



Institut  
**eXposUM**  
UNIVERSITÉ DE MONTPELLIER

# Projets Nexus 2024

SECS, PYPHAS, COCKTAIL, EXPAIR, EMIPSA





Institut  
**eXposum**  
UNIVERSITÉ DE MONTPELLIER

# Nexus SECS

Société & environnement social face aux conduites  
suicidaires

Philippe Courtet





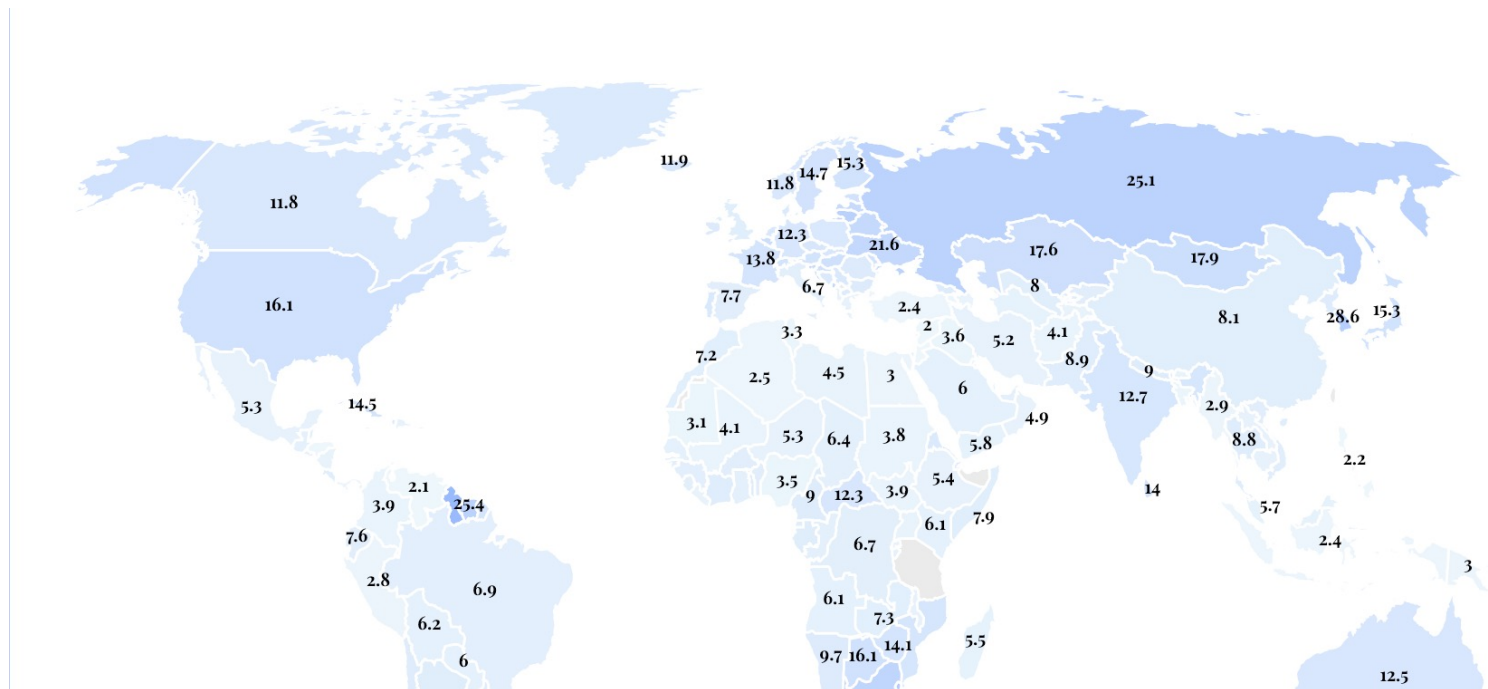
Appel à projets Formation ExposUM #2 2024  
*DOCTORAL NEXUS*

# **Société & environnement social**

## face aux conduites suicidaires (SECS)

### **Philippe Courtet**

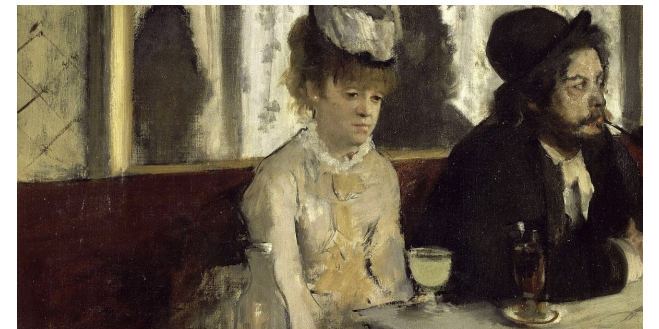
Dans le Monde,  
un mort par suicide toutes les 40 secondes



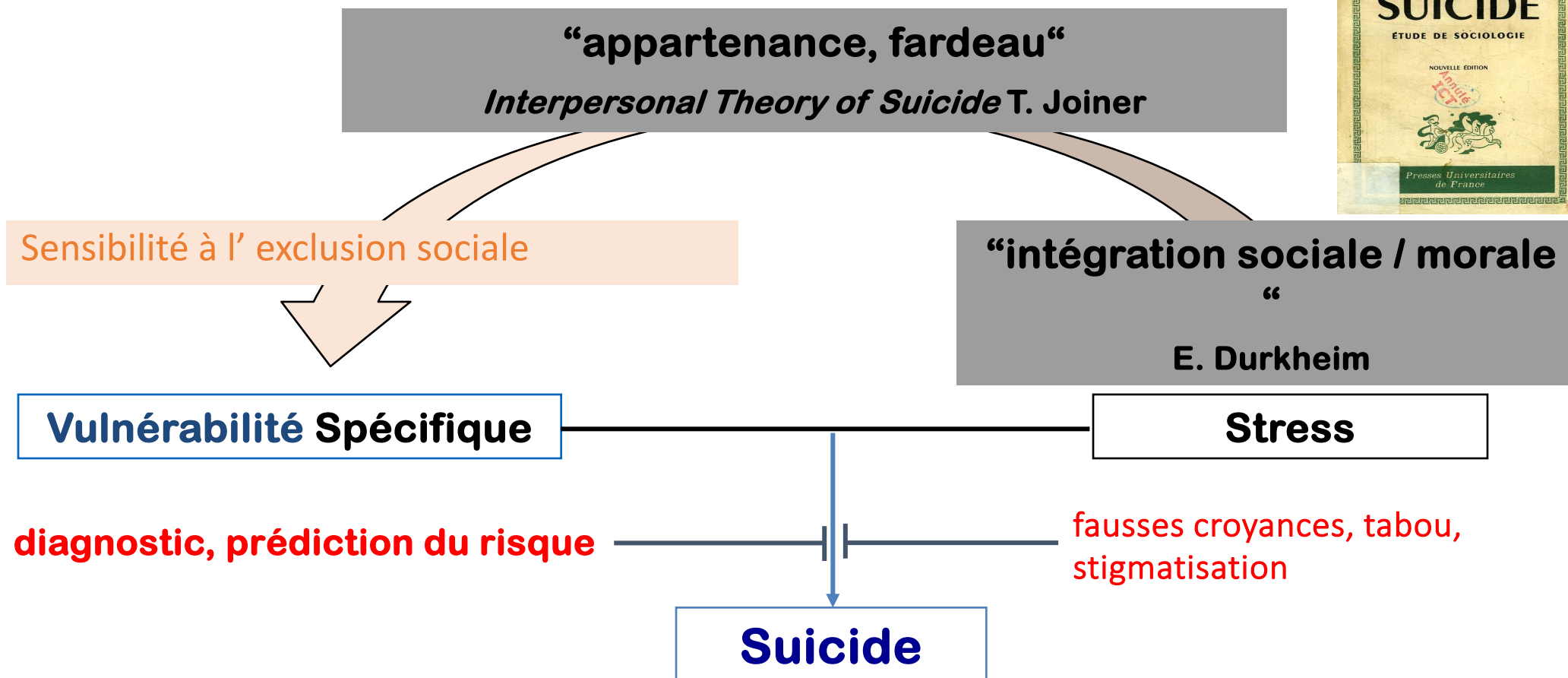
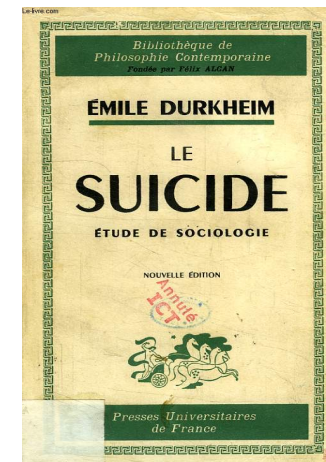
En France, le coût total (direct et indirect) des 10 000 suicides et des 200 000 TS est estimé à 24 milliards d'euros par an

Unavailable 0.4 per 100k 72.4 per 100k

# Directeur général de l'OMS: "transformer les environnements qui influencent notre santé mentale"

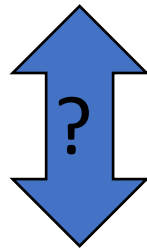


# La Vulnérabilité (sociale) au conduite suicidaire



# Axe 1 - Éthique et Représentations Sociales (Korane Hassan Bileh, Pr F Vialla)

Le suicide assisté en cas de souffrance insupportable et incurable



Prévenir le suicide en soulageant une souffrance psychologique insurmontable

définition consensuelle de la « souffrance »  
capacité à consentir (discernement)

...

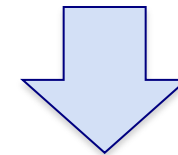
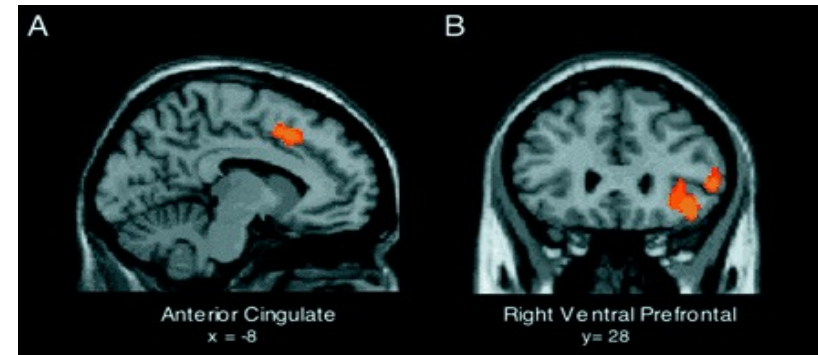
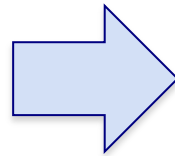
## Axe 2 - Modélisation et Prédiction du Risque Suicidaire (Sara Ibrahim, Pr N Molinari)

- Le risque suicidaire est associé à une plus grande consommation de soins
- Dans les 6 mois d'une TS, les patients ne bénéficiant pas de soins spécifiques de prévention du suicide ont plus de recours à la médecine générale, aux consultations de rhumatologie et à des actes de kinésithérapie
- La consommation de soins pourrait être un indicateur de l'état de douleur psychologique et pourrait aider à mieux prédire le risque de passage à l'acte.
  - Bases de données nationales type SNDS et locales (CHU de Montpellier)
  - IA: algorithmes prédictifs

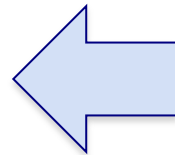


# Axe 3 - Biomarqueurs des conduites suicidaires (Mayssam Chahine, Pr Ph Courtet & E Olié)

ANTONIN ARTAUD  
VINCENT VAN GOGH,  
LE SUICIDÉ DE LA SOCIÉTÉ



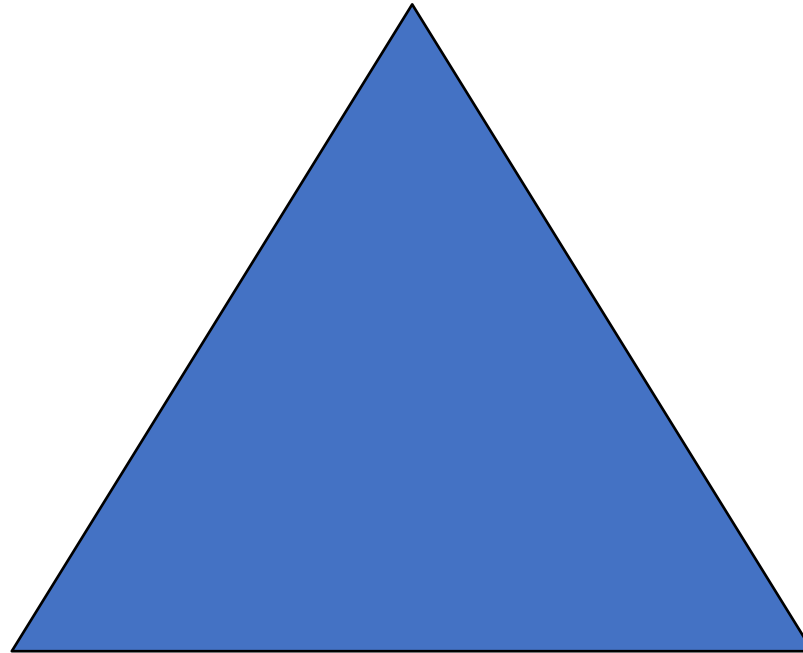
**Suicide**



**Douleur Psychologique  
Inflammation**

# Transdisciplinarité - Partenariat

« Fait Social »



modèle bio-psycho-social

entité clinique (neuroscientifique)



# Transdisciplinarité - Partenariat

« Fait Social »

poids des stress sociaux et la solitude

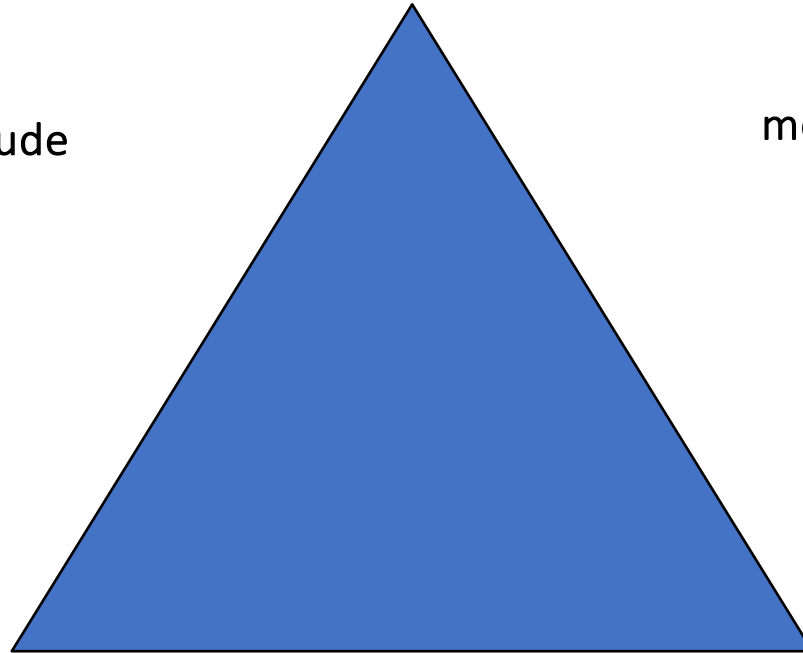
médecine préventive et personnalisée

légalisation du suicide assisté

Parcours de soins rationnels

modèle bio-psycho-social

entité clinique (neuroscientifique)







Institut  
**eXposum**  
UNIVERSITÉ DE MONTPELLIER

# Nexus PYPHAS

A global characterization of PFAS activity and elimination in  
drinking water

Julie Mendret



# A global characterization of PFAS activity and elimination in drinking water - PYPHAS

Porteur : Julie Mendret

[Julie.mendret@umontpellier.fr](mailto:Julie.mendret@umontpellier.fr)

Partenaires : Institut Européen des Membranes, L'Institut des Biomolécules Max Mousseron, l'Institut de Recherche en Cancérologie de Montpellier.



# What are PFAS and what are they used for?

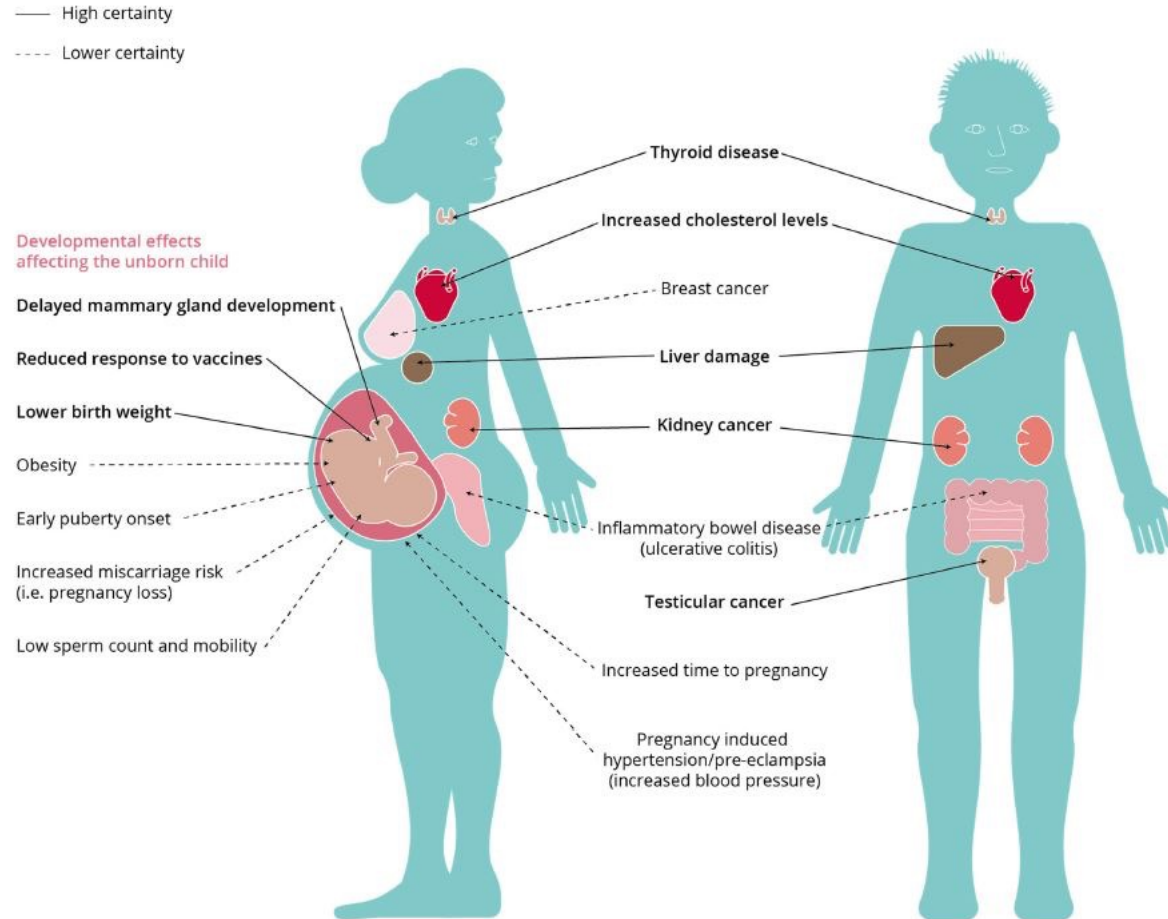
Per- and polyfluoroalkyl substances (PFASs) are a **large group of chemicals** widely used in industrial and consumer applications **since the 1950s**, most usually where extremely low surface energy or surface tension and/or durable water- and oil-repellency is needed.

PFAS are highly mobile in air, water and soil and are mostly persistent. They do not degrade - or only partially. Their lifespan is up to several thousand years, hence their nickname "forever pollutants".



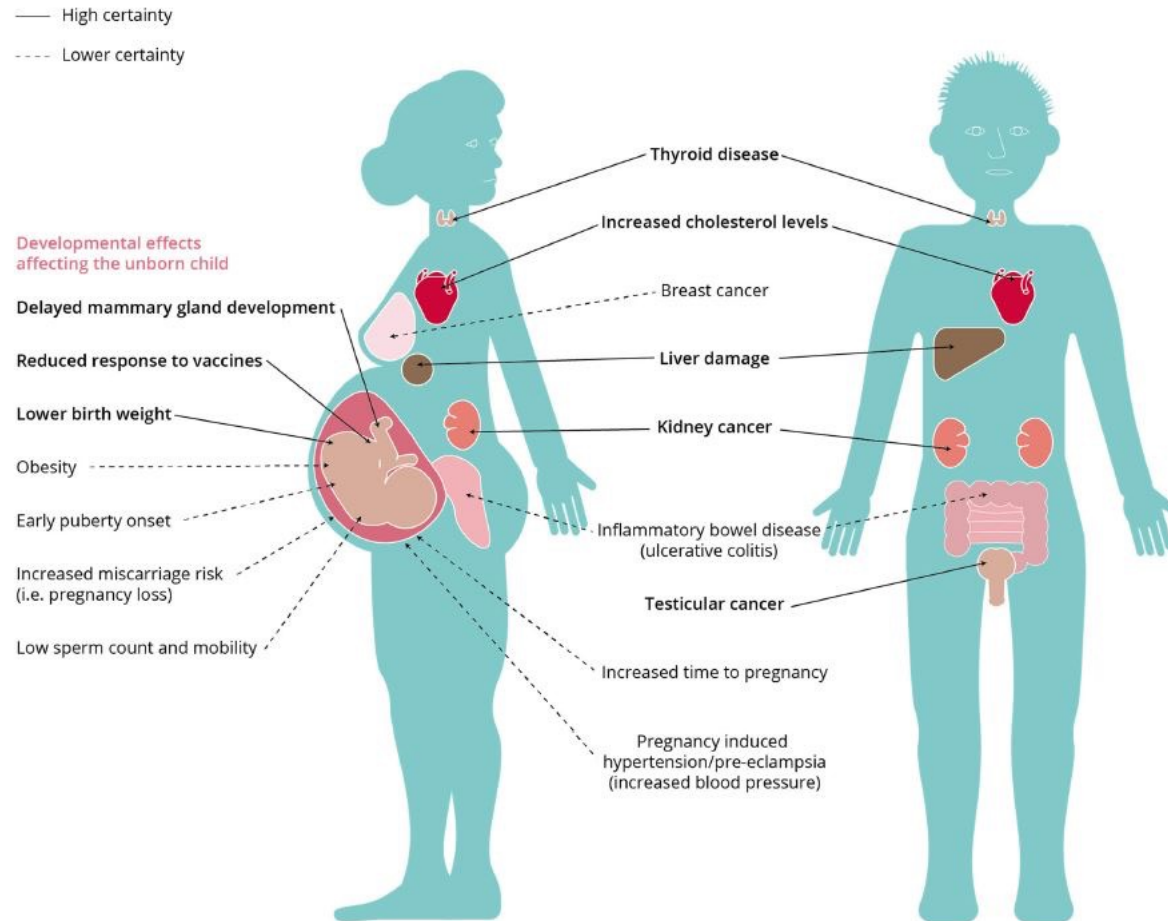


# What are the effects of PFAS on health?



*Environmental Toxicology and Chemistry—Volume 40, Number 3—pp. 606–630, 2021*

# What are the effects of PFAS on health?



A recent study suggest that **PFAS may activate the PXR nuclear receptor** which is a regulator of the growth and apoptosis of colon tumors.

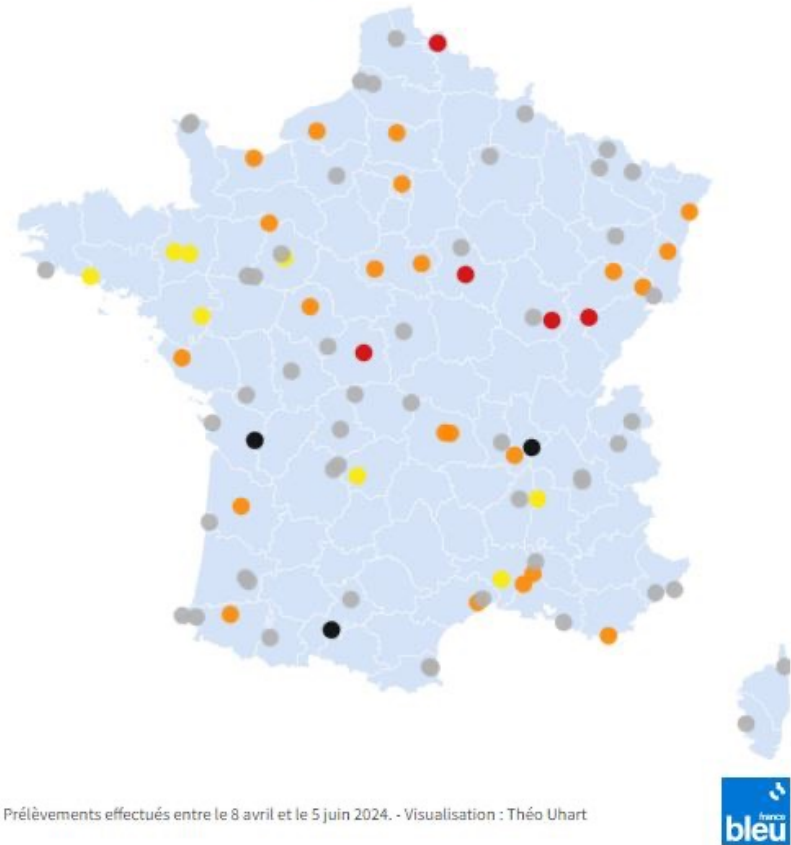
*High-content analysis shows synergistic effects of low perfluorooctanoic acid (PFOS) and perfluorooctane sulfonic acid (PFOA) mixture concentrations on human breast epithelial cell carcinogenesis - Environment International Volume 172, 2023*



# The problem of PFAS in drinking water



- Sous les seuils de détection
- PFAS en faible quantité
- PFAS cancérogènes ou interdits en faible quantité
- PFAS cancérogènes ou interdits en quantité importante
- PFAS en quantité trop élevée



Prélèvements effectués entre le 8 avril et le 5 juin 2024. - Visualisation : Théo Uhart



With evidence of substantial PFAS contamination in France, the cutback of these compounds in water bodies becomes an **urgent public health interest**.

Notably, the recent highlighting of the gap in epidemiological data regarding PFAS's effects on human health **emphasizes the necessity for research geared towards providing input for regulatory guidelines concerning drinking water**.

# Elimination of PFAS from water

## **Efficient processes:**

- Adsorption
- Ion exchange resins
- Membrane processes

....but the pollution is not destroy!

# Elimination of PFAS from water

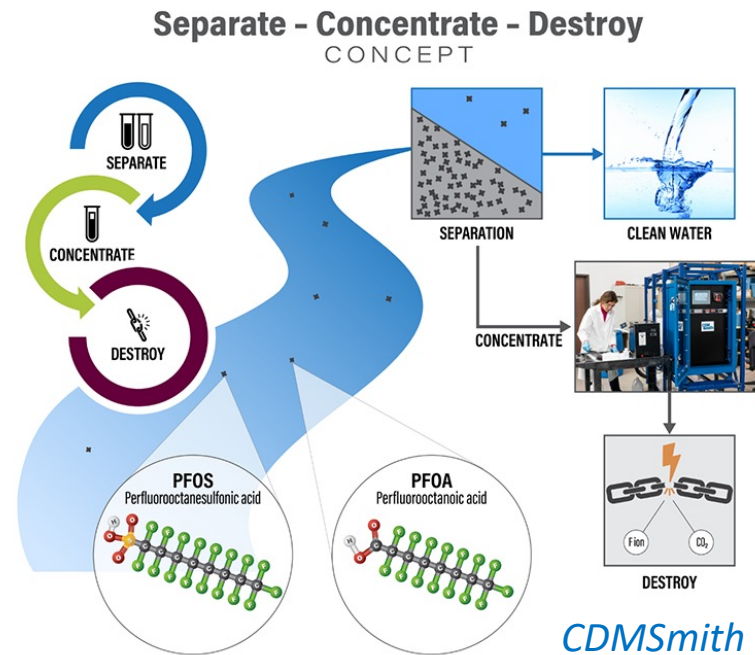
Efficient processes:

- Adsorption
- Ion exchange resins
- Membrane processes

....but the pollution is not destroy!



Using the coupling of membrane filtration and electro-oxidation to eliminate PFAS from water





# Doctoral Nexus PYPHAS

## General objective:

- (i) to propose new strategies to eliminate PFAS from the environment by developing a sustainable wastewater treatment technology
- (ii) to precise the ability of PFAS and its sub-products to activate the PXR signaling and the consequences on intestinal tumorigenesis and on the response of colon cancer to chemotherapies.

- **PhD 1: Coupling nanofiltration and highly effective and stable membranes for electro-oxidation of persistent pollutants in water**



- **PhD 2: Understanding of mechanisms and pathways of PFAS degradation by electro-oxidation in drinking water**



- **PhD 3: Activation of the PXR receptor by PFAS: effects on intestinal tumorigenesis and response to therapy**







Institut  
**eXposum**  
UNIVERSITÉ DE MONTPELLIER

# Nexus COCKTAIL

Development of an advanced airway on-a-chip model to study the effects of a cocktail of pollutants and respiratory viruses on lung tissue

Gladys Massiera, John De Vos



# Projet NEXUS - EXPOSUM

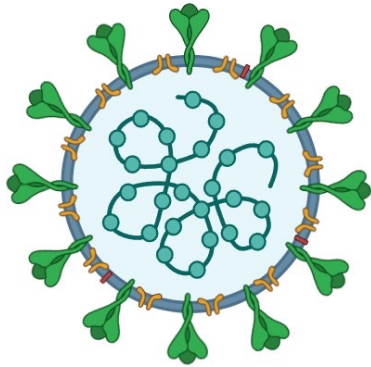


## Nexus COCKTAIL

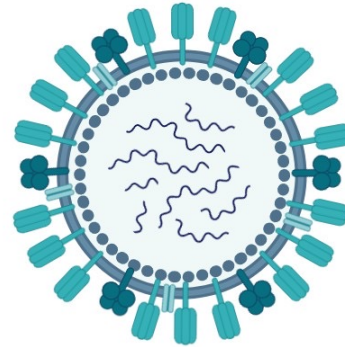
Impact de la combinaison d'une exposition à des polluants et à des virus respiratoires sur un tissu pulmonaire



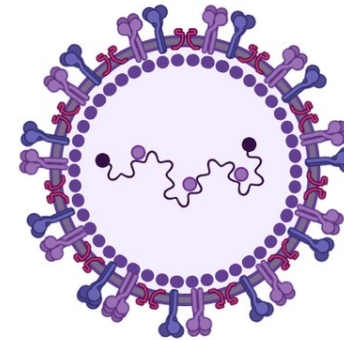
# Les virus respiratoires étudiés



**SARS-CoV2**  
7 millions de  
décès depuis  
2019



**Grippe**  
1 milliard de  
cas chaque  
année

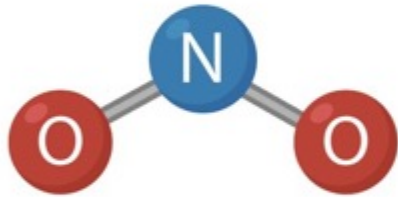


**VRS**  
100 000  
décès  
chaque  
année

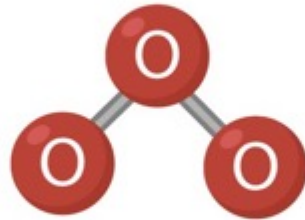
Facteurs de risques : malnutrition, pollution de l'air, exposition à des particules

# Les polluants

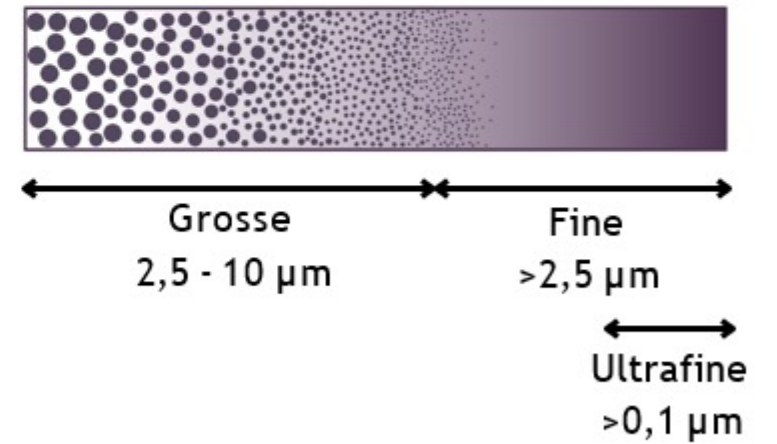
Dioxyde d'azote,  $\text{NO}_2$



Ozone,  $\text{O}_3$



Particules en suspension



Fumée de tabac



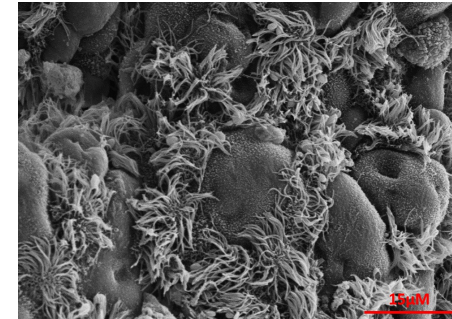
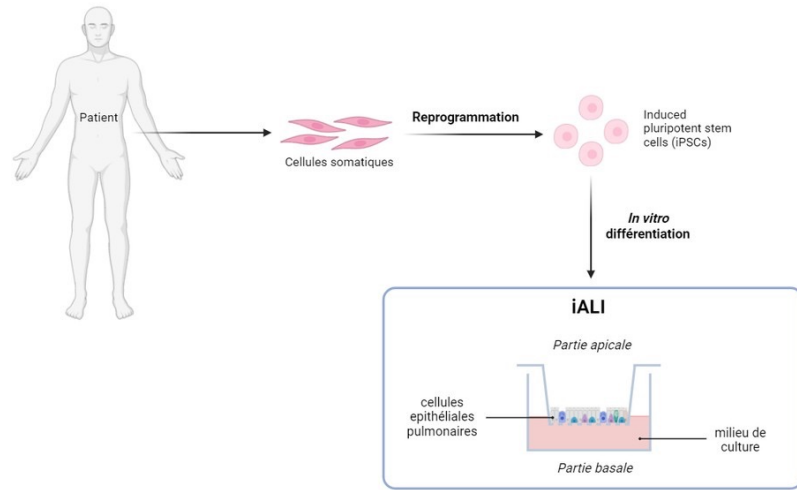
# Les axes de recherche

Exposition aux polluants et aux virus sur des modèles pertinents

Quantification des impacts

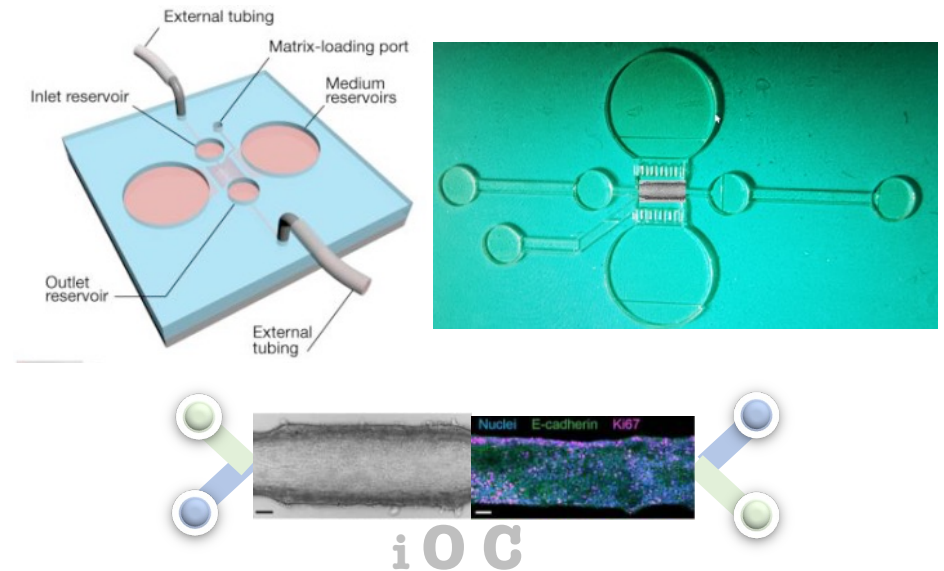
Compréhension des effets cocktail sur la fonctionnalité du tissu

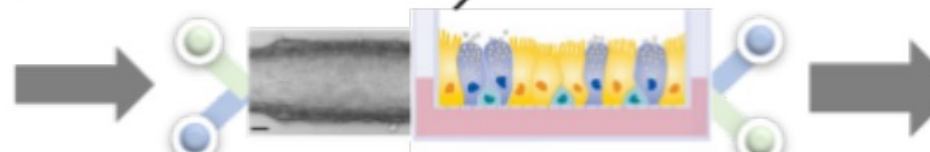
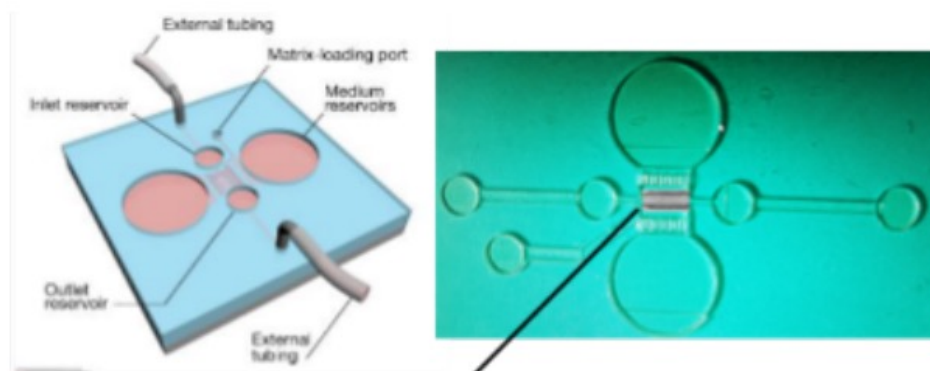
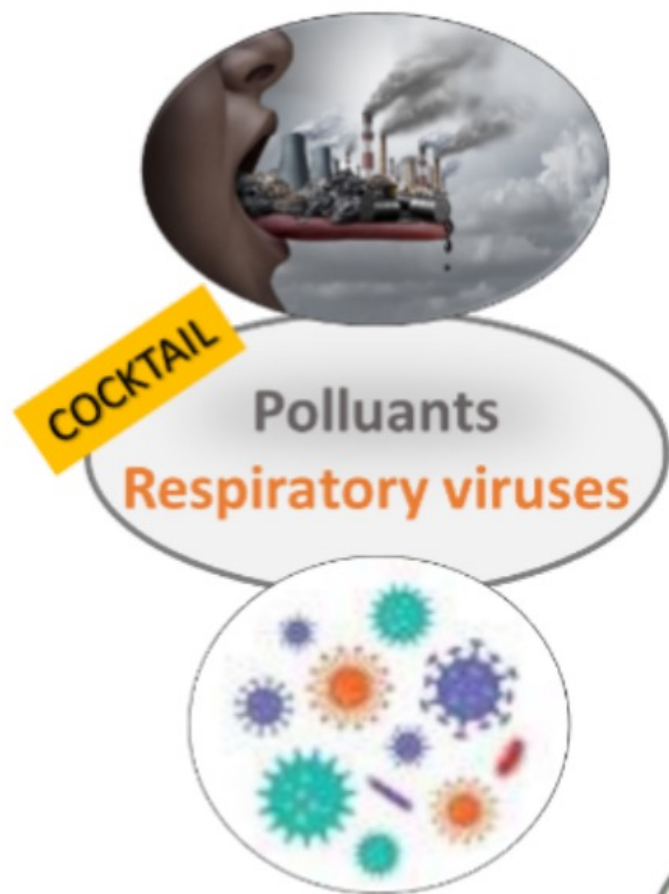




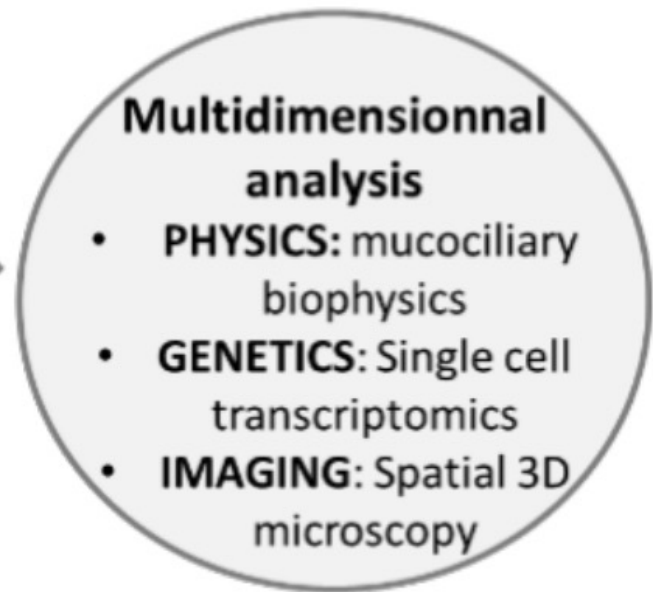
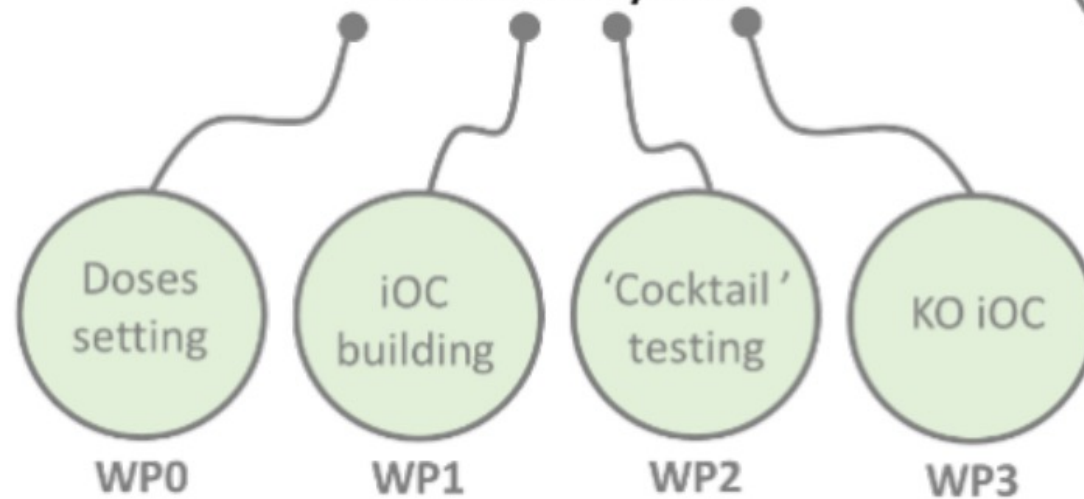
# Modèle iALI

# iALI on a chip (iOC)

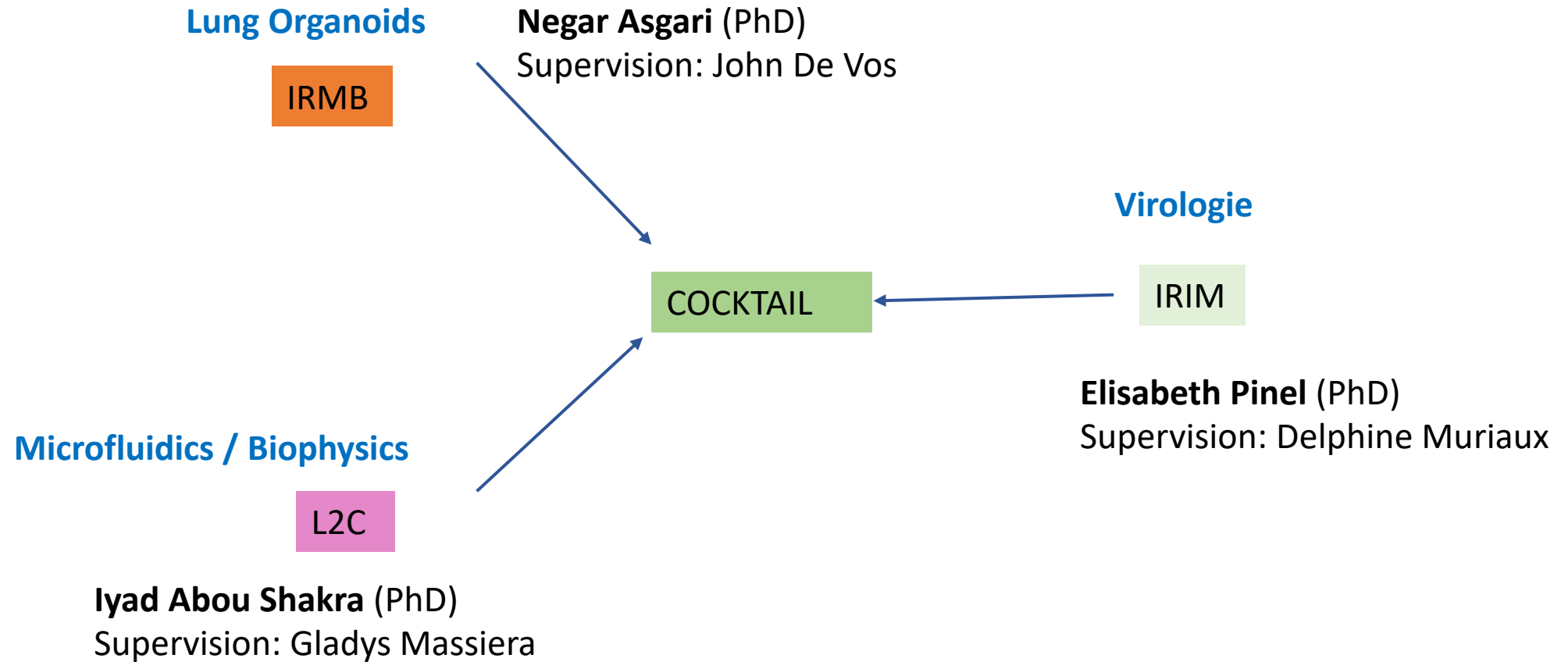




**iALI ON-CHIP / iOC**



# COCKTAIL







Institut  
**eXposum**  
UNIVERSITÉ DE MONTPELLIER

# Nexus EXPAIR

Development of innovative sensors for measuring  
EXPosure to pollutants in AIR to  
unravel cardiorespiratory effects

Aurore Vicet





UNIVERSITÉ DE  
MONTPELLIER

## Projet EXPAIR

# Development of innovative sensors for measuring EXPosure to pollutants in AIR to unravel cardiorespiratory effects

Coordination VICET Aurore, IES

Aurore VICET, Michael BHRIZ, IES – Thesis 1

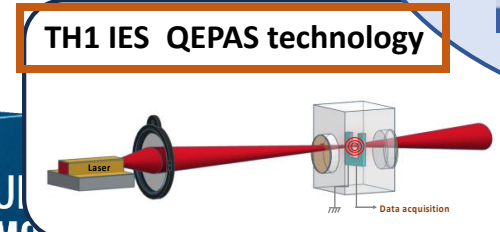
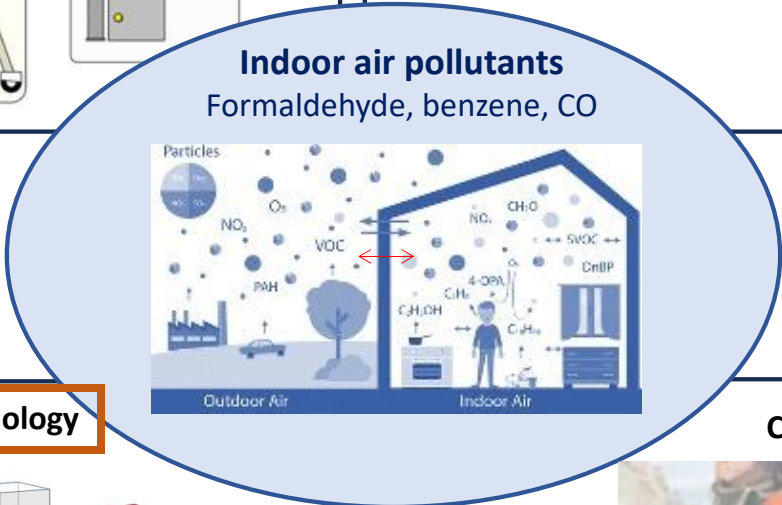
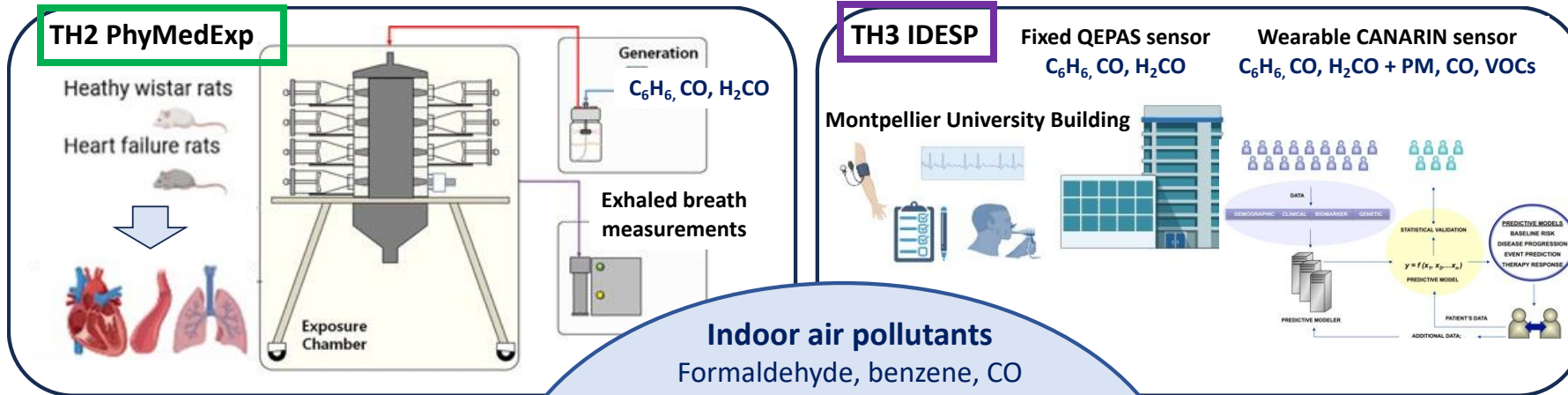
Fares GOUZI, Olivier CAZORLA, PhyMedExp – Thesis 2

Luciana KASE TANNO, Isabella ANNESI-MAESANO, IDESP – Thesis 3



# EXPAIR - Summary

The measurement of exposures to air pollution is crucial and addresses a significant demand from public entities, there exists a compelling necessity to comprehend the underlying phenomena associated with the emergence of human pathologies during both short- and long-term exposure. In this pluridisciplinary project, we will **develop innovative sensors** (QEPAS technology) and **implement low-cost wearable device** (CANARIN) to **perform high resolution environmental, spatio-temporal, individual and in animals exhaled breath measurements** reflecting indoor air pollutants (formaldehyde, benzene, CO) levels and then to **assess the impact of air pollution exposure on the cardio-respiratory health**. In the frame of an epidemiological survey, the totality of external exposome will be considered.



The three thesis are affiliated with IES, PHYMEEXP and IDESP.  
**Objectives :**

TH1) To fabricate sensitive sensors utilizing photoacoustic sensing techniques for the detection of CO,  $C_6H_6$  and  $H_2CO$  in ambient air monitoring and exhaled breath analysis

TH2) To investigate the influence of the internal exposome, assessed through exhaled breath sensing, on cardiovascular systems during chronic exposure

TH3) To analyze the effects of pollutant doses on respiratory health under real- life conditions





# EXPAIR – TH1 – Development of photoacoustic sensors to assess pollutant environment and exhaled breath pollutant exposure ( $C_6H_6$ , $H_2CO$ , $CO$ )

Doc : Fadia ABOU NAOUM

## Context

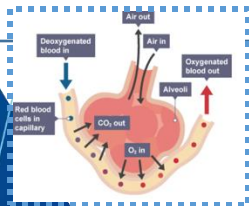
Photoacoustic sensing is a **highly selective and sensitive** method for detecting traces of gas in a gaseous mixture. It uses an **infrared laser** whose wavelength is absorbed by a spectrally fine absorption line of a target molecule. The modulated absorption generates an **acoustic wave** which is detected by a mechanical resonator (quartz tuning fork = QTF), to give rise to **Quartz Enhanced Photoacoustic Spectroscopy**.

This thesis is devoted to the development of photoacoustic sensors of unregulated species, where no precise, rapid and sensitive sensor is yet available ( $C_6H_6$ ,  $H_2CO$ ,  $CO$ ).

## Objectives

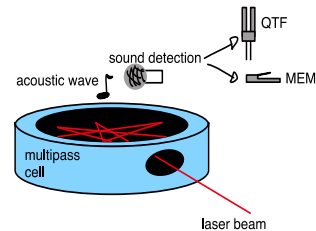
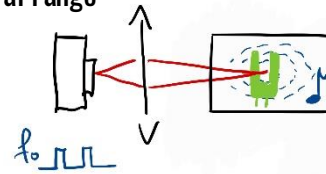
Development of ambient air sensors, assessment of exposure to pollutants. The sensor will be **optimized** in the laboratory and positioned at chosen strategic sites for 2 weeks measurement campaigns.

Development of **exhaled breath sensors for physiological analysis of pollutant levels in respiratory compartments**, application to animal model.

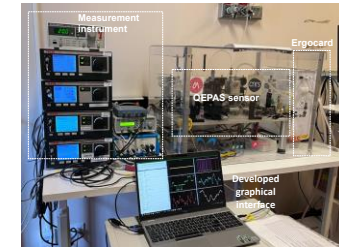
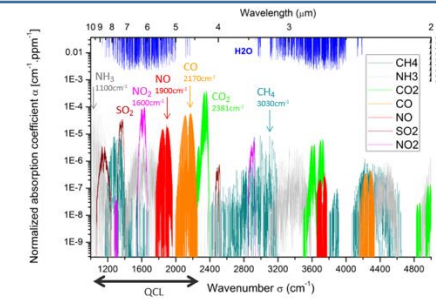


## Methods

Laser Quartz Enhanced Photoacoustic Spectroscopy in the infrared spectral range



- **multi-pass PA approach** → increase the light density near the resonator.
- An acoustically resonant cell will be considered to increase acoustic coupling : a **total gain of more than a factor of 50 can be achieved on previously published detection limits (QEPAS)**.



- **exhaled breath measurements** + respiratory sampling equipment.
- recording of expirograms: flows, volumes, capnography and simultaneous measurement of gaseous species of cardiovascular interest.
- multi-gas measurements in human breath and adaptation of the device to the **animal model**

## Interactions within EXPAIR

- measurement campaigns carried out during thesis 3 with ambient air sensors.
- Exhaled breath sensors will be used in thesis n°2 to analyze breath in the animal model

## Perspectives

- Enhancement of sensing performances thanks to a new optical approach
- New sensors for health can be transposed to many real life gas sensing demands

# EXPAIR – TH2 – Role of internal exposome assessed by exhaled breath sample on cardio-vascular and lung systems during chronic exposure of emerging pollutants

Doc : Joudi HELLO



## Context

Emerging pollutants, benzene (C<sub>6</sub>H<sub>6</sub>), carbon monoxide (CO), formaldehyde (CH<sub>2</sub>O) sulfur dioxide (SO<sub>2</sub>) may have a negative impact on the cardiovascular and respiratory systems. Yet, they are mostly found indoor, inducing intermittent and low-dose exposure. Measuring their concentration in the human exhaled breath is a non-invasive method that reflect more closely the body burden of these pollutants.

→ During experimental model of chronic exposure to emerging pollutants (C<sub>6</sub>H<sub>6</sub>, CO, CH<sub>2</sub>O et SO<sub>2</sub>), **exhaled breath concentrations could impact the cardio-vascular and lung systems, in a dose-dependent manner.**

## Objectives

- To characterize the exhaled breath concentrations during tidal breathing of pollutants (C<sub>6</sub>H<sub>6</sub>, CO, H<sub>2</sub>CO) in healthy and chronic heart failure rats during long duration and low concentrations/intermittent exposure.
- To assess the dynamic of exhaled breath concentrations of pollutants during chronic low concentration and acute intermittent exposure to pollutants in exposed rats. Define a protocol of exposure to standardize the exhaled breath concentrations of pollutants in exposed rats.
- To assess the impact on hemodynamic and on the cardiac vascular and lung functions and remodeling of exhaled breath concentrations of pollutants *in vivo* and *ex vivo*.

## Methods

### Animal model and exposure

Healthy Wistar rat

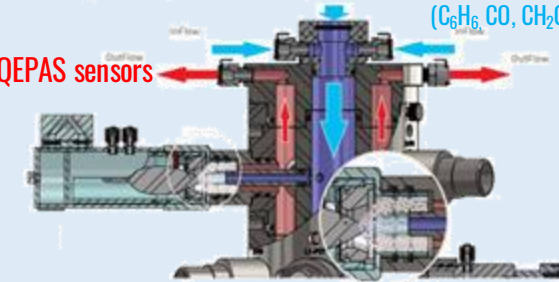
COPD Wistar rat



Inhalation tower

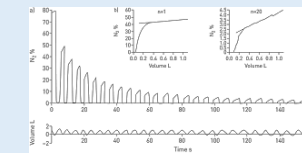
Pollutants exposure  
(C<sub>6</sub>H<sub>6</sub>, CO, CH<sub>2</sub>O and SO<sub>2</sub>)

QEPAS sensors



### Physiology and internal exposome assessment

Pollutant clearance: tidal ventilation



Protocol for standardized exposure



Cardio-vascular and respiratory functions *in vivo* / *ex vivo*

Dose-toxicity assesement

## Perspectives

- Develop and validate a innovative method of assessment of internal exposome through exhaled breath measurement
- Evaluate the impact of chronic and low-dose pollutant on cardiovascular and respiratory systems

# EXPAIR – TH3 – Impact of external exposome focusing on air pollutants on cardiorespiratory health under real-life conditions

Doc : Pham Thao Van LUONG

## Context

Respiratory and cardiovascular diseases significantly impact global health, and their incidence is increasing due to environmental exposures changes, particularly in terms of air pollutants

-> An urgent need exists for research into the comprehension of respiratory effects of air pollution at the individual level in real time

### Challenges:

- Taking into account the complexity of pollutants exposure in real time at the individual level
- Considering indoor air pollution exposure that depends on lifestyle
- > To assess a multipollution exposure score

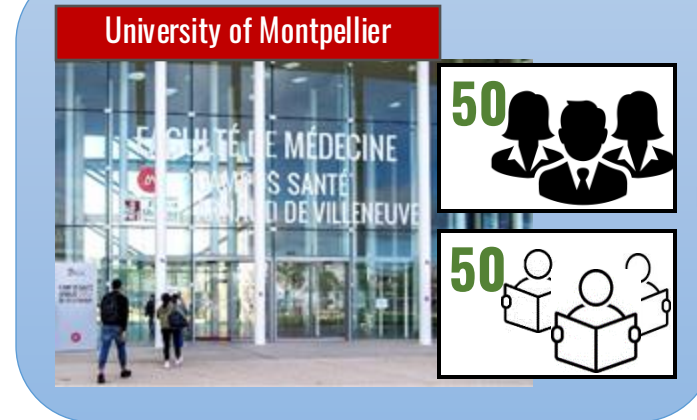
## Objectives

- To evaluate how subjects drawn from the general population are exposed to air pollutants (benzene, formaldehyde, PM, CO, VOCs) and comfort parameters (T, Hum, CO2) in real-life using fixed and mobile sensors (at the individual level the latter) and how their exposure evolves in time.
- To take the spatio-temporal dimension to air pollutants and comfort parameters through a portable sensor (Canarin) at the individual level in real time and thus exposure evolution into account.
- To assess a multipollution exposure score
- To evaluate the relationship of exposure to air pollutants and comfort parameters to cardiorespiratory clinical parameters through an exposomic approach taking other exposures and risk factors into account.
- To estimate inhaled doses of pollutants based on heart rate and specific equations.

## Methods

### Study design

#### Recruitment of participants



#### Data collection



### Data analysis

- Descriptive and time-series analyses: to examine air pollution exposure and health outcomes across the three visits
- Environment-wide Association Study (EnvWAS) methods: to assess associations between external exposure to pollutants through QEPAS and Canarin sensors and clinical cardiorespiratory outcomes
- Inhaled doses assessment: will be estimated based on heart rate and ad hoc equations

## Interactions within EXPAIR

- QEPAS sensor (Th1)
- Innovative cardiopulmonary outcome assessments (Th2)
- External vs. Internal exposome (Th1 and Th2)

## Perspectives

- Raise public awareness about outdoor and indoor pollution hazards
- Promote individual-level exposure monitoring
- Support evidence-based public health policies by providing valuable data on the dose-dependent health effects of specific pollutants





Institut  
**eXposUM**  
UNIVERSITÉ DE MONTPELLIER

# Nexus EMIPSA

Épidémiologie et évolution des maladies  
infectieuses dans des populations structurées en âge

Rémi Choquet, Sébastien Lion



**Présentation du Projet Doctoral Nexus « EMIPSA »**

**Épidémiologie et évolution  
des maladies infectieuses  
dans des populations structurées en âge**

Journée annuelle de l'Institut ExposUM – 13/11/2024

# Motivation

## Leçons du COVID-19

- Les flambées **épidémiques** de **pathogènes** participent à notre **exposome**, de façon intermittente mais critique.
- La dynamique **épidémiologique et évolutive** des maladies infectieuses est **difficile à prédire**.
- La **structure des populations** (âge, espace, immunité) affecte la dynamique des maladies infectieuses.

## Approche écologique des maladies infectieuses

Pour comprendre et prévoir l'épidémiologie et l'évolution d'un pathogène, il faut :

- prendre en compte l'**effet de l'environnement** sur le succès d'une souche de pathogène
- coupler **santé publique, écologie, évolution et mathématiques**

# Le Nexus EMIPSA (2024-2028)

## Organisation

- Une équipe interdisciplinaire de **biologistes, statisticiens, mathématiciens** et **cliniciens**
- **3 sujets de thèse** en interaction à **Montpellier**
- **1 collaboration** avec un 4ème sujet de thèse à **Toulouse**
- **7 unités de recherche**

## Objectif

**Analyser et comprendre  
la dynamique épidémiologique et évolutive des pathogènes  
au moyen de modèles structurés en âge**

## 4 contrats doctoraux

**Sujet 1: Évolution des stratégies d'histoire de vie des pathogènes : âge d'infection, hétérogénéité et plasticité** [*Écologie évolutive (ED GAIA)*]

Doctorante : **Armelle Poisson**

Dir: S. Lion et S. Gandon (CEFE) + O. Ronce (ISEM)



**Sujet 2: Dynamique épidémiologique et évolutive intra-hôte du paludisme** [*Mathématiques et Modélisation (ED I2S)*]

Doctorante: **Ndeye Khady Gningue** (Sénégal)

Dir: R. Djidjou-Demasse (MIVEGEC-Sénégal), Q. Richard (IMAG), S. Gandon (CEFE)



**Sujet 3: Préparation du système de soins critiques aux futures crises sanitaires** [*Biologie - Santé (ED CBS2)*]

Doctorante: **Ana Guijarro-Matos** (Espagne)

Dir: M. Sofonea (PCCEI), J.-Y. Lefrant (CHU Nîmes), R. Choquet (CEFE)



**Sujet 4 (hors Nexus) : Dynamique évolutive des populations structurées dans un régime de mutations faibles: application à l'épidémiologie**

[*Mathématiques et Modélisation (ED Toulouse)*]

Doctorante: **Caroline Guinet**

Dir: S. Mirrahimi et J.-M. Roquejoffre (Toulouse) + S. Lion (CEFE)





# Nexus EMIPSA : Montpellier

