

# Freedom in Spectroscopy

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# Overview

What is Spectroscopy ?

Fundas :)

Spectrum

Kinds

What is a Spectrophotometer ?

Constitutes ...

In simple terms ...

What is the Necessity ?

Ecology

Geology

Space

Medicine

Why not make it Free ?

How can one Participate ?

Making One !

Know to Start

Know the Limits

What can be done with it ?

Ask: What I can do ?

Ask: What We can do ?

Dreams !

Any Values ?

Attempts

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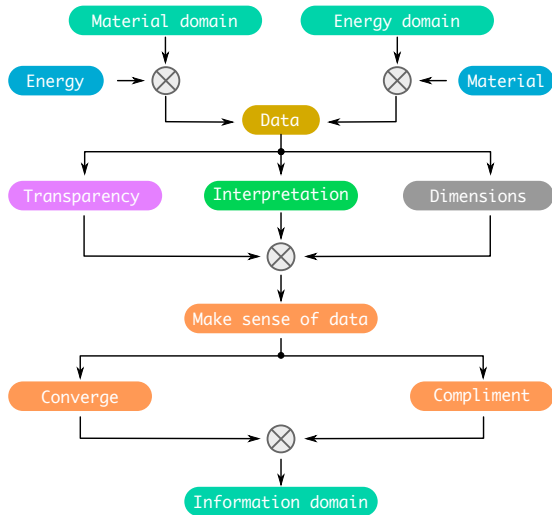


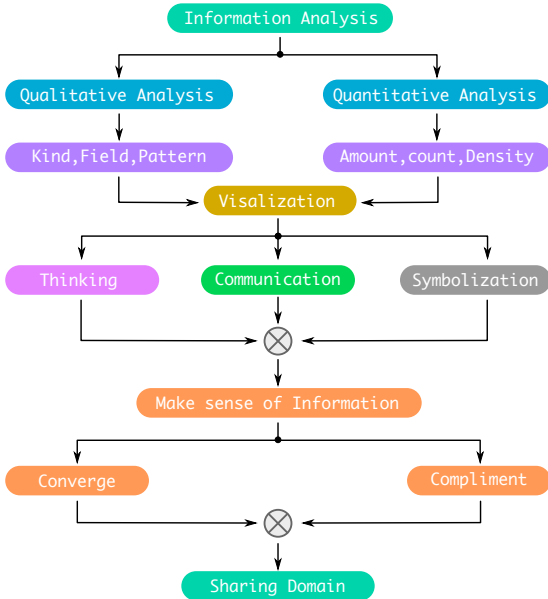
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Let's Start ...

Why need Instrument ?



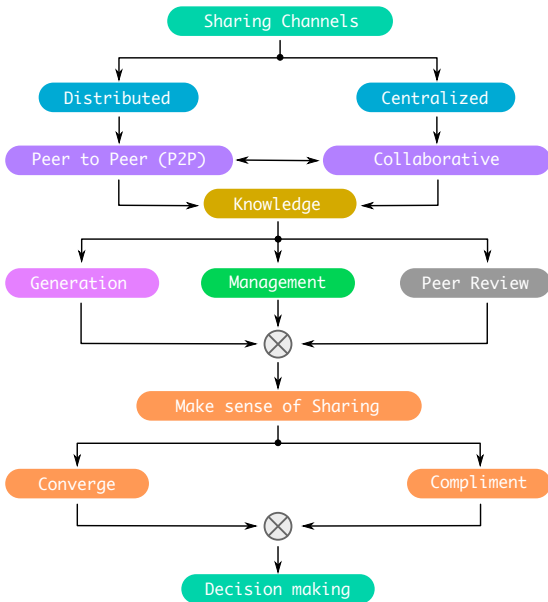




Begin to Share without any middle man

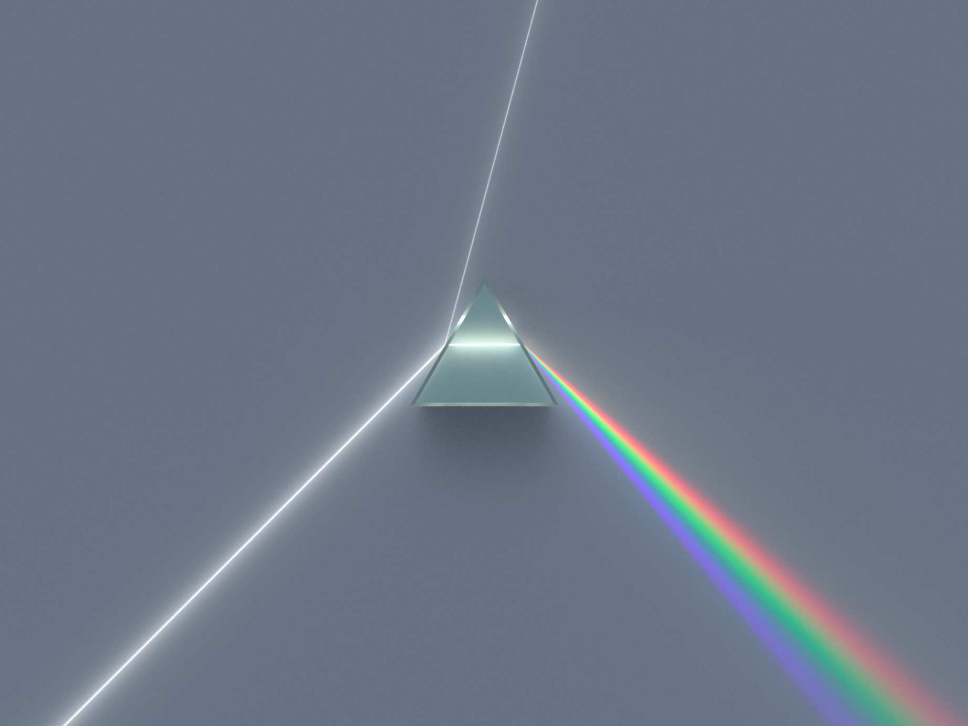
Manage Knowledge personally & Collaboratively

Sharing to make sense depends on critical decisions



if you want to find the secrets of the universe, think in terms of  
energy, frequency and vibration

- Nikola Tesla



# Why Spectroscopy ?

**For communication or exploration or analysis or identification or for fun :)**

- ▶ Smell
- ▶ Taste
- ▶ Texture
- ▶ Shape
- ▶ Size
- ▶ Mass
- ▶ Structure
- ▶ Composition

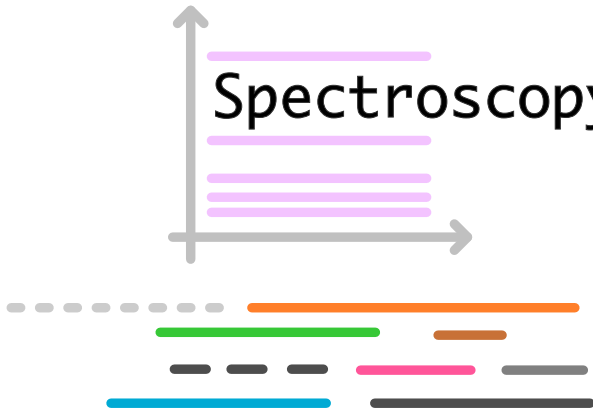
Which one is the most fundamental that can help derive other measurements ?  
Or can one be mixed with other ones to make a most accurate, precise, reliable  
– possibly true or factual measurements possible ?

Think ! Think ! Think :)

$$E=h\nu$$



Spectroscopy



$$c=\lambda\nu$$

# What is Spectroscopy ?

Study of Interaction between Matter & Electromagnetic Radiation

- - - - -

Measurement of Radiation Intensity as a function of Wavelength

Resonance

- - - - -

Resonant Frequency

- - - - -

Spectrum  $\equiv$  Collection of Resonant Frequencies

Wave Nature, or Particle Nature or Quantum Nature

- - - - -

They are all our ideas & triumphs to understand Nature better

- - - - -

through Material & Energy



Electromagnetic spectrum through the eyes of XKCD :)

I love xkcd. Don't U ?



It is the fundamental part of Nature



Air, Water, Soil

## Depends on:

- ▶ *What part of Spectrum (Energy) one is looking at ?*

- ▶ Radio - VLF, LF, HF, VHF, UHF, MW
- ▶ Infrared - Thermal, FIR, MIR, NIR
- ▶ Visible
- ▶ Ultraviolet
- ▶ Ionizing - X rays, Gamma rays
- ▶ ...

- ▶ *What Excitation Energy involved ?*

- ▶ Translational
- ▶ Rotational
- ▶ Vibrational
- ▶ Electronic
- ▶ ...

## Depends on:

- ▶ *What Interaction theory used for study ?*

- ▶ Emission
- ▶ Absorption
- ▶ Reflectance
- ▶ Transmittance
- ▶ Fluorescence
- ▶ Molecular
- ▶ Infrared
- ▶ Raman
- ▶ Impedance
- ▶ Atomic Mass
- ▶ ...

## Depends on:

- ▶ *How one sees & uses it ?*
  - ▶ For Communication
  - ▶ For Exploratory Analysis
  - ▶ For Testing
  - ▶ ...
- ▶ *What technology used for Measurement ?*
  - ▶ Fourier Transform
  - ▶ Acousto-Optics
  - ▶ Electro-Optics
  - ▶ Nuclear Magnetic Resonance
  - ▶ ...

# Applications

## Used primarily in:

- ▶ Material Identification
- ▶ Food Inspection
- ▶ Drug Inspection
- ▶ Remote Sensing
- ▶ Space Probes
- ▶ ...

## Can be coupled with:

- ▶ Microscopy
- ▶ Telescopy
- ▶ Astronomy
- ▶ Remote Sensing
- ▶ LIDAR
- ▶ Robotics
- ▶ ...

# Spectrophotometer





# What is a Spectrophotometer ?

## An Instrument that:

- ▶ Helps study the ***Interaction*** between Energy and Matter.
- ▶ ***Measures*** Radiation Intensity during such ***Interaction***.
- ▶ ***Analyze*** collected Spectrum within the Bandwidth.
- ▶ ***Identify species*** of the material under test.

# What does a Spectrophotometer Constitutes of ?

1



Excitation Source

2



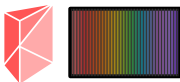
Sample Placement

3



Collimation

4



Dispersion or Diffraction

5.a



Electronic Detection

5.b



Manual Observation

6.a



Measured Spectrum

7



8



6.b

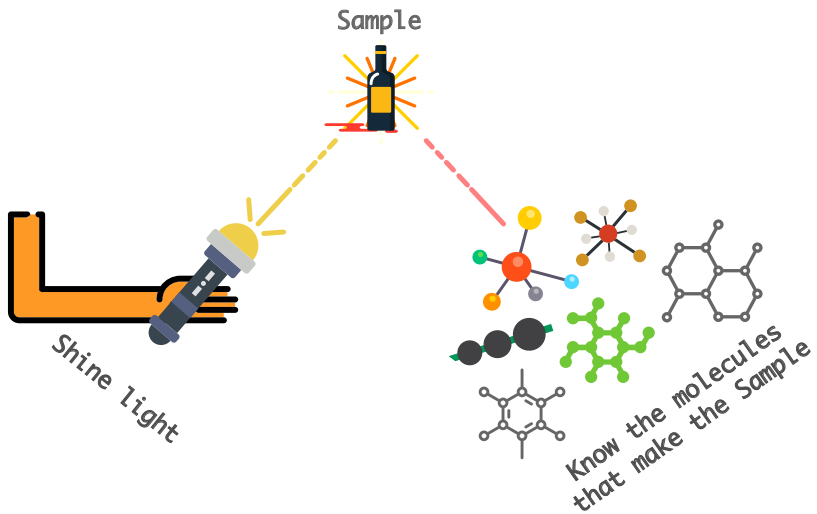


Observed Spectrum

Pal... ! can you make it Simple !...



Ok ! Le me Try 😊



So What ???



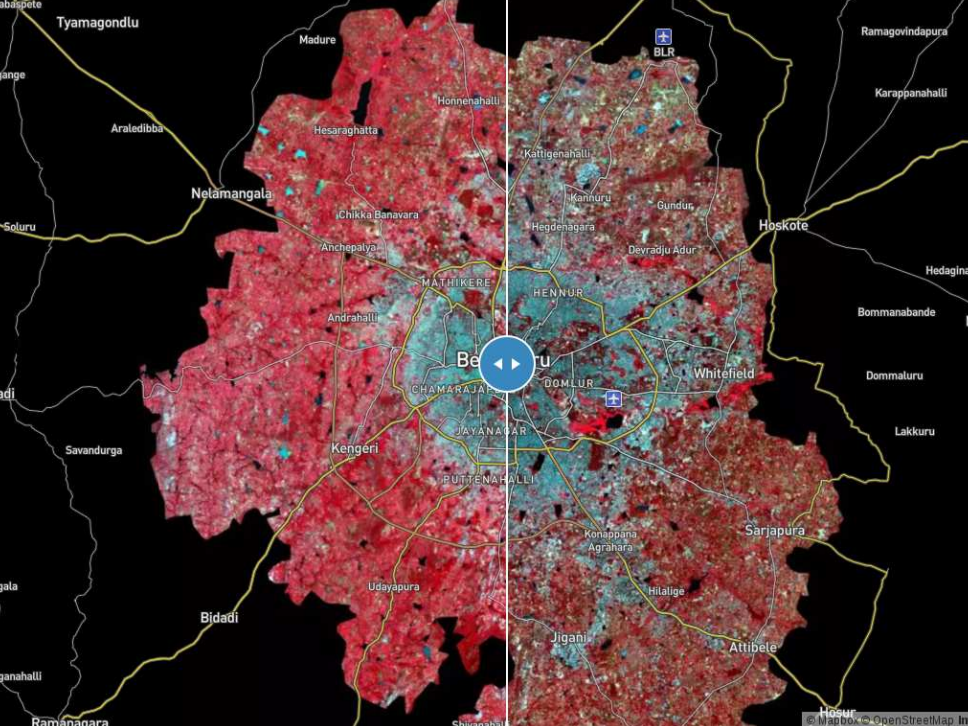
# Necessity

**We Humans always tend to damage Systems, learn from it & again attempt to repair it !**

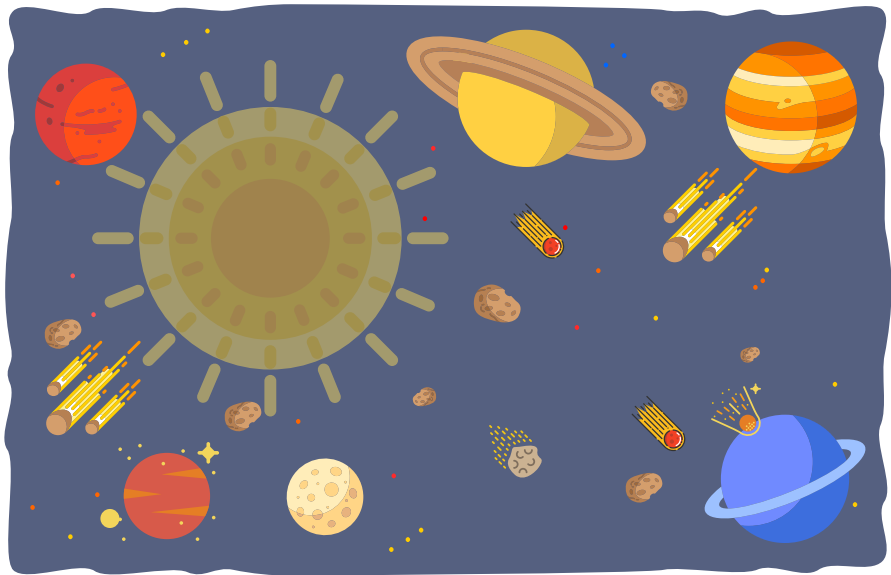
- ▶ Don't u want to know the truth ?
- ▶ Every instrument at some point of time is a DIY triumph of someone ! Its time to make it open !
- ▶ Is it not the right time to make Scientific Instruments Democratic ?
- ▶ Is it not the time to make Education more fun through Discovery ?
- ▶ Is it not the time to practice Collaboration based Peer Production (**CBPP**) principles ?
- ▶ I do want to know what is my food ? without believing the data provided by somebody else !
- ▶ Be the inspector yourself ! (**end to end inspection** is never before democratized)
- ▶ Now i can stamp my food with its true nutritional value, which others can verify !
- ▶ With **e2e inspection**, no need of "monitoring" establishments :p



Some of us interested to know what's in these ... TRULY ! & REALLY







Are you interested in knowing what's there & what they made of ?

A collage of various medical and pharmaceutical icons. It includes several pills and capsules in different colors (red, blue, green, purple, yellow) and shapes (round, oval). There are two syringes, one large and one small. A blood pressure monitor is also visible. The icons are scattered across the page, some overlapping, creating a busy, healthcare-themed background.



Cool ! It's getting Interesting ...



Freeeeedom !



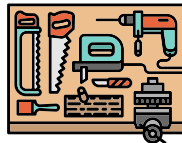
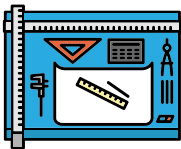
# Freeing :)

- ▶ As open community with collaborative practice
- ▶ Using Free Software based CAD/CAE tool for design
- ▶ Using Free Hardware designs & tools to make
- ▶ Using Free Software OS, libraries to create firmware, software stacks
- ▶ Using Free Database stack
- ▶ Using Free Data Analysis tools (discipline specific)
- ▶ Using Free UX design stacks
- ▶ Using Distributed architecture for Sharing Data, Analytics

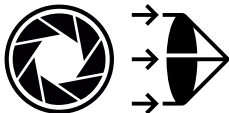
# Participation

What kind of guys do we need for Co-operative + Collaborative participation ?

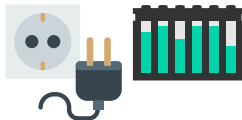
- ▶ Documentation
- ▶ Mechanical
- ▶ Optics, Electromagnetics
- ▶ Electrical
- ▶ Electronics
- ▶ Software
- ▶ Data Sharing & Distribution
- ▶ Data Analytics
- ▶ Chemoinformatics(Chemometrics) (depends on data)
- ▶ Proteomics (depends on data)
- ▶ Bioinformatics (depends on data)
- ▶ Pattern Recognition & Matching
- ▶ Machine Learning
- ▶ Knowledge generation & Management



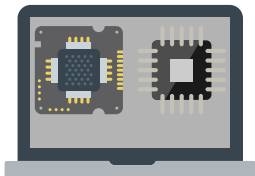
Mechanical - Design & Construction



Optical - Design & Construction



Electrical - Power conditioning



Electronics - Design, Fabrication

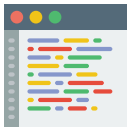


Chemoinformatics - Data Analysis  
Pattern Matching  
Machine Learning



Bioinformatics - Data Analysis  
Pattern Matching  
Machine Learning

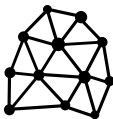




Software - Algo. Dev., UX Design



Data Analytics



Distributed - Data Sharing, Network Systems

# Construction



# Construction !

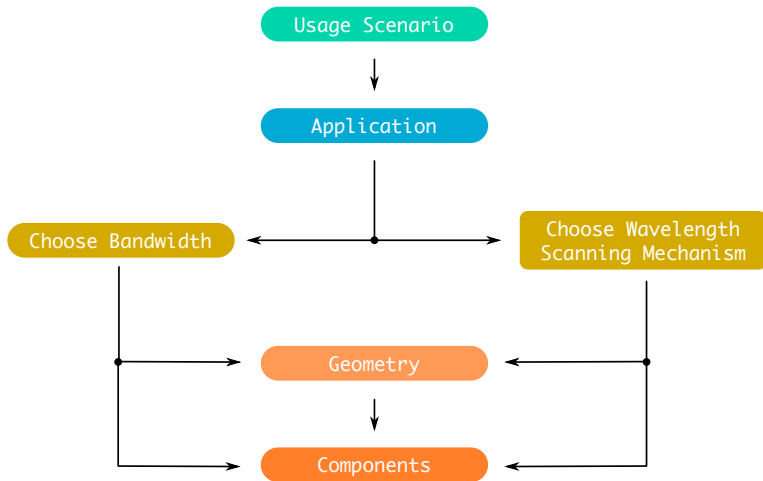
Construction depends on Architecture that deals with  
Wavelength Selection in best possible way.

## **It contributes to:**

- ▶ Selection of Components that influence the energy flow
- ▶ Geometry to guide the energy flow between the components
- ▶ Sensitivity & Resolution of the instrument
- ▶ Repeatability, Accuracy & Precision of the measurement
- ▶ Specify the Efficiency of the instrument

Sweet corner for Makers, Hardware hackers, Designers, Architects ... ! :)

# Where to Start ?



# Know the Limitations

## **When band changes, even ideas & thought process changes :)**

- ▶ No single instrument can cover the entire Electromagnetic Spectrum
- ▶ It is practically hard to build a spectrophotometer to cover multiple bands
- ▶ For common man, the organics are very interesting to Explore, Learn & Use
- ▶ Most of the organics can be explored with UV, Visible, NIR, MIR, FIR bands
- ▶ Covering multiple bands may involve using different diffraction techniques
- ▶ Covering multiple bands, in single floor, may require multiple source & detectors
- ▶ Availability (or) Affordability of standard open spectra is a major problem
- ▶ Analysis Problem : Data analysis are specific to the bands, diverse

Don't get intimidated

# Bandwidth

Spectral Bandwidth is the common factor of  
Excitation Source, Diffracting element, & Detector

**To Start : Find a bandwidth with :**

- ▶ Band that covers most of the Organics
- ▶ Availability of lot of Standard/Known Spectra
- ▶ Optional : Consider (available + affordable) Source & Detector

# Wavelength Selection Mechanism

With new materials, techniques, and research, new wavelength selection  
(scanning or tuning) mechanisms are discovered & implemented

- ▶ Prism (Dispersion)
- ▶ Interferometer (Interference)
- ▶ Grating (Diffraction)
- ▶ Prism Grating Prism (Dispersion + Diffraction)
- ▶ Volume Phase Grating (Diffraction)
- ▶ Acousto-Optical Filter (Diffraction)
- ▶ Electro-Optical Filter (Diffraction)
- ▶ Digital Light Processing (Reflection + Diffraction)

# Energy Source

Depending upon the bandwidth the selection of source varies.

- ▶ Look for long life time (understand how it works !)
- ▶ Check whether cooling increases life and efficiency
- ▶ Check whether reflectors improve optical output behavior
- ▶ Study its optical & spectral characteristics by comparing with:  
color temp. / solar spectrum
- ▶ Confirm that its spectral characteristics matches chosen bandwidth
- ▶ Power requirements change drastically depending upon the source type
- ▶ Understanding its electrical behavior, helps design better power conditioner

From coolidge tube to magnetrons, from LED's to LASER's, from nichrome wires to halogen lamps – all are sources of electromagnetic energy at different frequencies.



Depending upon the bandwidth and application requirement the selection of detector varies.

- ▶ Look for low noise detector (understand how it works !)
- ▶ Check whether cooling reduces noise
- ▶ Most detectors require matched pre-amplifier unit
- ▶ Study its optical & spectral characteristics
- ▶ Confirm that its spectral characteristics matches chosen bandwidth

Structured conductors, Thermometers, Thermocouples, Photoconductive, Photoresistive, Photomultiplier, Semiconductors(Photodiodes, Phototransistors), CMOS arrays, CCD arrays, Scintillators etc.. are all commonly used different type of detectors – mostly influenced by the application.

What i planned?



What I did so far ?

# Scavenging for packages

Purchase the "factory" food you are interested in

or

Free load your friends purchase

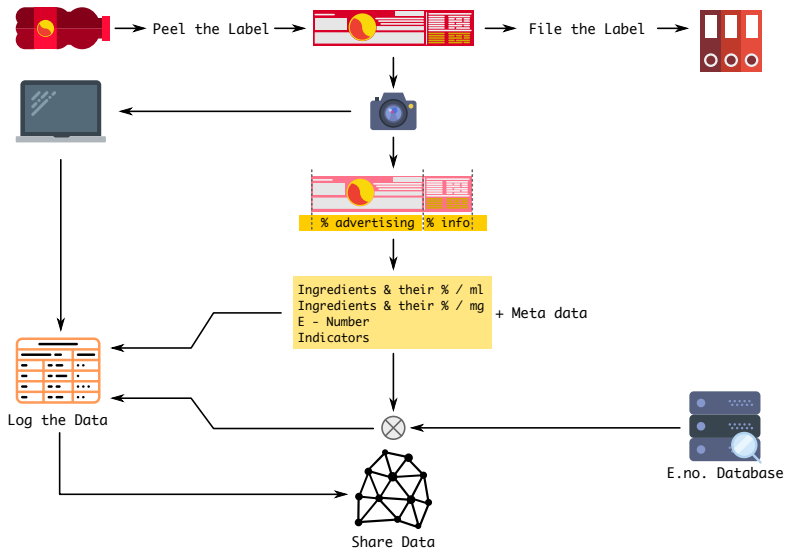
or

Hit the recycle shops

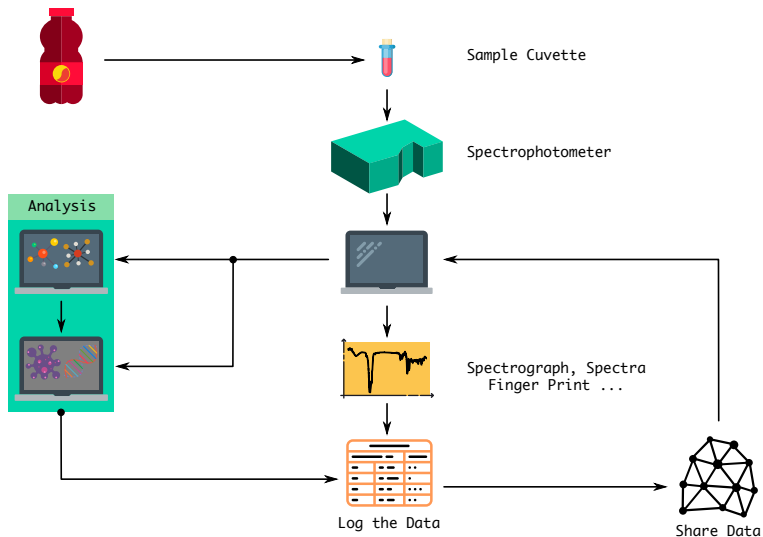
or

Hit the sidewalk

# Collect Spatial Information



# Collect Spectral Information



# Sharing & Analysis

Mutually share data through distributed internet



Synchronize local DB



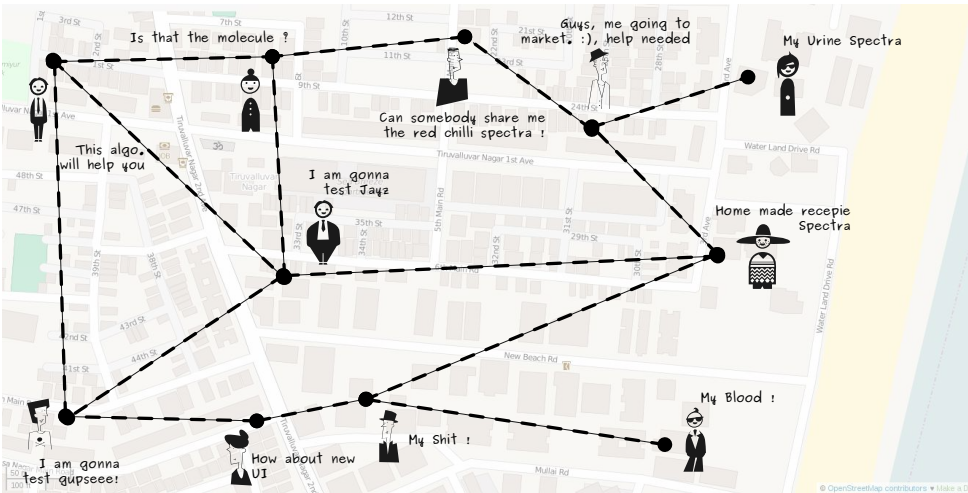
Run analysis with acquired Data



Share it back to the distributed internet

How about doing that Collectively ?





Apply Mesh & Geotransformation. This may be exaggerating.  
But this is possible !



# Dreaming

- ▶ Spectrophotometer along with Telescope, Microscope as an integral part of home
- ▶ With Mesh & SDR, let commons share the tools & data mutually
- ▶ Huge dictionary of TRUE spectra that continuously gets updated by commons
- ▶ With Distributed system available, working on mesh let commons to share analysis too
- ▶ Like e2e encryption, e2e inspection will become day to day necessity

# Any Values ?

- ▶ Educational (Learning, Discovery & Doing, Science)
- ▶ Ecological (Food & Environment)
- ▶ Democratic (Distributed Participation in Sharing)
- ▶ Economic (Come onnnn think ! think ! think !)

# Why not Centralization ?

## Why not derive the values through centralization ?

- ▶ Centralization disengages symbiotic policy & mechanism relation
- ▶ Looks organization structure as hierarchy rather than a tree, or cycle or mesh
- ▶ Relies on templating - template business models and creating them
- ▶ Individual experimentation cannot be afforded without any returns
- ▶ Liberty maximization is with commons contribution and collaboration
- ▶ Dictates protection of knowledge through patent is right
- ▶ Dictates competition is encouraged through sustained obscurity & monopoly
- ▶ Always appoints a middle man to do the work, make transaction, serve ...

# Any other Attempts ?

## Communities:

- ▶ OpenFoodFacts (So far only collaborates on Spatial info.)
- ▶ OpenWetWare - Urinome project
- ▶ Spectrduino - Satellite related
- ▶ Hackaday RamanPi by flatcat - Great guy like us
- ▶ Public Lab DIY spectrometer - Great community like us

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# Thank you !

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