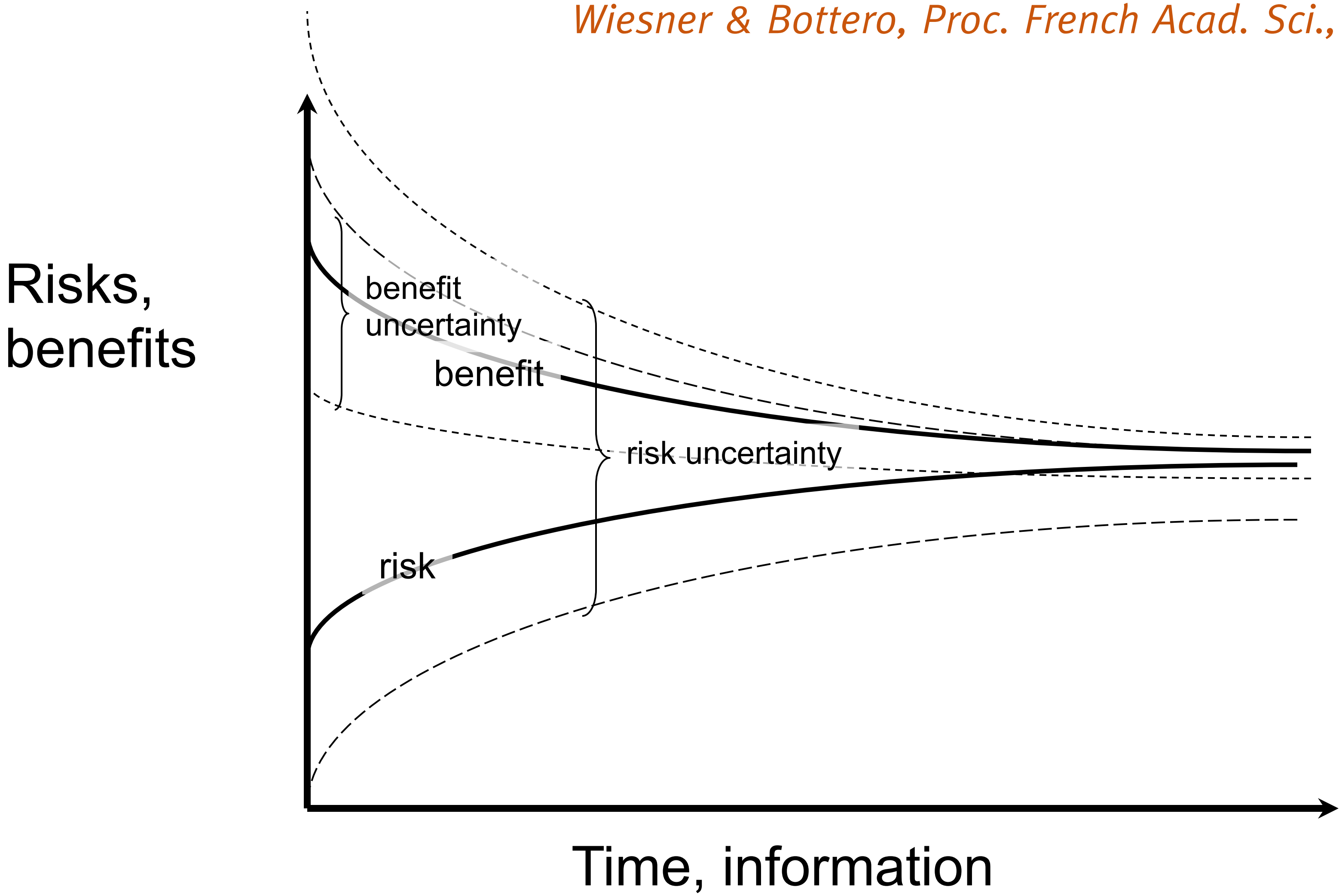
Wiesner & Bottero, Proc. French Acad. Sci., 2011



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Desirable Elements of a risk forecasting framework for nano

1) *generates forecasts and associated levels of uncertainty for questions of immediate concern*
2) *Incorporates fundamental properties of nanomaterials with goal of forecasting risk for new materials*
3) *Considers all pertinent sources of nanomaterials*
4) *Includes life-cycle and ecosystem-level impacts*
5) *Ability to adapt and update risk forecasts as new information becomes available*
6) *feedback to improve information gathering*
7) *feedback to improve nanomaterial design*

Wiesner & Bottero, Proc. French Acad. Sci., 2011

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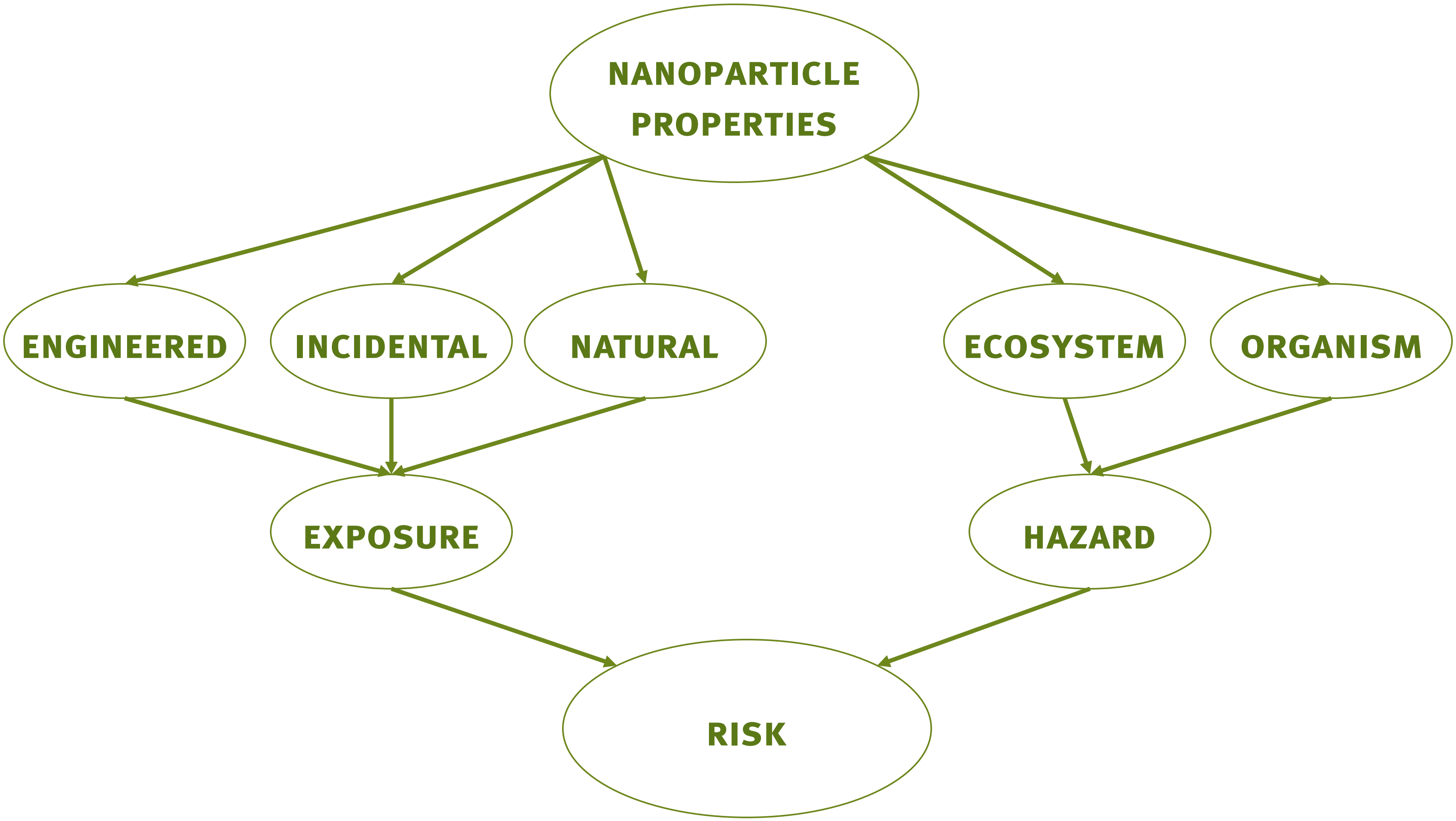
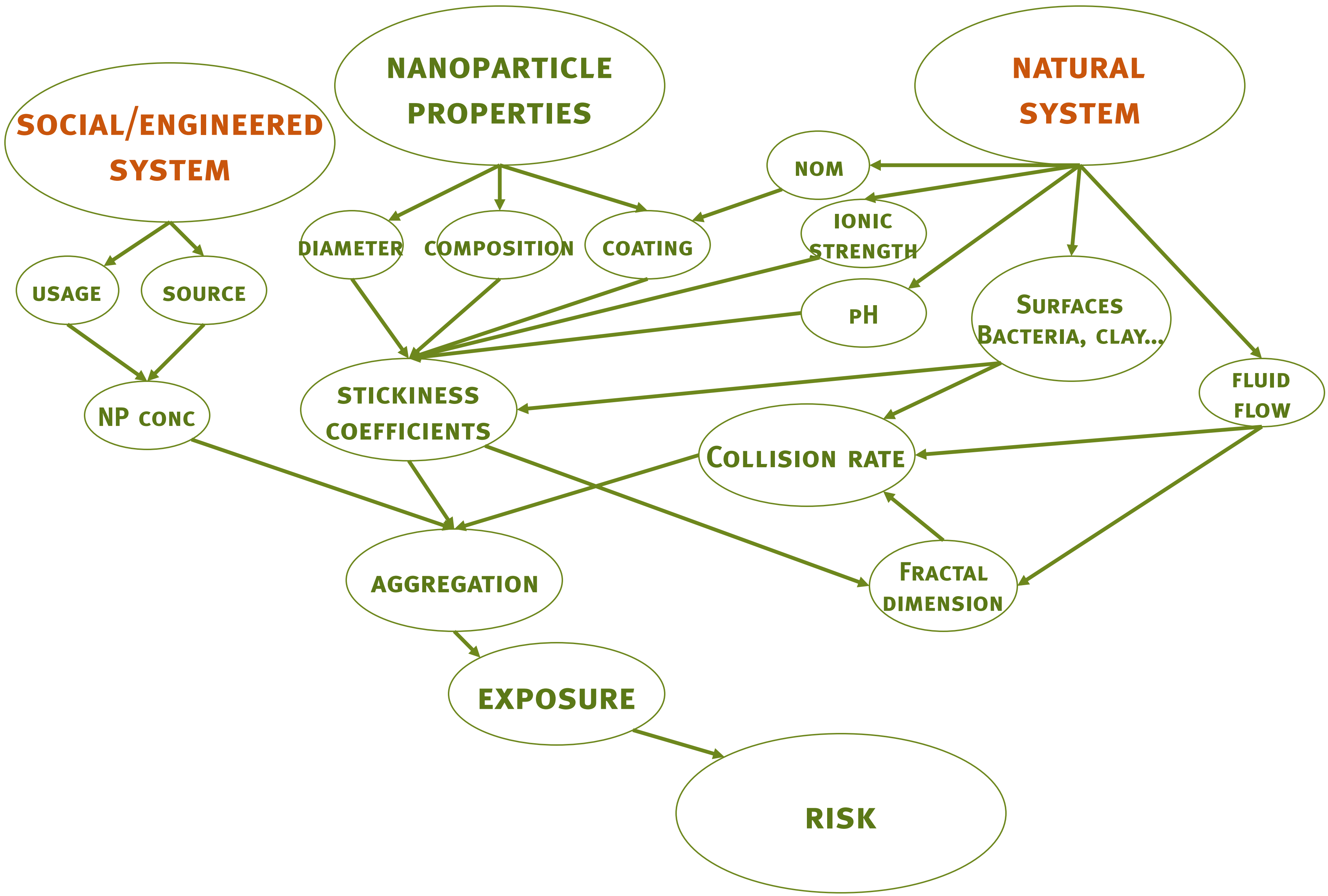
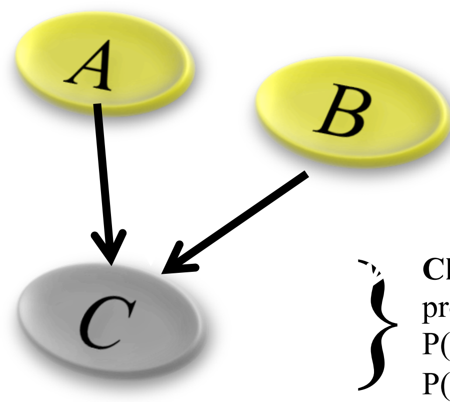
Multiple sources, multi-scale impacts




SOCIAL/ENGINEERED SYSTEM
NANOPARTICLE PROPERTIES
NATURAL SYSTEM
USAGE
SOURCE
DIAMETER
COMPOSITION
COATING
NOM
IONIC STRENGTH
pH
SURFACES BACTERIA, CLAY...
FLUID FLOW
NP CONC
STICKINESS COEFFICIENTS
COLLISION RATE
FRACTAL DIMENSION
AGGREGATION
EXPOSURE
RISK

Bayesian Networks

Parent Nodes: Marginal Probabilities
P(A) = probability of A
P(B) = probability of B



Child Node: Joint (conditional) probability
P(C) = probability of C
P(C|A) = probability of C given A

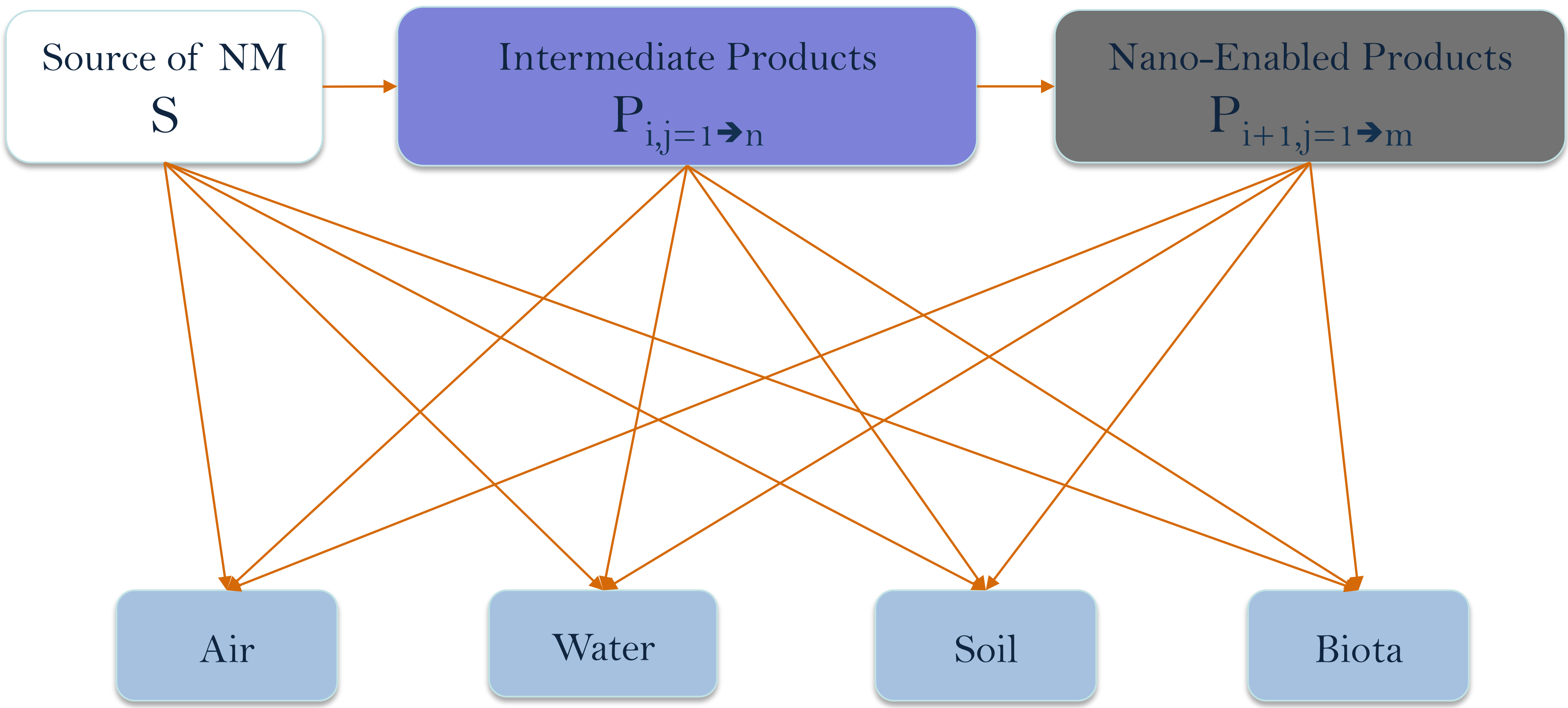
- BayesNets use a combination of probability theory and Bayes Theorem

$$P(X_1, X_2, \ldots, X_n) = \prod_{i=1}^{n} P(X_i \mid pa(X_i))$$

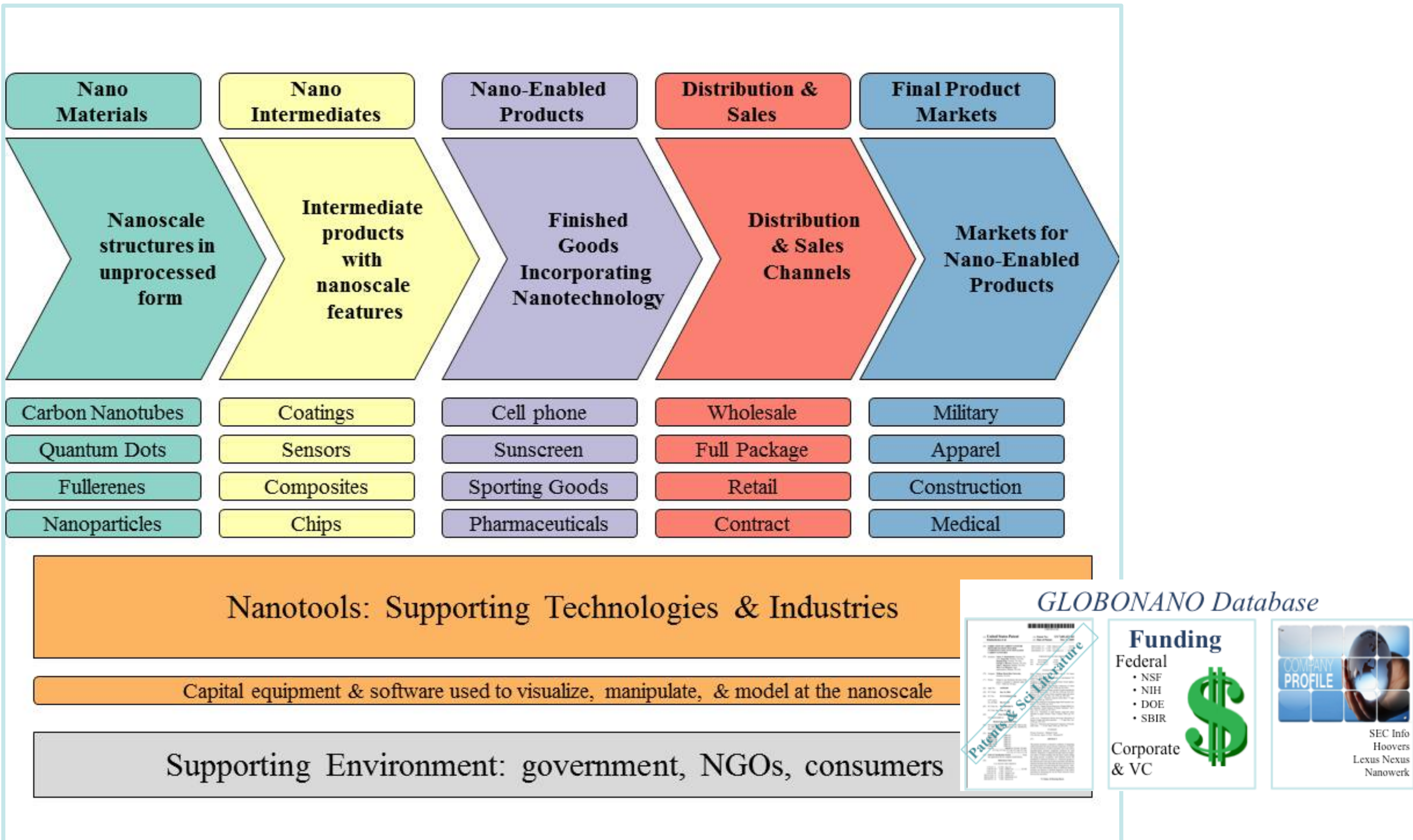
Variable

Conditional On… 'Parents' of…

Describing the Social/Engineered System: A value chain/ life cycle approach



Identification of nanomaterial value chains



Tim Lenoir, Patrick Herron, Stacey Frederick

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Nanomaterial fabrication estimates

Product	Lower bound (tpy)	Upper bound (tpy)
nano-TiO_2	7,800	38,000
nano-Ag	2.8	20
nano-CeO_2	35	700
CNT	55	1101
Fullerenes	2	80

C. Hendren, Mesnard, Dröge, Wiesner, ES&T 2011

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Thank You

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