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New Academic Positions: The Outlook in Europe and North America

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Universities in the United States will offer few new academic positions during the 1980's. This creates the prospect that the vigor of basic science will decline unless there is a sustained flow of young persons into academic science. Similar problems exist in Sweden, the Federal Republic of Germany, Denmark, Norway, France, the United Kingdom, Canada, Japan, the Soviet Union, and perhaps other countries. The current and prospective difficulties have given rise to analyses, proposals for action, and some actual programs (*1*). Aspects of the situation in some of these countries and of the measures that they have taken are pertinent to the United States.

Summary. During the 1960's, Canada, France, Germany, the United Kingdom, and the United States all experienced periods of rapid growth of research expenditures and of university enrollments followed by declines in growth rates. This sequence has generated the current severe shortages of new academic positions, with a resulting long-range threat to the vitality of academic science. Declines in the 18-year-old cohort in the United States, and especially in Canada, aggravate the problem. The United States is the only one of these countries that has not adopted a modest program to deal with the problems by creating fellowships or new positions.

Research, Enrollment Growth Rates, and Academic Jobs

During the 1960's, all Western industrialized countries rapidly increased support for university research in the natural sciences and engineering. Between 1968 and 1972, these countries experienced a slowdown or "a declining beginning" (*2*).

University enrollments have followed the same trend as university research support—rapid increases and then a decline of the rate of increase (*3*). Funds for university operating costs are strongly influenced in all countries by levels of enrollment, universities being regarded at the political level primarily as teaching institutions. A substantial part of the cost of academic science is paid for out of the general operating funds, mostly in the form of salaries paid to faculty members who are engaged in both research and teaching. Funds available for academic science and for faculty positions are therefore strongly influenced by enrollment trends.

The reduction in the rate of expansion of enrollments, combined with the slowdown in the growth of research expenditures, will sharply reduce the number of new academic jobs. The number of new jobs can shrink even while enrollment and research expenditures are still rising. This will happen not only in universities but in any research organization that experiences a rapid rate of growth followed by a slower growth rate or a decline. Indeed, the number of new jobs in academic science has dropped markedly in virtually all Western countries (Table 1) since the 1960's, when rapidly increasing undergraduate and graduate enrollment and rapidly rising budgets for academic science produced an unprecedented demand for college and university teachers in all disciplines. In Germany, for example, faculty positions increased by 23 percent a year from 1961 to 1965. The comparable figures for the United Kingdom and the United States were 13 percent and for Canada 17 percent. Then, beginning in the early 1970's, as the rates of increase in both enrollments and expenditures declined, there was a sharp drop in the demand for young academics. By the late 1970's the growth rate of faculties had dropped to 1 to 4 percent per year (*4*).

As a consequence of the large-scale hiring of faculty in the 1960's, most universities have an abnormally high proportion of young faculty members (Table 2). [Normal is defined as the age distribution in a steady-state system (*5*) with a constant number of undergraduates and reasonable assumptions as to mobility, retirement age, and mortality.] This bulge, although aging year by year, will remain in the national systems for 20 to 30 more years. At the same time, the abnormally low proportion of faculty members at the upper end of the age scale, the 51- to 60-year-old age bracket (Table 2), will mean that relatively few vacancies will be created by retirements during the next 5 to 15 years. In addition, the earlier hiring bulge provided positions to some persons who would have had difficulty in competing successfully either before or after the period of rapid increases in enrollments. In all countries, most of those hired during the 1960's have a high degree of job security because of contractual agreements (tenure), civil service status, job protection laws, or some combination of the three.

Low Future Growth Rates

The continuing consequences of the declines in rates of increase in both university enrollments and research expenditures will be augmented or moderated by future changes. The future may bring

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surprises, but in no country, with the possible exception of Japan, is it now considered realistic to assume resumption of the growth that characterized the 1960 to 1970 period.

The outlook for university enrollment varies widely. One factor influencing enrollment is simply the number of persons entering the traditional university age bracket, and this varies among countries. In the United States and Canada, a 20 percent decline in the 18-year-old cohort began in 1980 and will recover somewhat after 1990. In Germany, the United Kingdom, and the Netherlands, the 18-year-old cohort will grow until 1985 and then decline precipitously for a decade; the drop in Germany will be more sudden and deeper than in any other Western country. In Sweden, Norway, and France, the 18-year-old cohort will remain at or above the 1975 level until 1990 and then drop moderately until 1995.

While the United States and particularly Canada are concerned over the consequences of the decline in the 18-year-old group, Germany, the Netherlands, and the United Kingdom worry about how to accommodate over the next few years what the Germans call "the student mountain" and the English call "the student hump." Despite the prospect for sustained rates of enrollment growth these countries will nevertheless have few new academic positions over the next few years. In Sweden, Norway, and France, there will be a few new academic jobs, but future enrollment changes are not expected to aggravate the serious effects of the decline in rates of growth of research support and enrollment.

Declines in growth rates and prospective changes in research support levels and enrollments play different roles in these countries, but the outlook for new academic positions is fairly uniform and has led to the proposal or adoption of a variety of national programs.

Germany

The Science Council (Wissenschaftsrat) recognized in 1975 that new academic positions would be created only at the rate of about 1 percent a year for about a decade. The alarming outlook led the council, together with other major scientific and academic organizations, to urge that a special program be established to hold outstanding young scientists in academic life until permanent posts become available with the retirement at age 60 of large numbers of those hired in the 1960's (*6*). This program, the Heisenberg Program for the Development of Young Scientific Talent, was ratified by the federal government and the states (*Länder*) on 4 November 1977. The initial intent was to provide 150 10-year fellowships in each of the 5 years from 1978 through 1982.

Responsibility for administering the program was given to the Deutsche Forschungsgemeinschaft (DFG), the independent German research association (*7*), which set up a special body to establish guidelines for the program (*8*). This group decided to insist on high academic qualifications, even if this meant the award of fewer stipends than originally planned. The guidelines limited competition to those formally declared eligible to teach and carry on research in universities, and a maximum age of 33 was set. Those in all fields of science and the humanities (the traditional scope of German *Wissenschaft*) were eligible to compete. The stipend level was set at about $24,000 a year, a generous level for a fellowship but a modest salary for an outstanding young academic. Finally, negotiations with governments resulted in reduction of the term of the awards from 10 to 15 years.

There were only 484 applicants during the first 2 years of the program, even though the age limit was relaxed. The budget provided funds for 300 stipends, but the selection board decided that only 144 applicants were qualified. The successful applicants were divided among broad fields as follows: humanities and social science, 33 percent; biomedical sciences, 27 percent; physical sciences and mathematics, 37 percent; engineering, 3 percent.

The average quality of applicants, as well as the number, was lower than expected, perhaps because the program was new and not well known. Also, some academic positions were still available; in fact, 27 of the 144 successful stipendiaries resigned during the first 2 years of the program, most to take permanent academic positions. In addition, a new federal law provides that a negotiated proportion of professors should be given the status of civil servants (tenure in U.S. terms) provided that staffing requirements exist and the state budgets are adequate (*9*). In this situation, the nontenured university teacher-investigators who were best qualified and hence most likely to be given tenure under the law stayed at their university posts. Finally, some potential applicants apparently saw themselves faced with unemployment after expiration of the 5-year stipend or with incomes that would lag behind those of their colleagues with regular university jobs.

In spite of these initial problems, the DFG has announced that the program will remain in place and be expanded. Whether expenditures will increase from the $8 million spent in 1979 to the $27 million envisioned for 1982 remains to be seen (*10*).

In addition to the Heisenberg Program, the Arbeitsgemeinschaft der Grossforschungseinrichtungen (AGF), the association of big science establishments, has proposed that 800 new positions be created in the large research establishments over the next few years and that the AGF eliminate the posts when retirements create vacancies on a large scale late in the 1980's. The Ministry of Science and Technology has approved this proposal in principle. Another program, the so-called Fiebiger Program, proposed by the German Rector's Conference, would link the creation of university posts to increases in enrollment. Since enrollments are expected to increase for a number of years, the proposal would provide for continuing growth of faculty. Then, when enrollments decline and retirements begin on a large scale, the positions vacated would be eliminated, and the system would have a reasonable age distribution. This plan is unlikely to be financed, at least at the proposed level, primarily because the federal and state ministries of finance are unconvinced that any positions vacated by retirees would actually be eliminated.

The United Kingdom

The Science Research Council (*11*), the governmental body in the United Kingdom with primary responsibility for academic science, has noted:

> The almost complete absence of expansion of universities in recent years, coupled with the age distribution within the academic profession—itself a consequence of the rapid expansion of the sixties—has discouraged many potentially high calibre research workers from proceeding to post-doctoral work.

The Medical Research Council has stressed the fact that government laboratories, which perform a larger proportion of basic research than is the case in the United States, face a similar problem (*12*). The United Kingdom has established two modest programs to deal with these problems. First, the Science Research Council awards advanced fellowships to carefully selected scientists, under 35 years of age, who are well qualified for academic careers but do not yet hold tenured posts. The awards are made for periods of up to 5 years. The purpose and the terms of the program are similar to the German Heisenberg Program and to Canadian programs described below. Applications for these fellowships declined from 251 in 1977 to 48 in 1979, apparently because young people are not enthusiastic over such short-term arrangements. Awards over the same period declined from 33 to 19, a reflection of a decline in the quality of the applicants.

Second, the Science Research Council decided in November 1979 to establish a Special Replacement Fellowship Scheme, under which a small number of outstanding senior research scientists may be released from tenured university positions and formal teaching responsibilities to concentrate full time on research. At the same time, the university would agree to make an additional tenured position available to a young faculty member, chosen in the usual way by the university, in any scientific or engineering field supported by the Science Research Council. Ten awards were to be made in the fall of 1980, 15 in 1981, and 10 in each of the subsequent 3 years. As planned, the program would cost approximately $3 million. The number of awards, however, will be influenced by the funds made available to the Science Research Council by the government.

These experimental programs are small for a number of reasons. Neither the research councils, the universities, nor the proposed beneficiaries are certain how much these programs will contribute to solving the problem even if generously financed. In addition, a difficult national economic situation and the philosophy of the Conservative government may inhibit proposals that involve substantial additional expenditures. Finally, universities have more general financial difficulties, and the fellowship programs must compete for attention and money with other issues: research policy problems involving an impending change in the traditional dual system of support of universities, a shift to greater selectivity in support of universities, the need to strengthen links between industry and universities, and managing the balance between big science and little science.

Table 1. Average annual growth rates of full-time university faculty from 1965 to 1977 in five Western countries. [Data from (*25*)]

Country	Faculty growth rate (percent)			
	1961 to 1965	1965 to 1969	1969 to 1973	1973 to 1977
United Kingdom	13	6	4	1
United States	13	10	3	4
Germany	23	12	11	1
Canada	17	20	7	2

France

In France the major institutional homes for research are governmental laboratories. These include the extensive network of laboratories of the Centre National de la Recherche Scientifique (CNRS), many of which are associated with, but not a part of, universities. Other nationally financed, staffed, and operated laboratories exist in such fields as health [Institut National de la Santé et de la Recherche Médicale (INSERM)], atomic energy (Commissariat à l'Energie Atomique), and agriculture [Institut National de la Recherche Agronomique (INRA)]. Universities and the elite national technical institutions (the *grandes écoles*) pay the salaries of faculty members who teach and conduct research, but most research by university faculty members is conducted in the associated laboratories. The government has tended to express its concern for the health of basic research mainly through measures to strengthen the government laboratories. One aspect of concern was expressed in an influential report (*13*):

> Investigators were recruited in large numbers between 1960 and 1968. Today, the average age of CNRS investigators is 40 years—a relatively young group. The shape of the age pyramid is such that substantial blocking of promotion can be foreseen until 1990.

France's approach is different from that of Germany, the United Kingdom, and Canada. France has decided to increase the number of permanent positions in government laboratories (primarily CNRS and INSERM) by 3 percent a year even though this reduces the funds available for research in budgets that are already tight. National budgets provide specific sums and specified numbers of new positions by agency. In 1980, 370 new research positions and 698 new supporting positions (engineers and technicians) were created at an initial annual cost of about $13 million (*14*).

Other steps taken to speed the entry of young researchers into the government laboratories include the introduction of a uniform 4-year probationary period instead of an indefinite one and the gradual reduction of the age of appointment to permanent posts (*15*). These two measures increase the number of persons at the lowest grade who are eligible for promotion. Later, as more people become eligible for successively higher permanent posts, more jobs at the higher levels will be funded.

The government is also trying to encourage more exchange between laboratories and universities. Positions in the laboratories are being made more closely equivalent in pay and prerequisites to the corresponding positions in universities, and the government has stated that scientists have an obligation to move between governmental laboratories and universities.

These changes have generated opposition among those affected, who claim that they were not adequately consulted. Some point out that mobility between laboratories and universities is stated as an obligation of employees but that the system does not provide positive incentives for mobility. Others note that many of those who serve the 4-year probationary period will not be appointed to permanent posts. For the most part, the protests reflect the high value placed on equity and security by employees, and the position of the government reflects the priority it gives to efficiency, productivity through selection by merit, and promotion on the basis of achievement.

At the universities, even fewer new positions have been available than at the government laboratories, essentially because the rate of growth of universities was greater and the cessation of growth came more quickly (*16*):

> The number of permanent posts has been increasing in both industry and the public establishments, but in universities there was a severe reduction in new posts. . . . Only 275 new teaching-research posts were created in the universities in 1976—only about 1.0 percent of the total of posts. This is much below the 3 percent rate for the public establishments.

The Ministry of the Universities proposed that a fixed number of new academic posts be created annually, but the Ministry of Finance has not approved such a plan. The government, however, promoted several thousand of those already in the system to newly created positions, an action that will decrease further the possibility of adding new positions for young persons.

The markedly more favorable treatment of staff in the government laboratories is attributable to a number of factors: repercussions at the universities from the 1968 disruptions, the strong power base of the research function in the national government, and the large financial burden that would be generated by creating a substantial number of faculty positions. The net effect of all these factors is to make the prospect for new university positions rather dim.

Canada

The Natural Sciences and Engineering Research Council of Canada (NSERC), the central government agency for funding academic research in science and engineering, has called attention to the serious adverse effects on basic research of declining rates of increases in R & D expenditures and in university enrollments (*17*). The Science Council of Canada, a semiautonomous group that provides an independent point of view on science policy, has also sounded a warning (*18*). Both organizations reviewed the outlook for research in the natural sciences and engineering in Canada and made recommendations.

The Science Council concentrated on manpower measures, advocating such steps as (i) improving pension portability, (ii) granting special status to outstanding older university staff members to encourage them to continue research, (iii) establishing special university research chairs in the provinces in fields of special interest to them, and (iv) encouraging university staff to spend a year in industry. The 5-year plan of the NSERC is more ambitious, advocating measures to elevate total national R & D expenditures sharply as a percentage of gross national product in order to deal with the obsolescence of research instruments, increase the effectiveness of university-industrial relations, attain a more reasonable regional balance in research, and expand targeted research while also maintaining a strong foundation of free research.

To sustain a flow of young scientists into the academic system, the central recommendation of the NSERC, which endorsed the measures proposed by the Science Council, was to establish a new program of University Research Fellowships. Awards would be made to outstanding young researchers for 3 years with 2-year renewals available and the possibility of a second 5-year award for up to 50 percent of the recipients. The applicants would hold all university privileges of an assistant professor (except full tenure) and would be eligible to apply for NSERC research grants. The purpose is "to retain some of the excellent researchers as the nucleus of the new generation of Canadian professors that will be required for the 1990's" (*17*, p. 61). During the summer of 1980, there were 385 applications for the new fellowships and 100 fellowships were awarded. The intent is to award about 100 fellowships in each of the next 4 years. The first year's cost will approximate $3 million.

Table 2. Proportion of faculty in two age brackets in various countries in 1977 and the steady-state distribution (*5*). [Data from (*5*, *26*)]

Country	Proportion of faculty	
	31 to 45 years old	51 to 65 years old
France	64	11
Germany	59	14
Great Britain	54	17
United States	57	20
Canada	62	15
Steady state	46	25

United States

Over the last few years in the United States a number of developments constitute a de facto but unplanned and unheralded beginning of adaptation to the prospect of few new permanent academic positions. One device, used in various forms in all countries, is to hire people on short-term or indefinite contracts and without the status and benefits of faculty members (for example, the protection of unemployment security laws in Europe). The most widely used variation of indefinite employment status in the United States is the nonfaculty postdoctoral position. In 1978 there were about 4000 nonfaculty postdoctoral research staff in science and engineering in U.S. universities. The group is growing about 2½ times as rapidly as faculty (*19*). These new research positions do not depend on university enrollments and usually do not involve teaching. They also tend to create an unequitable two-class society.

Another form of adaptation is the continuing formation of extradepartmental research laboratories, institutes, and programs that also do not depend on enrollment and that may or may not provide faculty for teaching. For example, the National Institutes of Health now support almost 700 university-based research centers for the medical sciences, at a cost of about $350 million a year.

There is a widespread belief, however, that such spontaneous forms of adjustment may be inadequate. Reports analyzing trends and proposing action have been prepared, among them a Carnegie Council report (*20*), and public officials and various organizations have advocated a number of lines of action. A committee of the National Research Council (*5*, p. 37), the operating arm of the National Academy of Sciences, has advocated a plan almost identical to the United Kingdom's special replacement fellowship program, except for greater emphasis on differences in the job outlook among fields. The National Science Board, the governing body of the National Science Foundation, has considered various kinds of fellowships and postdoctoral awards designed to hold a small number of outstanding investigators in academic science until permanent jobs open up. Others have advocated new kinds of structural adjustments. For example, Frank Press (*21*), science and technology adviser to President Carter, suggested the establishment of national centers for research:

> A number of university science departments might be designated as National Research Centers. Such Centers might receive coherent area grants for 3- to 5-year periods from government agencies, but many projects in them would be judged individually and competitively. They would be staffed primarily by recent Ph.D.'s supported full time by government grants, with the universities offering rolling 3-year periods of tenure and space and other amenities to make the positions attractive. Faculty members in departments might become researchers at the centers for periods of 1 to 3 years and vice versa. These Centers would enable universities to bring young scientists into the university community, in close connection with established departments. In this way, it would ensure the flow of the best young minds into the basic research structure of the universities.

Richard Atkinson (*22*), former director of the National Science Foundation, made these suggestions:

> There are several areas where government assistance might play a role. Programs to facilitate mid-career shifts for tenured faculty interested in striking out in new directions might open positions for younger Ph.D.'s. The government could contribute at least a portion of the funds necessary to maintain a retirement plan in effect, and only on condition that the vacated position is made available to a younger person. A second possibility might be a program of Senior Research Scientist Grants for outstanding scientists . . . to permit them to devote more time to research. Meantime, the university would use the released salary to appoint a young faculty member. A third idea is the encouragement of joint university-industry research institutes which would be housed at the university and under university auspices.

Some analysts, however, question the desirability of federal action. Klitgaard (*23*) described the most significant reservations.

1) Individual scientists and universities tend to believe that during periods when funds are limited, the quality of

academic science may be sustained more effectively by strong support through existing channels than by special governmental programs designed to provide new positions. Indeed, the executive agencies themselves have not been willing to include specific proposals in budgets submitted to Congress, and there has been no public objection to this omission from the scientific community or from universities.

2) Universities tend to shy away from federal programs that interject the government, even indirectly, into personnel decisions.

3) Spontaneous adjustment and market forces will result in a reasonable flow of young investigators into the various research sectors, including academic science.

4) Movement of a large share of talented scientists and engineers into nonacademic careers can have many positive consequences for them, for the economy, and for the society.

5) A large component of the problem is the high proportion of university faculty with tenure, and modification of tenure practices involves not the federal government but the parties to the private contract, universities and individuals.

6) Most assessments of the effects of a declining 18-year-old group on university enrollments did not differentiate among types of higher education institutions. Enrollment will almost certainly not decline at the major universities where most academic research is carried on.

7) It is not clear that there will be as few new jobs as earlier analyses indicated, or that the period of job scarcity will last as long as was projected.

These reservations may or may not prove to be valid. In any case, it appears certain that discussion will continue about the most appropriate action to take in the face of shortages of academic jobs, the effects of which are not forseeable.

Conclusion

Experience in other countries may be valuable in assessing the actions contemplated in the United States to respond to consequences of the shortage of new academic positions.

The most direct action on a significant scale has been taken by France, where new permanent jobs in government laboratories are being created at the rate of 3 percent a year. Neither in Canada, Germany, nor the United Kingdom have additional permanent positions been created in universities.

The devices designed to keep young scientists available until retirements make permanent jobs available in universities (the Heisenberg Program in Germany, the Special Replacement Fellowship Scheme in the United Kingdom, and the University Research Fellowships in Canada) are experimental and are operating on a small scale. Experience in both Germany and the United Kingdom suggests that unanticipated developments, such as changes in the job market, may be expected and that it is wise to begin programs on a small scale. Further, most of the programs that are in place do not appear to provide support long enough to cover the full anticipated period of shortages of permanent positions. This is a warning signal that the plans as initially put into effect may not meet the stated objectives.

Both short- and long-run forecasts of such matters as enrollment levels, new academic jobs, industrial employment scientists, and numbers of advanced degree holders have proved to be fallible in all countries. Any actions taken should not be based on the assumption that such forecasts are precise (*24*).

There is greater emphasis on government action to promote mobility in Europe than in the United States not because mobility is considered more important in Europe but because the barriers to mobility are greater there.

The shortage of academic jobs is seen in all countries not as an isolated phenomenon but as part of a complex of science policy issues. Some countries have adopted specific measures to deal with the scarcity of new academic jobs, but all face broader and more urgent problems related to science policy, and the measures they are taking have been put in this context. The goal of any action taken in the United States should be stated not only in terms of sustaining the vitality of academic science as traditionally organized, but also in terms of providing new institutional forms (within, attached to, or separate from universities) as sites for basic research and as sites for jobs for young investigators. These avenues have been explored in other countries in ways which differ in many respects from the United States.

Finally, the actions described in this article may be insufficient to provide enough new jobs in those countries where strong forces are leading to particularly sharp reductions in the number of new positions in basic or academic research. This suggests the importance of general measures designed to sustain the vitality of national basic research systems when there are few new posts. Such measures include organizing research teams better, improving communications among various parts of research systems, increasing mobility within the research system, enhancing the relevance of academic science to the solution of national problems while sustaining a good environment for basic science, inaugurating special efforts to exploit emerging scientific fields, and minimizing the bureaucratization of academic science. Attention is paid to such measures as a matter of course in all countries but with varying degrees of effectiveness. The scarcity of new academic positions is simply one additional reason for concentrating on increasing the productivity of science.

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Vitellogenesis and the Vitellogenin Gene Family

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One of the early steps in embryogenesis is the appearance and establishment of the primordial germ cell population. These cells then enter a complex course of successive events, eventually producing the completely differentiated gametes in the sexually mature organism (*1*). The differentiation of the oocyte itself can be divided into stages according to various morphological and biochemical characteristics. In the frog *Xenopus laevis*, the premeiotic oogonia measure 5 to 10 micrometers in diameter whereas the mature oocytes reach a size of 1.3 to 1.4 millimeters. This dramatic growth is to a large extent a result of massive deposition of yolk protein (*2*). Experimental work over the past 15 years has demonstrated that the yolk proteins that are deposited in the growing oocyte are derived from a common precursor named vitellogenin. In *Xenopus*, as in all oviparous vertebrates, vitellogenin is synthesized in the liver of the mature female under the control of estrogen, is secreted into the bloodstream, transported to the ovary, selectively taken up by the oocytes, and cleaved into the yolk proteins lipovitellin and phosvitin (*3*). In this article we review earlier findings and present some new data on yolk protein production and the genes encoding the major yolk proteins in *X. laevis*, an organism that has proved useful for studying various aspects of vitellogenesis.

Vitellogenin and Its Relation to the Yolk Proteins

Vitellogenin in *X. laevis* occurs as a dimer of two subunits of about 200,000 daltons each (*4–7*). These polypeptides represent a heterogeneous population of related molecules (see below), but it is not known whether the vitellogenin dimer comprises identical or different subunits. Vitellogenin in *X. laevis* blood consists of about 12 percent lipids, 1.5 percent phosphate, and 1 percent carbohydrate; in addition, calcium appears to be attached to the protein phosphate groups (*8*). Lipidation, phosphorylation, and glycosylation of vitellogenin occur prior to its secretion from the parenchymal liver cells, but very little is known about the mechanisms and the sites of these rapid and extensive posttranslational modifications (*9*).

Serum vitellogenin is a very stable protein with a half-life of about 40 days in males or in ovariectomized females. Its uptake by the oocytes is controlled by gonadotropins that also induce ovulation of the fully grown oocytes. Vitellogenin reaches the oocytes through the blood capillaries of the follicular theca and diffuses to the surface of the oocytes through channels between the surrounding follicle cells (*8*). The oocytes selectively take up vitellogenin by pinocytosis. This uptake is about 50 times faster as compared to that of other serum proteins (*8*, *10*). The molecular basis of this preferential uptake of a specific protein is not known but has been attributed to a vitellogenin receptor on the oocyte membrane. There is some evidence that the uptake is not strictly species-specific (*11*). Oocytes from which the follicular theca has been removed take up vitellogenin in vitro, grow at a similar rate as in vivo, reach normal size, acquire the typical pigment pattern, and initiate maturation after stimulation by progesterone (*12*). This culture method may allow studies on the regulation of oocyte growth and hormone-controlled maturation, and vitellogenin processing in the oocyte.

After its uptake by the oocyte, vitellogenin is converted into lipovitellin and phosvitin by specific proteolytic cleavages. Lipovitellin contains 22 percent lipid and is composed of two types of subunits with molecular sizes of 115,000 and 31,000 daltons. The large subunit contains almost no phosphate and the small subunit is significantly phosphory-

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