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THE SCIENTIFIC DYNAMICS OF A CITY: A STUDY OF CHEMISTRY IN MARSEILLE FROM 1981 TO THE PRESENT

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In a study of scientific publications originating from laboratories in the city of Marseille, we look at both the quantitative evolution of these publications over time and their thematic development. Using the section headings of the Chemical Abstract database, we identify the principal research poles of the city and their relationships.

Introduction

The development of a scientific discipline is affected by the policy decisions taken by a variety of research planning bodies. In France there are many actors involved in research planning: the CNRS, the National Education Ministry, the Regional administrations and members of ad hoc commissions (of the CNRS, National Education and, at the local level, of the University).

To our knowledge few studies have looked at the evolution of a field over several years at a regional level in order to attempt to measure the effects of research planning in a local context.

In this example, we will treat the scientific production of the City of Marseille. The information source used will be *Chemical Abstracts*. Three different types of analysis will be carried out:

First, we will use the section headings of *Chemical Abstracts* to determine the principal research poles of the city. We will then use the co-presence of pairs of these section headings in the references in order to identify the local research networks in different fields of chemistry. Finally, we will examine changes in these networks over the period from 1981 to 1986.

Is there any coherence to this change? Is there any global sense in which we can talk about the transformation of research laboratories – looked at from the point of view of their scientific publications – in a given geographical area like a city? Can we talk about it in the same way as we talk about the transformation of a research field? In other words, do the laboratories in a single city form a network so that changes in one laboratory affect the others in such a way as to lend the group some coherence?

1. Methodology

We did not want to conduct our study using a database confined to a limited number of scientific journals. We wanted to make some sort of comparison – either in time or in space. In order to do so, we needed to look at scientific production as a whole, and also at technical production (for example patents). We were led to study some very diverse subjects, giving rise to very different numbers of publications and citations at the local as well as at the international level. This prevented us from using the ISI database, whose information sources for the different fields of chemistry are not sufficient.

Our analysis of the global production in chemistry was carried out using information provided by the *Chemical Abstracts* database. This database is recognized by all chemists and covers 14 000 journals.

Chemical Abstracts includes an indexation by town and date of publication. An uncertainty of the order of 6% per year is introduced by the fact that *Chemical Abstracts* indexes only the address of the first author.[1] When a laboratory has a visiting researcher, publications resulting from any collaboration that mention the name of the visitor as the first author will be attached not to the town where the laboratory is situated, but to the visitor's town.

The references used were selected using the Orbit Information Technologies server,[2] and downloaded onto our machines.

The references downloaded were composed of different fields. We used the field CC (Category Code) which lists the sections of *Chemical Abstracts* attached to the work analyzed. This division of chemistry into sections does not necessarily follow any scientific rule; it reflects a division introduced by *Chemical Abstracts*.[3] Its main advantage is that it remained constant over the period under study.

The list of sections defining the fields analyzed (80 in all) is given in the *Appendix*. In its indexation system, *Chemical Abstracts* sometimes uses sub-sections. We do not take these into account, since the level of analysis in too fine-grained for our purposes.

According to its indexing policy, *Chemical Abstracts* classifies a work it analyses into a principal section, which is the first section heading that appears in the CC field, and then into one or several secondary sections (cross sections). The principal sections alone were used in determining the principal research poles of Marseille.

Some references in *Chemical Abstracts* only contain a principal section. In this case, they are only used in the determination of the principal research poles. The others allow us to calculate associations between research poles and consequently to identify the local research network.

2. The overall level of production at Marseille

The overall level of production was measured for each year, and compared with national production. It was learnt that even though there was continuing growth, it was at a slower rate than national growth. The respective figures are 1.78 between 1986 and 1987 for France and 1.09 for Marseille (Figs 1, 2).

Table 1 situates this production with respect to some other large French cities. Overall production provides a general indication of scientific work. It has been used for example to compare cities in the United States.[4]

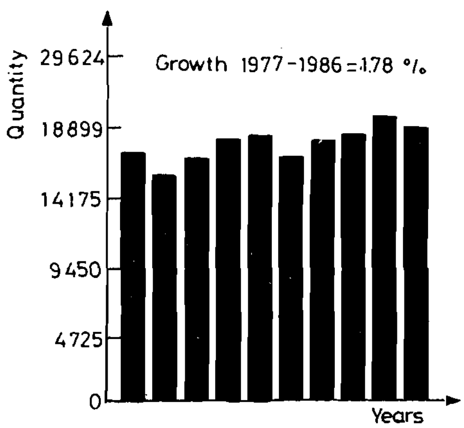

Fig. 1. French publications in chemistry from 1977 to 1986 (Source: *Chemical Abstracts*)

3. The principal research poles

The research poles are represented on a checkerboard, where the sections of *Chemical Abstracts* go from number 1 (upper left) to number 80 (lower right). This three-dimensional representation, with color contrast and a choice of threshold, permits a detailed analysis of the data on a local computer. The highest cylinder represents the section in which the largest number of the cities publications were classed during the year under study.[5] (see Figs 3, 4 and 5).

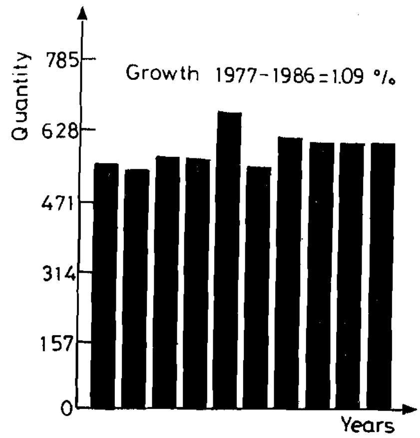

Fig. 2. Marseille publications in chemistry from 1977 to 1986 (Source: *Chemical Abstracts*)

Table 1
Number of publications by the major chemical research areas in France

Cities	total	1982	1983	1984	1985	1986
Paris	16973	2627	2865	2974	3050	3007
Orsay	5333	814	936	973	951	915
Strasbourg	4212	708	713	679	781	764
Lyon + Villeurbanne	4248	657	738	782	745	734
Grenoble + St-Mar.	4543	780	806	746	785	725
Toulouse	3425	546	588	593	630	617
Montpellier	2422	489	495	536	563	599
Marseille	3122	498	566	556	551	535
Bord. + Talence	2471	389	407	443	459	427
Lille + Vill. d'Ascq	1782	270	277	337	325	316
Rennes	1179	177	191	199	243	218
Dijon	903	142	128	154	168	176
Nice	963	137	169	187	173	176
Lille	827	116	135	162	144	160
Poitiers	879	140	165	158	145	156
Nantes	829	125	123	132	191	144
Palaiseau	788	125	125	128	167	135
Brest	475	91	72	74	110	64

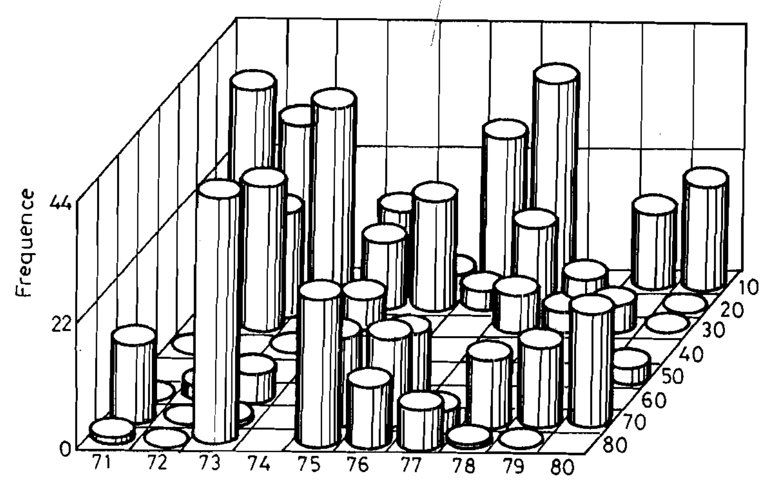

Fig. 3. Research axes in Marseille in 1981, using the principal sections of the *Chemical Abstracts*: Legend: principal axe: 73 optical; electron; and mass spectrometry and other related properties

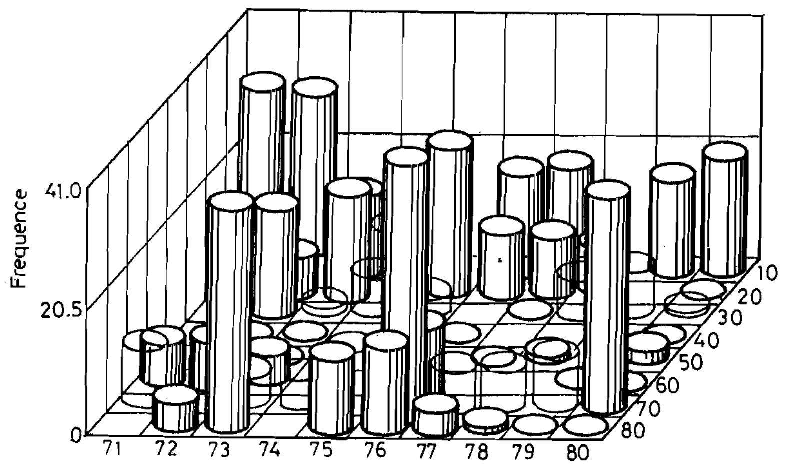

Fig. 4. Research axes in Marseille in 1985, using the principal sections of the *Chemical Abstracts*: Legend: principal axe: 66 surface chemistry and colloids

In order to simplify the results on the graphs presented, we used a threshold value of 2 (that is to say at least two articles were published by a laboratory of Marseille and classed in the section for a given year.)

A simple visual analysis brings out significant changes in the centers of interest of the chemical laboratories of the city of Marseille for the years 1981, 1985 and 1986

(Figs 3, 4, 5). This variation, which increases over time, involves the expansion of two general fields:

a) chemistry linked to life sciences,

b) chemistry linked to physics (surfaces, alloys, thermodynamics, semi-conductors ...).

Organic physical chemistry and organic chemistry in the classical sense of the terms continually diminish in importance.

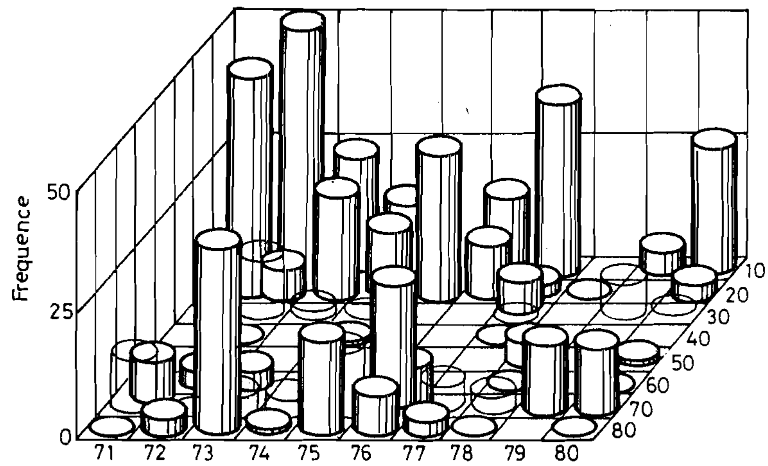

Fig. 5. Research axes in Marseille in 1986, using the principal sections of the *Chemical Abstracts*: Legend: principal axe: 2 mammalian horomones

4. Detailed analysis: networks of research poles

The co-presence each year of pairs of sections in the references allows us to trace a series of graphs of links between sections.[6] A graph of network relationships is traced using a single link clustering algorithm to exploit tables of pair frequencies. The program for the visualization of the graphs renders them superposable. This permits a dynamic tracing of the evolution of the networks on the computer in real-time.

In Figures 6, 7 and 8, the main research fields represented by a grouping of the sections are given for the years 1981, 1985 and 1986. The frequency of the associations is given in a box.

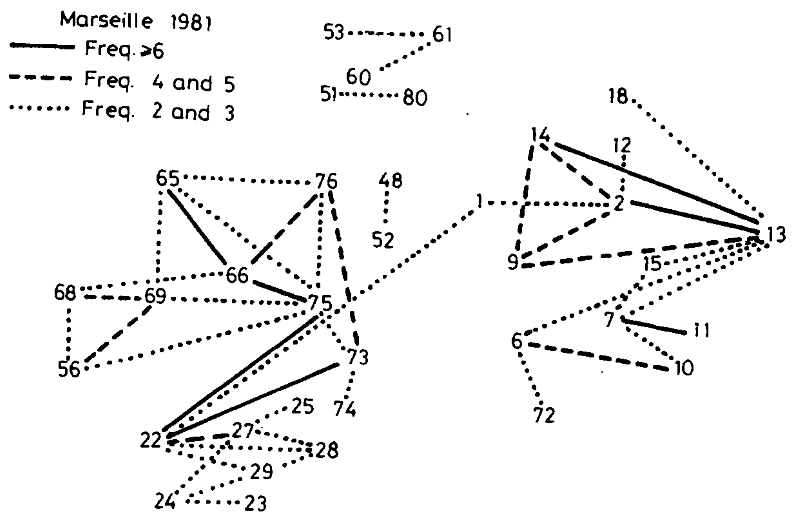

Fig. 6. Network of research in chemistry in Marseille, 1981

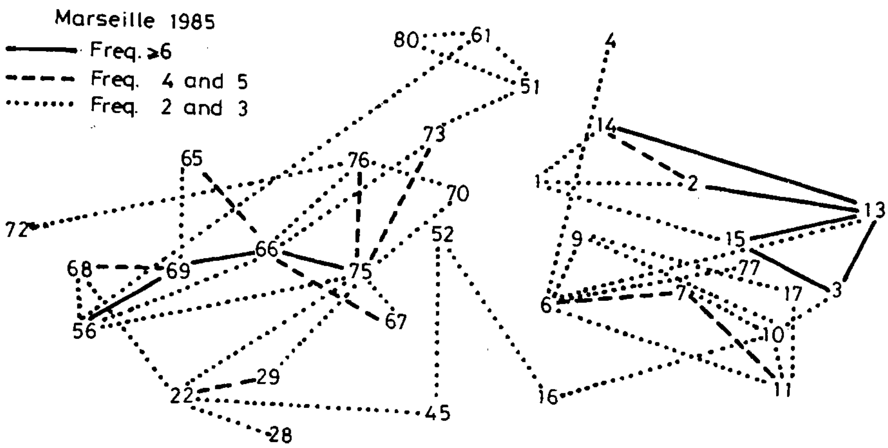

Fig. 7. Network of research in chemistry in Marseille, 1985

An analysis of the information provided by these graphs confirms the results of the identification of the principal research poles obtained in the first approximation. Classical organic chemistry is fragmenting into themes linked to life sciences. There is also a fragmentation of the group of chemical themes linked to physics.

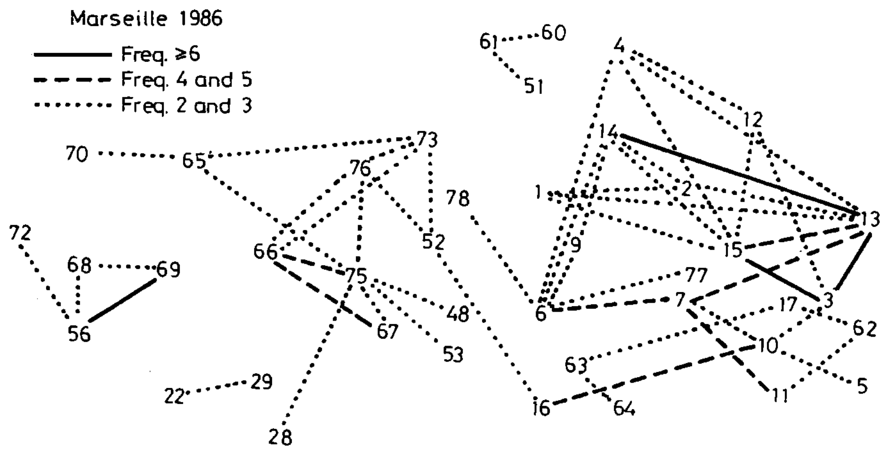

Fig. 8. Network of research in chemistry in Marseille, 1986

We note in passing that the fragmentation of the initially highly interconnected organic chemistry network seems to involve an intermediary stage of a starred network (pole 22). This network configuration constitutes an intermediary between reticulation and one of fragmentation. We already detected the appearance of a similar phenomenon in our study concerning the evolution of a research network working on the oxidation of coal, in relation with the general problem of better understanding the oxidation of organic matter.[7]

5. Detailed analysis of the poles

In our autonomic treatment, we can always link a pair of associated sections with the references that gave rise to them. We are consequently able to do back to the server and carry out an "on-line analysis" of the chemical abstracts database for each pair of associated sections in order to identify the name of the authors responsable for the link, their addresses and to obtain more detailed thematic information by reading the titles and examining the supplementary terms and indexing terms given by the database.[8-10]

To take an example from the year 1986, Table 2 supplies a wealth of information on a pair of linked poles. It should be noted that in this treatment the link between themes exists because the articles have points in common, and not necessarily because the researchers work together. This form of secondary analysis will consequently be of interest to research planners.

Table 2
Analysis of nodes 10 and 16, identification of works common to the two axes (1986)

WORK ON THE POLES 10 AND 16	
10- Microbial biochemistry	16- Fermentation and bioindustrial chemistry
Work specifically done on pole 10:	Work specifically done on pole 16:
4, 6, 34, 57, 64, 84, 85, 133 140, 162, 189, 191, 237, 255 291, 311, 312, 317, 329, 331 379, 389, 416, 451, 465, 466 467, 468, 502, 520, 533	2, 63, 88, 189, 285, 329, 350 359, 379, 380, 389, 402, 448 481, 502
Work concerning the two axes 10-16: 189, 329, 379, 389, 502	

We can also carry out the inverse operation, and take a single researcher or group of researchers and locate them on the preceding graph. This was done for works relating to the analysis of wine and aromas for the year 1986. In Figure 9 these works are positioned on the graphs by their section codes, which enable us to determine their situation with respect to Marseille as a whole. We can of course also situate any type of research carried out overseas on these graphs.

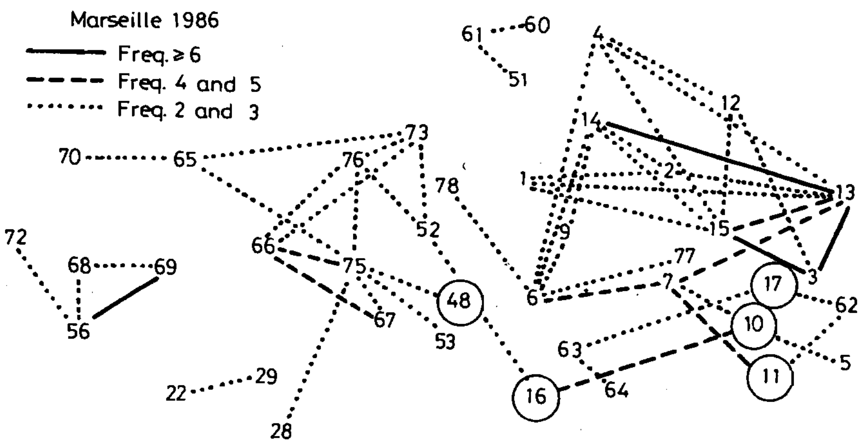

Fig. 9. Position of works in wine and aromas within all chemistry at Marseille, 1986

Conclusion

Our method has brought to light a progressive transformation of research carried out at Marseille. It has provided an analysis of the sections of *Chemical Abstracts* which list the publications and also the associations between the sections as operated by publications from Marseille. In particular, we note the fragmentation of classical organic chemistry into a series of themes linked to life sciences. We also see that it is possible to give a coherent interpretation of the evolution of research in a city context, just as it is to study the scientific history of a research field.

It seems to us that particular attention should be paid to the "scientific dynamics" of a city when making decisions about how to fund research.

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Notes and references

1. J.T. Dickman, M.P. O'Hara, O.B. Ramsay, *Chemical Abstracts; An Introduction to its Effective Use*, Audio Course, American Chemical Society, Washington DC, 1979. The difference of 6% cited in the text was measured in the analysis of the scientific production of CNRS Associated Unit 126. A collection of all their works, compared to all that could be obtained from the database, brought out a difference of the order of 6%.
2. Pergamon Orbit Infoline, 8000 Westpark Drive, Virginia 22102, McLean, USA.
3. 'Subject Coverage and Arragement of Abstracts by Sections', in Chemical Abstracts, American Chemical Society, 1982.
4. 'Top 20 Science Cities in the US', *The Scientist*, October 17, 1988.
5. H. Dou, P. Hassanaly, Mapping the scientific network of patent and non-patent documents from Chemical Abstracts for a fast scientific analysis, *World Patent Information*, 10(1987) 113-149.
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9. F. Jakobiak, Utilisation d'outils bibliométriques et de recherche terminologique. Exemple d'utilisation, *Actes d u Colloque Infodial Vidéotex*. Paris, 1987 pp. 18-21.
10. J.-P. Lardy, 'GET, MAP, MEM, ZOOM et les autres', *Revue Francaise de Bibliométrie*, 2(1987) 68-82.

Appendix

Section codes in Chemical Abstracts – numbered and labelled

1	pharmacology	41	dyes; organic piments; fluorescent brihhteners; and photographics sensitizers
2	mammalian hormones	42	coating; inks and related products
3	biochemical genetics	43	cellulose; lignin; paper; and other wood products
4	toxicology	44	industrial carbohydrates
5	agrochemical bioregulators	45	industrials organic chemicals; leathers; fats, and waxes
6	general biochemistry	46	surface-active agents and detergents
7	enzymes	47	apparatus and plant equipment
8	radiation biochemistry	48	unit operations and process
9	biochemical methods	49	idustrial inorganic chemicals
10	microbial biochemistry	50	propellants and explosives
11	plant biochemistry	51	fossilfuels; derivatives; and related products
12	nonmammalian biochemistry	52	electrochemical; radianational; and terminal energytechnology
13	mammalian biochemistry	53	mineralogical and geological chemistry
14	mammalian pathological biochemistry	54	extractive metellurgy
15	immunochemistry	55	ferrous metals and alloys
16	fermentation and bioindustral biochemistry	56	nonferrous metals and alloys
17	food and feed chemistry	57	ceramics
18	animal nutrition	58	cement; concrete; and related building material
19	fertilizers; solids; and plant nutrition	59	air pollution and industrial hygien
20	history; education; and documentation	60	waste treatment and disposal
21	general organic chemistry	61	water
22	physical organic chemistry	62	essential oils cosmetics
23	aliphatics compounds	63	pharmaceuticals
24	alicyclic compounds	64	pharmaceutical analysis
25	benzene; its derivate; and condensed benziod compounds	65	general physical chemistry
26	biomolecules and their synthesic analogs	66	surface chemistry and colloids
27	heterocyclic compounds (one hetero atom)	67	catalysis, reaction kinesis; and inorganic reaction mechanisms
28	heterocyclic compounds (more than one hetero atom)	68	phase equilibriums, chemical equilibriums; and solutions
		69	thermodynamics; thermochemistry; and terminal properties
29	organometallic and organometalloidal compounds	70	nuclear phenomena
30	terpenes and terpenöids	71	nuclear technology
31	alkaloids	72	electrochemistry
32	steroids	73	optical; electron; and mass spectroscopy and other related properties
33	carbohydrates		
34	aminoacids; peptides,; and proteins	74	radiation chemistry; photochemistry; and photographics and other reprographic processes
35	chemistry of synhetic high polymers		
36	physical properties of synthetic high polymers	75	crystallography and liquid crystals
37	plastics manufacture and processing	76	elecric phenomena
38	plastics fabrication and uses	77	magnetic phenomena
39	synthetic elastomers and natural rubber	78	inorganic chemicals and reactions
40	textiles	79	inorganic analytical chemistry
		80	organic analytical chemistry