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Mapping research networks in basic sciences at University of Costa Rica

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Resumen: Este trabajo es una contribución al estudio simultáneo de elementos ontológicos y metodológicos comprometidos con el conocimiento de la organización sociotécnica de la investigación científica universitaria. Se trata de la presentación de un análisis asistido informáticamente de bases de datos que genera mapas, de los que se pueden intelegir organización de relaciones heterogéneas de propiedades científico-técnicas y sociales contenidas en las fuentes de información, que son simultáneamente cuantitativas y cualitativas. Para ilustrar lo anterior, realizamos un estudio de caso analizando informáticamente las bases de datos de los proyectos de investigación en ciencias básicas de la Universidad de Costa Rica entre 1977 y 2005.
Palabras clave: mapeo de investigación, redes de investigación, análisis informático, ciencias básicas, Costa Rica.**Abstract:** This paper is a contribution to the simultaneous study of both the ontological and the methodological elements involved in the knowledge about the socio-technical organization of the university scientific research. In this work we present a computationally assisted analysis of databases which generates maps of heterogeneous relations of the scientific, the technical and the social properties contained in the information databases which are simultaneously quantitative and qualitative. In order to illustrate this, we present a case study analyzing databases of research projects in basic sciences from 1977 to 2005 of the University of Costa Rica.
Key words: research mapping, research networks, computational analysis, basic sciences, Costa Rica.

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Introduction[1]

Sociology and anthropology of the science and the technology have a double epistemological commitment when trying to improve the comprehension of the elaboration processes of knowledge and artifacts since their object of study expresses the subject of their own epistemology.

In this sense, the epistemology of these disciplines presents an ontological aspect in respect to the consideration of the nature and society statute, and a methodological one in respect to the use of the qualitative-quantitative approach of their studies. Regarding the first aspect, the researchers grouped in the school of the called actor-network[2] opened in the eighties the way to study the sociocultural relations inscribed in the techno-scientific phenomenon; this way was expressed in an sudden increase, throughout the world, of studies on the construction of knowledge and technological artifacts. Regarding the second aspect, it could be considered that only quite recently the alliance between science and technology studious and specialists in computing systems has brought the possibility of exploiting software for the textual and relational data analysis, giving way to the integration of qualitative and quantitative methods.

This work is a contribution to the simultaneous study of ontological and methodological elements by the analysis of results produced by an informatics assistant, which makes it possible to visually reckon the organization of heterogeneous elements emerged from information databases on institutionalized research; we empirically illustrate the latter through the analysis of databases on the research projects of the University of Costa Rica (UCR).

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[1] The author thanks the critical comments of Laura María Morales Navarro.

[2] This approach was established in the 1980's by Michel Callon, Bruno Latour and John Law, and it was due to Callon's study on technological development and sociotechnical controversies to make an electric vehicle in France and the farming of clams and training of fishermen at the St. Brieuc Bay; to the Latorus' work on the powers of association and the life in the laboratory; to the Callon and Law's work on enrolment and contra-enrolment (the interests and its transformations); and to Law's work on social control tactics.

We start our presentation with the exposition of some conceptual-methodological elements on the heterogeneous study of social and techno-scientific entities. Then, we mention some background on the computationally assisted analysis of research heterogeneous networks. Later, we briefly expose some historic features of the research in the University of Costa Rica; after that, we present the results of our study by mapping and interpreting the research in basic sciences of UCR. At the end of the paper we present some conclusions in regards to the explicative capacity of the software used and to the research of basic sciences at UCR.

1. Connecting conceptually and methodologically social and techno-scientific entities

For over three decades, a large number of sociologists and anthropologists of the techno-scientific research have faced two great cognitive challenges: one of a conceptual- epistemological nature referring to the consideration of the role the natural and social aspects play in the expression of the techno-scientific phenomenon, and other of a epistemological-methodological nature referring to the representation of the qualitative and quantitative aspects involved in the demonstration of the knowledge on techno-science.

Regarding the first challenge, some researchers consider that the techno-scientific phenomenon has a cause the social action over nature (whom we will call sociologists); this cause would have the shape of groups in controversies (Bloor, 1982, 1999; Barnes, 1993-1994), of economic actions of innovation, of social actions in the world of life (Hess, 1992, 2001; Hess and Layne, 1992), to mention some. Some others consider that the phenomenon is explained by the development of a teleological logic sustained by the natural laws; such cause would have the form of an evolutionary development ineluctable of cognitive and artifactual aspects (Perrin, 1997; Basalla, 1991), etc cetera, (whom we will call technisists)

Both groups have applied variants of the network notion to approach the social and technical organization of the research, and show the role knowledge and artifacts elaborated by the scientists and engineers play (Callon, 2001). For the sociologists, the networks as associations of social actors organized around objects of study or artifactuals; for the technisists, the networks are a series of related scientific-technical elements supporting the social actions.

For the sociologists of sciences and techniques of the Paris Group[3] the use of the network notion only proposes a relational idea; conversely, it reveals a method problem to acknowledge the nature of the relation among the actors (Latour and Arellano, 1998); consequently, the works inspired by this group have been directed to study the action of the collectives and of the nature that are integrated in the form of socio-technical networks, by means of complex hybridization processes.[4] Under the consideration that the construction of scientific facts and technical artifacts imply the creation and consolidation of relations between social and natural entities, Callon has implied that the study of the history of these associations provides an entry to the analysis of the science and technology development (Callon, 2001).

In regards to the second challenge, the study of the techno-scientific activity dynamic has been led by researchers interested in the hermeneutic and quantitative aspects. The former ones have worked in the significant-conceptual elements of the information directly observed or produced in the quantitative descriptions of the research; whereas, methodologically, they have developed significant grading of the actors' actions. The latter have used quantitative information from publications, citations, patents, demographic-economic statistics, of the scientific activity; and methodologically have developed statistic techniques and algorithmic methods to group and compute their data and express their meanings.

A notion of network recently incorporated in the studied on techno-scientific research is directly related to the interdisciplinary works where the social sciences scientists, in alliance with specialists of informatics

[3] We call the Group of Paris those researchers grouped around the works developed in the Sociology of the Innovation Centre of the École Nationale Supérieure des Mines de Paris, particularly the studies directed by Michel Callon and Bruno Latour.

[4] From there that the study of the socio-technical networks inspired in the promoters of the Actor-network theory have proposed themselves to follow the actors in their research actions to render account of the construction of the translations.

systems, have developed a series of methods that allow the treatment of computationally assisted quantitative data (Allende and Arellano, 2004), when eliminating the opposition between quantitative and qualitative methods and introducing new significance sources. The results obtained have made it possible the treatment of surveys, interviews and ethnographic observations, as well as the analysis of content of texts and inquests for the categories and the biographic analysis (Tichit, 1999).

This work is a contribution to a double setting in relation, to know; relating society and nature and quantitative and qualitative methods. The setting in relation of the social and natural elements, and the qualitative and quantitative methods. The former has been institutionalized in the called actor-network Theory (TA-R). This double set in relation can be operated by means of computational programs capable of facilitating the analysis of heterogeneous data that make it possible to visualize structure and analyze data networks of different entities expressed qualitatively and quantitatively.

2. Computing analysis of heterogeneous research networks

The data measurement on research has been faced for decades trying to set into relation the quantity and quality of the researches. Such is the case of the studies directed to evaluate the quality of articles and the scientific journals through the elaboration of indexes (Buela-Casal, 2003; Lomonte and Ainsworth, 2000, 2002) or those directed to the establishment of a metric of the science (Price, 1978).

One of the main problems of the techno-scientific research analysis rests on the partiality and heterogeneity of the available data: databases, patents, publications and bibliographic bases, journals, databases of the university cooperation and links, the historicity of the available data, the diversity of texts and corpus, mainly (Mogoutov, 1999; Dodier and Barbot, 2000). But the biggest problem of the computational analysis of these heterogeneous data resides in the limits of the qualitative and quantitative analysis that reflect two separate words (Mogoutov, 1998). To solve this problem, a series of resulting data analysis and visualization advanced techniques has been developed. The important aspect of the computationally assisted analytical strategies to study the research heterogeneous networks consists on the possibility of representation of the information, through a scheme of categories graphically described.[5]

For Callon, the study of the socio-technical networks is founded in the actors' associationist capacity. According to Callon: "The limit of the (conventional) tools is that, when having as an objective discover (similitude) links between actors, do not pay explicit attention to the relations and relation settings operated by these very actors; they put into parentheses their capabilities of producing associations" (Callon, 2001: s/p).

The interrelation between the quantitative and the qualitative in instruments as the translation networks is characterized by the synthesis of translation strategies' descriptions (qualitative element) with the repetition of the translations (quantitative element); this means that a translation strategy is relationally consolidated or stabilized; conversely, a translation that remains isolated does not influence the network's configuration. In this way, "the quantitative analysis conceived as the consolidation measurement of a translation network is nothing more than the continuation of the qualitative analysis through other means" (Callon *et al.*, 1991a: 13).

The analytical procedure has an explicit objective to reconstruct the dynamic of these networks and of their connections so that the singularity

[5] According to Sowa (1991), the use of graphos for the description of the knowledge dates back to the neo-platonic philosopher Porfirio, thereafter settling with the works by Pierce in the late XIX century and with those by the philosopher Selz in the early XX century. Collins and Quillian (1969) introduced them as a way of hierarchic representation of concepts, although their model was harshly criticized due to its rigidity: in the practice it is difficult to conceive that the conceptual associations are done hierarchically because some prototypical concepts such as "hen", "tiger" or "water" are associated to "farm", "jungle" or "thirst", before their own "biological families" (Johnson-Laird, 1990: 311). The model revised by Collins and Loftus (1975) proposes a more flexible proposal called propagation of adaptation, where the concepts are not hierarchically related, but according to semantic distances (from example, the concept "red" can be related to other color categories, but also with other concepts such as "fire" or "passion"). The mental models are understood here as concept networks, and not as they are introduced in cognitive science by Johnson-Laird (1983), defined as analogical representations of reality.

and heterogeneity of the relations is preserved. But the current challenge in the study of association networks consists on not being satisfied with accepting the fact that are heterogeneous, but by the variety of action regimes (sustained in the textual inscriptions), where the entities are involved. In this sense, the notion of entity includes the social actors, but also all the series of non-human actors that play a role in the contemporary techno-scientific research (Callon *et al*., 1991b; Callon, 2001).

The RL software is a device to make the relations inscribed between the actors visible. In the case of the analysis of complex texts, such as articles and patents, the analytical space is quite wide and allows recognizing relation patterns that make it possible the heuristic of categories and descriptors; in the case of the *ex ante* qualified databases, the space is created by the categories and relations by the intrinsic possibilities attributed in the descriptors that organize the information of a text, for example, of a research project, of a patent or a scientific report. This software is a data analysis instrument that allows presenting the significant relations in sets of heterogeneous data, emerged from the use of analytical algorithms and visualization tools sustained in theory of graphos (Mogoutov and Vichnevskaia, 1995).

The heterogeneous networks produced by the RL software are graphic representations of relations between different-order entities obtained from large databases. These graphic representations correspond to the encounter of relation patterns between entities where their localization, size and frequency of relation intervene. In these charts or figures, each grapho is an entity. The entities are of a different nature (in the case we are studying they can be: research area, research units, discipline, project and author of the project), so that in one single figure it can be appreciated judgment elements for the analysis of the techno-scientific research. The interpretation can include the size of the graphos, their location in the analytical space context and the thickness of the line connecting the graphos.

Differently from the conventional parametric statistic information, the information provided makes it possible to distinguish in the smallest graphos a strategic reflection, indicating with this that an entity, not being statistically relevant, of a great visibility, or large relations with other entities can, however, represent emergency, novelty, recent visibility, etc., that implies a significant situation for the institution.

The size of the graphos depends on their absolute quantity in respect to the graphos of the same entity. Their location depends on the variables the reader determines; generally lines can be drawn between the graphos from the same entity to make work spaces, within which the relations can be analyzed with graphos of the same kind, and with different graphos.

It is important to take the consideration that the relations established in the extremes of the networks are the end of the relations manipulated and that these can be used as heuristic elements for the reflection of the possibilities of heterogeneous relations (included the interdisciplinary relations of the entities represented by the graphos).

RL corresponds to the linguistic turn of the social sciences so that particularly has been expressed in the complementation or substitution of the parametric statistic analysis by the textual analysis (Allende and Arellano, 2004), relational and visual of heterogeneous data (Mogoutov and Dodier, 1997). RL is a computational instrument that helps the study of the complexity of the sources and the data produced by the research institutions.

In this work we use it as an example of technical assistant belonging to a network analysis software family (Van Raan, 2003), from which it is intended to have consultation, visualization and empiric data analysis assistants that consider the nature and degrees of structuring of information concentration databases, figures and texts corpus.

In the case we are studying, it is about critically exploit the computational assistant when following a double interpretation route: the one that seek knowing the socio-scientific research networks, when interpreting the analytical results from the computational analysis of information on the university research, organized in databases on research projects from the University of Costa Rica; and the one that reflexively is applied to the knowledge of instruments that produce the information and analysis, parting from the case study of the research in basic sciences of the UCR.

Before moving to the mapping of the research dynamic in the UCR, it is essential to clarify that these computational techniques present certain advantages, but also some drawbacks that cannot be overlooked. The advantages of the science-metric instruments is that these allow processing a large number of data, as well as the matters of aggregation, and facilitate the identification of emerging structures; according to the capacity of the computational systems, the capacities of calculation and treatment of data have become really impressive.

But, on the other hand, according to Callon and Courtial (1995), these instruments have two big drawbacks: on the one hand, to ignore everything that does not appear under the form of a formal document of which the circulation space is public and are not obtainable;[6] and, on the other hand, the impossibility of containing all the scientific activity, mainly the technological, in written, leaving aside all the tacit knowledge.

3. The institutional dynamic of the research in the University of Costa Rica

Since 1941 and until the end of the seventies, the UCR was more oriented to the formation of professional, meeting that way the need of professionals for the socioeconomic development of the Costa Rican society. It was in the II University Congress (1972-1973) and with the UCR academic restructuring when it was expressed the need of developing a national scientific and technological capacity without the subordination to foreign interests (Gutiérrez, 2002).

In 1974 the Research Vice-rectory was established (VI), as the instance responsible for supervising, coordinating and stimulating the research at the University of Costa Rica; and in 1975 a formal financing projects program was established (34 projects of 16 research units) (CNR, 2003).

[6] In the case we are studying, it refers to researches performed without an institutional registration.

[7] New centers and institutes are created, reaching 22 research units, among which the most important: CIELEC (electrochemistry) CIHATA (abnormal hemoglobins), CIMAR, (sea sciences), CIPRONA (natural products), CIGEFI (geophysics), INII (engineering), IIMEC (education —now INIE).

[8] Research master plans are created in areas considered as critical for the country, to know; non-

Between 1976 and 1981 there is a research groups formation and consolidation period, as well as the creation of units,[7] and research programs.[8] The norms for the research are established and researchers from governmental entities are incorporated to the programs. In said period, the VI authorizes the amount of 100 full-time positions as researchers. The Vigilance Committee on Researches on Human Beings as a requirement by the Ministry of Health was established.

Between 1981 and 1988, 11 international scientists were invited to give advice on their correspondent discipline. The analysis of the new projects was established. The need of spreading the results from the researches in an organized and systematic way was set as an important goal. The inter-university projects with the Technological Institute of Costa Rica and the National University were created; and some international cooperation programs were implemented[9] (UCR, 1989).

Just the period between 1988 and 1992 is marked by three important milestones in the conceptualization of research: 1. There is a substantial restructuring in the Vice-rectory organization, the Technological Transference Unit (UTT in Spanish) appears as an instance in charge of strengthening the links between the research projects and the country's productive sector; the Direction of Research Management (with promotion, follow-up and evaluation units), Legal Assessment and Computing Assessment also appear. 2. The decentralization of procedures of the VI toward Academic Units begins. 3. The Vice-rectory is provided with administrative support, creating the databases on projects and researchers. An evaluation model of the university technological capacity is established, with a pilot plan in biotechnology; and the conditions so that young researchers start their careers were also established (UCR, 1989, 1990, 1991, 1992).

conventional energy sources, health and nutrition, education, agriculture (industry and technology) and rational use of natural resources.

[9] With Japanese institutions, the OAS, the International Agency for Development, with the CELA (Joint Studies of Latin American Economic integration), the Ford foundation and the Who.

Between 1992 and 1994, the Vice-rectory of Research participated actively in government meetings for the definition of policies and guidelines in the research field that would affect the country. Researches of a multidiscipline nature were fostered. The amount of current researches increased to close to 600; the search for external financial sources was intensified, conducting at the Juridical Advice Office in coordination with the UCR 160 agreements, treaties and pacts (UCR, 1992, 1993, 1994).

Between 1994 and 1996 the revision and updating process of the different regulations of the research units began. The proposal, researchers and units evaluation instruments were also inspected. The Research Days and more than 35 activities (conferences, seminars, etc.) were organized.

The divulgation via Internet started with the creation of the electronic bulletin of the Vice-rectory with 423 subscribers by 1995 and with the construction of the website of the same Vice-rectory. There is a considerable increment in the amount of current researches (more 820) in comparison to those averagely maintained in the previous administration. There is a strong external communication with public institutions, bilateral and multilateral organisms, NGOs and diplomatic bodies. Important international relationships with the Canadian government, Universities from Columbia, Iowa, California, the GTZ (German Cooperation Agency), the Bolivar Program, and the United Nations, among others were established (UCR, 1993, 1994, 1995, 1996, 1997).

Between 1996 and 2004, the University of Costa Rica made an important budget effort when investing between 13% and 15% of its resources in the strengthening of activities of research, postgraduate studies, library systems, documentation and information, editorial system and other support units. The Researcher Award was established in order to acknowledge the work of more than one thousand professors dedicated to research. The cooperation and internationalization process reaches its peak as fundament of the maintenance of excellence. The systematic evaluation of centers and institutes is done. Specific evaluation instruments for each process were created (presentation of proposals, evaluation, process extension, presentation of informs, etc). A Projects Formulation Institutional System was established. During this period 1,580 projects were successfully concluded (in average 198 per year) and 1,936 extended their validity. There is, in said period, a constant strengthening of the institutional programs. It can be observed an increasing research activity, in both the proposal of projects, programs and activities, as well as in the creation on new units (UCR, 1997 a 2005; Vicerrectoría de Investigación, 2004).

Currently, the UCR has 53 research units distributed in centers, institutes, manors, experimental stations and other units. There is a trend towards the creation of research teams. However, the percentage of individual researches is more than 40%. It is estimated that close to 70% of the scientific articles published in internationally indexed journals by Costa Rican researchers belong to scientists from UCR, which represents close to 47% of the scientific indexed production of Central America (Parral, 2004; Vicerrectoría de Investigación, 2004, 2005; CNR, 2005).

4. Mapping the research history in basic sciences in UCR

The first distinctive consideration on UCR is that it is a disciplinary complex university, but relatively small. Practically there is not a university discipline that is not practiced at UCR; nonetheless, it is relatively complex to be a national university. The second is the great consistence of the classification categories, the statistics of its research activities and the protection of its archive patrimony. These considerations make UCR a consistent object of study for the reticular analysis we have propounded.

For the study of the research projects databases of UCR it has been decided to distinguish historically the information available since 1977 to the date in four-year periods, selecting in conformity with the higher administration periods, specifically that of the rectorate times. This measure was taken under the consideration that each of these periods correspond to certain homogeneity in the concrete scientific policy and with depuration moments of the current projects.[10]

[10] The analysis we have done is sustained on a database of 61,685 registers of 4,259 projects inscribed in the Research Vice-Rectory in the period between 1977-2005 (VI, 2005).

The amount of research projects and research units has been increasing throughout the history of UCR. In the late 70's, the number of research projects was 224 and 22 research units. Between 1981 and 1988, the figure increases in more than 100%, when changing from 288 to 673, respectively; this period corresponds to only one Vice-rectorial administration. The same happens with the period between 1989 and 1993 when the projects increase from 673 to 1,268. Yet, in the period between 1997 and year 2000, the number of projects increases 10%, so that it reaches a total of 1,676 projects and then it decreases to 1,569 projects. This period 1997-2000 corresponds to only one vice-rectorial and can be interpreted as a regulation period and of the establishment of the previously rehearsed normativity (See Figure 1).

From 1981 to 2004, the coverage of the areas has changed; the triad of basic sciences, social and health sciences was maintained since the beginning of the institutionalized research until 1992. With the exception of the 1993-1996 and 1997-2000 periods, the health area was substituted by the agro-alimentary area of that triad. The visibility of the basic sciences has been slightly higher to that of the social sciences, except in the 1981-1984 and 2000-2004, when these have had a large number of research projects in process.

After that the previous analysis worked as a historic frame, next we present the basic sciences research networks. First we will analyze the research dynamics of the area under study in the 1997-2005 period. Then, we will analyze the main heterogeneous relations among the projects, disciplines and research areas. To conclude, we will take as cases the detailed analysis of the discipline and Research Units (RU) to show the research dynamics.

Mapping the research dynamics in the basic sciences area

Taking the long period between 1975 and 2005, the relevance of the RU, in respect to the number of projects registered, it has three visibility orders: the first one is represented by the CIBCM,[11] the BIOLOGY S. and the CIMAR; followed by a second where the CIGEFI, the PHYSICS S., the CICA, the GEOLOGY S., the CELEQ and the CIPRONA can be seen; and finally, a third order by the rest of the RU. In regards to the disciplines, there are two dimensions, that of higher visibility that corresponds to MATHEMATICS, CHEMESTRY, CELULAR BIOLOGY and MOLECULAR BIOLOGY; followed by a lower visibility of GEOLOGY, PHYSICS, AGRONOMY, MARINE BIOLOGY, the BIOLOGIC SCIENCES, OCEANOGRAPHY, and GEOPHYSICS (see Figure 2).

The reticular and socio-technical reading accounts for the relational realities; in this way, we have that there are regions formed by close relations between disciplines and institutions, standing out that represented by MATHEMATICS, PHYSICS and their correspondent schools (MATHEMATICS S. and PHYSICS S.) (Figure 2); A region formed between a discipline and more than one institution, as in the case of CHEMESTRY and the CELEQ and the CHEMESTRY S.; it can be seen a region of great complexity of relations among disciplines of the BIOLOGICAL SCIENCES, CELLULAR BIOLOGY and MOLECULAR BIOLOGY and the BIOLOGY S. and the CIBCM, it can be observed that CIMAR and CICA are not related in one discipline, but rather they are located egocentrically among several disciplines (see Figure 2).

Now, when reducing temporarily the observation period to that between 2000-2004, it can be seen that the RU with more presence for the number of registered projects were the CIBCM, the BIOLOGY S., the CIMPA, the GEOLOGY S., the CIMAR, the CICIMA and the CIGEFI (se Figure 3), in the rest of the units were distributed the rest of the projects. In this figure it can be observed with careful precision the disciplines and RU that are

[11] The name of the unit will be written as it is used in the origin databases and in the Annex 1 the acronyms will be explained.

highlighted by the research projects. Almost all the disciplines have a relatively similar visibility so that prominent icons are not to be clearly noticed.

According to the number of research projects, the central disciplines are CHEMESTRY, MOLECULAR BIOLOGY, CELLULAR BIOLOGY, MATHEMATICS, MARINE BIOLOGY, GEOLOGY, and PHYSICS. It is worth mentioning that there are projects that share these disciplines. The disciplines in the extremes constitute in themselves poles of frequency of important projects (see figure 3).

Interdisciplinary possibilities of the disciplines associated to the area of basic sciences

Next we present a heuristic exercise applied to the search of interdisciplinary relations associated to the basic sciences. From a relational perspective, it can be seen a region described in the long period between 1997 and 2005, formed by a strong relation between the CIBCM and the BIOLOGY S., and the MOLECULAR BIOLOGY and the CELLULAR BIOLOGY, where the institutions appear as being of the same visibility (see figure 2); in the 2000-2004 period it is visible that the CIBCM is in the centre of a network of disciplines; this can be due to the preponderance of the molecular and cellular biology, but also due to the relation with the TECHNOBIOLOGY and the VEGETAL GENETICS developed in the last years (see figure 4).

Similarly, a relation between certain disciplines such as PHYSICS, MATHEMATICS and GEOLOGY with their school, with the exception of the recent preponderance of the CIGEFI as a high multidisciplinary centre converted in executor of asymbolic disciplines (see figure 4).

Now, inverting the research units and disciplines analysis made before, it can be seen that the relations inscribed in the research projects show certain characteristics of interdisciplinary relations. We mean the fact that the same discipline is practices by research units that not necessarily had been visible in the basic sciences area.

In figure 4, the disciplines from the basic sciences are primarily related to the disciplines from other areas and in a second term with the shared RU, in both cases projects registered in the VI. This figure shows interaction possibilities between research units, that being from different areas, offer interdisciplinary possibilities around disciplines, no matter the area. This is possible due to the fact that projects inscribed in the basic sciences area evoke disciplines from different areas, thanks to the mediation of the RU where the projects have been inscribed. So, for example, from the perspective of the disciplines, the FOOD TECHNOLOGY relates the RU as the NUTRITION S., the CIITA, the CIHATA, and the INISA; but from the perspective of the RU, the PHYSICS S. relates the NAVAL TECHNOLOGY with the PHYSICS (see figure 4).

Mapping research units and disciplines

Now we will analyze two aspects of the research dynamics in basic sciences, one in regards to one discipline and the other to a research unit.

The Molecular and Cellular Biology Research Centre (CIBCM)

The two main disciplines practice at the CIBCM are molecular biology and cellular biology; this is consistent to a long-term analysis 1977-2005 (see figure 5), as in the analysis in the 2000-2004 period (see figure 6).

With the information of the projects developed between 2000 and 2004, it is possible to see at low observation scale the association the researchers have among them and with other research entities. So, it can be seen that the RBA researcher centralizes a network of projects in the two main action disciplines of CIBCM (MOLECULAR BIOLOGY and CELLULAR BIOLOGY), and collaborates with a large number of colleagues from the centre (see figure 7). It is possible to imply that this researcher is, to a certain extent, the representative of a phenomenon observed in both periods; the long term period 1997-2005 (see figure 2) and in the 2000-2004 period (see figure 3), as well as in the CIBCM analysis between 2000 and 2004 (see figures 5 and 6)

It is worth mentioning that in this observation exercise the computational instrument allows us to move from scales and work in the inter-representation of entities at different times and scale dimensions.

Chemistry at UCR

In regards to the disciplines, chemistry is the one with more visibility that has been worked with between 1977 and 2005 at the research units, in visibility order, the CELEQ, the SCHOOL OF CHEMISTRY, the CICA and the CIPRONA (see figure 8).

Between 2000 and 20004, CHEMISTRY was mainly practiced in the same three units during the long term period mentioned above; nonetheless, in this period the CICIMA becomes visible with three projects, as well as the CIPRONA (see figure 9).

The main researchers on this discipline are Marta Montero Calderón and Sandra Calderón Villaplana; both of them have individual projects, also, in collaboration they are developing the Project A1540 and their institutional ambits belong to CELEQ and CICA, respectively (see figure 10). On the other hand, Jorge Campos Montero has developed more projects than the other two researchers and institutionally his researches are inscribed in three research centers. Conversely, the work of Teres Somogyi Pérez is of an individual character, there are not collaborative researches with other scientists in his agenda. Anyhow, the analysis of these researchers' projects shows that the heaviest work no CHEMISTRY is done at CELEQ, as it appeared in the 1977 to 2005 analysis (see figures 8 and 9).

Conclusions

The University of Costa Rica was a consistent case of study for the knowledge and exploitation of these computational assistants since their two distinctive considerations present it as a disciplinary complex but relatively small university, but, above all, it is useful for the study because it has achieved creating great consistence of the classification categories and the statistics of their research activities and the protection of its archive patrimony.

Using the RL software, we have explored the complexity of the sources and the data produced by the research institution of the University of Costa Rica, to analyze the homogeneous networks represented graphically in the area of the basic sciences. The information provided has allowed us to distinguish in the most visible graphos the relevant actors and in the lines the resulting relations of the information intensity contained in the research projects, and even in the small graphos as in the resulting ones from the information from some researchers and significant situations for the institution, as the case of the visibility of a researcher in a complex context. The incorporation of information in areas different to that of the basic sciences has shown the possible and feasible multidisciplinarity between different research units and researchers.

The socio-technical reading of the projects registered between 1977 and 2005 account for the heterogeneous relational realities; so, we have that there are regions formed by close relations between disciplines and institutions in mathematics and physics, except that recently there is supremacy of the CIMPA in mathematics; a region formed between a discipline and more than one institution, as the case of chemistry and a research centre and a school; it can be appreciated a region of great complexity of relations among disciplines as the case of molecular and cellular biology, and a school of biology and a research centre that includes the two disciplines mentioned; and finally, it can be observed two research centers (CIMAR and CICA) located egocentrically among different disciplines.

Shortening the observation period to the rectorial period 2000-2004, it can be seen that the most visible RU for the number of projects registered were the CIBCM, the BIOLOGY S., the CIMPA, the SCHOOL OF GEOLOGY, CIMAR, CICIMA and the CIGEFI; the rest of the projects is distributed among the other units. Almost all the disciplines have a relatively similar visibility. According to the number of research projects, the central disciplines are CHEMISTRY, MOLECULAR BIOLOGY, CELLULAAR BIOLOGY, MATHEMATICS, MARINE BIOLOGY, GEOLOGY and PHYSICS.

From a rational perspective, between 1977 and 2005, it can be observed a region formed by a strong interaction among the CIBCM and the SCHOOL OF BIOLOGY and MOLECULAR BILOGY and CELLULAR BIOLOGY; however, recently in the period 2000-2004) it is visible that the CIBCM is in the middle of a network of relatively old disciplines as the cellular biology and the vegetal genetics, and of recent development as the biotechnology and molecular biology.

The recent emergence of the CIGEFI as a high multidisciplinary centre turned into the executor of apparently asymbolic disciplines stands out.

In regards to the analysis of the Molecular and Cellular Biology Research Centre (CIBCM) we found that the two main disciplines practiced at the CIBCM are the molecular and the cellular biology, this is consistent with the long-term analysis 1977-2005, as with the analysis of the period 2000-2004. We have observed how the relations of a researcher are representative of the previous phenomenon.

In respect to the analysis of chemistry, we observed that between 1977 and 2005 in the RU, in visibility order, the CELEQ, the SCHOOL OF CHEMISTRY, CICA and the CIPRONA; however, between 2000 and 2004, the CICIMA and CIPRONA become more visible. The analysis of the projects of the researchers of more visibility shows that the heaviest work on chemistry is done at the CELEQ as it could be seen in the analysis of 1997 to 2005.

In this work we have exposed the cognitive possibilities of the use of computational assistants applied to the study of the information from research projects, with which the results of the textual and relational analyses can be seen, and the integration of qualitative and quantitative methods. The exploitation of the computational assistant has made it possible to see graphically the organization of the heterogeneous elements result from the information databases on research projects, taken as a case the University of Costa Rica.

It has also been done the double set in relation between the analysis of different nature data that can express, visualize, structure and analyze data networks from different entities expressed qualitatively and quantitatively; with which we advance in the understanding of the knowledge and artifacts elaboration processes, and advance in simultaneous knowledge of the construction of the science and the technology and the constructions of the epistemology itself.

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Annex 1. Research Units Glossary

CELEQ: Centro de Investigaciones en Electroquímica y Energía Química

—*Electrochemistry and Chemical Energy Research Center*—

CIBCM: Centro de Investigaciones en Biología Molecular y Celular.

—*The Molecular and Cellular Biology Research Centre*—

CICA: Centro de Investigaciones en Contaminación Ambiental.

—Environmental Pollution Research Centre—

CICIMA: Centro de Investigaciones en Ciencia e Ingeniería de Materiales.

—Materials Engineering and Science Research Centre——

CIGEFI: Centro de Investigaciones Geofísicas.

—Geophysics Research Centre—

CIHATA: Centro de Investigación en Hemoglobinas Anormales y Trastornos Afines.

—*Abnormal hemoglobin's and related disorders Research Centre*——

CIITA: Centro Nacional de Ciencia y Tecnología de Alimentos.

—National Centre of Food Science and Technology—

CIMAR: Centro de Investigaciones en Ciencias del Mar y Limnología.

—Limnology and Sea Sciences Research Centre—

CIMPA: Centro de Investigaciones en Matemáticas Puras y Aplicadas.

—Applied and Pure Mathematics Research Centre—

CIPRONA: Centro de Investigaciones en Productos Naturales.

—Natural Products Research Centre—

INISA: Instituto de Investigaciones en Salud.

—Health Research Centre—

E. BIOLOGIA (BIOLOGY S.)

—SCHOOL OF BIOLOGY—

E. FÍSICA (PHYSICS S.)

—SCHOOL OF PHYSICS—

E. GEOLOGIA (GEOLOGY S.)

—SCHOOL OF GEOLOGY—

E- MATEMÁTICAS (MATHEMATICS S.)

—MATHEMATICS SCHOOL—

E. NUTRICION (NUTRIRION S.)

—SCHOOL OF NUTRITION—

E. QUÍMICA (CHEMISTRY S.)

—SCHOOL OF CHEMISTRY—

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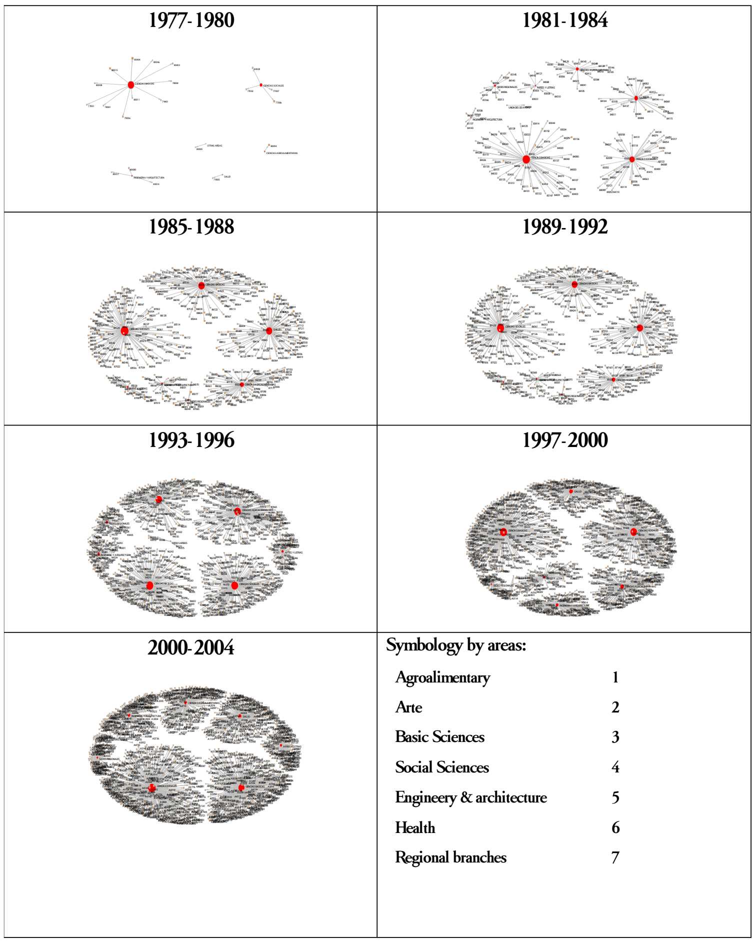
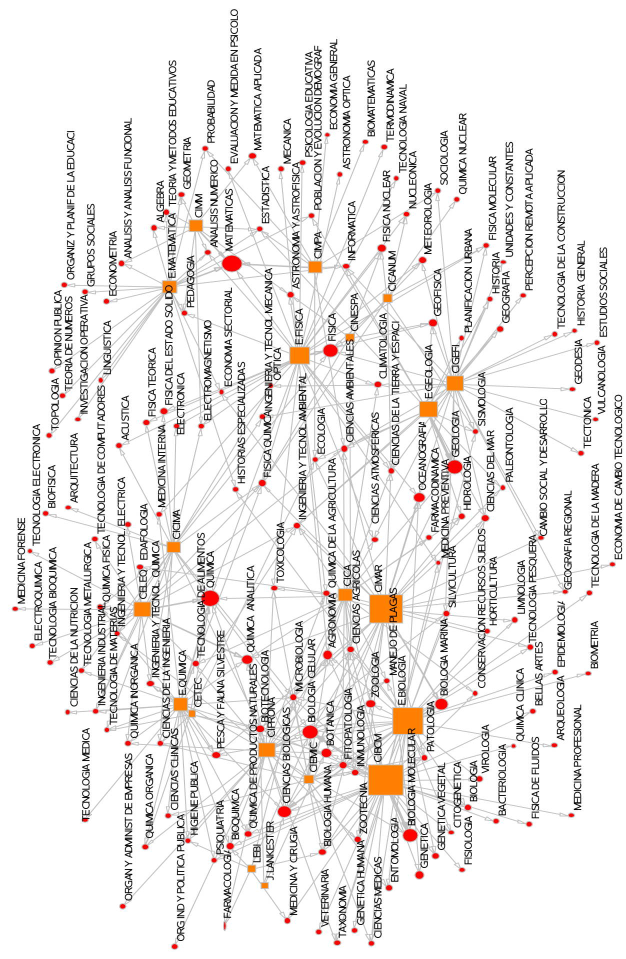
Figure 1.
Projects volume per research area at the UCR 1977-2004



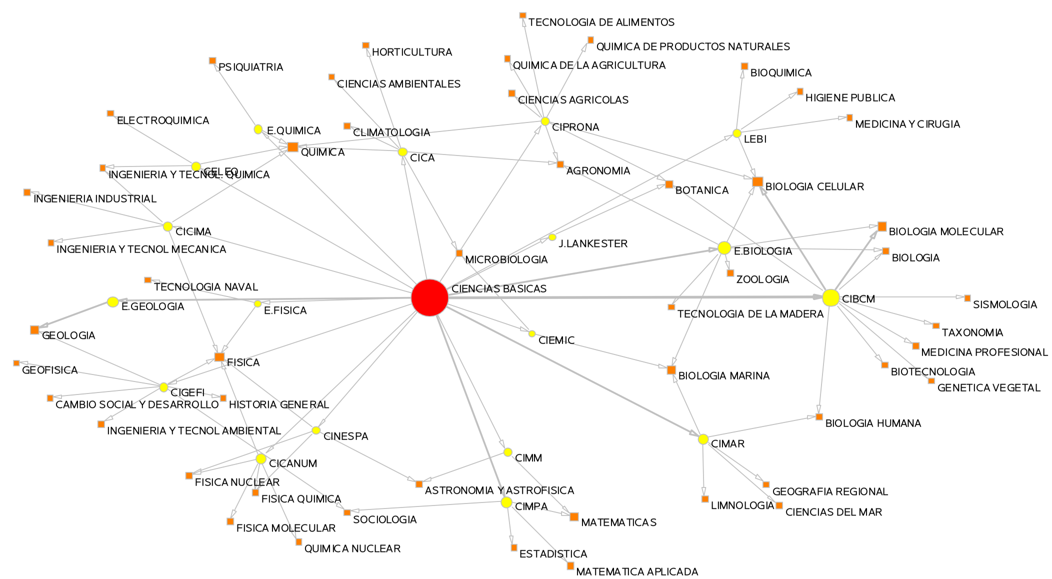
Source: own elaboration from the data on research projects (VI, 2005).

Figure 2.
Disciplines and Research Unites in basic sciences (1977-2005)



: Own elaboration from databases of the VI of the UCR (VI, 2005).

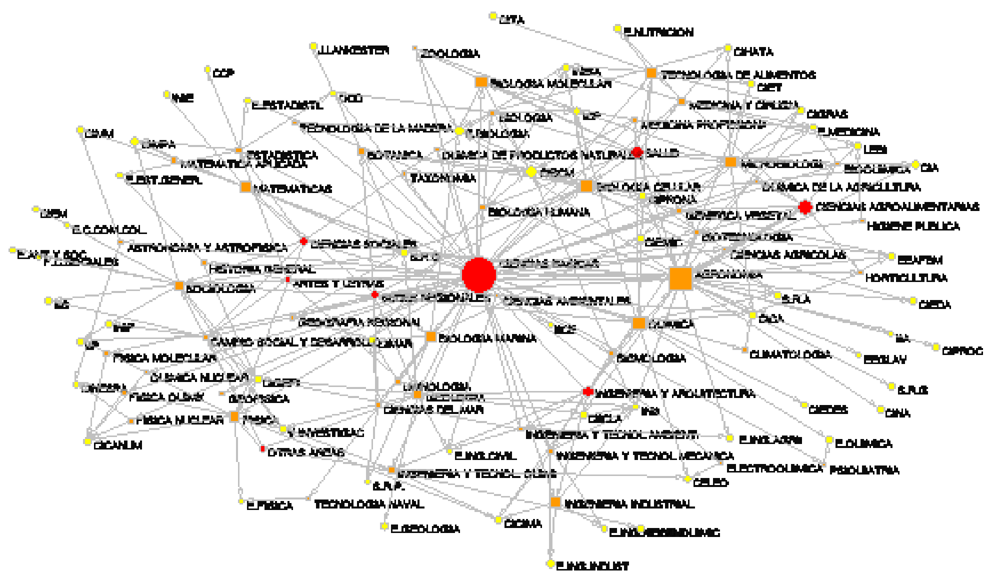
Figure 3.
Disciplines and Research Units in basic sciences (2000-2004)



Source: Own elaboration from databases of the VI of UCR.

Figure 4

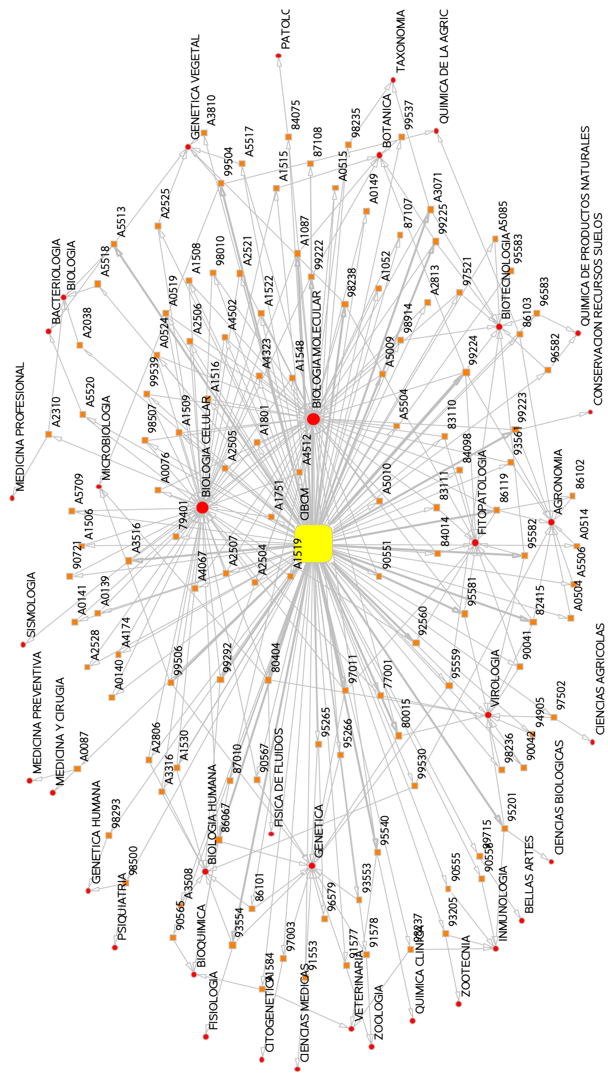
. disciplines and Research Unites related to basic sciences (2000-2004)



Source: Own elaboration from databases of the VI of UCR (VI, 2005).

Figure 5

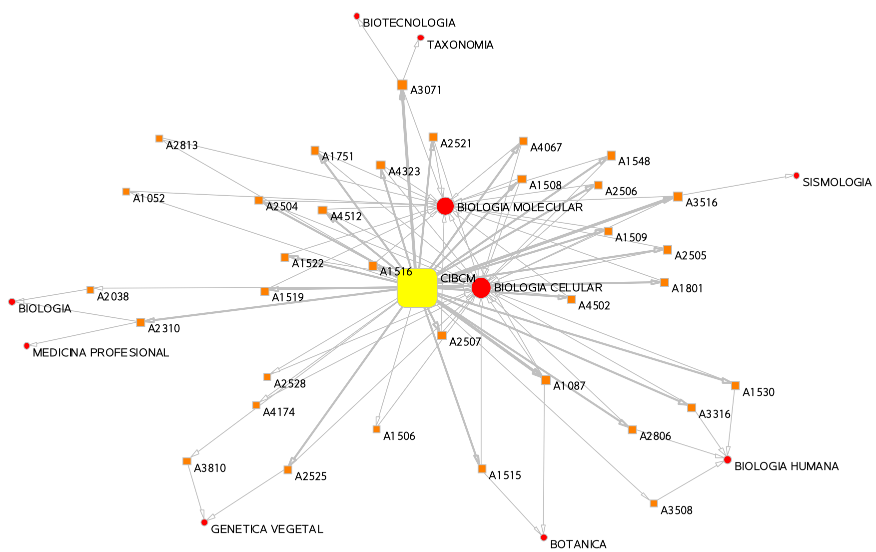
. Projects and disciplines developed at the CIBCM (2000-2004)



Source: Own elaboration from databases of the VI of UCR.

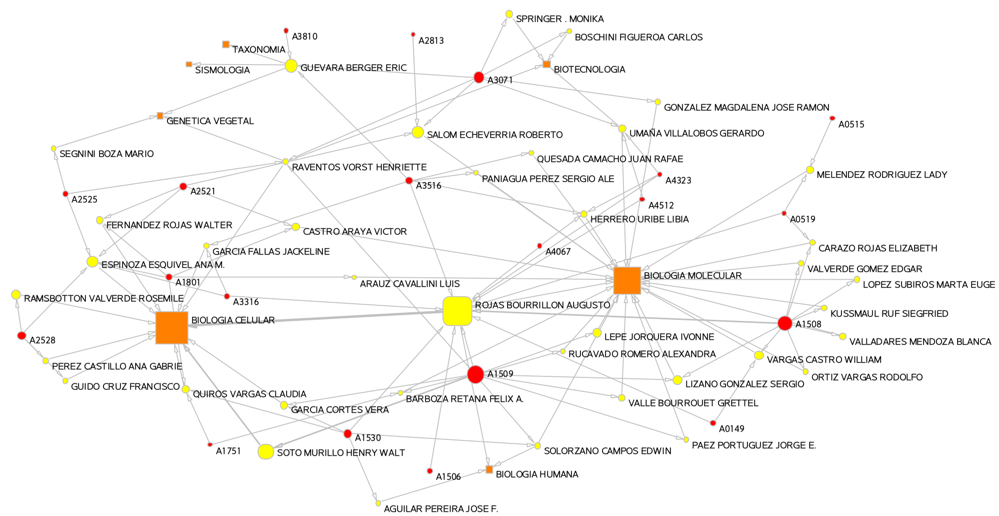
Figure 6

. Projects and disciplines at the CIBCM (2000-2004)



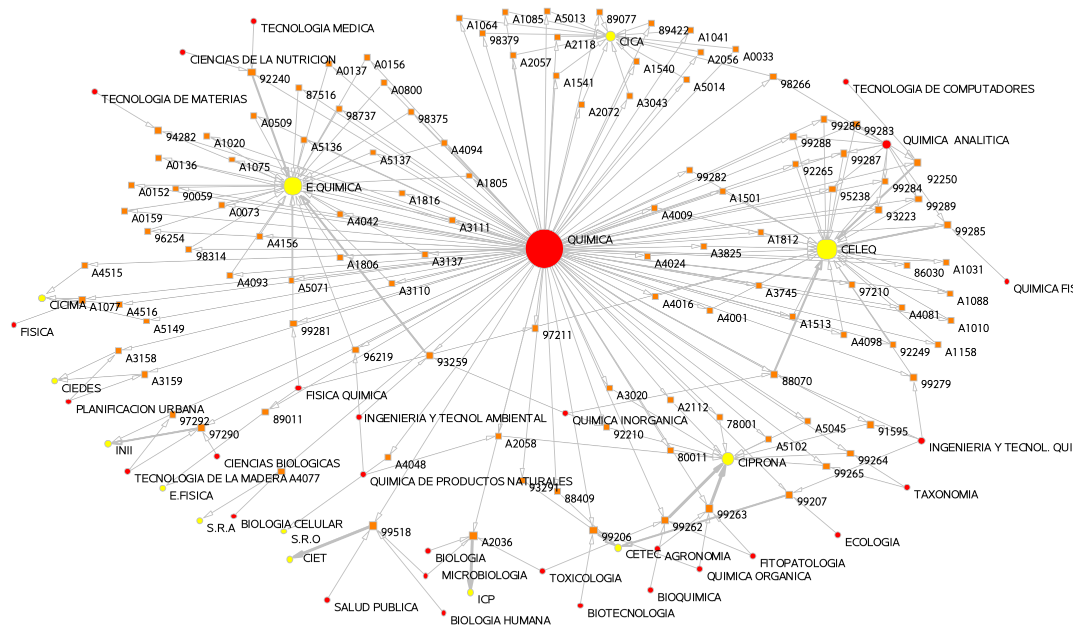
Source: Own elaboration from databases of the VI of UCR.

Figure 7.
Projects, researchers and Research Units from CIBCM (2000-2004)



Source: Own elaboration from databases of the VI of UCR (VI, 2005).

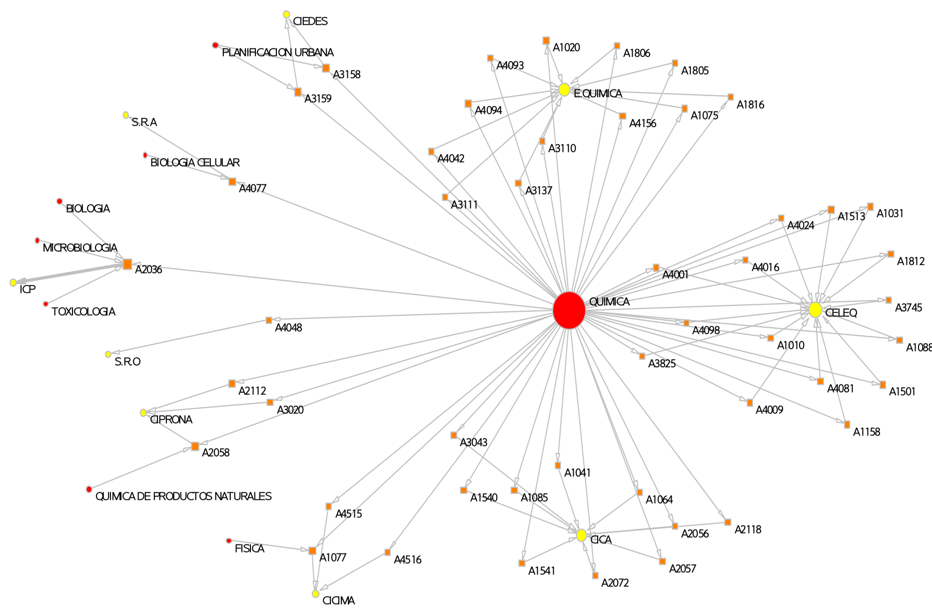
Figure 8.
Research units and projects on CHEMESTRY



Source: Own elaboration from databases of the VI of UCR (VI, 2005).

Figure 9

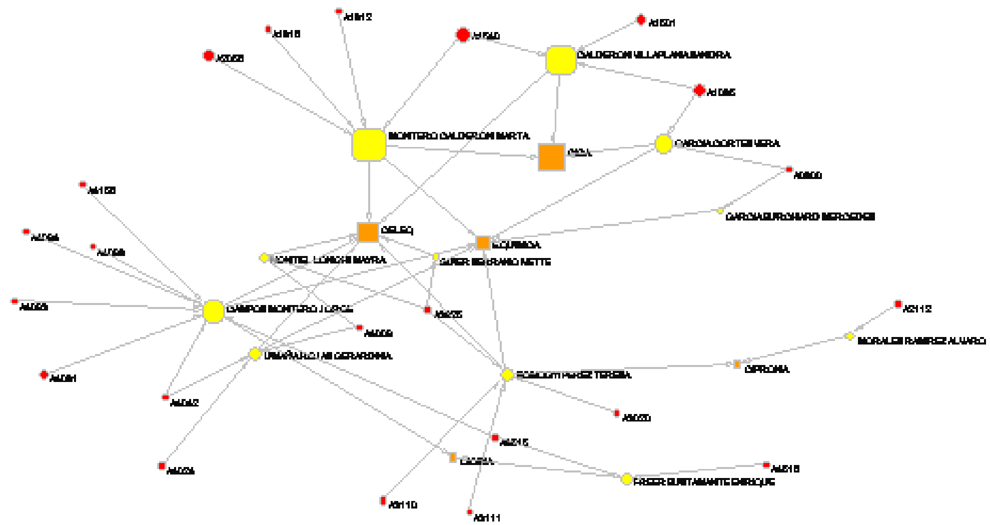
. Projects and Research Units where CHEMISTRY is practiced



Source: Own elaboration from databases of the VI of UCR (VI, 2005).

Figure 10

. Projects, Researchers and Research Units of CHEMISTRY (2000-2004)



Source: Own elaboration from de databases of the VI of UCR (VI, 2005).