the metallic remain largely unexplored despite the many strides in neurophysiology.' [M, p. 84]

'*Problem*: Explain in scientific terms how the universal, i e. the pattern, first being in the mind of the creator ... , gets ingrained in an object ... and then reenters the mind of the beholder ... [M, p. 88]

'... modern cybernetical research is still very far from solving the mind-brain problem, and ... considerable harder work lies ahead.' [M, p. 88]

This 'harder work', which must attend to Haldane's important idea of mind as quantum-mechanical resonance, belongs to *cognitive psychology*, a field which clarifies the concepts of the SM but is not the same as the SM. The cognitive psychologist needs the SM to do research. Hence, Narasimhan's remark that 'it is a pity' that I have not taken note of the recent work in cognitive psychology is misconceived. As Penrose's new book *Shadows of the Mind* shows, this field is still in too highly creative and volatile a stage to allow for a short comment. (The normal *Kybernetes* issue is under 100 pages, and the MCB Press were generous in granting me 32 more.)

XII. In [R, p. 955, col. 2, para 3] Narasimhan refers to Galileo's famous description of the Book of Nature as a 'second scripture written in mathematical language', and to my description of 'science as natural theology', but without saying how they fit into the SM [M, p. 63]. The fact is that all civilizations have felt the need for some notion of 'revealed truths' or scripture or *sruti*. These truths affect religious individuals, among them scientists, in personal and profound ways, and to them it is a matter of import that scientific truths not undermine the scriptural. A solution that ensures the impossibility of such undermining thus strengthens the role of science in civilization. Such was Galileo's solution that nature is as good a revelation of God as the holy texts, and that it is the same God speaking in different ways.

XIII. In [R, p. 955, col. 1] Narasimhan gives an accurate description of (i) the difference between animal violence and the bulk of human violence, and (ii) the ontogenetic–phylogenetic imbalance in man, evident in the havoc of human exploitation, and (iii) my attribution of (i) and (ii) to the freedom that the stochastic cosmos allows the human being, rather than to a law of nature. Unfortunately, he does not say whether my judgement (iii) is correct or incorrect. (Authors want to learn from reviewers.) Furthermore, he bypasses five important consequences that follow from (i) and (ii):

1. 'Human progress' has to be measured by the mitigation of this imbalance.

2. The evident constancy of this imbalance (small fluctuations apart) shows that mankind has not progressed during the last 5000 years [M, pp. 116–118].

3. We should not expect things to improve suddenly from now on [M, p. 118, para 2].

4. We must look upon the quest for a fully restored body-politic as never-ending, the goal being an ideal limit as $T \to \infty$ [M, pp. 118–119].

5. A viable concept of *duty* for the scientist, devoted to social prosthesis, must be premised on continual failure, and on the pursuit of goodness for its own sake [M, p. 119–120].

A trivial corollary of (1)–(4) is best stated in Narasimhan's own words with 'totally' substituted for his 'somewhat':

'It is totally simplistic to expect that what the moral teachings of these religious teachers have not been able to accomplish during the last several thousand years scientists will be able to achieve now or in the future.' [R, p. 956, col 1, para 2]

But inattention to the antecedents (1)–(4) led Narasimhan to the error of believing that I share this 'simplistic' expectation. As the quotations (3) and (4) show, I do not. He is also prevented from seeing that since 'sin grows with doing good', a scientist interested in social prosthesis, unlike the one interested in say chemistry or biology, etc., will get nowhere without the great wisdom in the Vedantic or the Greek concept of duty stated in (5).

XIV. It is well known that language and culture are important determinants in human life. But our understanding of social prosthesis will remain stagnant as long as we duck unique aspects of human culture such as the prevalence of homicide, warfare, avarice, sadism and masochism, and of linguistic misuses such as circumlocution, dishonesty, hypocrisy and treachery As for the word 'culture', unlike yesteryear, today it is a highly abused term. It is good to remember the deliberately modest title, *Notes Toward the Definition of Culture*, that T. S. Eliot chose for his book, and even more important to remember the wise words of Lord Acton with which it opens: 'I think that our studies ought to be all but purposeless. They want to be pursued with chastity like mathematics.'

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R. Narasimhan replies:

1. What is a *cybernetic system*? One can find a formal definition of a 'system' in any standard textbook on system theory. By a 'cybernetic system' what I intended was a system whose behaviour could be accounted for by use, primarily, of the concepts of cybernetics. I have listed some of these concepts in the last paragraph on the first page of my article. Can a cybernetic system serve as an adequate model of a human being? I have argued in my article that it cannot, because of conceptual inadequacies. But now Masani claims that cybernetics is not a science, *per se*, but rather a movement within science. This forecloses any further argument.

2. Coming now to Masani's monograph on scientific methodology, I think it would serve no purpose for me to answer Masani's comments one by one. Clearly, Masani and I disagree on what science is all about and the issues that a discourse on scientific methodology must grapple with. I would have to write another article to discuss my views. I would like, here, to deal with 3 or 4 points that Masani makes in his comments, to convince the reader that in my

review, I have not, misrepresented the thrust of Masani's arguments.

3. What is the difference, if any, between scientific knowledge and commonsense knowledge? Masani says: 'This has an easy answer ... scientific knowledge is a refinement of commonsense knowledge.' Surely, this is not an answer. For what does one mean by 'refinement'? When does one say that a set of explanations is a 'refinement' of another set of explanations?

4. I had remarked that Masani does not systematically analyse the relationships between science, engineering, and the 'useful arts' (i.e., crafts). Masani claims that what is relevant is the relationship between science and craft, and not between science and technology. According to him: 'The craftsman is invaluable to science in providing good apparatus to the experimenter.... Without the craftsman the scientist is lost.' Are particle accelerators and radio telescopes the contributions of craftsmen to science? The role of instruments in scientific methodology is a critical and important issue. Masani has nothing to say about this in his monograph.

5. About the 'trivialization' of technical terms. In claiming that moral evil is human teleological noise, clearly, the technical term 'noise' is being used, at best, metaphorically. Metaphorical extensions of technical terminology are powerful aids to creativity and conceptual thinking. But it is useful to distinguish between 'productive' metaphorical usages and 'unproductive' ones. Masani and I seem to differ in our perceptions of whether referring to 'moral evil' as 'human teleological noise' is a productive metaphorical usage or not.

6. Finally, Masani objects to my references to his 40-year-long association with Wiener's personality and his works, and the pervasive influence of this in the style and substance of his monograph. He claims these are irrelevant to scientific methodology. But I was not reviewing scientific methodology *per se*, but Masani's account of it in a certain historical context. My observations should be interpreted in the larger context of Masani's writings on Wiener – especially, his extended biography of Wiener. I would like to assure him, however, that when I wrote that 'Wiener inevitably tends to loom large in his thinking horizon'. I did not intend this in any pejorative sense whatever. After all, many of us have our own *gurus*.

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Methane emission from rice paddies: Need for a downward revision of global estimate

CARBON dioxide, CH_4, CFC-11, CFC-12 and N_2O are the most important greenhouse gases that are affected by human activities[1]. Among these, CH_4 is the only gas which directly affects the tropospheric chemistry, and forms a part of the highly interactive chemical system that largely determines the background concentration of the hydroxyl radical, which is the most important oxidizing gas in the troposphere[1]. Rice paddies are considered to be among the most important sources of atmospheric CH_4, contributing from 60–100 Tg per year[2–5]. Estimates, however, are beset with many assumptions[6]. Our analysis of published results indicates that CH_4 contribution from rice paddies has been *substantially overestimated.*

The frequency distribution of CH_4 emission rates ($N = 350$) compiled from a variety of studies in different regions[7–35] was markedly skewed towards left (Figure 1, curve a). In this and the following analyses, all data points are given equal weightage irrespective of the time of measurement, treatment or region. Thus, no attempt was made to integrate the CH_4 flux for the whole season, and all values were converted to mg $CH_4\,m^{-2}h^{-1}$. About 67% values were $< 16\,mg\,m^{-2}h^{-1}$; of these, 54% values were $\leq 8\,mg\,m^{-2}h^{-1}$. Values greater than 40 mg $CH_4\,m^{-2}\,h^{-1}$ were mostly from pot experiments[9–12] and a few from field experiments[14,30,33], involving high inputs of chemical fertilizèrs/paddy straw/horse manure. In these pot experiments inputs included 12–24 g rice straw per 3 kg of soil[9–12]. The field experiments had inputs of 30 t ha^{-1} of *Sesbania rostrata* or 2 t ha^{-1} of rice straw[14]; 710 kg ha^{-1} NH_4HCO_3 + 30 t ha^{-1} horse manure[30]; 694 kg ha^{-1} K_2SO_4/KCl + 1042 kg ha^{-1} rapeseed cake or only 1042 kg ha^{-1} rapeseed cake[33]. Curve b in Figure 1, illustrates the frequency distribution ($N = 326$) after these values were excluded. Curve c in Figure 1, represents the distribution of emission rates ($N = 280$) when all data from pot experiments[9–12, 34], including lower values (in addition to those from high inputs in refs. 14, 30, 33), were excluded.

Simple averages from data in Figure 1 (curves a–c) ranged from 12.29 to 14.89 mg $CH_4\,m^{-2}\,h^{-1}$ and were associated with high standard deviation values (Table 1). These averages compare with 12.92 (ref. 3), 14.58 (ref. 36), 9.99–33.33 (ref. 7) and 21 mg $m^{-2}\,h^{-1}$ (ref. 5) reported earlier.

Based on the FAO statistics, Neue and Roger[37] estimated a harvested rice area of 73.26 m ha for irrigated rice, 38.95 for rain-fed rice and 11.45 for deep-water rice (total $1.236 \times 10^{12}\,m^2$). Aselmann and Crutzen[3] have used the value $1.31 \times 10^{12}\,m^2$ for rice land area. Globally, 60% of the harvested area is managed under a triple cropping system, 15% is double cropped and 25% is cropped once a year[5]. CH_4 emission period ranges from 85 to 126 days