On account of my prolonged dedication to the three university functions in the biomedical field—assistance, teaching and research—I have been able to express my points of view on many questions related to this triple function. Thus, in the scope of assistance and by way of several lectures and articles, I have stressed the importance of the primary care doctor, as well as that of the internist and the relationships between general and specialized internists. I have been frequently concerned with the teaching aspects, particularly in connection with those related to the new pregraduate teaching models. I have also dedicated much thought to the organizational models of the Departments of Medicine and even of the University of Health Sciences. Finally, I have expressed my opinions on the methods used to foster research in University Hospitals.

The present article contains a series of reflections on biomedical research in Spain. Obviously enough, this subject is receiving increasing attention in many domains of the Spanish State, and hopefully my points of view will be useful to those who, one way or another, hold responsibilities in this area.

This article contains four sections: 1) Objectives and importance of research, 2) Research promoting methods, 3) Panorama of the Spanish scientific production in biomedicine and its financing, and 4) The importance of translational research.

## Objectives and Importance of Research

The objective of research is the achievement of new levels of knowledge, the discovery of truth. This is of high intrinsic value, because any attempt to approach truth dignifies man. Moreover, achieving new levels of knowledge is useful in terms of production and contributes to the population’s well-being. Countries lacking oil or other natural resources must produce more research in order to warrant their development. One of the most relevant and unexpected discoveries of economic sciences in the United States was that economic growth depended greatly on scientific and technological advance. Economist Robert Solow from the Massachusetts Institute of Technology was awarded the Nobel Prize in 1987 largely for having quantified such dependence. Indeed, this author came to the conclusion that, during the first few decades after World War II, scientific and technological discoveries accounted for approximately half of the economic development of his country. However, the causal relationship between the funds invested in research and development on the one hand, and economic growth on the other hand, is not a peculiarity of the United States nor is it limited to technologically advanced regions. The most recently industrialised countries in Asia (Korea, Malaysia, Hong Kong, Singapore and Taiwan) are good examples of this. In just two decades, they have increased their investment in research and development (R & D) from...
0.1 to 1.6% of the gross domestic product (GDP), whereby these formerly underdeveloped countries have become industrial powers. In sum, the nations that increase their R & D investment do benefit from a growth in their GDP within a few years. Finally, as the great late Spanish scientist Dr. Alberto Sols put it, «serious culture of research is valuable in that it warrants a capital of minds prepared to face the challenge of the unexpected, increasingly frequent in today’s world».(4)

The research we are dealing with here is biomedical research, whether basic or applied. Its primary objective is to favour the patient’s interests, that is, to offer him/her a longer, better life. All other purposes must be subordinated to the primary one.

RESEARCH PROMOTING METHODS
As already pointed out, one of the most effective methods to promote research is to increase investment. In this sense, it should be noted that worldwide leading countries like the US and Germany assign around 2.5% of their GDP to R & D, with a European Union mean of 2%. Regarding Spain, a great effort has been evidenced over the past two decades, and this percentage has been multiplied by more than five between 1982 and 1992. The results of this increased investment were dramatic, as shown by a greater scientific production increase in Spain during this period compared to most other countries. As from 1992, however, some slowdown was apparent whose correction is presently being attempted. Indeed, the objective of the Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica 2000-2003 [National Plan of Scientific Research, Development and Technological Innovation 2000-2003] is to increase R & D from 0.89% in 1999 to 1.29% in 2003, a goal still far below the European mean.

In this context, it should be reminded that governmental authorities frequently exert some dirigisme on the prioritisation of applications destined to research funds. This is somewhat arguable, the way from innovation to application being a sinuous, unpredictable line difficult to regulate and codify by politicians and bureaucrats. If the importance of scientific policies for the progress of research is beyond doubt, by no means should it be aimed exclusively at preset objectives. At least part of the resources should be assigned to free research, without objectives preset by scientific policies. The really important issue is to create an environment to facilitate the development of science. In this sense, the creation of an ideal social atmosphere is a pending subject in some European countries, including Spain. While today’s society obvously renders a tremendous cult to sports and entertainment personalites, the prestige of scientists is scarce. The media are to play a significant role in modifying this. The call for and award of important prizes, as well as aids for research, may contribute to improve the public image of researchers, although dignified wages and the removal of precariousness of labour are more important goals to be achieved. Finally, given that culture increases the appreciation of scientific research, the entire society should use its best efforts to raise its cultural level.

The promotion of research in University Hospitals calls for specific methods.(5). It is unanimously accepted today that a university hospital must play a triple function, i.e. assistance, teaching and research. No hospital can be exempted from the obligation of offering the best possible health assistance to its assigned population. Just as obvious is the university hospital’s duty to actively participate in teaching tasks, whether of pregraduate, postgraduate or continuous medical education. As far as research is concerned, not long ago clinical hospitals used to exert little activity in this field, and focused preferably and mostly on assistance and teaching. Unquestionably, however, any university professional —even at a clinical level— has an obligation to research. This idea is gaining more and more insight, as evidenced by the increased quantity and quality of the research presently carried out in university hospitals. The organization and the promotion of investigational tasks in hospitals is not easy sometimes and requires, besides strong will and persistence, a solid dose of imagination.

At present, the high level reached by the Hospital Clinic of Barcelona (HCB) in the field of biomedical research is widely acknowledged. Indeed, bibliometric studies repeatedly report this centre as being number one among all Spanish hospitals in this field, well ahead of the rest.(6). How was this privileged position reached? In an article published a couple of years ago(7), Joan Rodés and myself referred to five actions that have greatly influenced the development of biomedical research in our Hospital. The first one consisted in the reform of the functional structure of our institution, dating back to 1972. By breaking with the classical organisation of university hospitals —that is, the simple apposition of clinics associated to their respective professorships and otherwise unconnected— we had the foresight to develop a departmental structure which was 12 years ahead of the LRU (University Reform Law). The modern organisation arising from this reform allowed to create the right climate where the three university functions —assistance, teaching and research of best possible quality— could be developed on a coordinated basis. In 1980, this first action was followed by another two, still in force, which have greatly contributed to the development of research activities amongst us: the
creation of post-resident research grants and the creation of
the so-called sabbatical years, or paid leaves to expand
studies. Similar initiatives are presently arising in Santander
and in the autonomous region (AR) of Valencia. In addition,
the Carlos III Health Institute called for 30 aids in a pilot
program to hire junior doctors willing to complete their
education in Biomedical Research and Health Sciences. The
fourth action, already emulated by a number of health
institutions, was the creation of the Private Foundation Cliní
para la Investigación Biomédica, with legal personality of its
own and independent of the Hospital’s healthcare resource
management. Finally, in order to draw fine-quality basic
and clinical research together in a common environment,
an agreement was signed in 1993 whereby a consortium
between the Hospital Clinic, the University of Barcelona
and the Generalitat of Catalonia was formed, with further
adherence of the Biomedical Research Institute of Barcelona
belonging to the Spanish Institute for Scientific Research
(CSIC), to create the August Pi i Sanyer Biomedical Research
Institute (IDIBAPS). This initiative was an attempt to
unite the three domains where biomedical research is typically
developed: hospitals, university and CSIC.

**PANORAMA OF THE SPANISH SCIENTIFIC
PRODUCTION IN BIOMEDICINE AND ITS FINANCING**

Undoubtedly, any attempt to progress in research tasks
will be all the more fruitful with a better knowledge of the
present situation. In this sense, it may be useful to: a) discuss
the methods used in the assessment of scientific activities;
b) analyse the situation of the Spanish science in an international
context; c) discuss comparative data related to biomedical
research in different autonomies and different institutional
sectors; and d) approach some questions related to its
financing.

Researchers usually show great interest in having
their scientific production duly assessed, this being the way
to obtain more resources to carry on with their activity.
Assessment tasks have become a specialty in its own
right, described with the term scienciometry. This specialty
is usually based in two methods: a) bibliometric analysis
and b) peer review, or expert assessment. The former is
considered to be more objective, while the latter is more
relevant. In his/her analysis, the expert reviewer shall
include, in addition to bibliometric techniques, other criteria
such as patents obtained, projects financed, degree of efficiency
(productivity versus human resources and available material),
and, above all, his/her own global insight in the context
of a specific scientific field. Among the bibliometric parameters,
the so-called impact factor is most frequently used. However,
the different biases incurred during the preparation of
this indicator are well known –particularly in terms of abusive use. As pointed out by Camí(6), the «impactitis»
shown by institutions, clinical departments or services and
by some researchers –which could be summarised as
«you are what your impact factor is»– should undergo critical
review. These comments, however, are not meant to be
interpreted as negative for bibliometry. Consequently, the
attitude of «impactophobics», whose position may simply
be a defence mechanism to protect «low-profile» scientific
careers, is just as objectionable as that of «impactomaniacs»,
if not more. Indeed, while a researcher who achieves publication
in high-impact journals may not be excellent, that who fails
to publish in such journals is certainly mediocre. It should
be borne in mind that a high impact factor of a journal does
not assign the same scientific value to all the works published,
and obviously not to each and every author of an article.
Moreover, the impact factor of a journal is not a good predictor
of the quality and importance of its works, and the same
criticism goes to any attempt to standardise the impact factor.

A much more reliable bibliometric parameter to assess
the quality of publications is the citation index, that is, the
number of citations received by a work from other authors.
Two other parameters of interest stem from the former, i.e.
the average of citations per document (C/D) of a group of
publications and the percentage of non-citation. When using
citation indexes, it is important to: a) establish the period
of analysis; and b) proceed to their standardisation. A citation
index will only be reliable if the work has undergone a
period of exposure of several years. Therefore, groups of
publications likely to be compared must have undergone
the same number of exposure years. On the other hand,
some standardisation technique should be used, since not
all disciplines or specialties receive the same number of
citations.

The Centre of Science and Technology Studies, Leiden,
Holland(7,8) considers as one of the best scienciometric
parameters the so-called «Internationally standardized
impact indicator». This is defined as ratio CIPx/FCSmx,
where CIPx is the average number of citations per publication
without self-citations, and FCSm corresponds to the average
citation rate of all articles in a field. According to this indicator,
the performance of a scientific group is far below (<0.3),
below (0.5-0.8), around (0.8-1.2), above (1.2-2.0) or far above
(>2.0) the international level. The higher the aggregation
degree or the larger the volume of publications, the more
difficult it is to have the impact above the international level.
Bibliometric studies have evidenced Spain’s great effort
in scientific production in the nineties. While this accounted
for less than 1% of the world production in 1984, this
percentage rose progressively up to 2.57 in 1999. Also, as acknowledged in the 2002 report of the US National Science Foundation, Spain is one of the countries with greater increase in the number of citations received over the past few years. Nevertheless, the number of citations received is still proportionally lower than the amount of works produced. For instance, Spain provided 2.57% of documents to the worldwide bibliography in 1999, but received only 1.62% of citations.

In order to discuss the bibliographic map of different regions and institutional sectors of Spain, I must inevitably refer to an excellent work carried out by Jordi Camí’s group at the IMIM of Barcelona, released last July in the portal of the Carlos III Health Institute(10). This work shows that more than 50% of the documents and more than 60% of the citations are accumulated by the AR’s of Madrid and Catalonia. These two communities are followed by those of Andalusia and Valencia, with 12.4 and 9.2% of documents, respectively. The remaining Autonomies contribute with 5% or less of citable documents.

The data about the institutional sectors involved in research activities are interesting. In that respect, three main patterns can be recognised in Spain. The first profile, represented by Andalusia, is characterised by the great importance of Universities. The second profile is represented by Catalonia, where most of the research originates in hospitals. The remaining AR’s can be related in varying degrees to the two above two profiles, with the exception of Madrid, a third and unique profile showing an important concentration of research resources.

Concerning economic resources, there is still one additional aspect of extreme importance which I cannot help but discuss. In some more advanced countries, a great part of research resources originates in the civil society. In the US, there is a blossom of Universities and Scientific Institutes thanks to patronage. We are still far from that in Spain, despite a recent modification of the related law. A great Catalan politician and former member of parliament, Miquel Roca i Junyent, analysed this question recently(11). Mr. Roca referred to the two versions by which the patronage phenomenon is considered in Spain. The sad version would be patronage as a way to evade taxes or, mind you, as another way of paying them. The positive version would recall that the civil society, on a committed and joint basis, is to make the country move forward. According to Roca, society is much more dynamic than an ever suspecting, untrusting administration. Ultimately, there is a need for the fiscal improvement of the new law is quite limited. Our fiscal treatment paralleled by civil liability claims regarding the excessive centralism of the CSIC—which concentrates more than 40% of its centres in the AR of Madrid. Fairly enough, however, this has somewhat lessened in the past few years. The same applies to the construction of big research centres in Madrid, charged against State General Budgets. We should imitate more the North American culture, where the activities of the National Institutes of Health (NIH) are mostly extramural. In this sense, some recent initiatives of the CSIC and the Carlos III Health Institute are praiseworthy and cited later here.

### TABLE I. R & D expense percentage versus GDP per autonomous region(10)

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<tbody>
<tr>
<td>Total</td>
<td>0.83</td>
<td>0.82</td>
<td>0.80</td>
<td>0.89</td>
<td>0.94</td>
</tr>
<tr>
<td>Andalusia</td>
<td>0.62</td>
<td>0.61</td>
<td>0.68</td>
<td>0.65</td>
<td>0.67</td>
</tr>
<tr>
<td>Aragon</td>
<td>0.57</td>
<td>0.52</td>
<td>0.71</td>
<td>0.74</td>
<td>0.71</td>
</tr>
<tr>
<td>Asturias (Principality of)</td>
<td>0.57</td>
<td>0.51</td>
<td>0.74</td>
<td>0.55</td>
<td>0.61</td>
</tr>
<tr>
<td>Balearic Islands</td>
<td>0.21</td>
<td>0.23</td>
<td>0.29</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Basque Country</td>
<td>1.23</td>
<td>1.17</td>
<td>1.25</td>
<td>1.16</td>
<td>1.20</td>
</tr>
<tr>
<td>Canary Islands</td>
<td>0.50</td>
<td>0.44</td>
<td>0.53</td>
<td>0.48</td>
<td>0.49</td>
</tr>
<tr>
<td>Cantabria</td>
<td>0.53</td>
<td>0.58</td>
<td>0.83</td>
<td>0.60</td>
<td>0.47</td>
</tr>
<tr>
<td>Castilla – La Mancha</td>
<td>0.40</td>
<td>0.51</td>
<td>0.48</td>
<td>0.33</td>
<td>0.57</td>
</tr>
<tr>
<td>Castilla – León</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
<td>0.62</td>
<td>0.64</td>
</tr>
<tr>
<td>Catalonia</td>
<td>0.92</td>
<td>0.93</td>
<td>1.08</td>
<td>1.06</td>
<td>1.11</td>
</tr>
<tr>
<td>Extremadura</td>
<td>0.34</td>
<td>0.39</td>
<td>0.43</td>
<td>0.41</td>
<td>0.54</td>
</tr>
<tr>
<td>Galicia</td>
<td>0.48</td>
<td>0.52</td>
<td>0.54</td>
<td>0.54</td>
<td>0.63</td>
</tr>
<tr>
<td>La Rioja</td>
<td>0.39</td>
<td>0.38</td>
<td>0.50</td>
<td>0.48</td>
<td>0.61</td>
</tr>
<tr>
<td>Madrid (Community of)</td>
<td>1.64</td>
<td>1.55</td>
<td>1.61</td>
<td>1.64</td>
<td>1.67</td>
</tr>
<tr>
<td>Murcia (Region of)</td>
<td>0.50</td>
<td>0.53</td>
<td>0.58</td>
<td>0.65</td>
<td>0.74</td>
</tr>
<tr>
<td>Navarra (Statutory Community of)</td>
<td>0.74</td>
<td>0.72</td>
<td>0.83</td>
<td>0.93</td>
<td>0.92</td>
</tr>
<tr>
<td>Valencian Community</td>
<td>0.56</td>
<td>0.57</td>
<td>0.63</td>
<td>0.62</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Finally, a positive aspect of this is the creation of important prizes and research aids by the private sector, which contribute not only to promote research activities, but also to improve the climate necessary for professional researchers to receive the social recognition they deserve.
THE IMPORTANCE OF TRANSLATIONAL RESEARCH

The adjective «translational» may lead to confusion, since it is sometimes applied to diverse intraocular phenomena and the attempts to modify them. In our case it is a completely different concept, namely, how discoveries in basic biomedical sciences can be translated to the clinical practice. Despite the outburst of new levels of knowledge in the field of biomedicine over the past 30 years, only a small proportion of it has been used to foster progress in diagnosis, prognosis, prevention and treatment of diseases. This dissociation calls for a new way of research which, in spite of its concept being relatively new, is gaining great renown. Translational (or transferential) research is necessary not only to convert basic knowledge to applied knowledge, but also to favour the opposite direction, i.e. to promote basic research from problems identified in the clinical field. In sum, whereas two types of research—basic and clinical—have been typically accepted in the field of biomedicine, we are now supporting a third modality whereby an intermediate phase will help establish the flow between the first two.

Who are the ideal candidates likely to develop this type of research? Professionals suitable for such a task may be obtained by two ways. One would be to have a basic researcher become interested in clinical research. In my experience, this has not been easy so far due to the classical tradition of clear-cut separation between holders of preclinical and clinical professorships, which hampers collaboration between them. Fortunately enough, basic researchers interested in clinical lines are already coming in sight, the paradigmatic case being Prof. López Barneo, Professor of Physiology, who has moved with all his team to the Hospital Virgen del Rocío of Seville. His basic research on dopamine-rich neurons of the caudate body has led him on to a clinical line consisting in the transplantation of these cells into the basal nuclei of Parkinsonian patients. On the other hand, emulating the Tufts University of Boston might also be interesting, on account of its broad experience in the organisation of pathology courses to foster the interest of basic researchers in clinical applications.

The second possibility is to offer basic instruction to clinic researchers by means of what is known abroad as MD/PhD (Medical Doctor/Philosophy Doctor) programs. The main objective of this type of programs is to provide the education and skill training required to carry out fine-quality medical research. The duration of these programs—which belong to the aforementioned call for post-resident scholarships by the Carlos III Health Institute—should be at least of two years and should be carried out in hospitals with fully acknowledged tradition of research, in university departments or in CSIC centres. These programs usually include common, main aspects on one side and particular features adapted to the circumstances of the imparting institution on the other. In the US, they are financed by public bodies like the National Institute of General Medical Sciences, responsible for 32 Medical Scientist Training Programs in 32 institutions (hospitals and universities), all credited as centres of excellence. Such a program will only be attractive to young doctors if the criteria presently used to decide on the access to hospital-based medical care posts are modified. Since the scientific curriculum is barely emphasised in reckoners and other access criteria, clinical research in Spain might be in crisis. In order for residents to be attracted by such a program—which should be inserted in the third cycle or Doctorate—scientific training should be considered as an outstanding merit to obtain a post. However, if the incorporation of such professionals to translational research is important, in-depth approach to scientific subjects will provide the former with better capacity for criticism and improved medical care abilities. In the past, research performed by a general internist on a reduced piece of work was considered inappropriate, on account of the possibility of unbalancing his/her knowledge. My point of view is exactly the opposite, since in-depth approach to a partial aspect will remind the student that the phenomena are actually more complex than what he/she might presume from his/her general training. In this sense, the Royal College of Physicians of London insists on the advisability of dedicating some time to research, not only in the case of professionals bound to pursue an academic career, but also in those opting exclusively for clinical activities. Indeed, such dedication will improve their capacity for critical analysis, and healthcare tasks will rest upon scientific grounds.

Another important step to promote translational research is the creation of multidisciplinary research institutes, where medical teams of internationally acknowledged reference hospitals can mingle with scientists not necessarily related to health, as those in universities and the CSIC. Furthermore, the Spanish scientific policy should conform to the 6th Framework Program of the European Union (2002-2006), aimed at specifically promoting scientific networks of excellence composed by multidisciplinary research institutes. These two initiatives would allow to overcome the present situation, characterised by the excessive atomisation of the research groups and by a notable unconnectedness between them. This would also allow the two main public bodies of research, the CSIC and the Carlos III Health Institute, to develop relevant extramural activities enabling a more equitable access to research resources throughout the national territory. Finally, the process of incorporation of new
CONCLUSION

I wish to conclude with a reflection that I deem essential: those involved in biomedical research in the 21st century should not forget the primary objective that should govern their entire activity, which is to favour the interests of both the healthy and the sick populations in order to provide them with longer, better lives.

REFERENCES

4. Camí J, Zuharti MA, Fernández MT, Bedana M, Gómez J. Producción científica española en biomedicina y ciencias de la salud durante el periodo 1990-1993 (Science Citation Index y Social Science Citation Index) y comparación con el periodo 1986-1989. Med Clin (Barc) 1997; 109: 401-9.

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