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SCIENCE IN THE THIRD WORLD

Whether or not a Third World article is highly-cited depends on the recognition it gets from authors in the developed countries

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MOST SCIENTISTS in the West are not aware of research going on in Peru, Ghana, Singapore or other countries collectively called the Third World. And what they do know about Third World science is dominated by the research of one or two Third World "research superpowers"—India or Argentina, for example.

In recent years there has been much talk about the New Information Order. Only four agencies currently account for more than 90 per cent of all foreign news transmitted around the world. All are in the West—Reuters, Agence France-Presse, Associated Press, and United Press International. In the light of the Western monopoly on international information, Third World nations sometimes feel powerless to control and contribute to what is said about them.

What holds good for international news holds good for the representation of Third World research in international scientific journals as well. How many research articles from Third World countries are published in journals from the developed countries? And what impact does Third World research have on the international scientific community? The term "impact" is vague without a definition. Here, impact is defined in terms of citations.

When a scientist cites a given article, he or she indicates that the article was somehow relevant to the research performed. The citing author calls attention to some useful piece of information included in that article—a method, statistic, result or whatever. And when an article is cited many times, it can be considered to have had a significant impact on the conduct of scientific research.

If we take into account only the number of articles an entire nation's scientists authored, we get an idea of their level of productivity. But when we also consider the number of citations these articles received, we have a measure of their utility or impact. The purpose here is to document the level and impact of Third World research in the world's scientific journals. Perhaps it will serve as a point of departure for a wider discussion on the need for a New *Scientific* Information Order.

The Institute for Scientific Information (ISI), of which I am founder and chairman, offers a unique viewpoint on Third World science. Every year, we monitor several thousand scientific journals in our *Science Citation Index (SCI)* database. In the year 1981, we processed 540,000 research articles, reviews, notes, letters, editorials, and other scientific communications.

We recorded the names and addresses of about 1.5 million authors, the title, issue, and pages of 3,000 journals they published in, and about nine million references they cited. This information allows us to tabulate the number of articles written by Third World researchers that were published in the journals we covered. That is, we can identify all articles with first authors who list a Third World country as their address.

Third World study

For this study, we considered 122 developing nations included in the Encyclopedia of the Third World.

As a source year for this study, we decided to use the 1973 *SCI* database. This gives a base year to compare the performance of Third World researchers in the future. We shall then be able to chart the growth or decline of Third World science from 1973 to 1978 and 1981.

Also, using 1973 as a base year gives us enough time to measure the impact of Third World research on the international scientific community. That is, we can determine the number of citations these Third World articles received over a period of several years. The data are taken from six annual *SCI* files covering 1973—78.

There are a few important caveats. This discussion of Third World science is limited to that fraction of the international scientific press covered in the 1973 *SCI*. The *SCI* covered about 2,500 carefully selected journals that year.

Our studies indicate that the "important" high-impact science journals actually amount to no more than 500 to 1,000 journals.

Twenty per cent of all 1981 articles were published in only 60 journals. And 400 journals account for 50 per cent of all published articles. Again, a small group of journals predominates in the scientific literature.

I am confident that the journals ISI covers represent the major channels of internationai scientific communication. It should be borne in mind that we are assessing the level and impact of Third World research in international scientific journals—it is not intended to provide an inventory of Third World scientific output in every journal from every country of the world.

Table 1 shows how the articles in the *SCI* were distributed by the country of publication. About 353,000 articles were indexed in the *SCI* that year, and these articles received 2 million citations from 1973 to 1978. US journals alone published 48 per cent of all *SCI* articles in 1973, and US published articles account for 60 per cent of the 2 million citations in the 1973—78 *SCI* files. The average article published in a US journal received about seven citations over that six-year period.

Table 1. Publishing countries represented in the 1973 SCI database

Geographical region	% of 1973 SCI articles	% of 1973 - 78 SCI citations	Impact
USA	48	60	6.9
UK/Commonwealth	16	16	5.5
Western Europe	15	10	3.4
USSR	6	2	1.4
Eastern Europe	3	1	1.9
Japan	3	2	2.9
Scandinavia	2	2	7.6
All Third World	2	—	.8
All others	1	—	1.4

Table 2. Locations of authors in the 1973 SCI database

Geographical region	% of 1973 SCI articles	% of 1973-78 SCI citations	Impact
USA	43	54	6.9
Western Europe	17	14	4.6
UK/Commonwealth	16	17	5.9
USSR	7	2	1.6
All Third World	5	2	2.3
Eastern Europe	4	2	2.5
Japan	4	3	4.1
Scandinavia	3	4	7.4
All others	2	2	5.2

If we add together the publication output of the USA, the UK and Commonwealth countries, Western Europe, Japan and Scandinavia, we see that these First World countries account for 84 per cent of 1973 articles, and 89 per cent of 1973 – 78 citations. Clearly, the *SCI* database reflects the dominance of First World scientific publications. Western journals control the flow of international scientific communication almost as much as Western news agencies "monopolise" international news. This is not a judgement, but simply a statement of fact.

Table 2 shows how the 1973 articles were distributed by nationality of the first author. Articles written by first authors listing a US institution as their address account for the largest portion —43 per cent. These articles also account for the lion's share of citations—more than half. And if we add together articles authored in the USA, UK and Commonwealth countries, Western Europe, Japan and Scandinavia, they account for 83 per cent of 1973 articles and 93 per cent of 1973 - 78 citations. The data indicate that researchers from First World countries are the major participants in international science, at least as it is reflected in the *SCI*.

Position of India

Table 3 identifies the top 25 countries in terms of the number of articles written by their authors; only two Third World countries appear—India and Argentina. India's rank is significant. It is considered to rank third in the world in the number of researchers, behind the USA and USSR. But it ranks eighth when we consider the number of articles its researchers authored in the international journals discussed here.

India dominates the Third World when we rank developing countries by the number of articles their researchers authored. In fact, Indian researchers alone authored half the 16,000 articles from the Third World. India is the research 'superpower' of the Third World. Argentina is a distant second, accounting for 10 per cent, or a fifth of India's output, followed by Brazil, Egypt, Venezuela, Chile, Mexico and Nigeria.

Ranking countries by the number of authored articles has its disadvantages. Small developing and developed countries producing high-quality science would tend not to appear. Their overall output is dwarfed by that of the large superpowers. But when we rank all countries by the impact of their authored articles, we see some interesting results.

Impact of Third World articles

Thirty countries averaged four or more citations to their authored articles from 1973 to 1978 (Table 4); 12 are developing countries, and they are indicated by asterisks. Three developing countries rank among the top ten in the world on impact—Liberia, Jamaica, and Thailand. However, we should note that Liberia's high impact is based on only seven authored articles. It would be difficult to derive much significance from so small a sample.

Articles authored in Liberia, Jamaica and Thailand together averaged seven citations over a six-year period. This comes close to matching the impact of those Scandinavian countries in the top ten—they averaged eight citations. Liberian, Jamaican and Thai articles, together or singly, had a greater impact than US articles. But India is conspicuous by its absence.

If we then examine the impact of Third World articles only; we see that 27 developing countries had an impact of 2.5 or greater. But India still does not appear, even though it dominated the Third World in authored articles. The average article from India was cited twice over six years. Argentina, which accounted for only a fifth of India's output, had a higher impact—2.7.

Languages

Third World articles were written in ten different languages. More than 85 per cent of the 16,000 Third World articles are in English. Spanish is a distant

Table 3. Top 25 countries, ranked by number of articles their authors produced. Asterisks indicate Third World countries.

Country	Articles	Citations	Impact	Cited articles	Uncited articles	% citedness
USA	151,939	1,047,854	6.9	97,852	54,087	64
UK	32,189	202,600	6.3	21,387	10,802	66
USSR	24,715	40,455	1.6	11,159	13,556	45
FRG	20,137	93,233	4.6	12,981	7,156	64
France	17,707	72,912	4.1	11,069	6,638	62
Japan	15,569	64,160	4.1	10,161	5,408	65
Canada	15,362	86,654	5.6	10,688	4,674	70
*India	7,888	15,515	2.0	4,568	3,320	58
Australia	6,985	38,342	5.5	4,798	2,187	69
Italy	6,012	22,276	3.7	3,448	2,564	57
Sweden	4,989	42,078	8.4	3,748	1,241	75
Switzerland	4,483	29,078	6.5	2,940	1,543	66
Netherlands	4,114	28,415	6.9	2,971	1,143	72
Czechoslovakia	3,497	9,859	2.8	2,207	1,290	63
Israel	3,199	20,788	6.5	2,274	925	71
Poland	2,918	7,072	2.4	1,676	1,242	57
Belgium	2,675	12,532	4.7	1,772	903	66
Denmark	2,398	18,460	7.7	1,745	653	73
GDR	2,344	6,401	2.7	1,463	881	62
Hungary	2,209	5,025	2.3	1,068	1,141	48
Norway	1,850	11,200	6.0	1,292	558	70
Austria	1,753	5,205	3.0	1,106	647	63
South Africa	1,676	5,182	3.1	992	684	59
Finland	1,669	9,467	5.7	1,162	507	70
*Argentina	1,526	4,110	2.7	655	871	43

Table 4. Countries with impact of 4.0 or greater for articles their authors produced, ranked by impact. Asterisks indicate Third World countries

Country	Impact	Articles	Citations	Cited articles	Uncited articles	% citedness
Bermuda	11.5	2	23	2	—	100
*Liberia	8.7	7	61	7	—	100
Sweden	8.4	4,989	42,078	3,748	1,241	75
Denmark	7.7	2,398	18,460	1,745	653	73
Antilles	7.5	4	30	4	—	100
*Jamaica	7.0	77	545	63	14	82
*Thailand	7.0	138	970	96	42	70
Netherlands	6.9	4,114	28,415	2,971	1,143	72
USA	6.9	151,939	1,047,854	97,852	54,087	64
Israel	6.5	3,199	20,788	2,274	925	71
Switzerland	6.5	4,483	29,078	2,940	1,543	66
UK	6.3	32,189	202,600	21,387	10,802	66
Norway	6.0	1,850	11,200	1,292	558	70
Finland	5.7	1,669	9,467	1,162	507	70
Canada	5.6	15,362	86,654	10,688	4,674	70
Australia	5.5	6,985	38,342	4,798	2,187	69
*Guatemala	5.3	18	96	12	6	67
Ireland	5.2	539	2,791	359	180	67
*Panama	5.2	16	83	13	3	81
*Ethiopia	4.9	50	247	40	10	80
Belgium	4.7	2,675	12,532	1,772	903	66
*Iraq	4.7	54	248	31	23	58
*Kenya	4.7	127	595	89	38	70
FRG	4.6	20,137	93,233	12,981	7,156	64
*Uganda	4.4	132	587	93	39	70
*Zambia	4.4	41	179	24	17	58
Japan	4.1	15,569	64,160	10,161	5,408	65
*Cameroon	4.1	16	65	9	7	56
France	4.1	17,707	72,912	11,069	6,638	62
*Congo Peop Rep	4.0	8	32	5	3	62

Note India does not find a place here.

second, accounting for 11 per cent. Also, Third World articles had the highest impact (measured as total articles published divided by number of citations) when they were authored in English (impact of 2.6). German language articles had the next highest impact (2.0), followed by French (1.4) and Italian (1.0).

Clearly, English is the *lingua franca* of Third World science. This is even more true in recent years. For example, the 1978 *SCI* database included 22,000 articles from the Third World; 92 per cent of these were in English. And English language articles again accounted for 92 per cent of the 27,000 Third World articles in the 1981 *SCI* file.

In fact, the same pattern holds true for *all* the other countries in the *SCI* files, developed or developing. More than 80 per cent of the 350,000 articles in the 1973 *SCI* were in English. And English language articles had the highest impact—6.3. In the 1978 *SCI*, 87 per cent of the 530,000 articles were in English. And English language articles accounted for 88 per cent of the 605,000 articles in the 1981 *SCI* file.

So far, we have looked at 350,000 articles in the 1973 *SCI* file by the nationality of the first author. India was found to be the "superpower" of Third World research, accounting for half of all articles from developing countries. But when impact was considered, Indian articles did not rank among the top 25 countries, developed or developing. But three Third World countries—Liberia, Jamaica and Thailand—had a combined impact close to Scandinavia's, and greater than that of the USA.

Nationality

We now consider the same articles by the nationality of the publisher. Fifteen Third World publishing countries are represented in the 1973 *SCI* database. We covered 52 of their journals. These journals published 5,500 of the 16,000 articles written by Third World authors. That is, 35 per cent of all the articles by Third World authors were published in Third World journals.

Impact of Third World publishing countries

Again, India is the giant of Third World science. It published 60 per cent of all articles in the Third World scientific press. Argentina ranks second, accounting for 20 per cent. The remaining 13 Third World publishing countries account for only 20 per cent.

India and Argentina also rank among the top 25 scientific publishing countries in the world. India ranks 13th and Argentina 20th.

India also ranks first among Third World publishing countries when impact is taken into account. The average article published in an Indian journal was cited once from 1973 to 1978. However, about 52 per cent of the articles published in Indian Journals do not get cited even once in six years of their publication. Costa Rica has an equivalent impact, even though its output of published articles was much smaller than that of India.

Publishing opportunities

The USA published more Third

Table 5. Countries that published 50 or more Third World articles, ranked by the number of articles. Asterisks indicate Third World countries

Publishing country	Articles	Citations	Impact	Third World countries
USA	3,755	13,706	3.6	75
*India	3,351	3,690	1.1	12
UK	2,542	8,401	3.3	68
*Argentina	1,069	348	.3	13
Netherlands	885	3,440	3.9	53
FRG	648	1,512	2.3	43
Switzerland	555	1,488	2.7	41
*Venezuela	431	53	.1	5
France	360	566	1.6	42
GDR	319	602	1.9	17
Japan	293	477	1.6	19
*Chile	283	123	.4	5
Italy	228	280	1.2	29
*Mexico	174	94	.5	7
Australia	134	267	2.0	20
Denmark	126	351	2.8	23
*Brazil	89	22	.2	2
Canada	86	152	1.8	20
Hungary	74	84	1.1	10
Austria	64	107	1.7	8
Czechoslovakia	54	94	1.7	9
*Costa Rica	50	58	1.2	12
Totals	15,570	35,915	2.3	
All others	308	250	.8	
Totals	15,878	36,165	2.3	

World articles than any other country In all it published 3,700 Third World articles. This amounts to only 2 per cent of all US published articles. But it accounts for 24 per cent of all Third World articles. Also, Third World articles published in the USA came from 75 different developing countries. That is, more Third World nations found a publishing opportunity in the US than in any other publishing country.

India is a close second publishing 3,300 Third World articles. But 98 per cent of all Third World articles published in India were authored by Indian scientists. Eleven other developing countries managed to publish only 56 articles in Indian journals. The other Third World countries followed the same pattern. Only Costa Rica published more articles from Third World countries other than itself. Of the 50 articles published in Costa Rican journals, 23 were from Costa Rica.

Significantly, no Third World publishing country had an impact of 1.5 or greater for the Third World articles it published. Costa Rica had an impact of 1.2, the highest of all 15 Third World publishers. India followed with an impact of 1.1. Third World articles had the greatest impact when they were published in the Netherlands, USA or UK.

Table 6. Third World journals that published 50 or more Third World articles, 1973 SCI

Journal	Third World articles	Total number of articles	Third World impact
1. Current Science (India)	620	629	.8
2. Acta Physiologica Latino-Americana (Argentina)	613	647	.3
3. Indian Journal of Chemistry	544	553	1.9
4. Acta Cientifica Venezolana	431	473	.1
5. Medicina (Argentina)	359	374	.2
6. Indian Journal of Pure and Applied Physics	335	340	1.1
7. Journal of the Indian Chemical Society	309	312	1.2
8. Indian Journal of Medical Research	269	272	1.5
9. Indian Journal of Agricultural Sciences	261	266	.4
10. Indian Journal of Experimental Biology	221	230	1.3
11. Revista Medica de Chile	181	185	6
12. Indian Journal of Technology	157	188	.4
13. Indian Journal of Physics and Proceedings of the Indian Association for the Cultivation of Science	108	112	.7
14. Archivos de Biologia y Medicina Experimentales (Chile)	102	103	0
15. Indian Journal of Biochemistry and Biophysics	98	98	2.3
16. Revista de Investigacion Clinica (Mexico)	73	76	.4
17. Indian Journal of Genetics and Plant Breeding	72	75	.4
18. Archivos de Investigacion Medica (Mexico)	60	65	.5
19. Journal of Scientific and Industrial Research (India)	57	79	1.2
20. Proceedings of the Indian Academy of Sciences Section B	57	57	.9
21. Turrialba (Costa Rica)	50	71	1.2

Journals

We can now identify the journals from the developed countries that published at least 50 articles from the Third World. Nineteen journals are shown (Table 6). Included is the overall number of articles each journal published to give an idea of the proportion from the Third World.

Twenty-one Third World journals published at least 50 articles from the developing countries (Table 7). More than half are Indian journals. These journals published Third World articles almost exclusively. 96 per cent of all articles in these journals, taken together, were from the Third World.

When we rank journals that published Third World articles by impact, no Third World journal appears among the top 25. The USA accounts for two-thirds of the journals with the highest impact for Third World articles. Seven were published in the UK and one each in Denmark and Switzerland.

For 18 of these journals, the impact of Third World articles was greater than the journal's overall impact. That is, Third World research reported in their pages added to the overall impact of these journals.

Of the 52 Third World journals covered in the 1973 *SCI*, 14 had an impact of 1.0 or greater for articles it published from developing countries (Table 8). The highest impact for any Third World journal was 2.3. Nine Indian journals are listed. Argentina accounts for three. Mexico and Costa Rica account for one journal each.

Table 7. Journals that published 50 or more Third World articles, 1973 SCI

Journal	Third World articles	Total number of articles	Third World impact
1. Journal of Inorganic and Nuclear Chemistry (USA)	138	634	3.6
2. Phytochemistry (UK)	121	655	3.6
3. Experientia (Switzerland)	104	1,114	1.9
4. Transactions of the Royal Society of Tropical Medicine and Hygiene (UK)	100	312	3.6
5. Lancet (UK)	88	2,626	6.9
6. Notices of the American Mathematical Society (USA)	78	2,236	0
7. International Journal of Electronics (UK)			
8. Genetics (USA)	73	1,033	0
9. Pure and Applied Geophysics (Italy)	68	224	6
10. Biochimica et Biophysica Acta (Netherlands)	66	2,311	13.0
11. Physical Review B—Solid State (USA)	66	1,382	4.9
12. Bulletin of the World Health Organization (Switzerland)	60	177	4.0
13. Lettere al Nuovo Cimento (Italy)	60	571	1.3
14. Physica Status Solidi B—Basic Research (GDR)	60	669	1.5
15. Physics Letters A (Netherlands)	57	996	2.0
16. British Medical Journal (UK)	56	1,776	7.4
17. Journal of Tropical Medicine and Hygiene (UK)	52	72	2.1
18. Tropical and Geographical Medicine (Netherlands)	52	66	1.8
19. Tetrahedron Letters (USA)	51	1,406	0

Most-cited articles

We now examine the Third World articles that were cited at least 50 times from 1973—1978. First authors who were based in India, Argentina,

Table 8. Third World journals with an impact of 1.0 or greater for Third World articles, 1973 **SCI**

Journal	Impact of Third World articles	Impact of all articles	Third World articles	Citations
1. Indian Journal of Biochemistry and Biophysics	2.3	2.3	98	223
2. Indian Journal of Chemistry	1.9	1.9	544	1,027
3. Anales de la Asociacion Quimica Argentina	1.8	1.8	39	71
4. Acta Endocrinologica Panamericana (Argentina)	1.6	1.2	7	11
5. Indian Journal of Medical Research	1.5	1.5	269	404
6. Phyton (Argentina)	1.5	1.1	8	12
7. Indian Journal of Experimental Biology	1.3	1.2	221	286
8. Journal of the Indian Chemical Society	1.2	1.2	309	381
9. Journal of Scientific and Industrial Research (India)	1.2	1.3	57	71
10. Phytomorphology (India)	1.2	1.6	4	5
11. Turrialba (Costa Rica)	1.2	1.0	50	58
12. Indian Journal of Pure and Applied Physics	1.1	1.1	335	384
13. Patologia (Mexico)	1.1	1.3	16	18
14. Nucleus (India)	1.0	1.3	26	25

and Thailand each account for five most-cited Third World articles. Brazilian authors contributed four articles. Uganda, Chile, Iran and Jamaica account for one article each. There were 23 articles, of which at least nine had a developed country scientist as one of the authors. Thus, including a scientist from a developed country on the research team may be an effective strategy for increasing the impact of Third World research.

These 23 articles received about 1,800 citations. 86 per cent were from authors in developed countries. 10 per cent were from the first author's (developing) country. Only 40 per cent were from authors in other Third World nations. Thus, whether or not a Third World article is highly-cited depends on the recognition it gets from authors in the developed countries.

Part of the reason for this is that no Third World journal published the most-cited articles from the developing countries. Thirteen of the 23 most cited articles appeared in US journals. Seven were published in the UK, two were published in the Netherlands and one in West Germany.

We have not yet discussed, in a cognitive sense, the most active areas of Third World research. We have shown some research their scientists do best by examining the most-cited articles from the Third World. But any conclusion drawn from such a limited sample of Third World articles would be tentative, at best.

Clustering method

At ISI, a method has been developed to bring into view the cognitive structure of science. Here, I limit myself to a brief explanation of what is actually a complex procedure.

When we record the references in an article, we also keep track of the pairs of papers it cited together or co-cited. When the same pairs of papers are cited together with other papers by many authors, a cluster of research begins to form. The idea underlying this method is that co-cited articles share a common topic, subject area or method. That is, when an author cites two papers together, he or she indicates that both papers applied to some aspect of the research he or she performed. When the same cluster of papers are co-cited by several authors, a cognitive link is established between the research these authors perform. That is, the citing authors reveal what research area they 'belong to' through their citations. By examining the titles of the citing articles, we get an idea of the cognitive content of their research concentration. That is, the citing authors themselves provide the words to define what their research area is about.

At another level, we can also identify co-citation links between clusters. This is possible when authors cite together articles included in different clusters. Again, we assume that authors who use the same clusters of articles are engaged in similar types of research. The more frequently two clusters of articles are co-cited, the greater the possibility of determining how close or far apart clusters should be depicted in relation to each other.

We used the 1981 *SCI* file to see what clusters were cited in articles from Third World countries. This gives an understanding of the *current* areas of activity in Third World science. We started by identifying all articles from Third World countries in the 1981 *SCI*. We then identified all the articles they cited that year. We then determined which 1981 articles from developed countries referred to the same group of papers cited by Third World authors. These data were entered into our computer and more than 2,000 clusters of co-cited papers were generated.

Before we identified clusters that were cited by Third World articles, we decided to separate India from the developing countries. As we have seen,

Third World articles cited at least 50 times in 1973-78

Total	First author's country	Third World	Developed world	Bibliographic data
192	8	1	183	Paintal A S, Vagal sensory receptors and their effects. **Physiol Rev** 53:159-227, 1973. Delhi Univ, Vallabhbhai Patel Chest Inst, Delhi, India.
72	10	0	62	Ramachandran G N, Lakshminarayanan A V and Kolaskar A S. Theory of the non-planar peptide unit. **Biochim Biophys Acta** 303:8—13, 1973. Indian Inst. Sci, Mol Biophys Unit, Bangalore, India; Univ Chicago, Dept Biophys, Chicago, Ill.
70	3	0	67	Raheja R K, Kaur C, Singh A and Bhatia I S. New colorimetric method for the quantitative estimation of phospholipids without acid digestion. **J Lipid Res** 14:695—7, 1973. Punjab Agricult Univ, Dept Chem Biochem, Ludhiana, India.
57	4	7	46	Chandra R K. Reduced bactericidal capacity of polymorphs in iron deficiency. **Arch Dis Child.** 48:864—6, 1973. All India Inst Med Sci, Dept Paediat, New Delhi, India.
53	2	0	51	Srivastava R K, Kulshrestha V K, Singh N and Bhargava K P. Central cardiovascular effects of intracerebroventricular propranolol, **Eur J Pharmacol** 21:222—9, 1973. Univ Lucknow, King George's Med Coll, Lucknow, India.

India overshadows the rest of the Third World in the number of scientific articles it authors and publishes. By considering India separately, we have a clearer picture of Third World scientific activity.

Maps of clusters

Thirty-nine clusters were cited by at least 15 articles from the Third World, excluding India. Each of these circles represents a single cluster. The shading indicates different disciplines of research. Connecting lines indicate co-citation links between these disciplines.

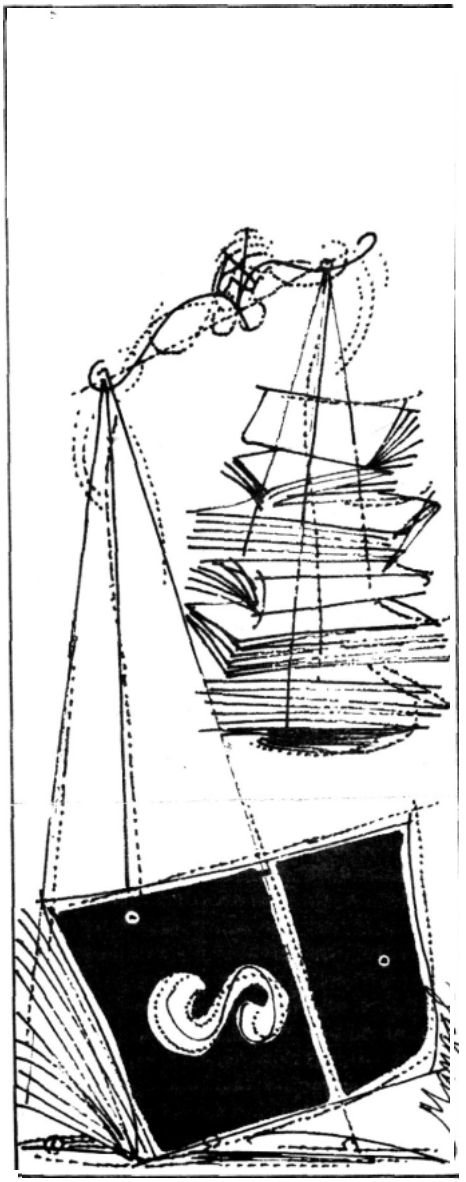
The clusters are densely packed and highly interconnected for a good reason. 90 per cent of them deal with topics in closely related fields—clinical and biomedical science. Thirteen clusters concentrate on various aspects of immunity, particularly viral and bacterial diseases; seven deal with hormones and fertility; and four discuss circulatory and heart diseases. The ten clusters on "miscellaneous" topics in clinical and biomedicine concern cancer, neurotransmission, physiology, metabolism and other topics. The remaining five clusters in this figure are in fields other than clinical and biomedicine—two in physics, one in astronomy, and two in agricultural and environmental sciences.

Obviously, Third World research activity is focused on clinical and biomedical science. That is, developing country scientists tend to cite clusters of articles in clinical and biomedical research almost exclusively. But what specific areas of clinical and biomedical research are cited *most* frequently by Third World scientists? This can be determined by considering the proportion of all articles citing these clusters that were from the Third World.

Third World articles amounted to at least 15 per cent of all citing articles for 11 clusters. The level of Third World participation is significant in seven clusters of research on immunology and infectious diseases.

Another area of Third World scientific expertise is in hormone and fertility research. Third World scientists also accounted for a significant proportion of all papers citing research in the agricultural cluster.

The cluster names read like an agenda of Third World concerns: diseases transmitted by parasites, bacteria and viruses; immune responses to these and other infectious diseases; hormones, steroids and fertility; and grains and legumes. Except for the last, all Third World science is focused on clinical and biomedical research. Of course, Third World scientists do research in physics, chemistry, mathematics and other fields. But they are *most* active in clinical and biomedical research.



Indian clusters

When we examine Indian science and exclude the rest of the Third World (see Figure 1), we see that 32 clusters were cited by at least 16 articles from India. The smaller structure that stands apart to the left includes seven clusters. They are all in chemistry: these clusters discuss valence states, electron density, and phase transitions of various crystals and liquids.

The larger structure to the right includes 25 clusters. They can be organised into three separate fields of concentration. Eleven clusters deal with the synthesis and properties of various metal and ligand complexes. For convenience, we categorise them as being in chemical physics.

Nine clusters concentrate on biochemistry, and deal with protein

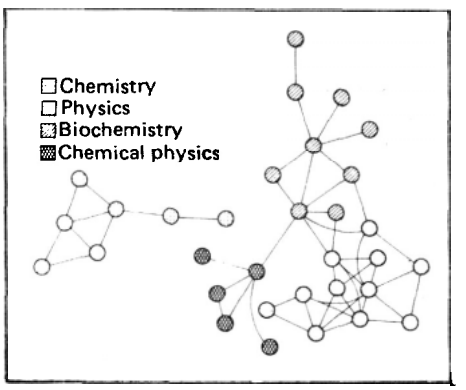


Figure 1. Clusters of research cited by 1981 articles from India, excluding the rest of the Third World

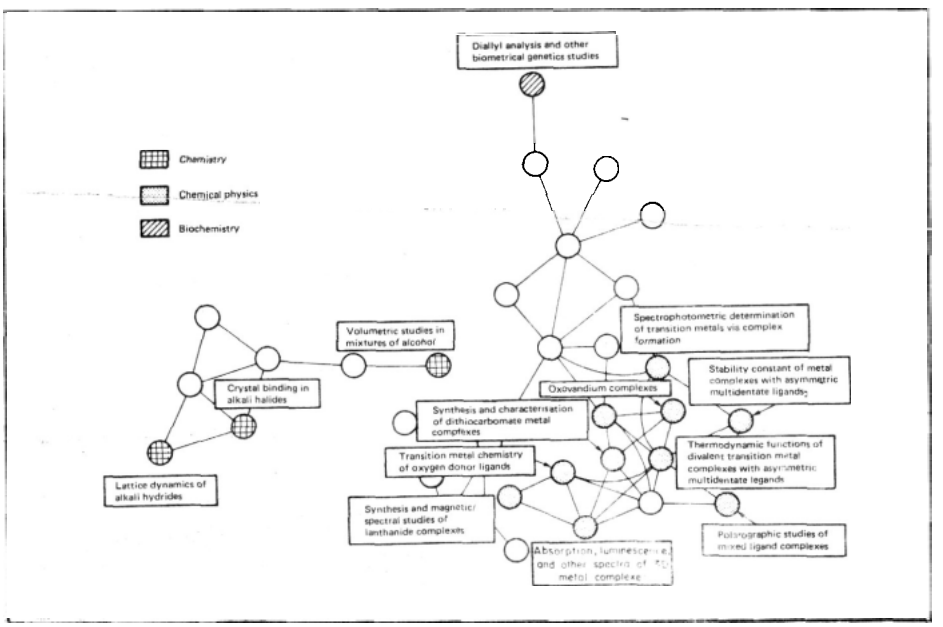


Figure 2. Names of clusters for which Indian articles amount to at least 25% of all citing articles.

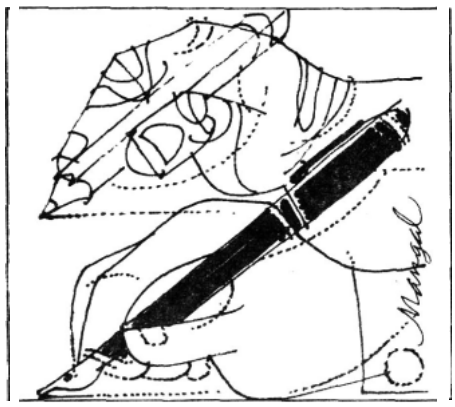
analysis, plant genetics, DNA conformation, and the structure and bioactivity of various substances. One of these discusses viral gastroenteritis, the only biomedical cluster on the map of Indian science. But only 3 per cent of the article citing this cluster were from India.

The remaining five clusters deal with physics. They discuss quantum chromodynamics, quark models, unified field theories and other topics.

Unlike the other developing countries, Indian science is not focused on any one field. It is interesting that Indian science was not active in clinical and biomedical research, which preoccupied the rest of Third World science. Instead, Indian scientists cited research in biochemistry, physics, chemistry and chemical physics. But Indian research activity was concentrated in chemical physics.

Indian articles amounted to at least 25 per cent of all citing articles for 12 clusters (see Fig. 2). Nine of these clusters deal with metal and ligand complexes which we have categorised as topics in chemical physics. In the cluster named "Stability Constants of Metal Complexes with Asymmetric Multidentate Ligands", the level of Indian participation was very high. More than 100 articles published in 1981 cited this cluster, and 77 per cent were from India.

Chemistry is another active area of Indian science. These clusters deal with chemical properties of alcohol and various crystals. And one cluster in biochemistry showed a significant level of participation by Indian researchers. Of the 108 articles that cited this cluster on 'Diallyl Analysis and other Biometrical Genetics Studies', 27 were from India.



Conclusions

When we talk about Third World science, we have to distinguish between India and the rest of the developing world. In many respects, Indian science is unlike the mainstream of Third World research.

First, Indian science is not clustered in clinical or biomedical research. Of course, Indian scientists do research in

clinical and biomedicine, but they are not the most active areas of Indian research. In contrast, the rest of the Third World actively participates in clinical and biomedical research.

Also, Indian science is clustered in research fields that other Third World scientists have not significantly penetrated—biochemistry, physics, chemistry, and chemical physics. And the level of participation of Indian scientists in chemical physics is especially remarkable.

India also stands apart from all other developing nations in the number of articles its scientists authored. Remember that half the 16,000 Third World articles in the 1973 *SCI* were authored in India. And India's dominant position in the Third World has remained constant over the years. For example, there were 22,000 Third World articles in the 1978 *SCI* database. Of these, 52 per cent were authored in India. The 1981 *SCI* database included 27,000 Third World articles, and 49 per cent of these were from India.

India overshadows the rest of the Third World in the number of articles published in its scientific press, as well. Indian journals accounted for 60 per cent of all 1973 articles published in the Third World.

When we consult data from other indexing services that claim to be comprehensive for the world's publications in physics, chemistry, and biology, India's position remains the same. For example, the number of particle physics papers from India accounted for 3 per cent of the input to *Physics Abstracts* in 1982. Indian chemistry papers represented another 3 per cent of the *Chemical Abstracts* file in 1981. And Indian biology papers again accounted for 3 per cent of the *BIOSIS* file from 1978 to 1981.

I cannot say whether the data presented indicate that Third World research, with or without India, is "under"-represented in international scientific journals. Granted, articles authored and published in Third World countries amount to a very small proportion of the international scientific press. But this might be explained in several ways.

For example, Third World countries cannot afford to devote a large percentage of their gross national product to scientific research. This has an obvious effect on the availability of scientific instruments, supplies, and materials in developing countries. Without all this, the conduct of research in the Third World is diminished.

Or, Third World countries may not have a large enough research community to generate significant numbers of articles. This would also affect the number of scientific journals the research community can support.

I am sure there are many other factors that might explain why Third World scientific output amounts to such a small proportion of the international scientific output. Until these factors are analysed, we cannot decide if the coverage of Third World research is equitable. And until we make that decision, we cannot talk about the need for restructuring the world scientific press. It remains to be seen whether or not a New Scientific Information Order is needed.

Dr. Garfield, a pioneer information scientist, is president of the Institute for Scientific Information (ISI), which produces a broad spectrum of information services and systems. The inventor of 'Current Contents' and the 'Science Citation Index', he received his BS in chemistry from Columbia University and returned there for a Master's degree in library science. He was awarded his PhD in structural linguistics at the University of Pennsylvania.

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