# 13. Laboratories

- Latour & Woolgar's (1979) *Laboratory Life*:

> "Since the turn of the century, scores of men and women have penetrated deep forests, lived in hostile climates, and weathered hostility, boredom, and disease in order to gather the remnants of so-called primitive societies. By constrast to the frequency of these anthropological excursions, relatively few attempts have been made to penetrate the intimacy of life among tribes which are much nearer at hand. This is perhaps surprising in view of the reception and importance attached to their product in modern civilised societies: we refer, of course, to tribes of scientists and to their product of science."
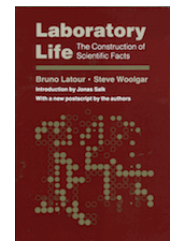
Latour & Woolgar (1986)
Laboratory Life

- *Central question*: How are facts made? (How is knowledge produced in a laboratory?)

> *Claim (The indexical nature of scientific reasoning and actions)*: Scientific reasoning and actions are tied to concrete circumstances and unpredictable in advance.

- _Recall_: Kuhn's distinction between seeing *that* and seeing *what*:
  - *Seeing that: observing "raw data"*
  - *Seeing what: interpreting raw data*
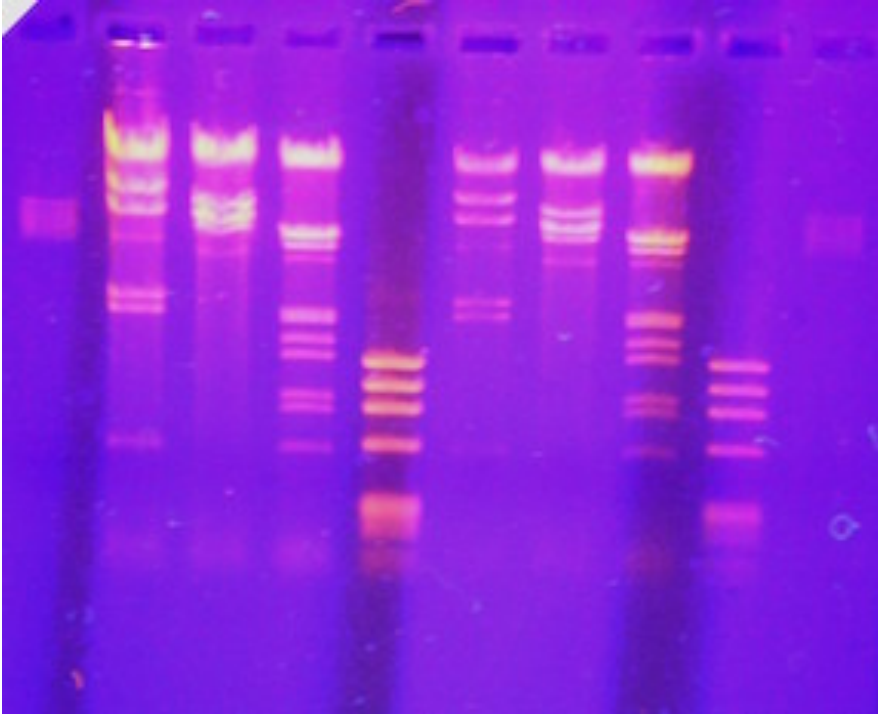
Question: Where should the distinction between "raw data" and "interpreted data" be drawn?

Two characteristics of laboratory work:

(1) Lab work requires **<u>tacit knowledge</u>**.

Tacit knowledge = embodied knowledge

- *riding a bicycle*
- *growing a crystal*
- *cloning an antibody*
- *running an electrophoresis gel*

● Tacit knowledge cannot be formalized in a set of instructions; it must be taught as a skill (socialization process).

<u>*Algebra example (Collins 1974)*</u>

Ability to solve an algebraic equation requires tacit knowledge that the symbol $'x'$ usually means the same, regardless of whether it's written in ball point, chalk, or print, or, if spoken, irrespective of the day of the week, *etc.*

(2) Lab work is characterized by **inversion**.

- Early doubts become absolute "facts".

  > "Through all the early stages, there are doubts, disagreements, and above all work to define a fact. Almost all agency appears to belong to researchers. Once they have decided on it, though, they attribute reality and solidity to the fact. They deny their own agency, making the fact entirely responsible for its own establishment."

- *Ex*: Published images are only those selective images that underwrite the agreed-upon interpretation of the data.

  Published images are:
  - *filtered, to show only a "limited range of visible qualities"*
  - *made more uniform, so that judgements of sameness are projected onto the images*
  - *upgraded, so that borders are more sharply marked*
  - *defined, by being visually coded and labeled*

- Images transform from instances of *seeing that* (raw data) to instances of *seeing what* (interpreted data).

- From "splodges on the graph were observed" to "solar neutrinos were observed".

Ex 1. Restivo, S. & Zenzen, M. (1982) 'The Mysterious Morphology of Immiscible Liquids'
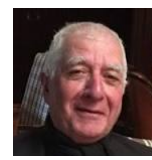
Sal Restivo   Michael Zenzen

- Two year study (1979-80) of colloid chemistry lab at RPI.
  - *Sydney Ross (lab director)*
  - *Ralph Kornbrekke (grad student)*
  - *Henry Hollinger (resident theoretician)*

- Ethnographic methods:
  - *in-depth interviews*
  - *observations*
  - *analysis of notes, conversations, draft manuscripts, published papers*
  - *direct participation in lab work (...)*

Claim: Contingencies (social and otherwise) do not simply affect the course of scientific work, but rather they are an integral part of that work.

Rashomon "theorem": There are numerous ways of describing and interpreting any given phenomenon; the status of any given account is not determined *a priori* by whether it is "true" or "real" in some absolute sense, but by how *useful* it is in the competitive realm of knowledge production and utilization.

Colloid = substance in which one substance of microscopically dispersed insoluable particles is suspended throughout another substance.

Ex: *milk = butterfat molecules suspended in water-based solution*

- *Project*: Determine the emulsion type ("morphology") of a benzene-water system: is it benzene dispersed in water, or water dispersed in benzene?
  - *Funded by NASA; interested in alloys of two metals for space applications.*

- *Method*: Manually shaking test tube mixtures of benzene and water and visually examining them.

- *Obstacle*: Standard techniques for determining emulsion type apply only to stable emulsions, and benzene/water mixtures are unstable.

"Kornbrekke had to teach himself to see what a short-lived emulsion 'looks like'."

Characteristics of lab work:
- *Seeing-that versus seeing-what.*
- *Tacit knowledge: How much shaking? When does emulsion form? How does it form? When does it dissipate?*
- *"Anomalies everywhere": Not a temporary Kuhnian situation, but characteristic of a creative research environment.*

Inversion and rhetoric in the process of publication:

- Three documents:
  - NASA report "Emulsion-type inversion for the system benzene, ethanol, and water".
  - (M1) Submitted paper "Change of morphology of a liquid-liquid dispersion as a stochastic process".
  - (M2) Revised, published paper.

M1 vs NASA report

- more general argument
- less controversial
- more technical
- less speculative
- less equations
- replaces abstract entropy analysis with concrete magnetic coin example

NASA report	M1
"a certain range"	"an intermediate range"
"is shaken a large number of times"	"is given a large number of trials"
"phase diagrams and morphology"	"factors affecting morphology"
"defined"	"defined operationally"
"cohesive forces overcome to some degree by the physical action of shaking"	"cohesive forces must be overcome by an input of energy from mechanical agitation"

M2 vs M1

- Replaces magnetic coin example with statistical mechanics analysis.
- More mechanistic and causal/deterministic.
  - *M2's abstract*: "We report a new phenomenon... that the morphology of an unstabilized liquid-liquid dispersion is predicted by a statistical law rather than a causal law."

M1	M2
"disappears"	"retraction"
"created"	"extended as films"
"tend toward coalescence of like liquids"	"cause the etended liquids to retract"
"manual", "hand-shaking"	"vigorously mixed", "thorough mixing", "vigorously shaken up and down", mechanically conferred motion", externally applied agitation"

"...in the two instances in which we were present when the morphology research was presented to a scientific audience, physicists, chemists and engineers raised strenuous objections to, and queries about, the shaking procedure."

- *Inversion*: The mechanization of rhetoric in the move from initial to later stages of scientific practice.

- Day-to-day ongoing lab work appeared as a series of responses to:
  - *Background knowledge and experience of the researcher.*
  - *Equipment availability.*
  - *Pressures associated with funding, graduate program, job prospects, productivity.*
  - *Interpersional relationships (professional respect, roles in research process and university community.*

- "A multitude of *contingencies* have to be continually managed."

Claim: These contingencies are *constituative* of the research process.

"It is not as if a determinate path to some piece of information pre-existed and the researchers are deflected toward or away from that path by various sorts of perturbations. Rather, there is always a context, an inherited, assigned, or constructed problem situation which must be continually problematized and kept in motion."

Ex 2. Collins, H. (1974) 'The TEA Set: Tacit Knowledge and Scientific Networks'

Harry Collins

Questions:

- How is knowledge diffused?

- How is technology transferred from one lab to another?

- *Focus of study*: a set of scientists in different laboratories engaged in the building of a Transversely Excited Atmospheric (TEA) laser.

- *On tacit knowledge*:

  - Technological knowledge is the property of people rather than documents.

  - "All types of knowledge, however pure, consist, in part of tacit rules which may be impossible to formulate in principle."

- *Background*: Late 1960s, Quebec, Canada. Defence Research Establishment, lab develops transversely excited atmospheric pressure CO_2 laser (TEA laser).

Laser fundamentals

- *Light Amplification through Stimulated Emission of Radiation.*

- *Stimulated emission*: Emission of a photon by an atom when it is hit by another photon: One photon before emission, two in phase after (light amplification).

- *Population inversion*: Situation in which there are more atoms in a gas in high-energy states than low-energy states. Required for sustained stimulated emission to occur.

- To create a population inversion, *pump* the gas to excite atoms. Use electric discharge in a chamber. Use the emitted radiation to generate further stimulated emisions by bouncing it off mirrors. Use a partially transparent mirror to allow portion of the coherant beam to emerge.
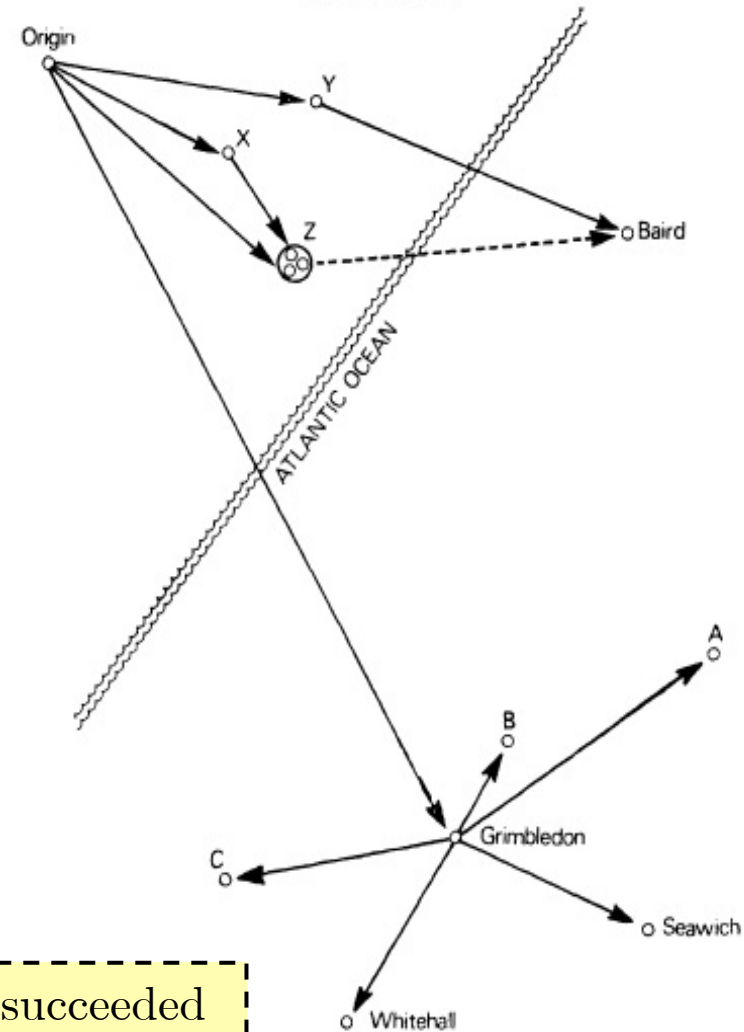

Transverse excitation: Discharge perpendicular to beam.
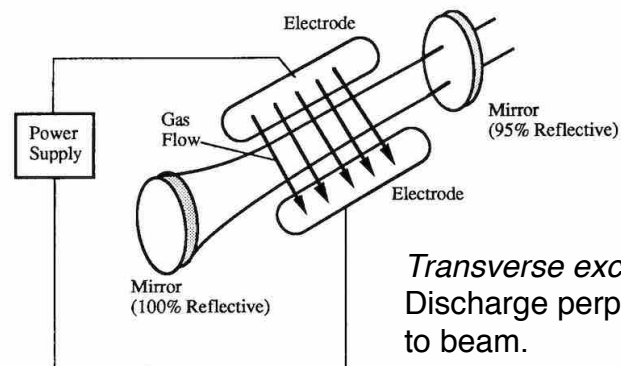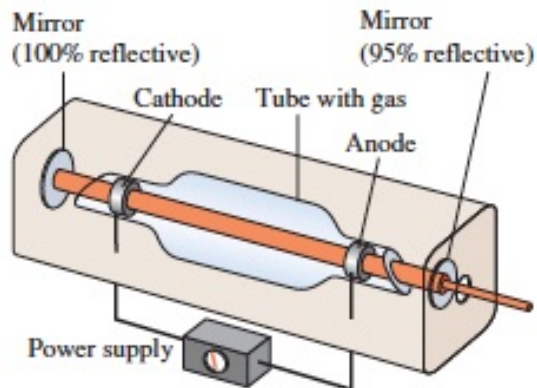
- **_Ethnographic Method_**: Interviews with 7 British and 4 North American labs.

  - _British labs_: Grimbledon, Whitehall, Seawich, Baird, A, B, C.
  - _North American labs_: Origin, X, Y, Z.

Tacit knowledge in TEA construction:

- "Even today there is no clear idea about how to get this thing working property. We are even now discovering things about how to control the performance of these devices, which are unknown..."

- "I have four theories (for how they work) which contradict each other..."

- "The crucial part (in getting a device to operate) is in the mechanical arrangements, and how you get the things all integrated together."

- "What you publish in an article is always enough to show that you've done it, but never enough to enable anyone else to do it. If they can do it then they know as much as you do."

FIGURE 1.

"In fact, to date, no-one to whom I have spoken has succeeded in building a TEA laser using written sources (including pre-prints and internal reports) as the sole source of information..."

<u>*Factors that influence the transmission of tacit knowledge*</u>:

- Tactics for maintaining secrecy.
  - *only answering questions without volunteering information*
  - *only demonstrating parts of the set-up*

- Personal and biographical factors.
  - *prior history of information exchange*
  - *interpersonal relationships*
  - *common academic/professional backgrounds*

- "...when a laboratory has developed a useful link with another, technically senior to itself... there may be nothing to be gained from a collaborative link with a research peer."