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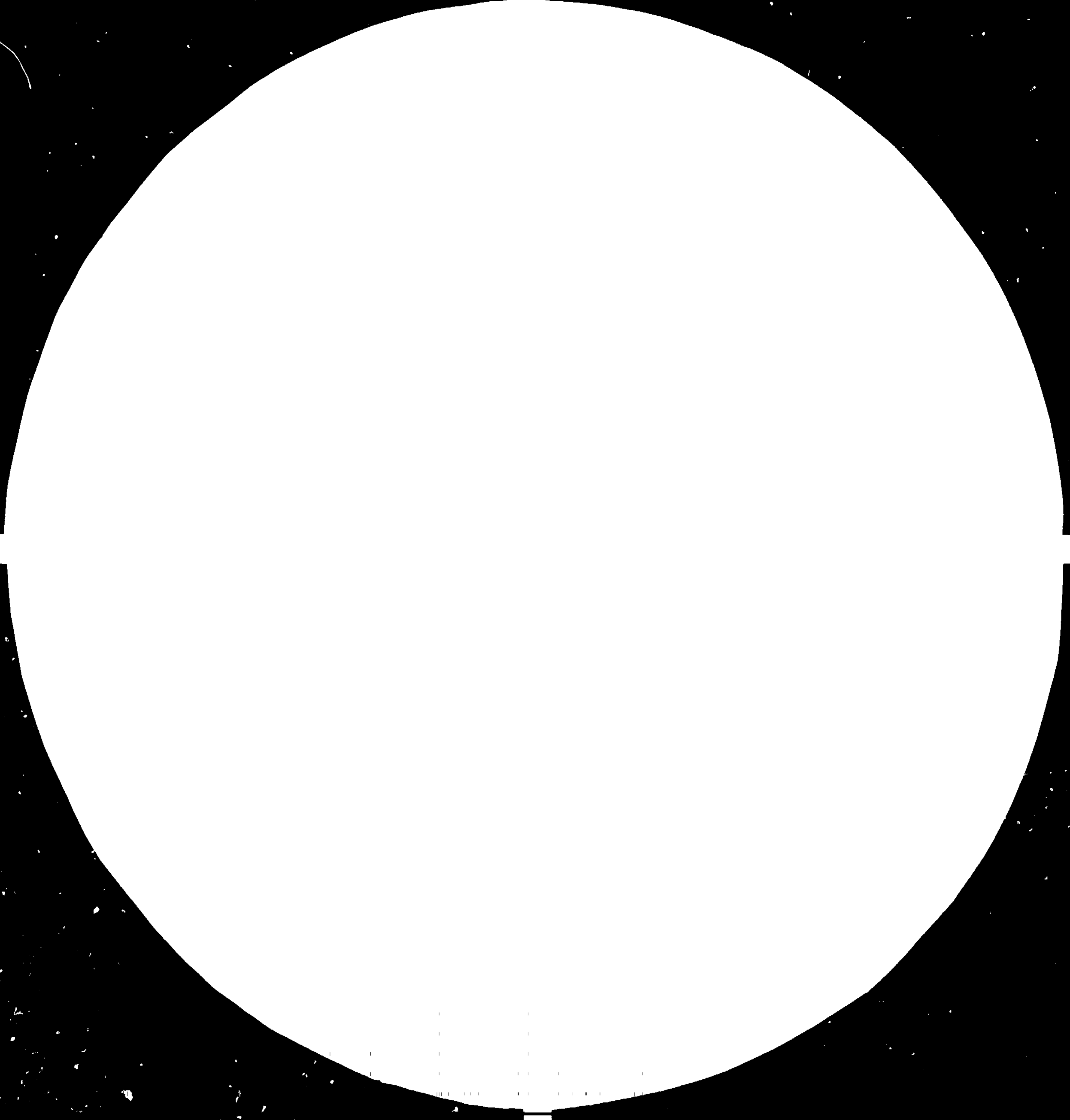

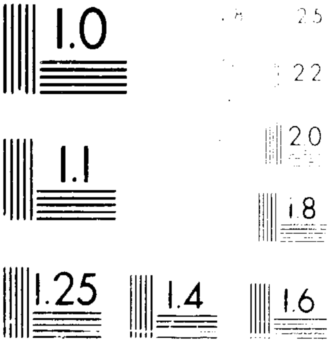
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Carl Göran HEDEN

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AN INTERNATIONAL CENTRE FOR

GENETIC ENGINEERING AND BIOTECHNOLOGY

LOCATED IN MORE THAN ONE SITE

AN ANALYSIS OF OPTIONS

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Mr Kim

This paper examines the possible ways in which a multiple-sited ICGEB might be defined, and explores the implications of such a model in terms of costs, organization and administration, legal considerations, and its effectiveness in meeting the goals of the ICGEB, including the breadth, depth and effectiveness of the work programmes and the Centre's training function.

I. STRUCTURAL ALTERNATIVES FOR A MULTIPLY-SITED ICGEB

1. The ICGEB Located in a Single Site

1. The first and, originally, the only siting option, was for the ICGEB to be located in a single site, with integrated research, development and training functions. Previous documentation[2, 3, 4] has discussed in detail possible organizational structures for such a centre. The importance of having a "critical mass" of outstanding scientists and technologists in one place, and the advantages this confers on the research, development and training functions of the Centre has been emphasized throughout.

2. The costs and organization of a singly-sited ICGEB are based on the figure of 50 permanent scientific and technical professionals plus 26 post-doctoral fellows, and the administrative and service staffing required to support an operation of that magnitude. For the purposes of the comparisons in this analysis, the structure and cost figures as most recently revised for a single centre[5] are used as the basis upon which the nature of the components of a single centre are determined and the costs computed.

2. The ICGEB Containing up to Four Facilities, Each with all Functions of a Single Centre

3. For the purposes of this discussion, it is assumed that the maximum number of sites would be four, reflecting the outstanding offers among the signatories to the ICGEB statutes. This option specifies four complete facilities, all under the ICGEB administrative umbrealla, with four times the staff, four times the cost, and the capacity to train four times as many people.

3. The ICGEB Containing up to Four Facilities, but Each Emphasizing One or Two Elements of the Work Programme of a Singly-Sited Centre

4. Under this concept, each unit or campus would include all research and development functions common to all applications of genetic engineering, but instead of a work programme in several areas as envisioned for a single facility, each would emphasize a specific area of biotechnology, perhaps one most appropriate to the existing capabilities of the host country of that site. For example, one possible structure might be a site in Trieste with a speciality in the molecular engineering of proteins, taking advantage of the computational expertise at the International Centre for Theoretical Physics, a facility in Thailand

specializing in tropical disease vaccines, one in India concentrating on scale-up and large-scale fermentation, process development and the site of the only pilot plant among the four, and one in Spain concentrating on genetically-engineered pharmaceuticals. Many other options are, of course, possible with centres specializing in two instead of one area, but not five or six. Plant genetics and cell biology directed toward crop improvement, hydrocarbon microbiology, the development of biological pesticides, or a programme to develop generalized cloning vehicles might be other instances where there would be a geographical preference for concentrating a specific programme in a particular site.

5. Overall, the size and costs of this version of the ICGEB, while not an integer multiple of those for a single site, would be substantially greater.

II. SPLITTING THE WORK PROGRAMME

A. Rationale for the Scientific Organization of the ICGEB and Selection of Work Programme Areas

6. At this point in the discussion, it is necessary to look in some detail at the rationale for the scientific and technical portion of the ICGEB and the staff and equipment requirements it entails. If, indeed, it is possible to split the work programme into different geographical locations, how may this be done in a rational way so as to maximize any advantages and reduce any drawbacks?

7. Several previous documents have dealt with the work programme and the organization of scientific departments. In the original proposal and the documents prepared for the Belgrade Meeting,[2, 3, 4] an organization for the ICGEB was proposed consisting of three scientific and technical departments, (a) Molecular Biology and Biochemistry, (b) Microbiology and Molecular Genetics and (c) an Advanced Biotechnology Department, consisting of a pilot plant and large-scale fermentation and purification activities. A "Bio-informatics" supporting department was also defined, including all library and computer services. The work programme originally suggested included six subdivisions which included these general information services, a range of very general methodologies, and some specific, directed programmes. While these proposed elements all

have merit, they could, as written, logically form the organizational divisions of the ICGEB. These proposals also contained some important omissions, especially in the area of cell biology.

8. In a more recent analysis, in which the work programme was examined from the perspectives of the structural organization of the ICGEB and the breadth, depth and efficiency of the research, development and training functions of the centre, a somewhat different and more logical organization of the scientific and technical departments emerged. The major divisions include (1) Molecular Biology and Molecular Genetics, (2) Microbiology and Molecular Genetics, (3) Immunology and Infectous Diseases, (4) Genetics, Cell Biology and Biochemistry of Plants, and (5) Process Development and Manufacturing. The fifth category above is really the technology part of biotechnology, and may be applied to any of the first four areas which are primarily research, in order for the practical benefits to be realized. Most of what was previously called Bio-informatics is incorporated into the ICGEB as essential, information services.

9. These four subject areas plus bio-engineering technology are viewed as fundamental to any research and development programmes covering all facets of biotechnology. It is important for the ICGEB to have programmes in each of these general categories. Moreover, this breadth is absolutely essential in order for trainees to gain experience in all of the areas of biotechnology and especially those relevant to the needs of developing countries. For example, the importance of developments in agriculture demands a division devoted to plants. A department of immunology and infectous diseases would provide fundamental training not only in the development of vaccines and treatment for tropical and esoteric diseases, but training in monoclonal antibody techniques, which today are of fundamental importance in nearly all areas of biotechnology. Obviously, all four of the scientific departments overlap and are interdependent to some degree. Few problems today are so simply defined that they could be entirely addressed in one discipline, no matter how its boundaries are drawn.

10. For example, the development of a malaria vaccine would entail a great deal of basic molecular biology with regard to the isolation of the appropriate DNA, its cloning and expression. The culture and characterization of microorganisms is basic microbiology. A molecular

engineering department would need to be strongly interdisciplinary among molecular biology, microbiology and large-scale production groups, in addition to molecular biophysics. If the molecules to be engineered were antibodies, then an additional partnership would be required. The examples are endless. On the other hand, it is difficult to find a problem which would lie within any single disciplinary area

B. Essential Vs. Non-Essential Programmes

11. In spite of the extreme importance of having the full breadth of the above disciplinary areas available in one place in order for the success of any one programme, it is still possible to separate certain specialized programmes from each other. This can be done as long as those activities fundamental to any programme are present in every site of the ICGEB.

12. From a scientific viewpoint, then, the success of an agricultural enhancement project involving the cloning of pest resistance toxins in the leaves of a plant species but not the edible root or fruit, would not require the presence of a vaccine development programme. Nor would a molecular engineering project demand the proximity of a plant biology group. From a training perspective, however, there would be more limited exposure in a site concentrating on only one or a few areas, unless the trainee were to move about among the sites, which has its practical drawbacks.

13. Those scientific and technical areas that are basic to all or most programmes include what were referred to as technique development and research services in a previous paper. These include expression vector development, a DNA/RNA nucleotide sequencing laboratory, a polynucleotide synthesis group, a protein characterization and sequencing laboratory and the capability for isolating restriction enzymes. A microbiology laboratory with full culture and incubation facilities is also essential and must include a culture collection, although the strains in the collection at each facility might differ depending upon the specific projects undertaken.

14. All sites would also require at least some automated fermentation facilities for moderate scale-up, although it could be possible to allocate projects so that full-scale pilot plant and manufacturing facilities would be required at only one site. However, provision would have to be made for transferring projects from other centres when ready

to be developed into efficient, large-scale processes. In practice, of course, laboratory research in expressing efficiency and product yield overlaps process development. Physical separation would, therefore, not be desirable and would certainly slow down the overall development time for any substance produced.

15. From the point of view of expense, the pilot plant facilities account for more than half of the fixed costs of a centre at a single site; three additional pilot plants would add at least US$ 20 MM to the overall costs of a four-site ICGEB, not including the specialized buildings which must be built to house them.

16. Every site would require a main-frame computer facility. Such facilities are essential parts of the information and library facilities and services and would need to be duplicated at every location. Such advanced computational capability is also indispensible to most scientific research.

17. While not absolutely essential for all research programmes, it would be highly desirable that each facility have some capacity in cell biology, including both animal and plant cell and tissue culture facilities. Again, from a training perspective, these techniques are so fundamental to a large fraction of the scope of possible activities in biotechnology, that it would be remiss not to include them in a particular facility. Also, because of the rapidly changing nature of knowledge and its applications, it is expected that the projects comprising the work programmes of the various sites would change with time. Therefore, it is far better to build programmes and facilities that are able to accommodate change easily.

18. In terms of personnel requirements, of the fifty scientists and engineers in a centre at a single site, 17 could be designated as belonging to essential programmes. To that number, one should add two microbiologists and two cell biologists, as essential. However, 8 of these 17 are associated with pilot plant and manufacturing activities and two with plant biology. This leaves, then, a minimum of 11 scientists to run the basic technical programmes to be duplicated in all locations. To those figures, at least one bioengineer should be added for fermentation technology, if only on a small scale, except at the one site that would have a full pilot plant.

19. To summarize, then, there would be three sites with 12 and one with 19 scientific and technical personnel in predetermined roles. It then becomes a matter of how to determine how many additional scientific and technical professional slots each site could accommodate, and what the scope and substance of the work programme should be, within the overall requirements of the ICGEB.

20. Let us first examine the facility containing the pilot plant. It could presumably be in either a developed or a developing country. From the point of view that a number of developing countries have large-scale fermentation facilities already, for biomass conversion and other applications, but not much experience in advanced industrial genetic engineering, it might seem suitable to put such a facility in a developing country.

21. The foregoing implies an administrative decision to provide additional skills (eg, gene splicing) to a country in order to enhance and make use of the level of industry already present. Here, the chances of developing a more successful industry from one of conventional capabilities would be good, but the likelihood of opening new areas of biotechnology would be low.

22. The opposite argument that is, to locate an advanced pilot plant in a country with no such capability, is that it would introduce a new technology in a geographical area where it did not exist before, rather than reinforce a pre-existing capability. In either case, the demands on a split location for extending the benefits of a variety of training to those from all locations are great, since without some conscious effort, the four sites may become primarily local training facilities rather than truly international ones. To the extent that each of the four sites are still primarily international rather than national facilities, the reasoning behind speciality facilities especially suited to the host country's meeds and capabilities becomes less valid.

23. With regard to those facilities without a large pilot plant, most of the resources would be expected to be involved in research and early stage development, rather than those aspects of biotechnology directly relevant to establishing an industrial capability. While

the advanced projects carried out provide a rich training ground for the foundations of biotechnology, they would do little to help bring them to practical fruition in the trainees' home countries without additional industrial experience. Thus, not only would trainees in a fragmented ICGEB receive a somewhat less broad exposure to biotechnology, approximately three quarters of them would miss out on an aspect of fundamental importance to industrial development. This would require some additional provisions to provide trainees with industrial training, perhaps directly in established industries.

24. To possibly offset the above drawbacks, it is true that the overall capacity for training of a four-site centre would be considerably greater than for a single centre (albeit more expensive). If one assumes forty (40) scientific and technical professionals at each site, then 128 trainees (32 at each site) could be accommodated at any one time, rather than 40. The effectiveness of providing a uniform (geographic, disciplinary and quality) benefit to trainees from member nations is a potential problem, however, that must be faced when the mechanism of the Centre's governance and administration is established.

C. Selection of Elements of a Split Work Programme

25. As the previous section implies, the selection of the research programmes in a split as opposed to a single ICGEB requires taking into account not only a set of programmes of sufficient breadth, relevant to the needs of member countries, but the exposure of trainees to sufficient variety. In comparison with a single-site centre, a component facility may still be able to handle a relatively wide variety of programmes. For example, without a full-scale pilot plant, a centre of 40 scientists and technologists would have 28 positions to be distributed among the research programmes selected. A single-site centre of 50 scientists and technologists with a pilot plant, on the other hand, has approximately the same number to be distributed among optional programmes. While it is important that at least one location conducts a programme in plant genetics and cell biology, and one in a major area of microbial engineering (both deemed fixed in a single centre), there still remains considerable room for breadth and flexibility in a site with 40 instead of 50 professionals. In the pilot plant site, there is correspondingly less, but still enough for at least two very different programme areas.

26. Of course, 40 is an arbitrary number and selected only for illustrative purposes. The number actually chosen will depend on many indeterminate factors, including the funds available. Whatever actual number is possible under such a structure, a basic choice must be made: Does one try for the same breadth in each location as in a single centre, with perhaps one or two programmes curtailed somewhat, or does one take advantage of the greater number of skilled personnel that can be supported overall and concentrate on larger, specialized programmes, one in each of the four sites, than could be done with the personnel and resources available to a centre if it were to be located at a single site?

III. COSTS OF A MULTIPLE-SITED ICGEB

27. The concept of an ICGEB established in up to four geographical sites is based upon the assumption that this is how the maximum benefit of the resources offered by each of the countries from which, offers to host the ICGEB are currently outstanding, can be realized. Obviously, the number and size of the components of an ICGEB will depend upon the resources available.

28. The following analysis of costs is provided as a guide to estimating the scope of an ICGEB that it would be possible to create, once it is known what resources are available, both initially and for the annual operating costs of the ICGEB. The most recent figures estimated for the costs of a single-site centre with a complement of fifty scientific and engineering professionals are used as a point of comparison.

A. Land and Buildings

29. It is assumed throughout that all necessary land and buildings will be provided by the host country of each individual site. It is further assumed that host country offers include the construction of the specialized facility needed to house the advanced pilot plant to be installed at one of the sites, as well as any other specialized accommodations necessary for certain types of equipment. Because the costs of land and buildings will vary considerably depending on the country, the portion of each offer for this purpose should be deducted from the total offer before available resources are estimated.

B. Fixed Costs

30. The fixed costs at all locations include all laboratory equipment, computer facilities, library equipment, books and back issues of periodicals, computer software, office and laboratory furniture, office equipment, tools, shop equipment, and vehicles. In general, most of these costs are basic to any facility, even if the number of scientists and technologists is to be reduced from 50 to 40 or even 35. The principal variable, is laboratory equipment. Even there, most of the equipment required for the ICGEB is basic to a variety of programmes, regardless of how many people use it. For that reason, the only

significant variable cost is that of pilot plant equipment, accounting for more than half of the fixed costs of a centre at a single location. A minimum estimate for such equipment, exclusive of the building necessary to house it, is US$ 6 MM. In practice, especially at a time in 1984 or 1985 when the equipment might actually be ordered, it is likely to be more. For comparison, a 1.5 cubic meter pilot plant was constructed for a biotechnology company in the United States in 1982 for US$ 12 MM, including the specialized building needed to house it. While construction costs in most countries would be somewhat lower than in the United States, perhaps much lower in a developing country, most of these costs are subsumed in the lands and buildings figures and do not appear as part of the fixed costs of a pilot plant. On the other hand, such equipment and its installation would cost significantly more in a developing country than in a developed country near the site of its manufacture, perhaps as much as 20% more.

31. Fixed costs are first shown for a singly-sited ICGEB, located either in a developed country or in a developing country. The figures shown in Table I reflect the higher costs of equipment in a developing country. The three right-hand columns of Table I show cost estimates for the three different structures of a multiply-sited centre described above. For four sites each having all facilities, the fixed costs are simply two times those for a site in a developed country plus two times those for fixed costs for a location in a developing country. The model of four sites, each with forty scientific and technical professionals and only one site having a pilot plant, includes a slight reduction in the costs of general equipment and other laboratory equipment, but a substantial reduction due to having only one major pilot plant. This figure is offset somewhat due to the requirement that minimal fermentation equipment will be required at all locations.

C. Personnel Costs

32. Personnel costs were computed originally on the basis of the United Nations salary structure in 1982 plus a post allowance for Vienna. The figures for a single location in a developed country are taken from the document cited previously for a centre of 50 technical professionals and 209 employees total. The personnel costs for a centre of the same configuration located in a developing country are somewhat less due primarily to the lower post allowance for developing countries. The figure in the second column of Table I for professional and skilled salary costs are computed using the post allowance for India, resulting in a reduction of approximately 25% compared to the figures computed for Vienna. For Thailand, these figures would be about 20% lower than the Vienna figures. In addition, approximately 50 workers in jobs requiring skills readily available in every country might be recruited from the host country. For developing countries, this could mean personnel costs for these positions of perhaps only a third of what they would cost in a developing country. Taken together and using these assumptions, the reduction in personnel costs for a single-location ICGEB in a developing instead of a developed country is US$ 1.4 MM or about 29%. If the host country could provide other amenities, such as housing and transportation in lieu of part of the salary, the cost burden to the ICGEB might be lowered even further. (It should be kept in mind, however, that these reductions are partially offset by significant increases in both fixed costs and operating costs for a centre located in a developing country.

33. The personnel costs for a four-site ICGEB, each of the size of the Centre proposed originally, are a simple multiple of the costs for a single centre. For four facilities of 40 scientific and technical professionals in each, the costs of the scientific and technical staff (144 out of 209) are reduced by 20%. However, only a very slight reduction of the administrative and support staff would be possible. That is, within rather broad limits, nearly all of these other positions are relatively independent of the number of technical staff. The library will be the same, whether there are 40 or 50 scientists and bioengineers. A machinist, security guards, a personnel officer and dishwashers are still required, with about the same work load, even if the scientific operation were reduced by half. Therefore, overall personnel costs would be only about US$ 3.4 MM lower than for 4 complete facilities.

D. Operating Costs

34. For a centre in a single location, internal operating costs, including the expendable supplies used by both the laboratories and offices, equipment maintenance and repair, the costs of meetings, journal subscriptions, will generally be on the order of 20 - 30% higher for developing countries. One should perhaps also figure in an intangible cost due to delays, including experiments that must be repeated or cannot be done when planned due to the unpredictability of receiving crucial perishable reagents on time. However, it is difficult to include such events in an accounting scheme.

35. For the various models of multiply-sited centres, the internal operating costs (other than personnel costs) are related to the number of personnel, but not proportionately. The US$ 2.7 MM reduction shown for the operating costs of four sites with 40 technical professionals at each is essentially all due to an overall reduction of 40 scientists and bioengineers, plus the savings in supplies of operating only one pilot plant instead of four. This is offset somewhat in all of the multiple-site models by increased external operating costs, which would be many times those of a single location, due to the increased necessity for staff travel, telephone and computer conferencing, and the administrative complexity such structures would entail.

E. Training Costs

36. The figures shown in Table I for training are the indirect costs of training and are assumed to be directly proportional to the number of trainees, wherever they are located. This figure includes additional supplies and audio-visual materials, the indirect costs of increased laboratory space, and the additional costs of services provided to the trainees by the ICGEB. The costs of the trainees' stipends are assumed to be borne by the sponsoring country or institution, contributed to a training fund to be administered by the ICGEB to ensure a degree of uniformity in the compensation and benefits received by all trainee scientists and engineers. The figures shown reflect the varying capacities of the various models to train individuals, ranging from 40 at a given time in an ICGEB at one location to 160 at four equivalent sites.

F. Overall Costs

37. It should be kept in mind that the figures shown in Table I are based upon many assumptions, any of which may be challenged. In all likelihood, all of the costs will undoubtedly be higher when the ICGEB is actually established. The relative differences are the best estimates one can make within the constraints of the assumptions made. However, these figures should be considered to be no more than a first order approximation; it is simply not possible to do better at this stage of planning. Thus a difference of 10% should not be considered significant, whereas differences of a factor of 2 or 3 are significant.

38. The big differences occur when one attempts to split the ICGEB while preserving essential functions and retaining a degree of breadth in the work programme at each location. With four locations, each concentrating on a speciality area, the costs of operation are more than three times as high as that of a single, complete facility.

IV. THE EFFECTIVENESS OF AN ICGEB IN SEVERAL LOCATIONS IN MEETING ITS GOALS

39. Table II gives a roughly quantitative evaluation of the capacity of the various models of the ICGEB discussed in this analysis to meet the objectives that have been set for it, and about which there has been a general consensus from the beginning. The five categories discussed include training, research, process and product development and testing, information management, and the promotion of biotechnology. The emphasis of the research and development programmes, training and technology promotion is, of course, to be upon the needs of developing countries.

40. In all previous documentation, there has been a stress on excellence in the professionals who will staff the ICGEB, and it is this staff that will actually carry out research and the training of individuals. The quality of research, development and training will, therefore, largely be a reflection of the quality of the scientific and technical staff. Thus one must evaluate the quality and depth of these functions of the ICGEB in terms of the probability of attracting the best scientists and bioengineers to the ICGEB under the various models proposed.

41. It has always been assumed that a single, complete facility in a developed country, supported by the local university and industrial institutions, would be capable of attracting a staff of world-class individuals. Before such an assumption is taken for granted, one must also ask if there is a Director with the ability to organize and bring together such an assembly of individuals, and whether all of the criteria that would attract these scientists and technologists are present in the ICGEB proposal in whatever form it is presented to the rest of the world. Can one really get crucial supplies easily without customs delays? Can one get quick, efficient equipment service? All questions of this sort must be answered affirmatively. So, the location in a developed country does not, in itself, guarantee that the world's best will flock to the ICGEB. Many additional assurances would have to be made in advance, such as a continuance of financial support for at least five years, the commitment of other outstanding individuals to come to the ICGEB, the cultural, educational and social amenities important to the staff and their families, and access to their colleagues around the world.

42. Nevertheless, it has been assumed that it would at least be possible to meet these criteria and give these assurances in those developed countries that have tendered offers to host the ICGEB. It is extremely important that attention be paid to making sure that the ICGEB is an appealing place for outstanding individuals to want to live and work. Most of the people whom the ICGEB would like to attract already are very well situated in terms of all of the above points. They would have to be matched by the ICGEB and its location in order to induce them to undertake such a major move.

43. If we now consider the possible forms of an ICGEB, two sites in developing and two sites in developed countries, the situation is much different. Depending on the attributes of the facility at each site, it may well be possible to attract first-class professionals to the ICGEB. Because the sites in the developing countries are associated with those in developed countries as part of an ICGEB umbrella, with frequent travel and communication encouraged between the sites, it may be possible to attract some excellent individuals to sites in developing countries who might not otherwise have come to a single ICGEB located only in India or Thailand. This is, of course, speculation, and it is one part of this analysis which is really very difficult to evaluate.

44. To offset this possible influence of a multiple site structure, the diffuseness and dilution of the research programmes may actually deter other excellent individuals from joining the ICGEB. Another question may be asked: Are there enough outstanding individuals in the world willing to join an international centre to meet the increased staffing requirements of a siting structure in several locations? It is probably the case that there are not. At best, one may be able to have one or possibly two world-quality groups at each site, but not in all areas at every location. This dilution effect would definitely work against the self stimulating or synergistic effect of having a "critical mass" (to quote the original proposal[2]) of excellent people working in one place.

45. Because of the limited size of a single-site ICGEB, the diversity will always be somewhat limited and, therefore, can never be as great as one would like. In a multiple facility ICGEB, the total scope of programmes might possibly be greater. However, in terms of the training of a single individual, exposure to variety would not be greater.

46. The real problem with the lack of diversity of training comes with the model with a pilot plant in only one location. Three-fourths of the trainees would then be deprived of experience with the part of the ICGEB most germane to the industrialization of biotechnology, unless a programme of rotation among the various facilities was undertaken. But this would have many other logistic drawbacks and impose an added strain on the trainee and his or her family.

47. The same considerations with regard to the diversity of the training programme also apply to the diversity of the research programme. It is, however, less important to the scientist or technologist to have such variety in a single location as it is to the trainee.

48. The capacity of the ICGEB to develop an effective programme in process development and testing also is a reflection of the quality of the bioengineers who can be attracted to the ICGEB. For this reason, one would expect the effort to be very good at a site in a developed country. Perhaps the overall effort would be even better in a four-site ICGEB with a pilot plant at each location. This would, however, depend on getting enough qualified people to staff all four facilities. There is at present, a shortage of skilled bioengineers, who are in great demand on the growing world biotechnology industry.

49. The important function of information management is critically dependent on the existance of a good efficient communications network, as one finds in developed countries but rarely in developing countries. The ICGEB is dependent on the quality of such services in the host site and cannot create them, except with regard to its internal functions.

The problem becomes more complex when the ICGEB is fragmented among four locations. Four complete centres could perhaps do as well as one, making up for the separation of activities by the increase in personnel engaged in such matters. Since some of the sites would be located where good communications facilities exist, its external functions should be able to function effectively.

50. In order for the ICGEB to really live up to its promise, it must be able to foster the establishment of a local biotechnology industry in at least some of the participating developing countries. Of course, much of the success of this endeavor depends upon the commitment and resources available in the member country, once it decides how best to use its ICGEB trained scientists and engineers. In this case, it is difficult to choose among the models, except by virtue of the fact that the four complete site model has four pilot plants instead of one. The overall capacity to promote local industrial development directly, at least in the host countries, is probably somewhat greater in this than in the other proposed structures.

V. ADMINISTRATIVE AND ORGANIZATIONAL CONSIDERATIONS

51. Perhaps the most striking, obvious difference between an ICGEB at a single location and one with several components is in the administrative complexities created by such a division. If indeed the ICGEB is to be organized as a single international organization with a single Director and Board of Governors, there are several perspectives from which one must analyze the administrative problems which would occur.

52. The first is simply the case of administration. In order for the organization to carry out its functions efficiently, it must be managed in a well organized and effective way. Experience tells us that this is not so easy even for organizations in single locations. Like most of the matters discussed in this analysis, administration, too, depends far more on the skills of the administrators than on a particular organizational model. However, by separating an organization into sites in four different countries, with different monetary systems, rates of inflation, languages, levels of compensation, and with very many fundamental cultural differences, the challenges to any administrative system can be enormous. The ease of administering a single site is unlikely to differ significantly, whether or not the site is in a developed or a developing country.

53. In several sites, simply the communication barrier of distance is likely to make it difficult to overcome a sense of isolation from the sister components. It would be imperative for each site to have its own semi-independent administrative organization, including a laboratory director or chief administrative officer responsible for operations at each site. It should be possible to manage the day-to-day activities in this way without difficulty. Most difficulties will arise when co-ordination of activities among the various locations is needed.

54. Periodic overall ICGEB internal meetings, entailing additional costs and travel, would probably be necessary, especially in co-ordinating the training and external information functions of the ICGEB. Obviously, organizing meetings, where people have to come from great distances would be more complex.

55. Because of this increased complexity, the demands for an efficient, well managed organization are much greater than for a single facility. Without very careful planning and co-ordination of administrative activities, there is a danger of a highly inefficient organization developing with much administrative waste, duplication, and the lack of knowledge among the various segments of what each other is doing.

56. Perhaps the most difficult administrative matter is that of financial and monetary matters. In terms of ICGEB salaries, is there to be a common standard against which all are to be measured, with monthly adjustments at each site to reflect differences in exchange rates? There is also the question of which employees might be recruited from the local labour force. Should some or all be paid according to local salary scales or should all employees be compensated according to international organization standards.

57. A summary and comparative evaluation of administrative and organizational demands are shown in Table III.

VI. LEGAL CONSIDERATIONS

58. Patents filed by the ICGEB should not pose a problem. Patents are filed by one or more inventors, which can be persons or an organization, in each country in which patents are sought, regardless of the nationality or residency of the inventor. The assignee would, in all cases, be the ICGEB in accordance with paragraph 2 of Article 14 of the Statutes.

59. It may be mentioned that all sites of the ICGEB will be treated equally in accordance with Article 13 of the Statutes as regards immunity from legal process, inviolability of the premises, exemption from taxation including custom duties, privileges and immunities of employees of ICGEB and of representatives of member states, co-operation with local authorities of the host states on certain legal issues etc.

VII. SUMMARY AND CONCLUSIONS

60. As the above analyses indicate, there are many perspectives from which the advantages or disadvantages of a geographically-split ICGEB might be evaluated. Is it possible to come to an overall recommendation? Does one model offer overwhelmiug advantages over all others?

61. As the foregoing discussions have pointed out, so much of the success of any aspect of the ICGEB at any site will depend on the talents of the individuals staffing and running the ICGEB, and their ability to work together in a constructive way. Because these depend primarily on human qualities difficult to predict in advance, one must make certain other assumptions or look at the problem in different ways. With the exception of costs, which can be estimated on a rational basis, any comparisons are necessarily subjective.

62. First, one may assume that equivalent people are put into different situations and then may ask how much better or worse would they function under these varying circumstances. Or, one may examine the demands on the people in differing situations and ask what sort of person is needed to perform outstanding or merely competently under each. Either way, one is faced with the conclusion that it is possible to achieve the ICGEB's objectives under any model, but that, overall, it would be more difficult and most costly to achieve them if one were to try to establish the ICGEB in several sites.

63. It is within the realm of possibility that enough highly talented people may be found to staff both the administrative and scientific and technical positions at an expanded, multiple-site ICGEB. It is just that it is much less likely than finding them and inducing them to come to a single facility.

64. In arriving at a suitable course to follow, one must consider not only what ICGEB configuration and location(s) may be possible and desirable, but under what arrangement is the achievement of the objectives which have been set and accepted the most probable. It is difficult enough to establish a new organization under the best of circumstances. It is, therefore, imperative that the most realistic way of establishing a highly functional ICGEB most likely to meet the objectives in view of the resources at hand, be the one that is pursued.

65. Clearly, a critical factor in the decision on location(s) is the matter of financial resources. One <u>must</u> consider not only the outstanding offers from potential host countries but consider whether or not the resources from any or all of these offers will be fully available. The multiple-site model was suggested as a means of utilizing more of the offered resources than a small site would be able to do. But to what degree is this premise valid?

66. What other sources of funding can be identified for the continued support of the ICGEB? Before the ICGEB will be able to begin its actual existence and offer positions to prospective staff members, the funding over the first five years will have to be identified. People will simply not accept positions if their future is insecure.

REFERENCES

		Document Number
1.	Report of the Selected Committee 7 June 1983	ID/WG.397/1
2.	The Establishment of an International Centre for Genetic Engineering and Biotechnology prepared by a Group of Experts 9 November 1981	UNIDO/IS.254
3.	Five-Year Work Programme of the International Centre for Genetic Engineering and Biotechnology prepared by the UNIDO Secretariat 20 September 1983	ID/WG.382/2
4.	Proposed Budget of the International Centre for Genetic Engineering and Biotechnology prepared by the UNIDO Secretariat 28 September 1982	ID/WG.382/3
5.	Practical Considerations of the Operation and Work Programme of the International Centre for Genetic Engineering and Biotechnology prepared by Burke K. Zimmerman 16 August 1983	ID/WG.397/3

Table I

COSTS	ICGEB AT A SINGLE SITE		ICGEB AT FOUR SITES (2 DC, 2 LDC)	
	In A Developed Country	In A Developing Country	Complete Facilities In All Locations	Complete Facilities For All Basic Programs + Speciality
Land And Buildings (Provided By Host Countries)	High	Low	Very High	Very High
Fixed Costs US$ MM				Complete Pilot Plant In One Site Only
Laboratory Equipment And Computer	10.6	12.6	46.4	36.0
Library, Software	0.4	0.5	1.8	1.8
General, Including Office Equipment, Furniture, Shop Equipment, Vehicles etc	1.0	1.1	4.2	3.6
Total Fixed Costs	12.0	14.2	52.4	41.4
Personnel	(50 Scientists And Technologists) As Point Of Reference		50 Scientists And Technologists In Each Site	40 Scientists And Technologists In Each Site
	Number / Cost			
Professional And Technical	159 / 5.4 (1)	4.0 (2)	18.8	15.6
Non Professional	50 / 0.9 (1)	0.3 (3)	2.4	2.2
	209			
Total Personnel Costs	6.3	4.3	21.2	17.8
Operating Costs (Per Year)				
Internal, Including	2.7	3.2	12.0	10.5
Research And Office Supplies, Maintenance Of Equipment, Meeting Costs, Utilities, Journal Subscriptions, Depreciation etc,				
External, Including	0.2	0.5	2.0	1.8
Travel, Communication, Mailing, Printing etc				
TOTAL OPERATING COSTS	2.9	3.7	14.0	12.3
Training Costs (Per Year)	40 Trainees Total At One Time		40 Trainees In Each Site	32 Trainees In Each Site
Internal Costs Only	1.125	1.125	4.5	3.6
(Trainee Stipends To Be Administered By ICGEB From Assessment Made To Each Sponsoring Country Or Institution And Do Not Appear In This Table)				
TOTAL ANNUAL COSTS	10.325	9.125	39.7	33.7

(1) Based on 1982 figures for UN salary structure and post allowance for Vienna.

(2) Based on 1982 figures for UN salary structure and post allowance for India.

(3) Based on assumption that local non-professional [illegible] would be paid according to local usage scales.

Table II

ATTAINMENT OF OBJECTIVES	ICCEB AT A SINGLE SITE		ICGEB AT FOUR SITES (2 DC, 2 LDC)	
	In A Developed Country	In A Developing Country	Complete Centre At All Sites	Complete Basic Programs At All Sites + Speciality
TRAINING				
Quality	3	2	2	2
Depth	3	2	2	2
Diversity	2	1	2	1
Capacity/Yr	(40)	(40)	(160)	(128)
RESEARCH				
Quality	3	2	2	2
Depth	3	2	2	2
Diversity	2	1	2	1
Process And Product Development; Testing	3	2	3	2
Information Management	3	1	3	2
Technology Promotion	2	2	3	2

Table III

ADMINISTRATION AND ORGANIZATION	ICGEB AT ONE SITE		ICGEB AT FOUR SITES	
	In A Developed Country	In A Developing Country	Complete Center At All Sites	Complete Basic Programs At All Sites And Speciality
Ease Of Administration	3	3	1	1
Communication:				
Internal	3	3	0	0
External	3	1	-1	-1
Meetings And Seminars:				
Planning	3	3	2	2
Co-ordination	2	2	0	0
Travel	2	0	-1	-1
Financial Administration	3	1-2	0-1	0-1