Response:

The content of the referred article provides only a cursory technical description of the fatigue process in metals without any explanations regarding different crack growth regimes/limitations for one-to-one correlation between fatigue striations and load cycles, etc. It deals more about some alleged scientific controversy, including allegations of fraud and in the process has attempted a smear campaign against individuals and organizations of national importance, even after the allegations have been disproved. In response to the editors' request to provide a brief publishable response, I am including here a few comments pertaining to the serious deficiency in the scientific content of the said article, providing some useful references for the benefit of the readers, followed by presentation of certain facts that would provide the readers enough technical information to judge for themselves the real motive behind such a campaign.

While it is generally true that fatigue cracks start growing above the threshold Stress Intensity Factor (SIF) range at a rate, da/dN, as low as 10^{-7} mm/cycle and undergo accelerated growth with increasing crack length, this is not true in the case of fatigue cracks emanating from sharp notches under constant amplitude loading at a given stress ratio. In such cases, fatigue crack initiation and the initial growth of the short crack takes place at a much higher growth rate (say on the order of 10^{-6} to 10^{-5} mm/cycle) at a SIF range, ΔK, well below the long crack threshold-SIF range, ΔK_{th}. The growth of a short fatigue crack emanating from a notch root is controlled by the notch-generated bulk plasticity, which exhibits an initial decrease in Fatigue Crack Growth Rate (FCGR), followed by the gradual increase in FCGR, as the crack moves out of the notch-induced plastic zone. The crack growth is then controlled by the crack tip plasticity as in the long crack range, following the principles of Linear Elastic Fracture Mechanics (LEFM). This has been schematically explained in Figure 1(R) and Figure 2(R), reproduced from a review paper on 'Mechanics and physics of the growth of small cracks' by Ritchie and Suresh (Ref: AGARD-CP-328). The above growth behaviour of short cracks, wherein short cracks have been observed to start growing at FCGR as high as 10^{-5} mm/cycle and at SIF range far below that of the long crack threshold, ΔK_{th} in a given material, is called 'Short Crack Effect'. Since it was first brought to the notice of scientific community by S. Pearson in 1975, the problem of short fatigue cracks has remained an important topic in fatigue research and a critical factor in design and life prediction ever since. In the open literature there are several hundred published papers on short crack growth behaviour including in the proceedings of three Engineering Foundation Conferences (held in 1980, 1986, 1998) on 'Small Fatigue Cracks' and one AGARD Conference Proceedings (CP No. 328, 1983). In this context, it is very unfortunate that the author of the article did not comprehend the actual growth behaviour of small fatigue cracks, arising from a notch or fillet in any structure, which do not necessarily 'steadily accelerate' under repetitive

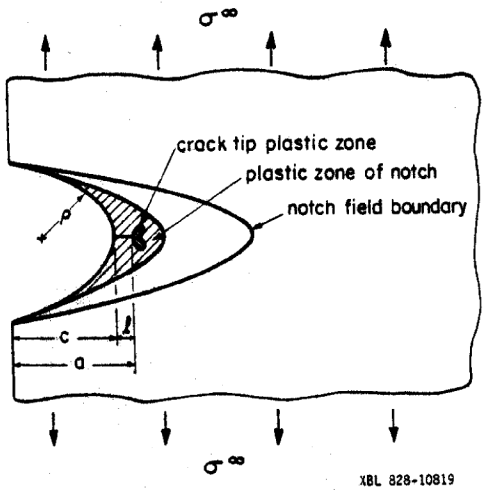

Figure 1(R). Schematic illustration of crack tip notch plastic strain field associated with the growth of a short crack, length l, emanating from a notch of depth c and root radius ρ. After Hammouda and Miller (1979).

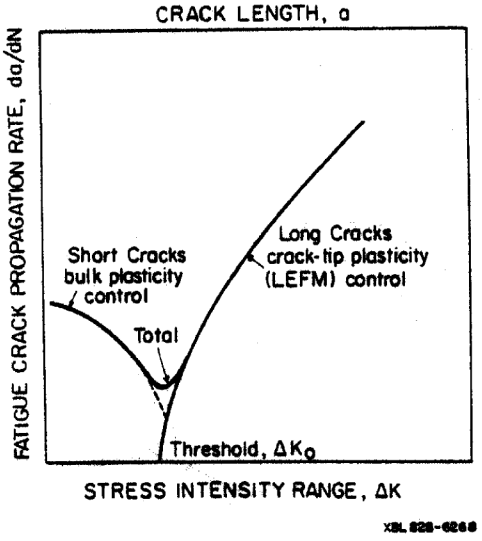

Figure 2(R). Schematic illustration of the elastic-plastic and linear elastic characterization of the kinetics of crack growth for a short crack propagating from a notch. After Hammouda and Miller (1979).

cyclic loading. In an earlier correspondence with ASTM the same author had presented two different equations for ΔK, not applicable in short crack range, and had also made a sweeping wrong statement, 'Crack growth rate at an EDM notch cannot decrease with crack size!'. Indeed several researchers, including Smith & Miller and Taylor & Knott have shown that a small crack after initiation and early growth from a sharp notch would not only exhibit slower growth rate, but may even become a non-propagating crack (Figure 3(R)), depending on the applied constant stress range and the Stress Concentration Factor, 'K_t' of the notch (Ref: paper by I. Le May in AGARD CP No. 328).

Similarly, the statement in the article, 'Striation patterns reproduce with almost digital precision' is generally untrue unless qualified by the specific FCGR range, wherein this would be valid. Knowledgeable readers would know that there are no generally accepted equations of fracture mechanics for accurate correlation of FCGR with SIF-range, other than in the limited 'Paris Regime' for any given material and definitely not in the short crack growth regime. Referring to a land-mark original fractographic work by McMillan and Pelloux published in their paper, 'Fatigue crack propagation under program and random loads' in ASTM STP 415, 1967, it may be noted that 'in case of aluminium alloys, the striations are remarkably well defined, at least for the crack growth rates ranging from 1 to 1000 μinch per cycle' (**2.5×10^{-5} to 2.5×10^{-2} mm/cycle**). McMillan and Pelloux have also observed, 'A limited amount of quantitative work has shown that for uniform cyclic loads and for crack growth rates greater than 1 to 10 μinch per cycle (**2.5×10^{-5} to 2.5×10^{-4} mm/cycle**), there is a one-to-one correlation between striations and load cycles. After carrying out optical and electron fractography work on the fatigue fracture surfaces of many structural test components, they have also stated: '. . . However, the complexities of the test components and the load spectra were such that it was not possible to make a direct correlation between each load and the observed striations, or to explain the unusual striation spacings often observed.'

Considering the above observations of McMillan and Pelloux, it must be clear that in case of fatigue crack growth, a statement like 'Striation pattern reproduce with almost digital precision' can only be true in a very narrow range of fatigue crack growth rate, which is around **2.5×10^{-5} to 2.5×10^{-4} mm/cycle** and definitely not over the entire range of crack growth rate from 10^{-7} to 10^{-2} mm/cycle as wrongly implied and conveyed to the readers by the author in his article. It should be understood that accurate fractographic reproducibility with one-to-one correlation between fatigue striations and applied load cycles is possible mostly in the narrow FCGR-range, as indicated above. One should be aware of the serious limitations of one-to-one correlation between striations and load cycles especially in the short crack range, as well as under complex variable amplitude loading while employing the fractographic method. This must be one of the important reasons, why there has been no consensus ASTM Standard written so far pertaining to fractographic reproducibility.

In the above context, Parida *et al.* had made some fundamental investigation on

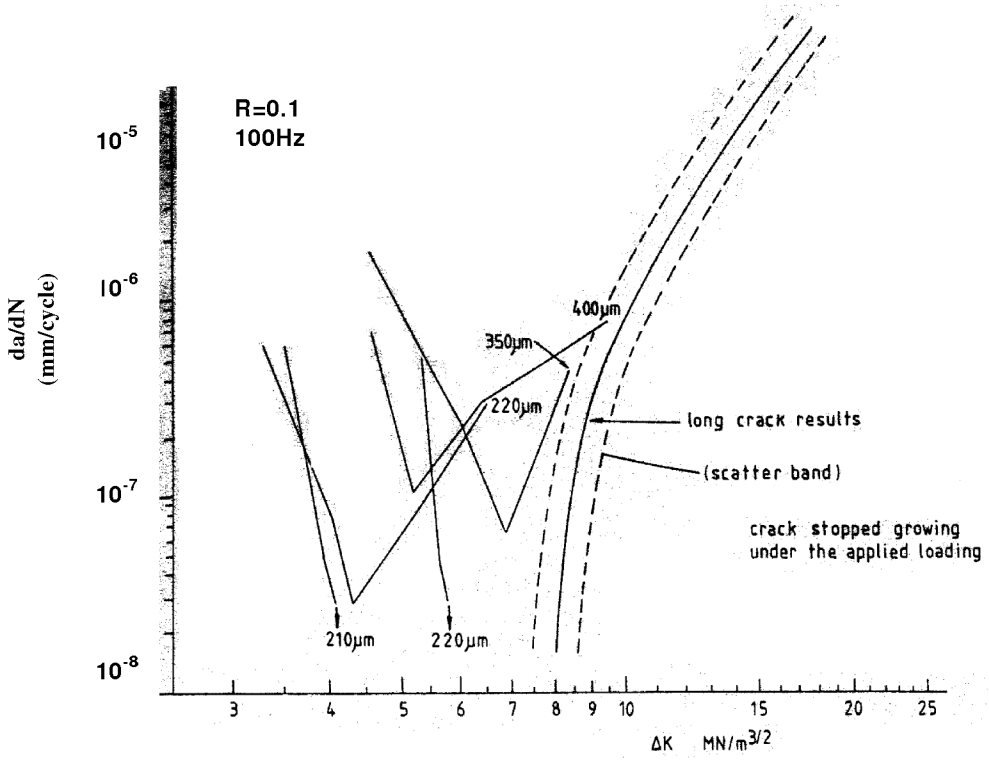

Figure 3(R). Results from five different constant load-range tests on short cracks. The final crack length in each case is shown (ref: figure 6 of D. Taylor and J. F. Knott, *FEM&S*, 1981, vol. 4, no. 2, 1981).

fatigue crack growth, including crack closure measurement in small cracks emanating from sharp wire-EDM notches during 1995–97 and had included the results of the above investigation in a manuscript forwarded to ASTM in 1997. Even before the said manuscript completed the ASTM peer review process, Sunder had made the allegation of scientific fraud to the DG-CSIR. He had misinterpreted the '*Schematic closure load sequence*' depicted in the manuscript as the literal closure load sequence used by the authors of the manuscript. In response to an ASTM peer reviewer's comment, the authors had merely elaborated the details of the same schematic closure load sequence employed by them in the text of their revised manuscript that they had forwarded to ASTM and never had they revised their used Closure Load Sequence, contrary to the claim made by him.

It is now on record that based on the findings of the expert committees, duly constituted by the DG-CSIR to investigate the authenticity of above allegations, he has concluded that the charges of fraud and plagiarism made by Sunder and his associates against the authors of the ASTM manuscript have not been proved. Curiously, Sunder having earlier involved others to spearhead the attack on the authors with the allegation of plagiarism, had himself disowned the same charge against the authors before the four-member expert committee. Furthermore, Sunder after having performed the repeat test, has not been able to prove his scientific claims before the same Committee. In essence, quite contrary to the claim of ability to reproduce striation patterns with almost digital precision (as shown in the TEM-micrograph at 60,000 X in Figure 1), Sunder has failed to reproduce the optical fractograph with one-to-one correlation by use of his own stated test material and programmed load sequence, even after deliberate gross-violation of the test conditions (earlier forwarded to ASTM in writing). Therefore it makes one wonder about the real purpose behind this protracted slanderous exercise. Possible motives behind the exercise are detailed in an article entitled 'Aerospace expert a victim of conspiracy of scientists', published in the 'SPOTLIGHT' column of *The Asian Age*, dated 19th September 2001.

So far as we are concerned, the above matter pertaining to false allegations made by Sunder and his associates was deemed to be closed after the verdict given by the DG-CSIR, based on the reports of the expert committees. The question of interpretation of data is a different matter, especially in a nascent field of scientific research wherein one cannot rule out the possibility of the prevailing understanding sometimes leading to misinterpretation of the effects of certain fundamental phenomena involved. Indeed, based on meticulous further research, the authors now have interesting results to explain the reasons for the unusually high growth rates observed in their earlier investigation, which will be published in due course. However, since the old issue is again being raked up by Sunder, ostensibly for the benefit of the readers of *Current Science*, it is important to state that Sunder, who resigned and left NAL in 1994, and his associates were involved in many instances where professional ethics were violated, for e.g. in the authenticity of claims in their publication ASTM STP 1303.

It is conceivable that they had attempted at the slanderous campaign against other individuals and organizations of repute with a view to cover up their old footprints by way of diverting the attention of the scientific community through fabricated false allegations without substance. The readers of *Current Science* are at liberty to investigate and find further details pertaining to the above matters, the evidences of which are readily available, and judge for themselves who has been practising questionable ethics!

B. K. PARIDA

Structural Integrity Division,
National Aerospace Laboratories,
Bangalore 560 017, India
e-mail: basant_p@usa.net

Response:

This matter refers to a manuscript submitted by B. K. Parida, Scientist, NAL for publication to ASTM based on the presentation he made at the November 1997 San Diego (USA) conference on Fatigue Crack Closure. There have been claims and counter-claims by Parida and R. Sunder (a former scientist of NAL who left NAL in September 1994) on two fractographic pictures in the manuscript – their origin, their ownership, material used and the load cycle employed.

Based on a request from R. A. Mashelkar, Director-General (DG)-CSIR, an initial investigation was conducted by P. Ramachandra Rao, Director, National Metallurgical Laboratory, Jamshedpur. Tests conducted under his supervision on 1.8 mm thick BSL-72 material samples (claimed to have been used by Parida, but material obtained from HAL which happened to be clad as against the original NAL stock which was unclad) showed that one of the figures had been wrongly interpreted by Parida, while the other result could not be reproduced. Ramachandra Rao also mentioned that:

> 'This dispute can be considered to have two facets, viz. (i) the reproducibility of the micrographs reported by Parida on BSL-72 and (ii) the claim of Sunder that Fig. 10(a) and 10(b) refer to BSL-73 tested earlier and not to BSL-72 tested by Parida *et al.* In the investigation so far, only the first of these was considered.'

Ramachandra Rao specifically recommended, therefore, the setting up a four-member expert committee for complete verification of claims and counter-claims of both Parida and Sunder, including investigation of the second aspect.

Accordingly, DG-CSIR set up a four-member expert committee consisting of V. V. Kutumba Rao (Director, Jawaharlal Nehru Aluminium Research, Development and Design Centre, Nagpur), R. N. Ghosh (Sr Deputy Director, National Metallurgical Laboratory, Jamshedpur), S. L. Mannan (Head, Materials Development Division, Indira Gandhi Centre for Atomic Research, Kalpakkam) and B. Dattaguru (Department of Aerospace Engineering, Indian Institute of Science, Bangalore). Meanwhile, based on the instructions of DG-CSIR, the controversial paper, which had been kept in abeyance, was withdrawn by Parida in July 2000. Thus, this paper has not appeared in print anywhere.

The Kutumba Rao Committee examined all the records, held detailed dis-

cussions with both Parida and Sunder and got repeat tests conducted to verify the claims of each. This four-member expert committee submitted its report sometime back and with total unanimity. DG-CSIR got the Kutumba Rao report examined by another highly respected senior metallurgist of the country and has accepted the report. The major technical findings from the report are the following:

(a) Parida has committed serious technical mistakes in the original paper submitted to ASTM in 1997–98. These mistakes pertain essentially to the selection of load sequence for obtaining the fractographs and interpretation of the fractographs. The net effect of these mistakes is that one of the conclusions of the manuscript, that the fractographic evidence supported the value of the crack closure stress obtained by the strain gauge method, is incorrect.

(b) The available records as well as the repeat tests do *not* provide conclusive proof of either BSL-72 (under experimental conditions claimed by Parida) or BSL-73 (under experimental conditions claimed by Sunder) having produced the fractograph given in Fig. 10(a) of the manuscript. However, Fig. 10(b) of the manuscript has been acceptably reproduced in repeat tests in both cases.

(c) There is no qualitative difference in the fractographic features of clad and unclad material. But there could be quantitative difference in striation spacing.

(d) There is enough ground to conclude that the fractograph in Fig.10(a) may not belong to any test done in NAL on BSL-73 with which Sunder claims to be associated in 1995 using SENT 1.MTL load cycle. The Committee has based this conclusion on the unequivocal statement of Girish, who is actually supposed to have done the tests, that he had not done any tests for Sunder on BSL-73 during the 1995 period as claimed by Sunder (Sunder left NAL in September 1994).

(e) Thus, with the available data, the four-member expert committee is unable to come to any definite conclusion on the ownership of the fractographs.

Based on the above investigations, DG-CSIR has come to the conclusion that the charges of 'plagiarism' or from Parida made by Sunder and his associates have not been proved. However, taking into cognizance the 'serious technical mistakes' made by Parida and the whole controversy, certain administrative action was asked to be taken by DG-CSIR and this has been done. Relevant organizations with which NAL is working in the area of structural integrity and also ASTM have been appraised of the position. As far as NAL and CSIR are concerned, the issue is closed. One wished the matter could have been left at that.

But *Current Science*, for some reason seems to want to keep the controversy alive. In addition to the above factual record, it has therefore become necessary to state the following in view of certain allegations made by Sunder and his co-accusers against NAL and CSIR and also the Expert Committee in his article to *Current Science*.

(a) There has been absolutely no 'cover-up' by NAL/CSIR as alleged. While it was initially felt by Director, NAL that the paper could go through its peer-review process with opportunity for others to comment after its publication, there was complete cooperation and support, once the investigative process was initiated by DG-CSIR. The completion of the investigation unfortunately took some time.

(b) NAL/CSIR took a position that they would take a final view on the matter only after the independent investigation was fully completed and would not 'hang' anybody prematurely. It is unfortunate that this was construed as a 'cover-up' operation. Not only have the motives of NAL/CSIR management been questioned, but also those of the eminent scientists who agreed to help us in this investigation.

(c) A related question perhaps arises whether there should not be a 'code of conduct' for the accusers also, especially if they are outside a formal institutional system or have held eminent positions earlier. In the present case, the manuscript and many data records were clandestinely removed from the laboratory by the accusers. A campaign was launched in the open against the accused scientist and the institution. Even before the investigation was completed, Parida was declared guilty by the accusers and letters were shot off to the Minister of Science & Technology; Vice-President, CSIR; Chief of Air Staff, Indian Air Force; Central Vigilance Commissioner; President, Society for Scientific Values; many senior colleagues of Parida at NAL; other senior scientists in country, etc. On scientific papers on other topics co-authored by Parida with scientists from Aeronautical Development Agency and Hindustan Aeronautics Limited, letters were written to these organizations cautioning them about their association with Parida and an attempt was made (which rather boomeranged) to intervene in the review process of these papers by the ASTM organizing committee. A very hostile attitude was taken against the four-member expert committee during the investigation, their scientific integrity and impartiality were questioned and intimidating letters were sent, almost dictating what conclusions the committee must draw. They have also attacked the expert committee report prepared by the members with total unanimity, after spending an enormous amount of their precious time to establish the scientific truth, to the best extent possible. Even popular press was used to sensationalize the matter mixing it up with many other extraneous issues. The accusers have taken on the roles of judges as well as hangmen – all in the name of 'ethics in science'.

(d) Unfortunately, science does not always seem to be the real or the only agenda behind such accusations and subsequent generation of publicity. It is submitted that, in the case, there are serious doubts about the purity of agenda of the accusers, knowing the many historical twists and turns in the personal and organizational relationships of the players involved (this is not the place to go into those details). Scientific institutions in India are built over several years by many people with painstaking hard-work and to smear them based on one or two issues, even before the truth is independently established, seems, unfortunately to be quite easy in this country. It is sad that it is done by fellow scientists, very often with their own axes to grind, wrapping it up under the cover of 'ethics' and using their own questionable methods. If a person working within an establishment is under a cloud for scientific and administrative misconduct, there are mechanisms to address the issue, but what is the mechanism for the 'freelancers' who are outside the system?

(e) While taking a final view on the

matter, DG-CSIR has expressed his unhappiness that charges of 'plagiarism', 'fraud', 'institutional cover-up', etc. were made without proper verification. The use of unusually harsh language against the competence and integrity of the committee appointed by him was also not appreciated, just as the use of other questionable means which included an approach to the media.

I consider it very unfortunate that a reputed scientific journal like *Current Science* has agreed to publish the paper of Sunder at this stage when an independent investigation has gone through the whole scientific matter and given its findings. While a small part of Sunder's paper addresses science, the larger part talks about other issues, mainly to malign a reputed organization, to show its management and its scientists in poor light and to question the scientific integrity of the expert committee members – all the while talking about lofty principles. In a letter sent to the Editor of *Current Science* some of the very senior and respected scientists of NAL have this to say –

> 'If Sunder's article was only an honest narrative about wrong reporting of scientific results, we would welcome its publication. But very soon it degenerates into an unacceptable diatribe against a respected R&D establishment (which, Sunder will recall, treated him extremely well and contributed in no small way to his professional enrichment), its scientists, its Director and its Director-General. By choosing to publish it, *Current Science* is maligning NAL severely and without sufficient basis. We wonder why you are doing it. In fact it is our considered view that any individual, or a journal like *Current Science*, making baseless charges against another individual or institution must be firmly censured.'

Perhaps it cannot be put more eloquently!

T. S. PRAHLAD

National Aerospace Laboratories, Bangalore 560 017, India
e-mail: director@css.nal.res.in

Adiposity and diabetes: Biochemical link

Indians appear to be on the verge of a diabetes epidemic[1] for which adiposity is a major risk factor. Attempts to biochemically link the two via resistin[2] could herald an etiology-based treatment.

Diabetes apart, obesity is becoming increasingly common in developed countries[3]. Further advances in molecular characterization are to be expected.

Currently diabetes mellitus (DM) is classified into type 1 diabetes, which includes the earlier insulin-dependent diabetes mellitus, and type 2 diabetes, which encompasses what was previously called noninsulin-dependent diabetes mellitus[4].

There are few epidemiological studies from India on the prevalence of obesity. Table 1 summarizes published information.

Based on the body mass index (BMI: [(weight in kg)/(height in metres)2]), we analysed the prevalence of overweight (BMI ≥ 25–29.9) and obesity (BMI ≥ 30) from our prospective computerized database on individuals with type 2 diabetes (Table 2).

The data obviously cannot be extrapolated to the general population. However being a fairly large sample, it reflects the magnitude of the problem at least in those who came for medical advice. They are accessible to weight-correcting measures.

Similarly, we calculated only the BMI, with its inherent limitations. Further studies may be taken up, perhaps on a smaller sample, which includes waist–hip ratio and skin-fold thickness. Direct visualization of fat mass is possible by computerized tomography and dual energy X-ray absorptiometry. It was recently shown that BMI was 'strongly associated with measures of adiposity derived from dual energy X-ray absorptiometry' in children[5].

Table 2 shows that there is a similar prevalence of overweight and obesity in those newly diagnosed to have diabetes and in those with less than one year of known diabetes. Type 2 diabetes cannot be diagnosed 'at onset'. Nearly 20% of patients have diabetic microvascular changes at the time of clinical diagnosis. Similar patterns of weight range in the two groups are consistent with the concept that clinical diagnosis of type 2 diabetes mellitus occurs as part of a continuum. The lower prevalence of both obesity and overweight in those with longer duration of diabetes could be due to medical intervention, and due to differing duration and degree of hyperglycemia. Further analysis of the data has not been attempted in this presentation.

In our computerized database on endocrine disorders[6], among 123 persons registered for evaluation and management principally of obesity, half were children (63/126; 34 boys, 29 girls)[3]. Using the ICMR centiles for weight and height, most of the boys (33/34) and all the girls were above the 95th centile of weight for age. A skewing towards pathological causes must be considered, as the children presented to a referral endocrine centre.

Data from India have shown that adiposity and insulin resistance began in childhood, and they originate *in utero*[7]. Therefore, preventive measures must begin early.

Obesity generally seems to result from decreased expenditure of energy, rather than increased intake of calories[3]. Indians have trunkal or central obesity, which may not be truly reflected in increased total body fat. It forms a component of the metabolic syndrome of insulin resistance, hypertension and dyslipidemia. While Reaven did not include obesity in his original proposal on insulin resistance, WHO definition of 'metabolic syndrome' has obesity as a diagnostic criterion[8].

Ultimately, obesity which results from a complex interplay of social, behavioural, cultural, physiological, metabolic and genetic factors, is as common as it is burdensome to manage. Currently available options such as lifestyle measures, are difficult to implement[9] and sustain.

Advances in adipose tissue-related hormones such as leptin, adiponectin[10] and now resistin could lead to an eventual etiology-based treatment of obesity. With the completion of the human genome project, rapid advances can be anticipated, such as the recognition of resistin-like molecule families[11]. Even