



EXPOSOME & SANTE A L'HEURE DE L'INTELLIGENCE ARTIFICIELLE

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Health & Human Genome



Success!

BUT

Genetics alone accounts for only **10-20%** of
Non Communicable Diseases (NCDs)

The latest **WHO** report on NCDs*

↻ **2012**: - 13 million deaths throughout the world

- Of these 8.2 millions caused by NCDs

⇒ NCDs are becoming « epidemic »

↻ **2015**: 400 million people affected by type 2 diabetes

⇒ Cost: • ≈ 250 billion € / year in Europe

• > 4000 € / year / person in France

**«Preventing Disease through Healthy Environments»*

http://who.int/quantifying_ehimpacts/publications/preventingdisease.pdf

GENETIQUE

Grandeur *versus* Modestie

- Analyse des variants alléliques (SNPs) de 34 241 patients: variance pression artérielle expliquée par variabilité génétique $\approx 3,5\%$ ⁽¹⁾
- Diabète de type 1 et type 2 chez les jumeaux monozygotes = 23% et 34% des cas, respectivement ⁽²⁾.
- Jumeaux monozygotes et schizophrénie : 40% des cas....

⁽¹⁾ Ehret et al., *Nature Genetics*; 48 (10), 2016

⁽²⁾ Kaprio et al., *Diabetologia*, 35:1060-1067, 1992

Genome & Environment

- **Genome** : finished set of billions of nucleotides; defined by its sequence and its alleles.

Precise units of analysis...

- **Environment** : multiple factors of variable categories

Cannot be reduced to single categories of data

*Valleron A-J & Bougnères
In: Santé et Intelligence Artificielle
CNRS Editions 2018 p259-271*

The **Exposome** Paradigm

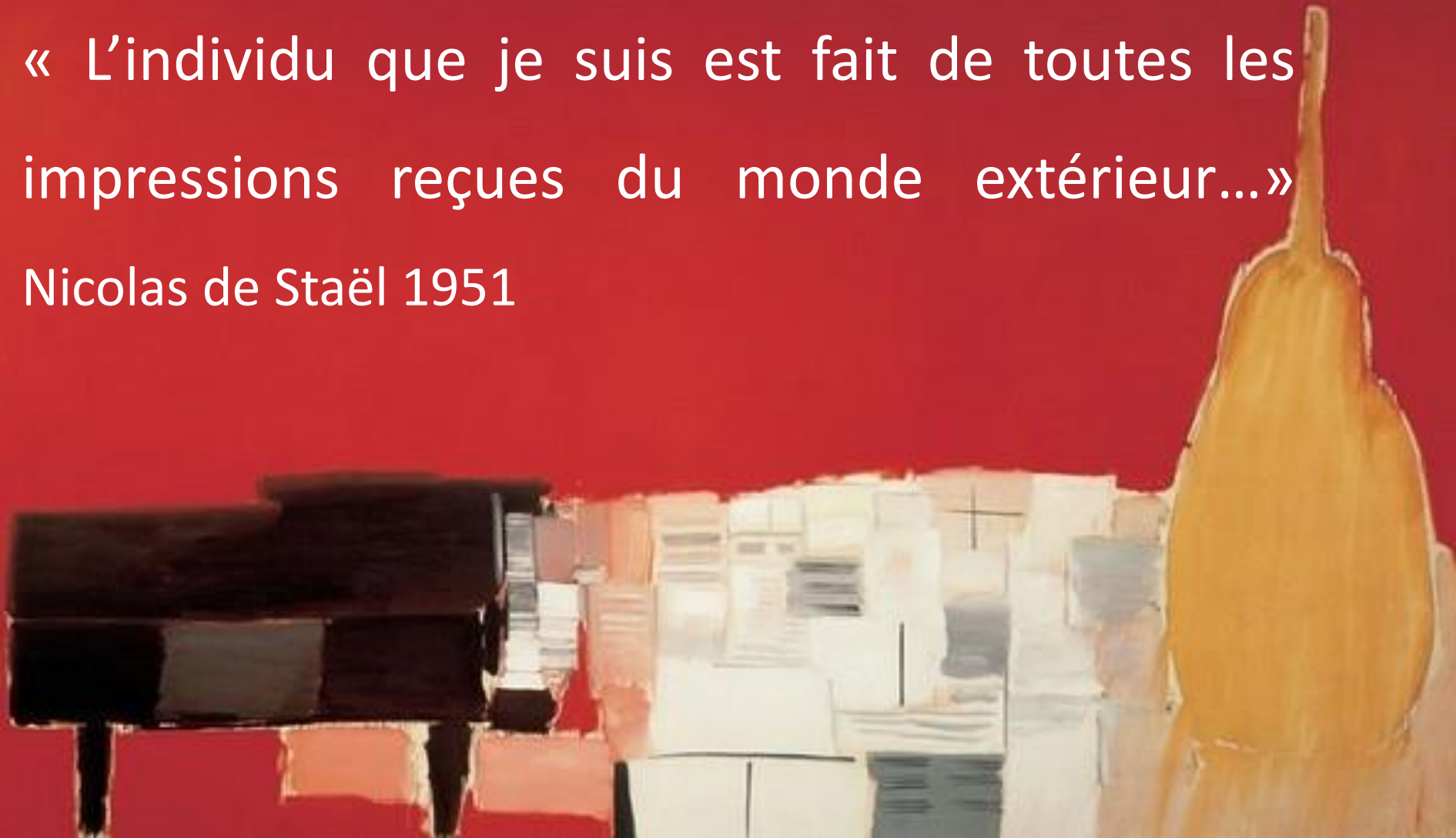
“ It is a representation of the complex and dynamic exposures a person is subjected to in a lifetime, including environmental chemicals, microbiological and physical agents, recreational and medical drugs, lifestyle choices, social influences, diet and infections. ”

*“The Human Exposome also represents how the person’s body responds to these challenges in terms of genetic, epigenetic and physiological interaction. ”**

**CP Wild. Cancer Epidemiol Biomarkers 2005, doi: 10.1158/1055-9965.EPI-05-0456*

« L'individu que je suis est fait de toutes les impressions reçues du monde extérieur...»

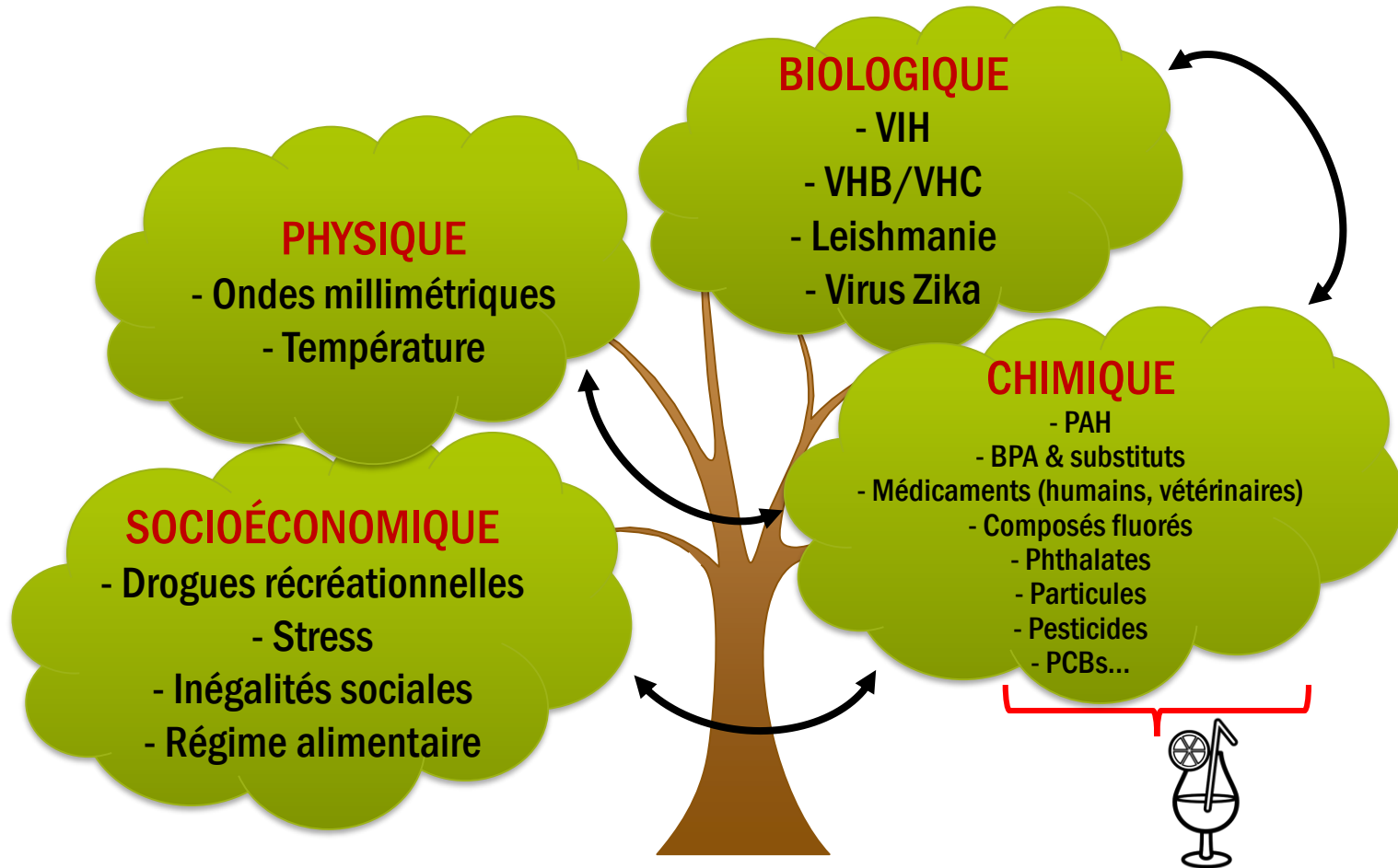
Nicolas de Staël 1951



... toutes les impressions = Exposome

which represents everything an individual is exposed to
from conception to death.

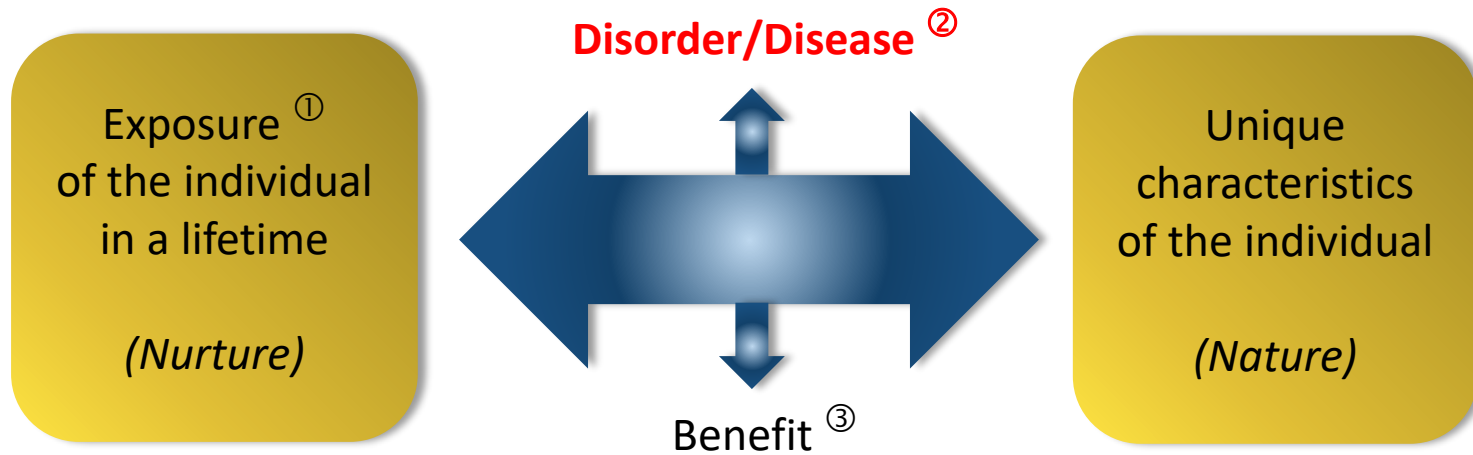
The Exposome represents everything an individual is exposed to from conception to death.



✓ **Greex** = Irset + Anses Ouest = « One Health » ≈ 700 personnes

✓ **Ice + Greek** +++ ≈ 900 personnes → CPER + S3

Nurture & Nature



How the interaction between our *Nurture* and our *Nature* impacts our health

- ① Exposure to environmental and occupational sources: environmental chemicals, pharmaceutical /veterinarian drugs, recreational drugs, physical factors, diet, lifestyle choices, behaviours, psychosocial influences, socioeconomic influences...
- ② Example of a “*disorder*”: Consumption of seafood (containing the contaminants) from the sediment is a *risk factor* for the intrauterine growth restriction (Guldner et al. 2007, *Environmental Health*, DOI:10.1186/1476-069X-6-33)
- ③ Example of a “*benefit*”: Consumption of fish *decreases the risk* of intrauterine growth restriction (Guldner et al. 2007, *Environmental Health*)



When Exposome met DOHaD

Developmental Origins of Health and Diseases

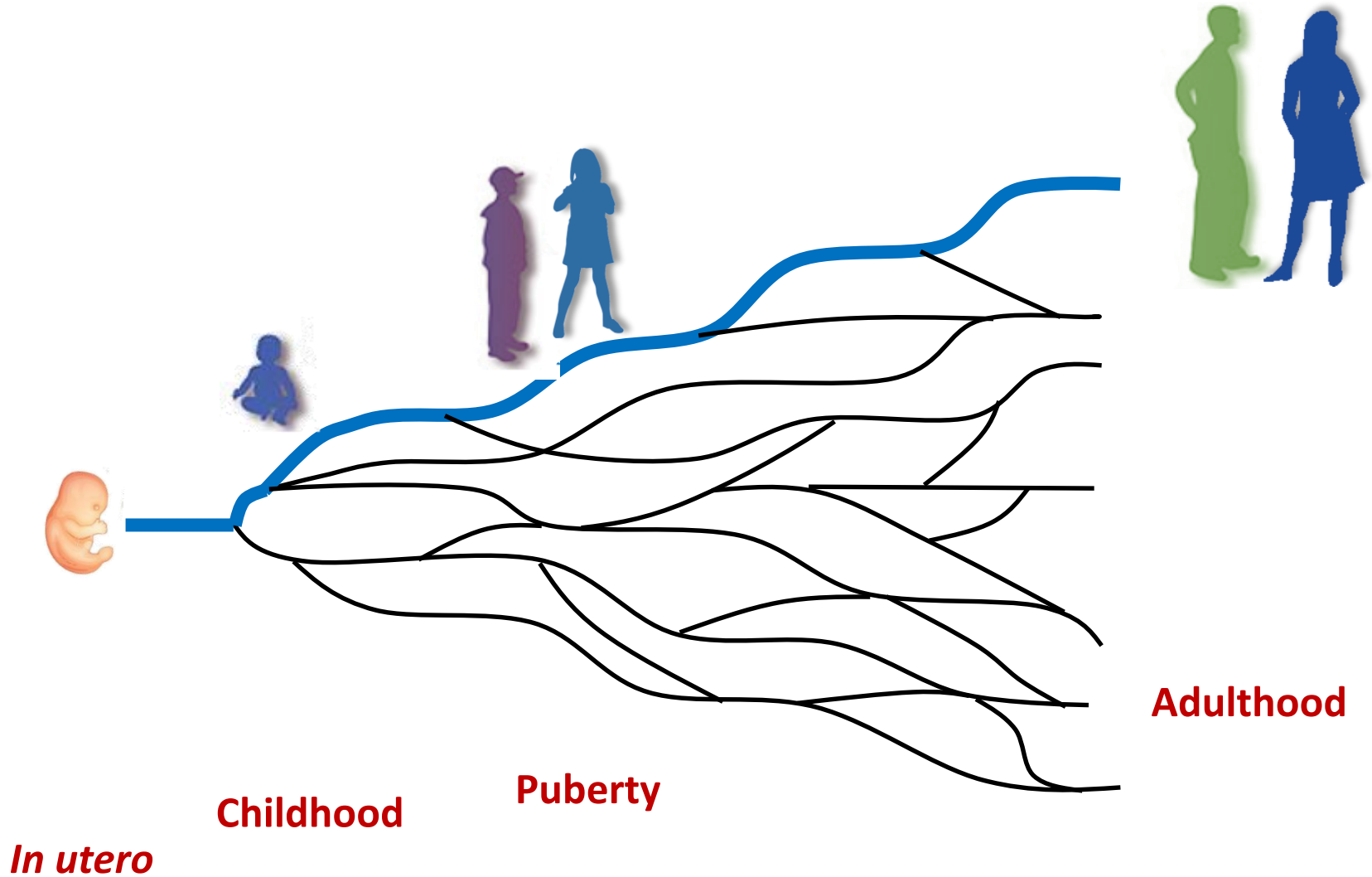
DOHaD

The DOHaD is defined as being *“a multidisciplinary field that examines how environment factors acting during the phase of developmental plasticity interact with genotypical variation to change the capacity of the organisation to cope with its environment in later life”*. *

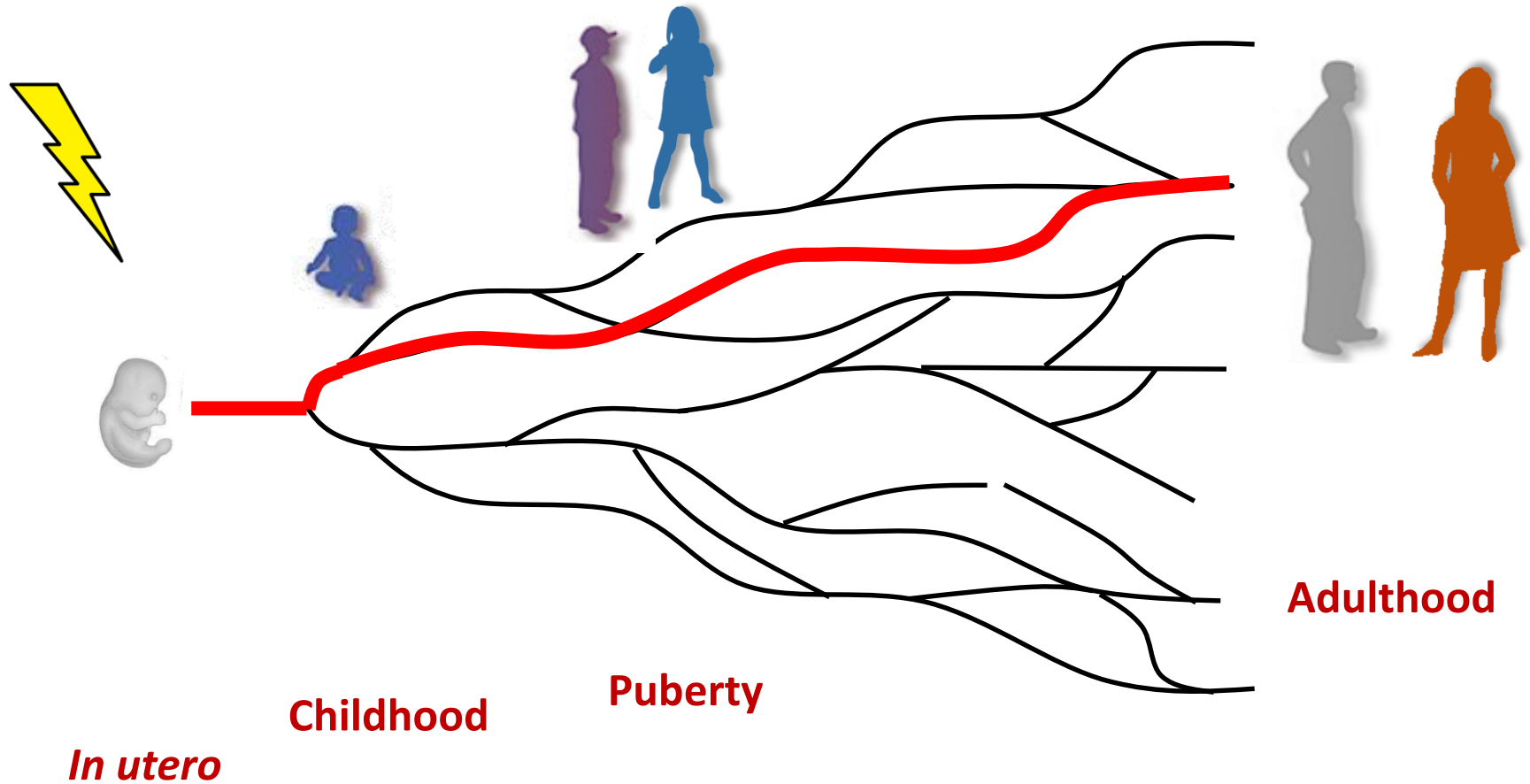
* Heindel JJ, Balbus J (...) Hanson M. 2015; doi: <http://dx.doi.org/10.1210/EN.2015-1394>

↻ The DOHaD paradigm is based upon the principle that aggressions suffered during the initial phases of somatic development enhance risk of NCDs.

Developmental Origins of Health

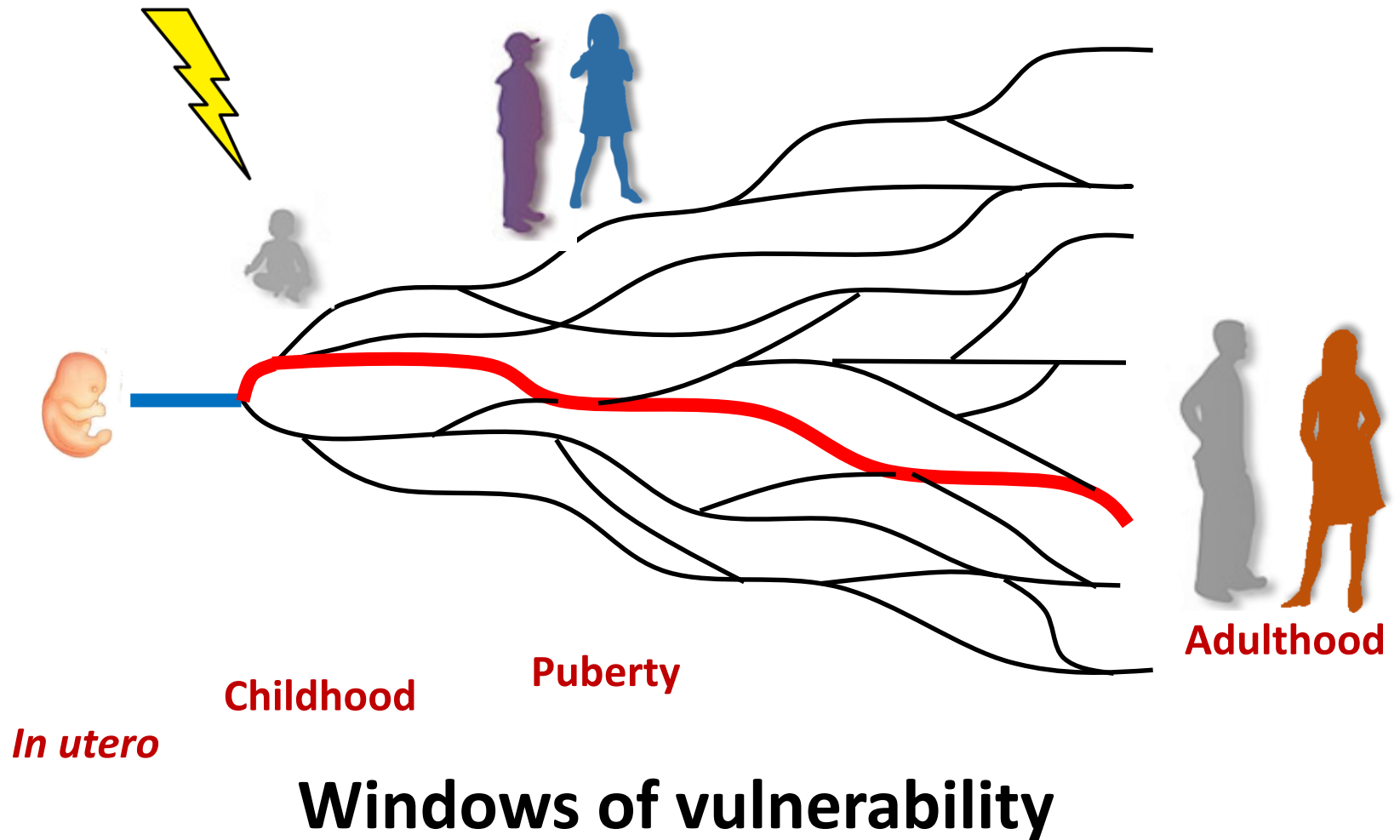


Developmental Origins of Health ~~Diseases~~

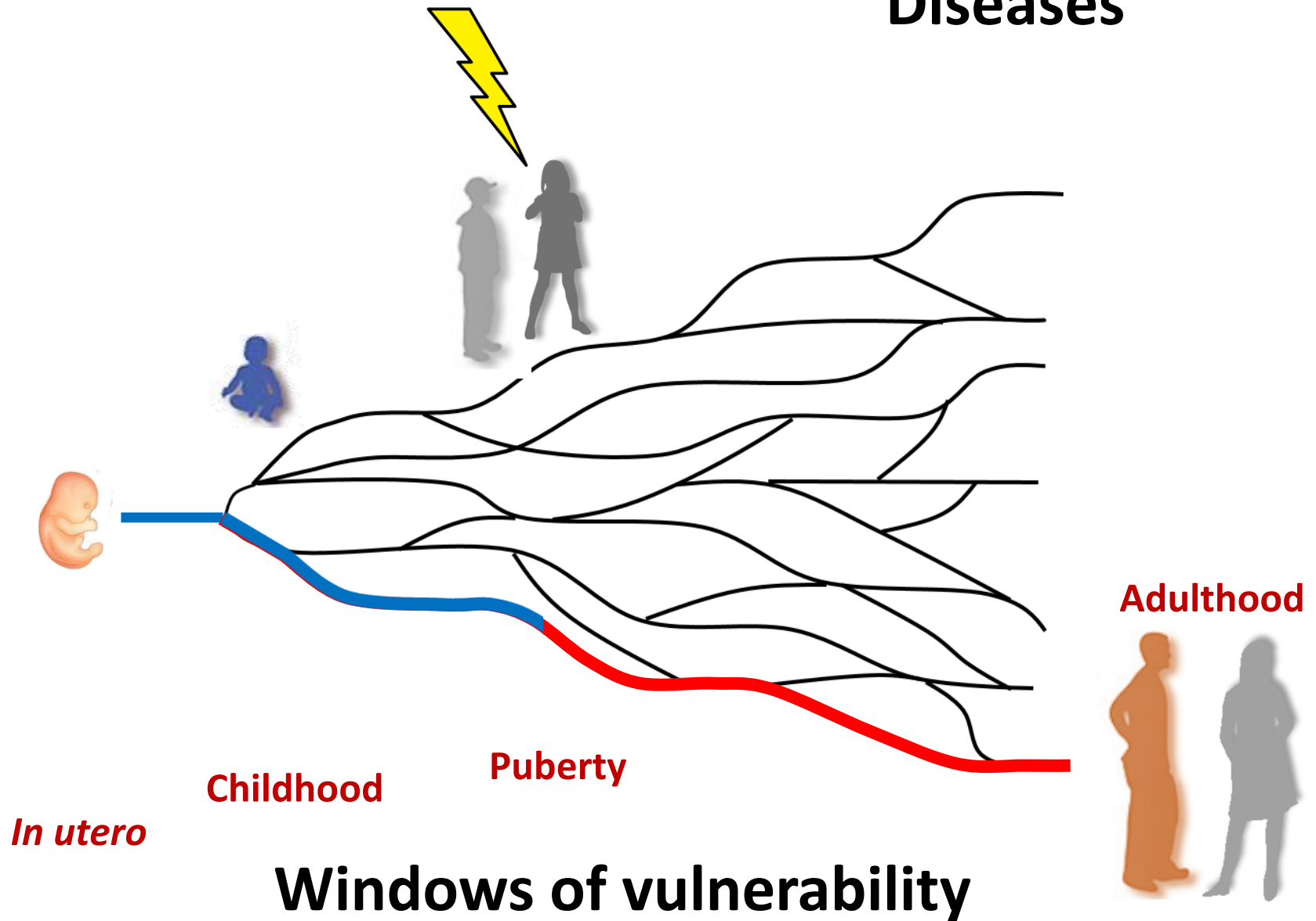


Windows of vulnerability

Developmental Origins of Health ~~Diseases~~



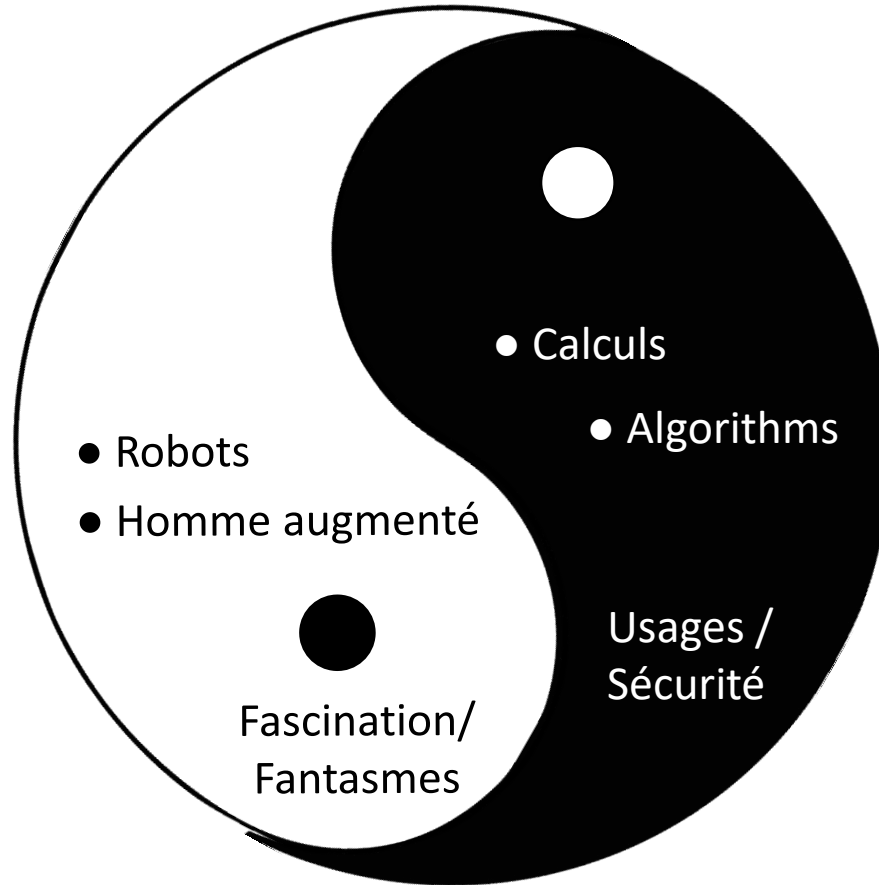
Developmental Origins of Health ~~Health~~ Diseases





Intelligence **A**rtificielle

yIng et yAng



« *Une Intelligence Artificielle vraiment Intelligente?* »

The third « **Industrial revolution** »* ?



« State of the art flight data recorders collect around 3000 data points per second »

→ Storage of **several gigabytes** of data per flight



« A conventional engine control unit gathers **dozens of datapoints** per second »



« The so called APGAR score (skin color, pulse rate, reflex, muscle tone, respiratory effort) still the most comprehensive check of a member's organism correspond to **5 datapoints** for life.

* « *A third revolution combining the power of devices and information has just started and transforms our understanding of life itself* »

Stefan Harrer, Plenary paper, Proc. of SPIE, vol.9518, 2015

Challenge : Toward an IA « explicable »

IA today = Deep learning = Millions of data = Powerfull

→ *Categorisation of situations*

IA future = an « organic » IA?

= *Continuous learning via Multiples devices*

Captation des données

- Ordinateurs
- Téléphones (O / F)
- Télévisions
- Objets intelligents
- Péages, caisses, ...
- Caméras



⇒ **6,4 milliards d'objets connectés en 2016, croissance exponentielle**

Chaque minute...

 > 300 000 tweets

 > 15 millions de SMS

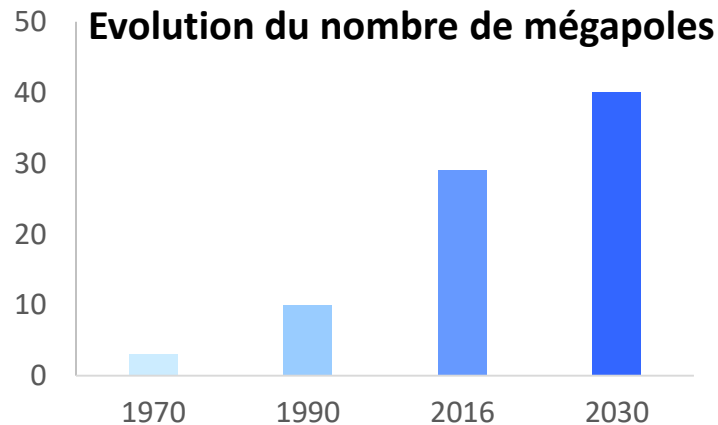
 > 200 000 millions de mails

 Tous les 2 ans le volume des données numériques double

⇒ Enregistrement de nos faits, gestes et déplacements

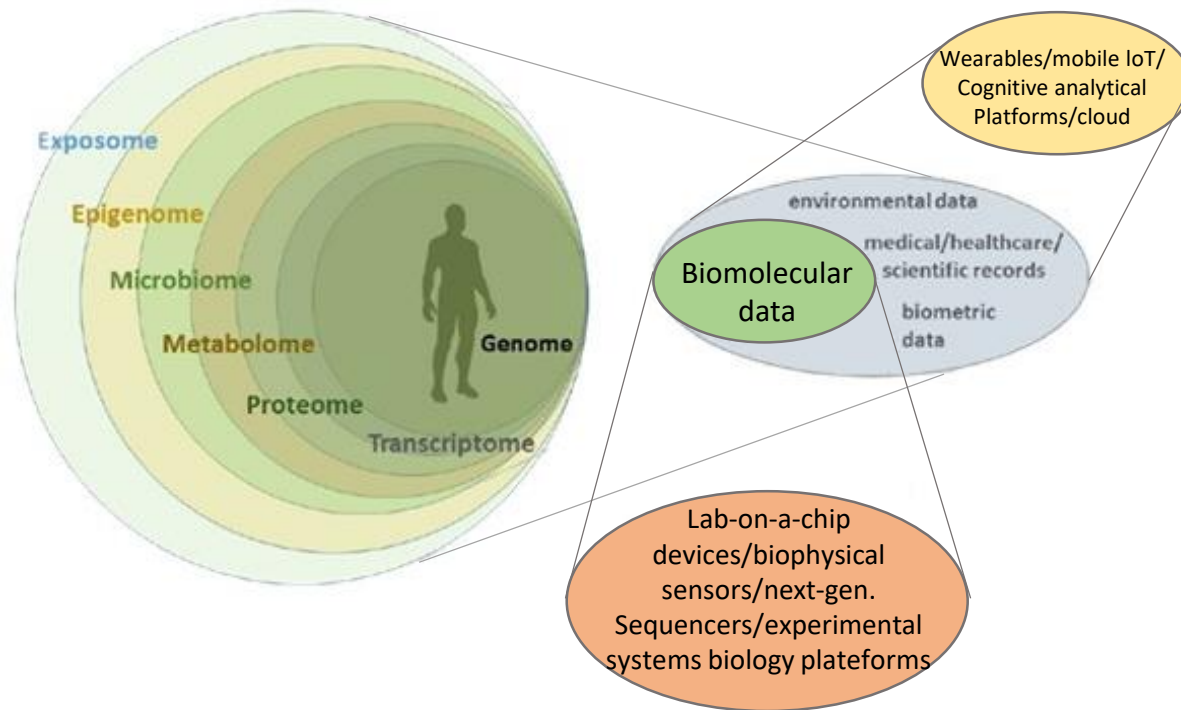
Villes « intelligentes »

- ↻ 2016: **1** personne / **2** est citadine
- ↻ 2050: **66%** des humains soit + **2,5** milliards de citadins
- ↻ 2016: 29 mégapoles (> **10** millions d'habitants)



- ↻ **78** collectivités en France ont une stratégie d'open data

Exposome, Santé & IA?



Sensors and Analytics for Exposome Investigations

Wearable Biometric Devices

Clinical trial



Michael Snyder

Monitoring of bacteria + viruses + chemicals + particulates including plants + fungi + animals.



Patterns on day to day, weekly, monthly (...) basis

Challenge...

To stitch databases...

- Bacterial, viral or fungi
- Chemicals (geographic, household)
- Global environmental data

Expected unprecedented advances in big data analytics for life sciences, healthcare genomics

Skin sensors are the future of health care

Exemples :



Thin, flexible, wireless monitoring systems could make medicine more predictive and personalized.



The single-use Zio patch from iRhythm in San Francisco, California, can monitor heart continuously for two weeks to detect irregularities.

Xu et al., Nature | 18 July 2019 | Vol 571

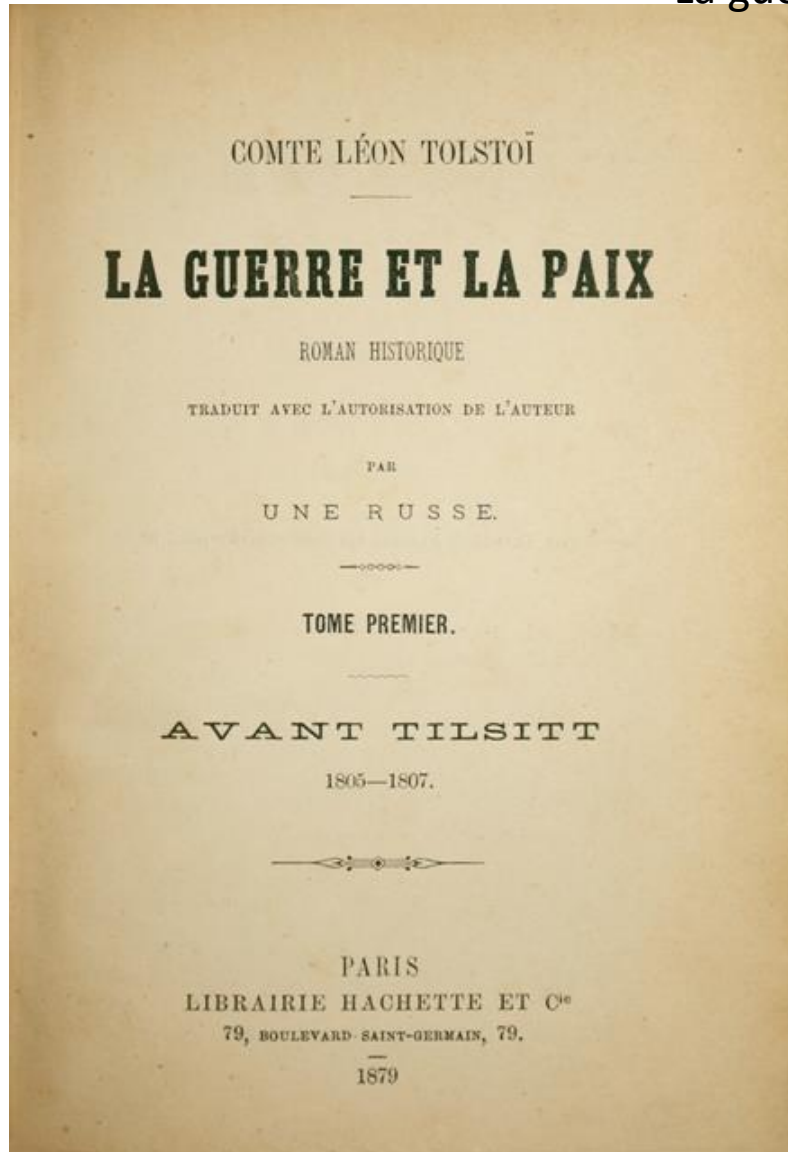
Reaction.... **ExOdE**, submitted on December 8th 2018

Acronym of the project	ExOdE		Partner institutions
Titre du projet en français	ExpOsome et dEveloppement		
Project title in English	ExpOsome and dEvelopment		
Project manager	<p>Bernard JÉGOU</p> <p>Institut national de la santé et de la recherche médicale (Inserm) Institut de recherche en santé, environnement et travail (Irset) / <i>Research Institute for Health, Environment and Occupational</i></p> <p>Inserm U1085</p>		<ul style="list-style-type: none"> ● Inserm ● Univ Rennes1 ● EHESP ● Inria ● ANSES ● CHU ● Univ Sorbonne Paris-cité
Requested funding	13 416 507 €		
Scientific fields of the project	<input type="checkbox"/> Sciences de la Matière et de l'Energie <input type="checkbox"/> Sciences du Système Terre-Univers-Environnement <input checked="" type="checkbox"/> Sciences de la Vie et de la Santé <input checked="" type="checkbox"/> Sciences du Numérique et Mathématiques <input checked="" type="checkbox"/> Sciences Sociales <input type="checkbox"/> Humanités		
Is this project linked to an IDEX/ I-SITE project?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes	

A *continuum* Research / Training / Transfer

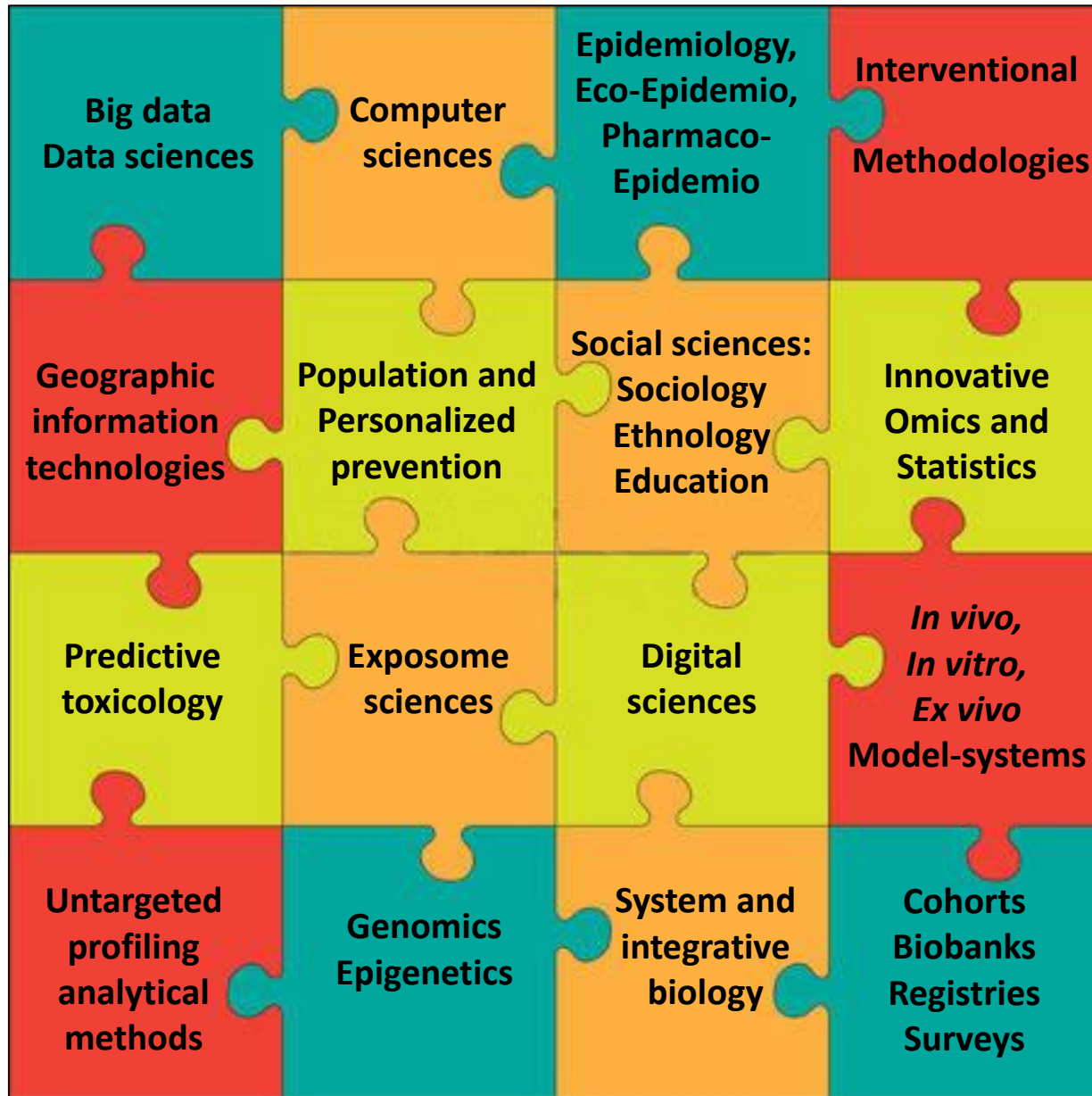
ExOde?

La guerre et la paix, Tolstoï (1879)



*« Lorsqu'un homme se trouve en mouvement, il donne toujours un but à ce mouvement. Afin de parcourir mille verstes, il doit pouvoir penser qu'il trouvera quelque chose de bon au bout de ces milles verstes. L'espoir d'une **terre promise** est nécessaire pour lui donner la force d'avancer. »*

Multi- & Interdisciplinarity



L'Irset aux Antilles depuis 2000

Exposome

PHYSIQUE

- Particules atmosphériques
- Poussières Sahara
- Chaleur

BIOLOGIQUE

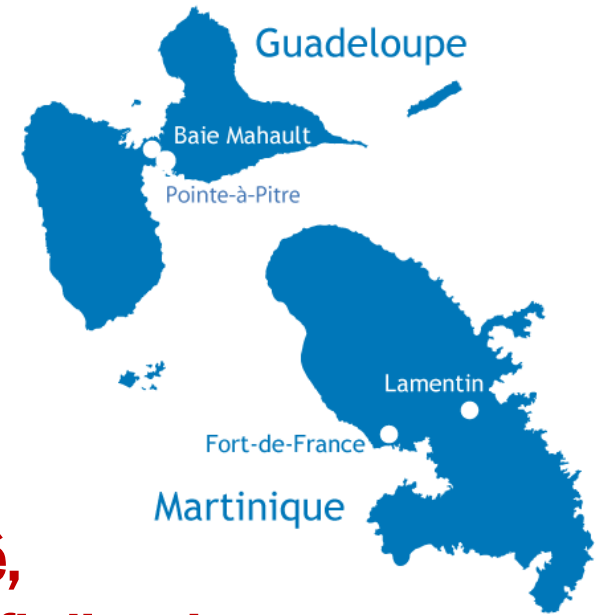
- HIV
- HBV/HCV
- Virus Zika
- HPV

CHIMIQUE

- Pesticides
- Chlordécone
- Sulfure d'hydrogène
- Décharges - Sargasses

SOCIOÉCONOMIQUE

- Inégalités sociales
- Travail
- Comportements



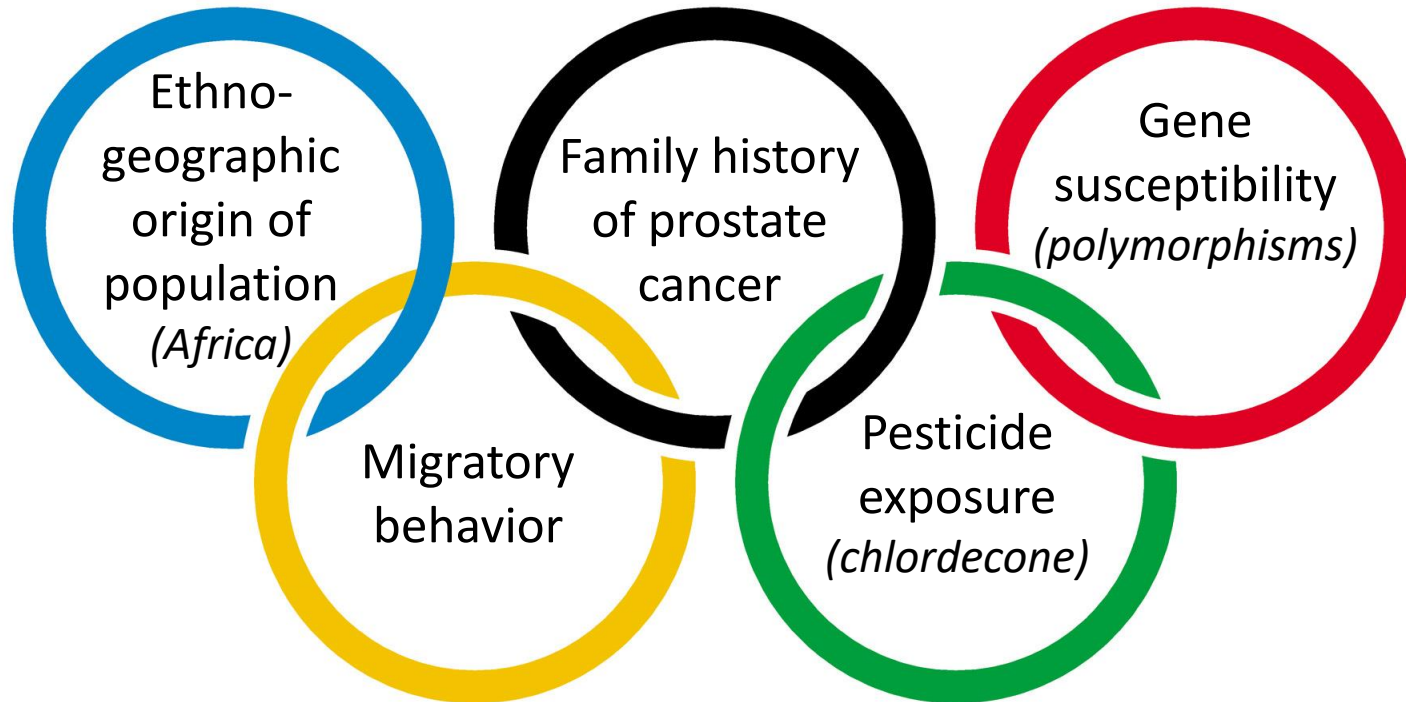
**...et Santé,
...et Défi climatique.**

- *Fertilité*
- *Grossesse - Croissance fœtale - Développement pré- et post-natal*
- *Cancers : prostate, foie, voies aéro-digestives supérieures, poumon*
- *Maladie virale sexuellement transmissible*
- *Gènes - Environnement - Insularité*

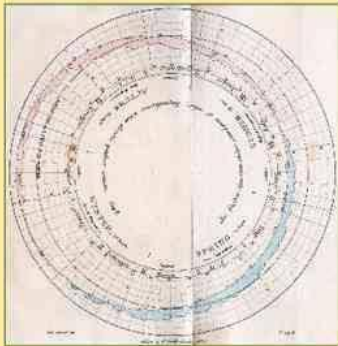
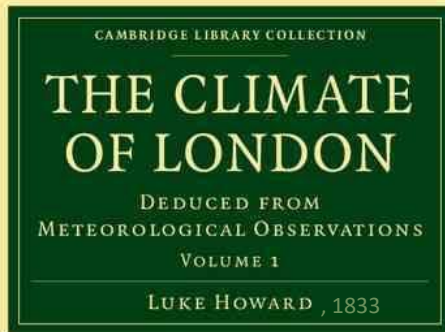
**« One health »
« Global health »**

Exposome tropical...

Exposome in relation to Prostate cancer in the French West Indies



De la *Climatologie* à l'*Expologie*...

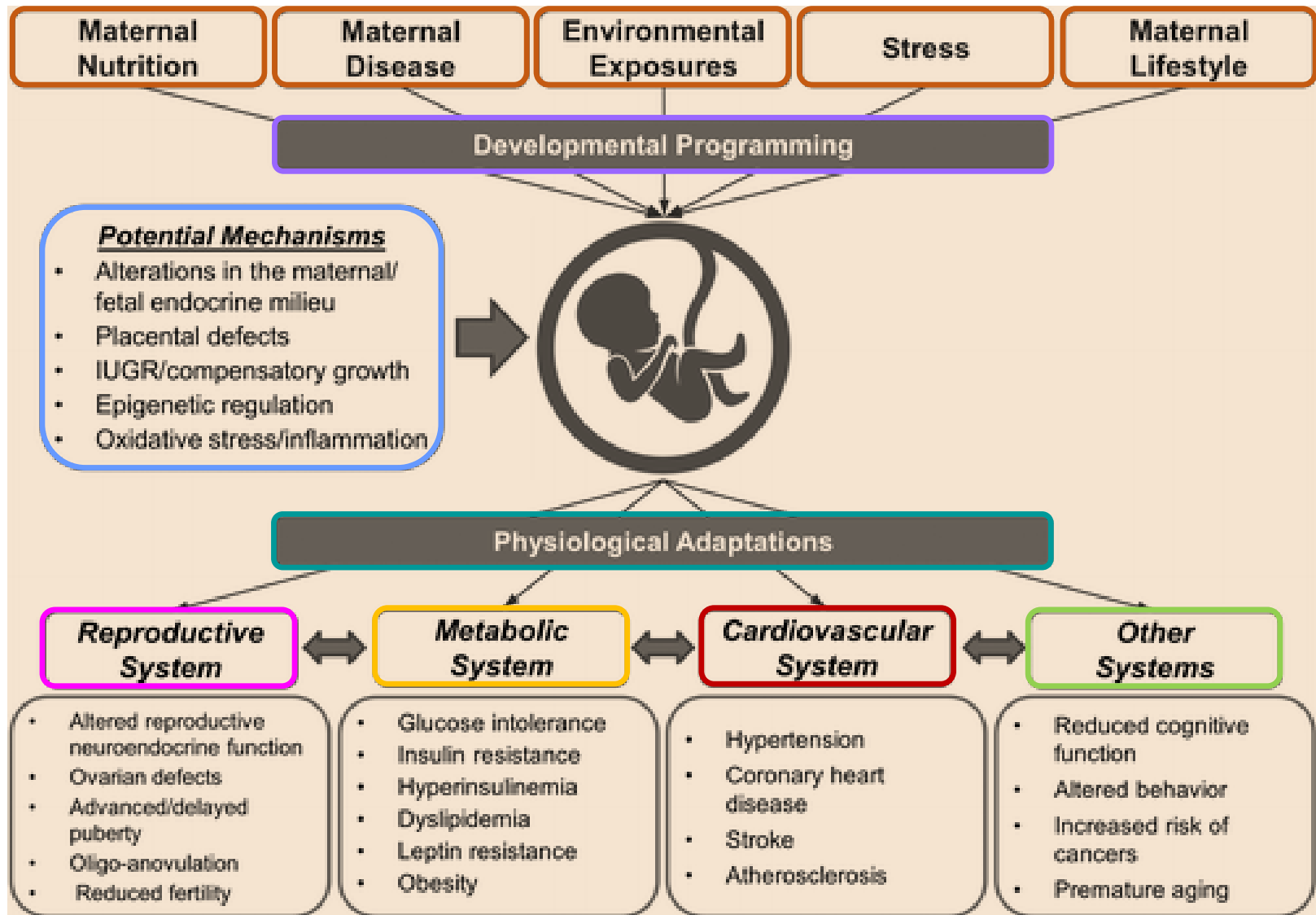


CAMBRIDGE

" Le « **Climat** » est l'agrégat des conditions météorologiques dans une région précise et dans le temps " ...

L'« **Exposome** » est l'agrégat des conditions environnementales dans une région précise et dans le temps.

Perinatal insults in programming adult pathologies in the offspring



Exposome & DOHaD

