

CORRESPONDENCE

Six Types of Research

SIR,—Rothschild correctly points to the importance of the question, "What is the object of the classification?" but fails to recognize that different people and organizations have different needs of a classification, so that the same classification may not suit them all. Moreover, by defining strategic research as part of applied research, he makes useful analysis impossible, and he also mixes categories in his classification: classification by research type (applied, strategic or fundamental) is independent of the classification product-process-operations.

Because Rothschild refers to some of the terms we use, we would like to explain how we arrived at them. Our aim has been to classify the ARC's research in such a way that one can ask either very broad questions (for example, "What are we spending on cattle?") or much more detailed ones (for example, "What strategic reproductive physiology projects are there, related to an applied project on the improvement of techniques of artificial insemination?"). By using a matrix system and classifying each project by a number of independent categories, one can retrieve the information in many different ways, and in small or in large aggregates.

Our approach, unlike most others, has been, and continues to be, empirical. We tested our initial system on the 1,000 projects listed in our Index (*Index of Agricultural Research*, Agricultural Research Council, 1969). Our type category then contained four varieties, corresponding to applied, strategic, fundamental ("pure") and service. (The latter, not mentioned by Rothschild, covers such things as analytical or statistical services.) As we found that more than half of the ARC's work was strategic, and that it varied very much in character, some of it being closely linked with applied work and some of it not, we decided that it might prove useful to subdivide strategic research.

On the basis of experience we devised a more sophisticated classification system (*A Revised Classification System of ARC Research*, Agricultural Research Council, Planning Section Report No. 2, July 1972), again based on the matrix principle, and have used it to code all of the ARC's current 3,000 projects. Our type category now includes seven varieties. In addition to service, development, applied, and

fundamental, there are three varieties of strategic research.

(1) Strategic A: research which is required to provide understanding of a current applied project; strategic A workers either form part of the applied project team or work very closely with it.

(2) Strategic B: research carried out with the main aim of understanding some particular aspect of agriculture in order to generate specific applied projects.

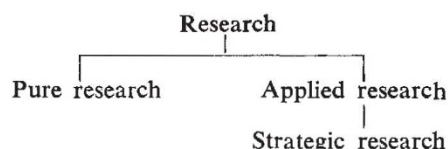
(3) Strategic C: research of an open-ended nature (with regard to application, not time as Rothschild states), but which is likely to further the scientific understanding of agriculture.

The point of subdividing in such a way is that one can aggregate as required. For example, the Parliamentary Select Committee asked the Research Councils to say what proportion of their research was spent on different types. From the definitions they gave it was possible to equate their varieties with ours, as follows:

Select Committee	ARC
Applied	Applied
Oriented—strategic	Strategic A
Basic—strategic	Strategic B and C
Basic	Fundamental

(Readers may find it instructive to compare the replies given by the various Research Councils to the Select Committee's question [*First Report from the Select Committee on Science and Technology—Research and Development*, xxxv–xlvi inc., HMSO, 237; 1972].)

Is it possible to suggest a basic classification which would be widely applicable? If one eliminates from Rothschild's Table 2 those items which logically belong to a different classification category altogether we are left with the following:



This does not seem very useful. It would be surprising if most organizations could not use five varieties as a basis: service, development, applied, strategic and fundamental. (Whether one prefers the term pure, basic, or fundamental is entirely subjective; many object to "pure", because of the

implied impurity of non-"pure" research.) Of course, some organizations may do no fundamental work, others no development, and these could then simply be omitted. Our classification has been designed with the particular needs of agricultural research in mind and not with a view to universal adoption. Each organization can subdivide any one type of research according to its own particular needs.

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Strategic Research

SIR,—Rothschild's Table 2 (*Nature*, 239, 373; 1972) may well represent the point of convergence of a protracted dispute, and certainly those who are engaged on long-range research, and yet do not object to its acquiring an ultimate application, will welcome his adoption of the term "strategic" for their activity.

It is a pity that his Glossary defines strategic research as "Research undertaken to generate specific applied programmes". Although the spirit of this seems right, the term "enable" could advantageously have been substituted for "generate", or alternatively the words "the preconditions of" inserted.

The point is not academic, as can be illustrated with the aid of a topical example. Work in a number of laboratories devoted to machine intelligence research, including that at Edinburgh, is concerned among other things with how to program computer-controlled robots to carry out tasks of assembly and/or navigation. Such studies will, without question, help to make feasible —i.e., will "enable"—NASA's "Mars Rover" project *inter alia*. However, this applied programme cannot possibly be generated by the research, but only by the skill and force of NASA's approach to Congress. Meanwhile, in case the approach succeeds, NASA has begun to create a relevant research base at the Jet Propulsion Laboratory, Pasadena. If this is to be termed "strategic" (as it surely must be) then similar research at Stanford, MIT, and Edinburgh is presumably also "strategic". The scientists concerned see it in this light and are aware that

their research will enable any Mars Rover programme that NASA or anyone else conducts.

A parallel for the creation of strategic research bases other than at the behest of a specific customer is the establishment in 1909 by the then Prime Minister, at the suggestion of R. B. (later Lord) Haldane, of the first laboratory for aeronautical research (as a section of the National Physical Laboratory).

The research initiated did not generate, but it certainly enabled, the massive aero-engineering programme subsequently forced ahead by the First World War.

Yours faithfully,

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Hysteria on Hysteria?

SIR,—I am sure many of your readers are shocked and offended by your persistent efforts to heap ridicule on the Club of Rome and Professor Meadows. One cannot help but be reminded of the hysterical outbursts which greeted Malthus and Darwin. Certainly the utter limits of ridicule were reached in the alleged "comments" of the World Bank (*Nature*, **239**, 248; 1972).

The only sensible thing that can be discovered in these comments is an acknowledgment that the model of Meadows is right in its treatment of population growth.

It would surely be a waste of time and an affront to your readers to try to refute the "slashing" criticisms of the distinguished but as yet anonymous authors of this report. After all, this has already been done most thoroughly by some of the best minds in the US and elsewhere, but I cannot resist the temptation to quote the following excerpts:

Says the World Bank "report": "Meadows and his colleagues have made a patently absurd claim by ignoring the extent to which known reserves of raw materials may be still further increased by technical developments yet to come".

Say the US National Academy of Sciences and the National Research Council (*Resources and Man, a Study and Recommendations*, 1969): "All postponements allowed for, however, it is clear that exhaustion of deposits of currently commercial grade is inevitable. When the time comes for living in a society dependent on scrap and on common rock, the affluent society will be much overworked to maintain a standard of living equal to that of a century ago".

To conclude with a citation from

Professor Ravetz's *Scientific Knowledge and its Social Problems* which may not be entirely irrelevant: "The opponents of critical science will usually be bureaucratic institutions which try to remain faceless, pushing their tame experts, and hired advocates and image-projectors, into the line of battle; although occasionally a very distinguished man is exposed as more irresponsible than he would care to admit.

"In such a situation, it will not be possible for a leader of science to be both honest and tame; and if the establishment of science chooses to serve its paymasters rather than truth, it will be recognizably corrupt".

Yours faithfully,

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Congress Caveat

SIR,—We have today received the registration form and second circular for the ninth International Congress of Biochemistry, to be held here in Stockholm on July 1–7, 1973, and would like to bring some facts to the notice of any readers who may be intending to participate in this congress. We consider that participants are being asked to pay an unrealistic sum for certain of the ancillary social events and excursions.

To quote a few examples: a steamboat trip has been organized through the Archipelago to the island of Sandhamn (conference price Sw.Kr. 75:–). However, the daily steamboat service to Sandhamn costs Sw.Kr. 24:–, excluding lunch. In addition, several companies have very cheap excursions through the Archipelago to the Finnish island of Åland. A water-bus trip around the island of Djurgården, including a visit to the 17th century ship "Wasa" will cost Sw.Kr. 27:–, while the tourist boat costs Sw.Kr. 7:–, and entrance to the "Wasa" costs Sw.Kr. 5:–. A conducted walk around the Old Town (conference price Sw.Kr. 17:–) is regularly available on Mondays and Thursdays at 7.30 p.m. for Sw.Kr. 5:–. A visit to the home and gardens of the sculptor Carl Milles (conference price, including transport, Sw.Kr. 25:–) is also available from the local bus company for Sw.Kr. 9:–. The prices quoted are valid at the time of writing.

It may also be of interest to participants to know that a month's unlimited public transport in the city and county of Stockholm is available for a present cost of Sw.Kr. 50:–. A booklet entitled *This Week in Stockholm* can also be obtained and contains full information of current tourist attractions.

We hope this information will assist participants to plan their visit to our city.

Yours faithfully,

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VIBEKE BERNSON
BARBARA CANNON
PER LUNDBERG
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Repair Endonucleases

SIR,—With regard to the News and Views editorial "Mammalian DNA Repair Endonucleases?" (*Nature*, **239**, 308; 1972), we would like to draw your attention to the article we published last August (*Biochem. Biophys. Res. Commun.*, **48**, 662; 1972).

We have been in correspondence with Dr Brent and we agree that, in view of the similarity of the assay conditions and characteristics of the enzyme, we are describing the same mammalian endonucleolytic activity. Your readers might therefore be interested to know that, as we have shown, the enzyme is present in xeroderma and De Sanctis Cacchione cells and does not act at the pyrimidine dimer sites.

Yours faithfully,

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Caution on Creation

SIR,—I was intrigued by your news editorial "Is Continental Drift Sacrosanct?" (*Nature Physical Science*, **239**, 137; 1972), especially when compared with your previous leader "Creation in California" (*Nature*, **239**, 420; 1972). I do not endorse the method of the California State Board of Education in imposing its views; and my academic specialization does not entitle me to a free subscription to *Nature* under your dispensation to heretics—surely a happy reversal of the methods of the Inquisition! But I should like to point out the possible value of applying the argument of the first article to the subject of the second. May I quote?

"It is one of the curious paradoxes of science as a human activity that where