THE SCIENCE AND TECHNOLOGY GAP IN THE ARAB-ISRAELI CONFLICT

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Science is universally recognized as a key element in economic development, technological change and military power. In most developing and backward countries, however, this recognition is never translated into practice and, compared with advanced countries, little scientific influence is visible in daily activity. In an advanced industrial country, not only is science sponsored as a means to national growth, but a scientific approach permeates normal life. Daily work anywhere offers numerous opportunities to observe, record, relate events and make deductions; the test of a society's scientific advancement is the extent to which each of its members — farmers, politicians, technicians, soldiers and teachers — can verify deductions, refine them, recast them and attempt to comprehend their significance. In an underdeveloped society such skills are lacking and science itself is seen as an entity foreign to life and limited to what is taught in the classroom and practised in the laboratory. Many circles in such countries still regard scientific activity as a form of conspicuous cultural consumption, the intellectual equivalent to adorning oneself with expensive jewellery or ostentatiously consuming large amounts of food, drink and services. The value of scientific production is often measured in terms of the facade of modernity which it bestows upon the society in question. This general failure to appreciate the central relevance of science to successful economic and military activity is an important factor impeding the advancement of underdeveloped countries.

One decisive factor influencing a society's development, although it was not fully appreciated until the nineteenth century, is the amount of scientific *research* which that society sponsors. The progress of Germany during the nineteenth century offered the first important illustration of this principle. German universities and technical Hochschules made such vigorous

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contributions to science that they ultimately enabled German industrial and military development to overtake that of Britain, where universities were more complacent. Some British science professors, like Lyon Playfair, pointed out the consequences of inadequate emphasis on research over a hundred years ago. Playfair wrote:

> A rapid transition is taking place in industry; raw material, formerly our capital advantage over other nations, is gradually being equalized in price, and made available to all by improvements in locomotion, and industry must in future by supported not by a competition of local advantages, but by a competition of intellect.... Until our schools accept as a living faith that a study of God's works is more fitted to increase the resources of a nation than a study of the amours of Jupiter or Venus, our Industrial Colleges will make no material headway against those of the continent.[1]

During the past hundred years in the advanced countries of the world, government involvement in the promotion of science has increased rapidly. World War II, in particular, witnessed considerable military exploitation of scientific know-how, and all such countries have subsequently maintained large research complexes to support their military posture. Intensive use has also been made of scientific research to expand science-based industry.

It is now possible, in the light of recent studies on science policy,[2] to specify the proportion of a country's Gross National Product (GNP) which must be spent on research in science and technology if that country is to be serious about scientific and military development. On the record of advanced industrialized countries, it has been shown that to conduct a modest programme of scientific research in 1972, a country must have roughly the equivalent of 1000 full-time *research-active* scientists per million inhabitants, and must devote approximately 0.7 per cent of its GNP towards the finance of their research work. These scientists may be university professors or researchers in scientific research institutions. Fifty per cent of them should be engaged in university teaching and research. Every year new scientists can be expected to graduate from these institutions, and a country that is moving along with the advanced countries should double the number of its research-active scientists every nine or ten years.

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[1] See Lyon Playfair, "The Chemical Principles Involved in the Manufacture of the Exhibition as Indicating the Necessity of Industrial Instruction," in *Lectures on the Results of the Great Exhibition of 1851* (London, 1852), pp. 193, 197. See also Professor W.H.G. Armytage, who has provided a study of some of these problems in *Civic Universities: Aspects of a British Tradition* (London: Ernest Benn Ltd., 1955).

[2] See, for example, Derek J. de Solla Price, "Nations Can Publish or Perish," *International Science and Technology*, October 1967.

To conduct research work in technology in 1972, a country should support roughly the equivalent of 3000 researchers per million inhabitants — or $3:10^3$; 2.8 per cent of the country's GNP should be devoted to financing this research work. Probably 30 per cent of these researchers would be employed in university teaching and research in departments of applied science and engineering. The rest would be engaged in various fields of research in institutions of applied science or in specialized institutions operated by the ministries of public works, agriculture, public health, defence, and the like.

The output of all this activity may be classified as follows:

1. Scientific publications.
2. A regular turnout of Ph.D. graduates.
3. Patents and inventions; Nobel and other prizes.
4. Industrialization; the design and construction of new industries.
5. The acquisition of military technological options.
6. Growth of GNP and improvement of the standard of living.

All of the above-mentioned products of science and technology are quantifiable. One may thus analyse the performance of a country over long and short periods of time as well as compare one country with another. When such a comparison is made between the scientific and technological output of two countries, the difference, if significant, is referred to as "the gap."

"The gap" is clearly a complex quantity. In some cases one country may be lagging in some products, but be more advanced in others. Numerically speaking, it is relatively easy to count the number of B.A. or M.A. or Ph.D. holders in a country and to compute the number of Ph.D. holders per 1,000 inhabitants. Science and technology, however, bear only an indirect relation to the number of Ph.D's per 1,000 inhabitants. If a country has 1,000 physicists who have no libraries, laboratories or income adequate to allow them to devote their time to their profession, then for all practical purposes this country does not have research in physics. Thus the above classifications stress the output and achievement of scientists rather than their number.[3]

It is also possible, on the basis of their current research in science and technology, to make projections as to the future output of one or a number of countries. Such analysis depends partly upon non-quantifiable factors. For

[3] When measuring the gap between two countries, some other points deserve mention. If per capita comparisons are made, it should be noted that the scale of scientific and technological activity also depends on the absolute size of the population. A large population and a large economy may encompass within its scientific establishment a much larger number of researchers, and it can thus handle and solve proportionately more problems. Thus of two countries with the same per capita scientific output the large one is distinctly favoured. Since the financial support is also based on a percentage of the GNP, the richer the country is, the more financial resources it can devote to the support of research in science.

nations such as China that have taken the road of science and technology, and for whom this decision is not mere verbiage but expressed in a substantial contribution to the support of this activity, the forecasting can, however, be rather rigorous and the outcome fairly certain.

In the case of the Arab states and Israel, past and present trends are sufficiently fixed to make comparison meaningful. As yet not one single Arab state has committed itself to spending even 0.5 per cent of its GNP on the development of science and technology.[4] The Zionist movement in Palestine, on the other hand, has set out from the beginning to develop the pure and applied sciences with unflinching vigour and full understanding of the key role of science in war and peace. Ever since July 24, 1918, when the twelve founding stones of the Hebrew University of Jerusalem were laid, the Zionists (now Israelis) have been actively developing their scientific and technical capabilities.[5] In Israel the present system of higher education and scientific research has, therefore, attained a stable level of performance and maturity. In such circumstances there tends to be an intimate relationship between the actual output of the system and its future potential, and it is possible to project either picture.

It is sometimes argued that Israeli growth cannot be maintained because of Israel's limited skilled manpower reserves. The present population of Israel is small (three million). Although there are some twelve million potential Jewish immigrants to Israel, the population in 1980 will certainly not exceed five million — even if the migration of Russian Jews keeps growing at the present rate. For this reason, it might be tempting to predict saturation effects in Israeli science. Two factors indicate, however, that Israeli science and technology may continue to grow unimpeded:

1. Half of Israeli high level manpower is traditionally provided by immigrant Jews. This migration flow is stable and may be increased.

2. Half of the population of Israel (the Oriental Jews) has not begun to contribute to the scientific work force of Israel. Furthermore, even among the Western ("Ashkenazi") Israelis the percentage of scientists and engineers, though high, has not attained the levels prevalent in the US. Saturation effects will most probably not become significant before the year 2000, unless the anticipated immigration flow dries up much earlier.

Thus the conditions determining the Arab and Israeli capabilities in science and technology appear to be well-defined and stable. On the Arab

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[4] Some background information may be found in: *Science and Technology in Developing Countries*, edited by Claire Nader and A.B. Zahlan (London: Cambridge University Press, 1969).

[5] For background information see A.B. Zahlan, *Science and Higher Education in Israel* (Beirut: The Institute for Palestine Studies, 1970).

side there is no sign that the present lack of commitment to the support of science and technology is on the verge of changing, while on the Israeli side there is no sign that the present high level of support for science and technology in on the verge of either stopping or of reaching a saturation level. Hence the conclusions that we will draw on the basis of existing conditions will be valid for the foreseeable future, or for as long as no radical change occurs in the science policies of either the Arabs or Israelis.

The first index of scientific output adopted is the number of scientific papers and books published by a country's scientists and technologists. To determine such a number is a difficult task. During the past five years, however, the Institute of Scientific Information publication *The International Directory of Research and Development Scientists* has provided a compilation of first authors[6] per country and city. This number is close to the actual number of publications. The ratio of such a number for two different countries would be an accurate comparison of the ratio of their publications. Tables 1 and 2 provide this information for the Arab world and Israel during the years 1967-69 and then again for 1971. One can make the following remarks:

1. The Israeli output (population three million) is about 2.4 times the output of the entire Arab world (population 126 million).

2. The Israeli output is four times the Egyptian output, while Egypt's population is twelve times Israel's.

3. The *increase* in the Israeli output over the period is nearly equal to the total annual output of the Arab world.

4. The average Israeli and Arab annual rates of growth in publications over this period were between twelve and fifteen per cent.

5. There is a considerable variation in the per capita publication figures for different Arab states. All of them are very low, but some are lower than others. The oil rich countries lead the way in the lowest published output. Sudan, if not the poorest, certainly one of the poorest Arab states, outproduces Algeria, Iraq, Jordan, Morocco, Syria and Tunisia. In fact, the Sudanese output is greater than that of the combined output of Algeria, Jordan, Morocco, Syria and Tunisia. Lebanon's apparently good comparative standing is misleading: sixty-one (1968) and fifty-seven (1969) out of sixty-seven publications and seventy-three out of eighty-nine publications (1971) came from the American University of Beirut. The American University of Beirut apart, the Lebanese output is six (1968), ten (1969) and sixteen (1971) — which would be on the same level as that of Saudi Arabia and Jordan.

[6] I.e., the names of sole authors and the first name on each book having more than one author.

TABLE I

DISTRIBUTION OF PUBLISHING SCIENTISTS IN THE ARAB WORLD BY COUNTRY

	1967 Number[7]	1968 Number[8]	1969 Number[8]	1971 Number[8]
Algeria	22	27	28	46
Kuwait	2	1	3	2
Lebanon	58	67	67	89
Libya	3	3	2	5
Iraq	32	29	42	44
Jordan	1	1	5	7
Morocco	11	5	7	12
Syria	2	2	2	1
Saudi Arabia	8	12	6	14
UAR	293	295	348	443
Tunisia	3	13	13	17
Sudan	30	38	58	70
Yemen	0	0	0	0
Total	465	493	581	750

TABLE 2

DISTRIBUTION OF PUBLISHING SCIENTISTS IN ISRAEL BY CITY

	1967 Number[9]	1968 Number[8]	1969 Number[8]	1971 Number[8]
Jerusalem	374	427	544	561
Rehovoth	252	261	305	308
Haifa	177	190	238	272
Tel Aviv	93	119	181	225
Yavne	38	33	40	37
Nes Ziona	27	19	19	23
Petah Tiqwa	27	34	39	47
Beersheba	24	37	33	45
Tel Hashomer	20	25	39	28
Ramat Gan	15	19	24	27
All Else	78	79	80	166
Total	1,125	1,243	1,542	1,739

[7] "Measuring the Size of Science" by Derek J. de Solla Price, *The Israel Academy of Sciences and Humanities, Proceedings*, IV, 6 (1969), p. 106.

[8] *International Directory of Research and Development Scientists* (Philadelphia: Institute for Scientific Research, 1967, 1968, 1969, 1971). The figures have been totalled from the index of authors in each country which is printed at the end of the volume.

[9] Derek J. de Solla Price, *op. cit.*, p. 106.

On the basis of this data one may compute a figure to compare Arab and Israeli per capita output between 1967 and 1971:[10]

$$100 \times \frac{3}{120} \times \frac{1796}{4406} = 1.025\ \%$$

In other words, one Israeli produces about as much science as 100 Arabs. This is a large gap indeed! If we were to compute the gap for Jordan we would find that it was 250:1. With Egypt the gap is 50:1.

We have cited six indices that would assist in assessing the products of science and technology. We have already examined one such index: that of scientific publications. The other indices are even less favourable to the Arabs.

Ph.D. level education in the sciences in the Arab world is of such a low level as to be non-existent in terms of practical effect. This, of course, is a natural consequence of the absence of any significant research activity. In Israel for more than a decade now Israeli institutions have granted some 100 Ph.D.'s annually. Most of these (over 75 per cent) are in the sciences. We do not have available data on patenting activities. As for Nobel prizes, neither party has received any in the sciences. A few Israeli scientists, though, have received some significant international awards.

In the field of industrialization, one observes an impressive difference between developments in Israel and those in the Arab world. Table 3 shows the

TABLE 3

STRUCTURE OF THE ISRAELI ELECTRICAL INDUSTRY[11]
ELECTRICAL AND ELECTRONIC EQUIPMENT
(ESTABLISHMENTS OF FIVE OR MORE PERSONS)

Year	1963/64	1965/66	1966/67	1967/68	1968/69	1969/70
Number of Establishments	340	281	268	226	264	225
Persons employed (in 1000's)	8.00	7.5	7.0	8.5	11.4	13.8
Gross Output, Million IL	170	220	221.0	262.5	409.7	625.2

[10] The figure is based on the totals for 1967, 1969 and 1971.

[11] Israel Central Bureau of Statistics, *Statistical Abstract of Israel, 1965*, pp. 417, 422-23 for 1963-64 figures; *Ibid, 1967*, p. 371 for number of establishments and persons employed, 1965-66; *Ibid.*, 1968, pp. 372-73 for gross output, 1965-66; *Ibid, 1968*, pp. 368-69, 372-73; *Ibid, 1969*, pp. 368-69, 372-73; *Ibid, 1970*, pp. 368-71; *Ibid, 1971*, pp. 368-71.

According to an article in *Bamahane* (26/4/1971), the sales of electronic products (excluding electrical machinery) during 1961 amounted to IL 7 million. The 1970 sales totalled IL 430 m ($120m); and the projections for 1971, 1972 and 1975 are: IL 560m ($ 135 m), IL 800 m ($200m) and IL 1450m respectively.

growth of the electrical industry in Israel. This is a high technology, science-based industry of considerable military importance. There is no electrical industry in the Arab world to compare with the Israeli one. In some countries there is an effort to assemble radio or television sets. In no Arab country is there adequate university-level instruction in those areas of electrical engineering of relevance to an electronic industry.

The importance of the electrical industry lies not only in providing the military with home-made equipment. In a small country, this activity also enables the military to make an appropriate choice of equipment. For example, one Arab country after the June War purchased — for some $ 30 million — an obsolete system of ground-to-air rocket defences consisting of phased-out subsonic rockets. The hydraulic system for the launchers, developed for a colder climate, never functioned in the more demanding desert conditions. One country ordered mobile field radar units that were so obsolete (vintage 1952) that in the United States even the National Guard did not use them any longer. They got 1954 models because of the difficulty of finding 1952 models. In another country facilities for ground training of pilots (computer-assisted simulators) were non-existent, resulting in the loss of scores of highly sophisticated front-line planes in training in a single year.

An awareness of devices, developments, counter-measures and like matters can be acquired only by persons practising the technology. At the moment many Arab armies and governments are the victims of the agents of the weapon systems scrap industry. If and when a really advanced weapon is purchased, it cannot be put to proper and optimal use without the underlying scientific and technological infra-structure.

If one compares the performance of the Arab and Israeli agricultural sectors the results are no different. The Arab (east of Suez) agricultural output per acre is one-tenth the Israeli output and one-sixteenth the Yugoslav or United States outputs. The Arab world in 1969 purchased $2400 million worth of simple non-electrical equipment, especially farm equipment. Up to 1972 the Arab world had not acquired the capability to manufacture such simple equipment — or the equally simple mechanical military equipment. On the other hand, Israel manufactures all of these and exports missiles.

One would have thought that the Arab world, with a $ 6000 million income from the sale of crude petroleum during 1970, would have acquired a strong capability in at least some aspects of this industry. It is most amazing that even in this domain there is not one single research institute or even a university department or programme that would receive international standing and recognition.

It can be fairly and accurately stated that not one single Arab state has acquired any military technological options since its independence. The only serious attempt was made in Egypt. This was the effort to design and build short-range heavy rockets and aeroplane frames and engines. This effort failed because of the limited science base in the country. Prominent features of this were: the absence of significant research in aeronautics at Egyptian universities; the over-dependence on foreign key technical manpower; the fact that the project was entrusted to the army and the lack of a technical base in the Egyptian armed forces; the relative isolation of this effort from similar activities elsewhere in the world; the lack of attention to quality control in manufacturing; the absence of adequate computer facilities and the absence of inhouse staff development and training. In contrast, the Israeli effort was successful and began by establishing a strong academic research base at the Haifa Technion in the field of aeronautics. Israel adhered to high standards in the maintenance and production industries associated with such activity, maintained active contact with the outside world, and developed a very effective and powerful system of computer and electronic support. Israel invested more effort and more resources than Egypt did. It is claimed that Israel has successfully developed a 300 mile range ground-to-ground rocket capable of carrying a nuclear warhead. Israel also manufactures the Gabriel, a short-range ship-to-ship rocket.

The other area where Israel has invested twenty-four years of hard work and considerable funds is that of nuclear physics and nuclear engineering. Fuad Jabber has recently reviewed the Israeli nuclear capability.[12] It appears that the Israelis have acquired a nuclear option and, even if they do not possess any nuclear devices at the moment, they are capable of producing them in a short period of time — sometimes estimated at between six months and one year. No Arab state has so far made any serious attempt to acquire the rudiments of nuclear know-how, let alone acquire an option.

The last index cited is an extremely complex quantity. Any worthwhile comments on the impact of science and technology on the GNP in the Arab world and Israel have to be preceded by detailed analysis. We will also abstain from a comparative analysis of the standards of living and their annual rates of improvement. The few examples already adduced are sufficient indication of the extent of the gap.

The absence of significant Arab government support for scientific research is one reason for the wide gap. In 1970 the Arab world GNP amounted to about $34 billion. $6 billion of these were attributable to crude oil exports. The Israeli GNP amounted to some $6 billion. If both the Arabs and Israelis devoted 3.5 per cent of their GNP to research in science and technology, then the Arab world should have outproduced the Israelis in research in science

[12] See F. Jabber, *Israel and Nuclear Weapons* (London: Chatto and Windus for the Institute for Strategic Studies, 1971).

and technology by a factor of ten. In fact the reverse has happened: the Israelis have outproduced the Arab world by a factor of three, and by 100:1 on a per capita basis.

Thus by rational planning and reasonably well-established criteria the Arab world should have spent 3.5 per cent of $34 billion — more than $1 billion — on *research* in science and technology during 1960 alone. In fact the Arab world expended *less* than $50 million during that year. In the Arab states east of Suez, expenditure on research did not exceed $7 million — or less than 0.06 per cent of GNP and 20 cents per capita.[13] No wonder no science or technology is sprouting in the Arab world: no Arab state has exhibited any genuine desire to acquire such a capability.

Professor A. Dvoretzky, the chief scientist of the Israeli Ministry of Defence, is reported to have stated:

> Israel spends between two and three per cent of its gross national product on research and development, a figure equal to that of countries like the USSR, Great Britain and France. However an analysis of the figures reveals a completely different picture, because Israeli military research accounts for a much larger part of the total. If we attempt to compare only civilian research, the Israeli position declines.[14]

We note here the concern Dvoretzky is showing for an imbalance in support for research in Israel. We compare this with the lack of concern in all Arab states for the lack of adequate support for any research activity.

Since the Israeli GNP is about $6 billion, two to three per cent is equivalent to $120-$180 million a year. Israel, if it were to keep up with the 3.5 per cent of GNP rate of top countries, should expend $210 million a year on research in science and technology.

Dvoretzky claims that between $6 and $12 million go to civilian scientific research, the balance going to military research. However the budget of the Weizmann Institute alone exceeds $12 million. It is more likely that Israel devotes one per cent of its GNP to the support of basic science. Daniel S. Greenberg claims that Israel spends $150 million, which is divided between civilian and military activities.[15] It is noteworthy that the US government contributes $8 million to the support of scientific research in Israel and the Volkswagen Foundation gives $1.2 million to the Weizmann Institute.[16] The annual growth rate of the Israeli research budget is 26 per cent. In contrast,

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[13] United Nations Economic and Social Office in Beirut, *Long-Term Perspectives in the Development of Selected Countries and Sub-Regions of the Middle East with Special Reference to Industrial and Labour Force Structures in the Year 2000*, September 1971, p. 25.

[14] "Yesrael Mia'bedet et Mqumah Ba'olam Hamada'" (Israel is Losing her Place in the World of Science) in *Davar*, October 21, 1970.

[15] *The New York Times*, July 28, 1971.

[16] Daniel S. Greenberg, *The Washington Post*, October 3, 1971.

the Arab states' research budgets have been, and still are, close to zero — and so is their growth rate. It is interesting to note that the Arab world research output *and* financial support are roughly one third of the Israeli research output and Israeli financial support.

The absence of scientific concern in Arab society is inevitably also reflected in normal daily activity. One striking military example is the neglect of maintenance essential to keep modern equipment in combat or operational condition. An Israeli account of the capture of the Egyptian destroyer *Ibrahim al-Awal,* which shelled Haifa harbour during the 1956 war, claims that its log-book read:

Ibrahim al-Awal	07.25	Our Haifa operation was successful. Cannot determine number of enemy casualties. We have some wounded. *We are sinking the ship.* [Italics added.]
Ibrahim al-Awal	07.32	We are all abandoning ship. We shall give ourselves up.
Alexandria	07.37	You have all fulfilled your mission and you should be proud of yourselves. We and the fatherland will always be proud of you. We shall look after your families. God be with you.
Ibrahim al-Awal	07.50	*We have opened the valves to sink the ship.* [Italics added.] We are between two Israeli destroyers, *Jaffa* on our left and *Eilat* on our right.[17]

Ibrahim al-Awal did not sink: apparently the valves were rusty and could not in fact be adequately opened. A few sticks of dynamite and a delaying fuse could still have been as effective in sinking the destroyer. However, the point would be that the lack of maintenance of the valves was such that when they were needed they were inoperative. More recently, in 1970, President Nasser's trip to Casablanca via Tripoli and Algiers to attend the Arab Summit Conference revealed a singularly glaring example of lack of appreciation for maintenance: the landing gears of the President's plane almost failed to work in three successive landings. The gear had apparently rusted for lack of adequate maintenance. It is most interesting that the gear was not put in order during the plane's stop-overs.[18]

More than one Arab army has such an inefficient and low standard maintenance system that, in some cases, up to 70 per cent of the armour is non-operational during a "state of alert."

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[17] Quoted in Moshe Dayan, *Diary of the Sinai Campaign* (London: Weidenfeld and Nicolson, 1965), pp. 113-114.

[18] See *al-Ahram,* January 10, 1970.

The Cost of Science and Technology

It is often thought that science and technology are expensive and that a small, relatively poor country cannot afford them. This is false, especially for a poor country at war. The cost of modern weapons (some $1 million for a jet fighter and $150,000 for a heavy tank) is such that no nation, no matter how small, can afford to have an army without a substantial scientific capacity. This must include:

1. The capability to have advisers from among its own citizens who are able to understand these weapons fully and who can assess their relative merits, proper use and maintenance.

2. The capability to at least design, though not necessarily manufacture, a good number of the weapons. This is important because a weapon should be adapted to fit the conditions under which it will be utilized. There is no universal weapon for all conditions. An army should always adapt its purchased weapons to its precise needs by well-conceived and tested modifications. This implies a very intimate and intelligent relationship between the soldier, the officer, the commander and their weapons. The scientist and engineer here work in close relation with those who use the weapons to find out in what ways they can render every part more useful and effective, through training and through design.

An excellent example of the adaptation of a weapon to the needs of its operator is supplied by the modification of French Mirages to the capacity of Israeli pilots. Unlike most others, the Israeli air force relies exclusively upon high school graduates. Since the instrumentation of combat aircraft is designed for college level pilots, the Israelis introduced about 600 modifications in the Mirage planes in order to adapt the plane to the capacity of the lower level high school pilot.[19]

It should be emphasized that new weapons and modifications of relatively new weapons are so numerous that engineers working in the forefront of technological research are now involved in inventing, designing and developing these weapons. A small country cannot, of course, support such large-scale and expensive research. It can, however, support a reasonable number of *active research scientists and technologists* at its national university and applied science research institutes. These researchers could rapidly and effectively scout a certain field to find out what is going on. The defence authorities then have the option of studying these findings and deciding whether certain fields of research merit top priority. If one maintains contact with scientific research on the international scale — as Israel does systematically — it is relatively

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[19] Information from the Rand Symposium on Pilot Training held in Santa Monica February 1970. Portions were published in Rand Report R-616-PR (December 1970).

simple to copy intelligently, and thus avoid the expensive work and expensive mistakes that are an integral part of scientific research.

On the basis of the above considerations it is clear that even a small army with *very limited* resources cannot afford not to use science and technology on a scale commensurate with its needs.

It is here proposed to measure these needs in the following fashion:

1. Every army has a fraction of its weapons "under repair" or otherwise in a non-usable state. If an adequate technical capability were available at design level, no more than two to five per cent of the weapons should be unusable at any one time. Hence, if at present one-third of the material is unusable, and this stock may be reduced to five per cent, a considerable saving is made in the amount of funds spent on weapons without cutting the effective budget of the army in any way whatsoever.

2. The inability of officers and soldiers to use their weapons properly has a demoralizing effect on an army. A tank officer who does not feel in perfect command of his tank and feels insecure about even a small portion of his weapon will be unable to meet the rapidly changing conditions of actual combat. An army that feels it possesses the complete ability to maintain, design and adapt its weapons has a new sense of self-confidence. The Israeli army has this sense and the Arab armies do not. Israel uses this growing sense of insecurity as a form of psychological warfare to weaken the individual Arab soldier. The only way to combat this is to provide the individual soldier with the required sense of security. The rapid and competent repair of weapons, the *clever and original* adaptation of devices, the close relationship between the engineer, the officer and the soldier all lead to this desired effect. Hence the existence of a scientific and technological establishment within and outside the army increases the *numerical efficacy* of the army without increasing its number of enrolled individuals or their actual cost. In other words, one gets more for the amount of money spent.

Science and Israeli Foreign Policy

Many areas of Israeli foreign policy are directly related to achievements in science and technology. First, and most obviously, there is the utilization of force to maintain the *status quo* in the area. There is a high sensitivity in Israel to the slightest activity in any Arab country that could affect the gap. One of the concerns of the Israeli Association for Futurology and Philosophy of Technics and Science, for instance, is to study "the influence of future developments in technology on the Arab-Israeli conflict, in the event of its continuing for the next 20-30 years." [20] The Israeli government has simultaneously

[20] *Futures*, June 1970.

conducted a strong internal propaganda campaign depicting the importance of science and technology to military victory and Israeli survival. In 1956, Technion leaflets spoke of "Israeli Brains versus Arab Brawn" and this viewpoint is still prevalent. Professor Bergmann of the Weizmann Institute, a past Chairman of the Israeli Atomic Energy Commission, stated in an interview with the Israeli Military Industries magazine:

> The gap between us and the Arab states is widening. I had thought for some time that the gap in the technological levels and performance was equivalent to a lag of 50 years. However, today I believe that the Arabs are lagging by 100 years relative to Israel. This fact is evident in all fields of science and technology. It appears that the fossilization of scientific thought over hundreds of years has rendered the Arabs incapable of ever catching up with the developments of our era.[21]

Davar comments as follows on the above-mentioned remarks of Professor Bergmann and also on a similar remark by Professor Youval Ne'eman that the Arab-Israeli gap is in the ratio of 1:7:

> ... One should have no doubt about the fundamental conclusions of these two scientists: that Israel must do everything possible to maintain and even widen this gap. This objective is essential not only for security reasons but also for the cause of peace.[22]

The motivations underlying Israeli concern with the maintenance and widening of the gap may be enumerated thus:

1. The wider the gap, the greater the certainty that Israel will win any future military confrontations.

2. The wider the gap, the lower the Israeli casualty rate in any military confrontation.

3. The wider the gap, the greater the Israeli economic domination of the Arab market in any peaceful settlement.

4. The more advanced Israeli technology, the greater Israel's capability to absorb additional population, increase its GNP and diversify its economy.

5. The wider the gap, the greater Israel's self-confidence, and Western willingness to aid Israeli supremacy over the Arab states.

Three other less publicized areas of Israeli policy are also directly linked to science and technology. They include:

1. The utilization of economic, diplomatic and political means as well as publicity to acquire legitimacy in the eyes of Third World countries. Israeli

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[21] *Davar*, April 11, 1971.
[22] April 13, 1971.

accomplishments in science and technology are always prominent among the factors used by Israel to obtain recognition anywhere.

2. The building of an image of culture, science and advancement to earn Western respect, admiration and continued support.

3. The campaign to increase the number of Jewish immigrants with advanced technical skills coming from Western countries and the Soviet Union.

It is rather interesting how these factors are interrelated. In the words of a Zionist testifying before a United States Congressional Committee on "the Middle East in the 1970's":

> The generation of young Jews in the free and affluent countries is one which has attained higher education and know-how to an extent unprecedented even in those countries. Unless they are attracted to Israel there is little prospect of their emigration to Israel or their collaboration in its development. Within the foreseeable future tens of thousands might immigrate within the framework of a development program capable of integrating them and these could enable Israel to attain its other vital needs in the sphere of development and economic independence and the advancement of science, and in strengthening its international status. They must be presented with the challenge of taking part in Israel's development, which for some of them will lead to settling in Israel.
>
> The co-operation of the know-how of the young generation, and the collaboration of the capital of the older generation, depend to a large extent on Israel's activities and international status. The simultaneous use of Jewish knowledge and capital in the development of Israel will increase as this development coincides with international development. The status of Israel in the eyes of Jews is, to a large extent, determined by Israel's status in the eyes of non-Jews. Israel's activities in the world, and especially in the developing world, are one of the most important conditions for intensifying Jewish participation in Israel's future.
>
> The combination of new Israeli development with international development is likely to enable Israel to approach Jews in the affluent lands with economic plans which combine a universal humanitarian objective with the chances of long-range economic profit. The creation and moulding of the tremendous potential market of the new developing states holds out an inspiring challenge.
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> The advancement of science is more vital for the security, economy and culture of Israel than for any other country, because of its special geopolitical situation: the whole region holds out a threat to Israel's very existence, prevents it from utilizing its natural markets, and forces it to foster a particular Jewish culture instead of a culture that is integral to the region.
>
> If Israel were to initiate the development of a new unconventional scientific-industrial economy that will not only serve Israel essentially as an export economy but will also serve international development by using the capital and know-how of the developed world, this will constitute a positive combination of social-national obectives and economic interests

which will, in the long run, attract Jewish (and non-Jewish) capital and know-how to Israeli development projects. Some distinction between the old and new economy will be both inevitable and desirable. For we shall be dealing with private and public capital which will be invested in specific projects. The new economy will establish certain suitable criteria — in know-how, administration, labor and marketing. At the same time it will indirectly assist the existing economy to approach economic independence by absorbing latent unemployment, by providing markets in certain spheres and, to a certain extent, by reflecting its own high standard of knowledge, management and labor. The economic alternative facing Israel in the next decade is that of appealing to the Jews of the affluent states to save it from a serious social and economic crisis — that would mark the bankruptcy of Zionism — or during that period of time confronting them with the challenge of a new economy which is in keeping with the needs and possibilities of the end of the 20th century — and that would mark the rejuvenation of Zionism.

The economic and scientific advancement of Israel, as that of any small country, is possible only by specialization in a sphere where it has relative advantages over other countries. Israel has two relative potential advantages in the sphere of the application and the implementation of the scientific revolution to the developing world: it has an association with the scientific revolution by means of the potential Jewish know-how in the developed world; and it has the association with the newly developing states as a result of the experience, the reputation and the status that it has acquired through its activities there. Until now it has fulfilled this function only in international conferences. It must put theory into practice in the potential laboratories and in industrial projects. By combining these two potential relative advantages in a Zionist program of the new Israeli development, Israel can become the scientific-industrial pioneer serving as a bridge between the developed and the newly developing world. This function will give Israel a great advantage from the economic and scientific points of view — and consequently from the political point of view — in both worlds.

From the point of view of its international status, a policy of this kind will free Israel from a situation in which it is assisted by the developed world (the American economy or the European market) for political reasons, and assist the newly developing states by a special and limited means of its foreign policy. It will convert Israel into an independent factor, bound up with both worlds, not for political reasons, but by virtue of its scientific and industrial abilities and power.

Israel's political needs, too, are special. Every state strengthens its position in the framework of the area in which it is situated. Because of Arab enmity in the region, Israel has to strengthen its international position by means of supraregional ties. Israel-Arab relations do not exist in their own right. They are interwoven in the mesh of international relationships of the developed world — the USA, Europe and the Soviet Union, and in the complex of relationships between the developed and developing nations, which include the Arab states.

Hence the efforts and attainment of Israel in the sphere of assistance to

> the developing states — on the basis that it is, from certain points of view, a developed and developing nation simultaneously — are not luxuries, but a vital and fundamental instrument of Israel's ability to invest manpower, and other means in assistance — agriculture, security, cooperation, communal and social work, etc. — to answer the needs of Israel's international cooperation: despite the great importance of these spheres of assistance for the future, too, two fundamental spheres of development in coming years are still untapped — science and industry. Moreover, these spheres are capable of placing Israel's international cooperation on a sounder basis — from the economic point of view. In this vital sphere, too, Israel is approaching the crossroads of unavoidable retreat or new impetus.[23]

The US Embassy in Tel Aviv in a statement dated November 28, 1970 mentions some of the usual statements on the subject and terminates with the following paragraph:

> *Future Prospects and Potential*
>
> Israel is one of the few countries of the post-World War II period which is indissolubly tied to science and technology as a principal motivating factor in social and economic progress. Judging from the innate Jewish love of knowledge and respect for the savant, one can predict a continuing stress by Israelis in future years on the advancement of education and more specifically the advancement of the sciences and engineering amongst a growing proportion of its youth. The dynamism and imagination of the ever-increasing number of scientists and engineers in Israel will certainly be used not only to increase the standard of living within Israel but to benefit other, less developed, countries. Once the political barriers of the Middle East are removed, the relatively much higher level of Israeli science and technology should flow quickly into the Arab countries to their mutual benefit resulting in a better and more efficient utilization of the region's natural resources and in increased trade. Until this desirable event comes to pass, the Israelis could offer increasing amounts of scientific and engineering services to the developing countries. Africa south of the Sahara is a case in point. The next half-century will undoubtedly see the exploitation by Africans of Black Africa's untapped wealth of natural resources. However, the Africans themselves will necessarily have to look outside the region for scientific and technological know-how to effect this exploitation. *As a small country, steeped in science and growing in stature in technology, and having no background in colonialism, Israel would seem to be in an ideal position to serve as a major scientific and technological consultant to the developing countries of Africa.* [Italics added.]

Any examination of the relations of Israel with Third World countries and with the international scientific community indicates that these statements do not refer to policies planned for the future but to activities that have been

[23] From the unpublished minutes of the Committee.

going on for at least a decade. The present concern is not so much to initiate new programmes but to consolidate and expand existing activities.

Science and Technology in the Arab-Israeli Conflict: Future Arab Possibilities

In the Arab mind and in the Arab world there is a display of considerable confusion in understanding the relationship between the various factors that influence the outcome of military confrontations. There is one school of thought that argues that science and technology need not be relevant to the outcome of military confrontations. To support this thesis it adduces the examples of Algeria and Vietnam. The other school of thought argues that the Arab states must acquire modern equipment and train a modern army prior to any confrontation.

Any military confrontation is primarily a contest involving faith and will. Science and technology have an important bearing on the faith and will of a nation and provide tools which enable each party to reduce their losses in human lives. For example, an effective military medical corps reduces death casualties enormously. Such a corps attempts to transport the wounded with the least delay to adequate medical centres. This operation involves excellent first aid service, helicopter transport, and field hospitals for emergency cases close to the front line. All of this organization, management and transport is a product of technology. It happens, very frequently, that the contesting parties enjoy different levels of science and technology. A rational nation would attempt to mobilize all of its scientific and technological capabilities to win at the lowest cost. The backward party has the following options: (1) pay for scientific and technological backwardness through greater devotion and sacrifice; (2) surrender; (3) "build up" a science and technology capability and postpone the day of confrontation.

In the case of Vietnam we note that the Vietnamese people have opted to pay for their backwardness through greater sacrifice *and through the effective utilization of science and technology on their level of development and operations.* Thus they have sought to minimize their losses. The US has used roughly $30 billion a year out of a $1000 billion GNP (3 per cent of national effort) to make war on a small country in a faraway place. The North Vietnamese had to mobilize all their GNP to continue their struggle. This nation showed extreme valiance and willpower; even so, its losses have been extremely high and the full impact of the US bombardment, defoliation and destruction will not be known until many years after the end of the confrontation.

In Algeria, the struggle for national liberation was also between a backward oppressed people and an advanced nation. Again the French utilized considerable science and technology and Algerian losses were very high. The

Algerians achieved their goal via their discipline and readiness to accept sacrifice. This sacrifice meant nothing short of death for a large proportion of the fighting population, the annual and continuous supply of fresh fighting men and a high degree of combat participation by males. Parallel to this mobilization of military manpower, economic mobilization is also needed for a country to sustain a war — higher taxes, boycotts, and abstinence from luxury goods and consumer commodities.

If we examine the Arab-Israeli conflict we do not find the required degree of mobilization and willingness to sacrifice: both factors are indices of low intensity of faith and will. In other words the Arabs are not prepared to trade human lives for their technological backwardness. The Palestinian resistance movement has clearly indicated that its strategy is designed to overcome Arab technological backwardness vis-à-vis Israel. Most of the existing Arab regimes have claimed that the route to liberation is otherwise. But since the type of war these states have opted to fight is utterly and completely dependent on research in science and technology and since, as we have already seen, the quantity and quality of Arab science and technology is far below the Israeli effort, it is most unlikely that the Arabs can ever win any confrontation involving regular armies unless and until Arab states devote a reasonable proportion of their GNP to research in science and technology. To avoid any misunderstanding, it is useful to stress that this expenditure on science and technology does not imply that the intensity of faith or will have to be any less: this expenditure would only be a contribution to decreasing the cost in terms of human sacrifices and increasing the chances of military success.

We have argued that there has been no indication that a single Arab state is committed to a policy of supporting research in science and technology. Though no change in current policies appears in sight it is useful to analyse the capability of Arab states to pursue a different policy.

The Arab world population is estimated at 123 million (1971). The Arab world has a GNP of $34 billion (1970) and some 600,000 university graduates, 400,000 university students at home and 40,000 students abroad. Furthermore the Arab world possesses immense financial and natural resources.

On the individual level Arabs have done reasonably well. But they have failed rather badly on the institutional level. The Arab universities are generally devoid of significant research activity. To give the reader a quantitative example, we note that in most, if not all, recognized institutions of higher learning in advanced countries the ratio of students to teachers is between four and twelve students to one teacher, with the average at ten. Furthermore, the annual mean scholarly output of a university faculty member is equal to two publications. Hence the 400,000 Arab university students should have some 40,000 professors who publish 80,000 articles and books per year in all fields of scholarship. Roughly one third to one half of these publications should be in science. With 600 publications a year, the Arab world is far from this point (see Table 1).[24]

Given this substantial number of university graduates, it is evident that the ingredients for the establishment of Arab science and technology exist. What is lacking is the political understanding and the political will. The establishment of the kind of science and technology that is needed and is possible would probably be the greatest and the most productive investment made in the modern history of the Arab world. But the Arab world cannot expect to reap the fruits overnight.[25] Any intelligent movement would begin by improving the quality and quantity of education in science and technology at all levels. These reforms would be followed by support for research activity in the region of 3.5 per cent of GNP. To provide incentives the governments should create a large number of prizes and awards to reward scientific and technical skills. These prizes and awards should be aimed at high school students, technicians, engineers, researchers, teachers and inventors. Given some imagination and a great deal of hard work the present state of affairs could be radically altered and the Arab world would begin to reap the rewards of such a programme in less than a decade.

It is worthwhile to remember that research implies trial and error. Scientists carry out more experiments that fail than experiments that succeed. The ones that succeed pay for those that fail. Hence, unless one has determination and understanding, programmes are given up at the first point of serious difficulty. The development of the Israeli scientific establishment was carried out over a period of fifty years. There is nothing abnormal about the growth of this establishment, which had to face and overcome all the usual problems of scientific development. By persevering in a rational approach, the Zionists have played the game correctly and they have reaped the fruits of their efforts.

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[24] See also, for example, A.B. Zahlan, "Science in the Arab Middle East," *Minerva*, VIII (1970), pp. 8-35.

[25] "The Acquisition of Scientific and Technological Capabilities by Arab Countries," A.B. Zahlan, *Bulletin of the Atomic Scientists*, XXV (1969), pp. 7-10.