IMPORTANT REQUIREMENTS FOR FUTURE ANIMAL PRODUCTION-ORIENTATED RESEARCH WITH PARTICULAR REFERENCE TO VETERINARY SCIENCE*

I had intended to start my address by thanking you for the honour you have bestowed on me to deliver the Theiler Memorial Lecture. Then I encountered this remark made by Theiler in 1935 in Gutsche's biography[2], which brought me down to earth, but did not diminish my gratitude:

Honours kept coming - "a sure sign of advancing senility", he told Alfred.

As theme for this lecture I have selected what I regard as 3 cardinal interrelated developments which will have a profound effect on animal production-orientated research requirements and the future education requirements for such research. I shall try to motivate this theme by means of facts, figures and my own thoughts, some of which are speculative, but will hopefully be convincing. Since this occasion commemorates Sir Arnold Theiler, particular attention will be paid to veterinary aspects of the theme.

THE FUTURE HOME OF ANIMAL PRODUCTION-ORIENTATED AND OTHER AGRICULTURAL RESEARCH

The correct home for agricultural research, which includes veterinary and other animal production-orientated research, in the South African household has occupied the minds of many; from the researcher at the bench, middle and top management levels, to politicians, in the past as well as in recent years. The so-called "Kolb Report" is the most recent and, at the moment, most tangible addition to the published line of thought.

I shall confine myself today to thoughts on and recent developments with regard to the home for research being done by the Department of Agriculture and Water Supply, which includes the Veterinary Research Institute, Onderstepoort and other animal production-orientated research being done by the Department.

It is clear from Gutsche[2] that Theiler felt strongly that the Onderstepoort Research Institute should be unfettered from the bureaucratic system applying to the Department of Agriculture.

Theiler was not prepared to accept these restrictions and proposed "a very strong protest demanding the right of Onderstepoort to be put outside general arrangements by reason of the nature of its work, by its traditions, by its standing in the scientific world and its outstanding success .... It has the right to have its own way - the psychology of scientific workers should not have to give way to the general machine-like way of working of the Treasury, the Auditor-General and the Agricultural Department".

*Theiler Memorial Lecture given at the 5th Faculty Day of the Faculty of Veterinary Science, University of Pretoria on 5 October 1988

Many have shared that view. It must, however, be realised that the account for Onderstepoort's research budget and those of other research institutions within the Department is being paid by the taxpayer. In pure government service, bureaucracy is a given fact. The Treasury, Commission for Administration and Auditor-General are essential for orderly government administration. These institutions are like the Rock of Gibraltar. There may be room for improvement in their *modus operandi*, but they cannot be wished away. Any move away from the "hated" bureaucracy will mean having to find funds, to a greater or lesser extent, elsewhere.

This is particularly relevant now in view of the Government's avowed policy of privatisation and deregulation. This can be interpreted to be a green light for state funded agricultural research to move out of the government service per se. Such a development and the anticipated advantages that will accrue, can also be construed as being a contribution to the State's declared policy to "restructure and rebuild agriculture" in order to achieve a better agricultural dispensation for the farmers and thus for the country as a whole.

A move towards a semi-state, also known as parastatal institution, which will probably be known as an Agricultural Research Council (ARC), is on the cards for research being conducted by the Department of Agriculture and Water Supply. The Onderstepoort Veterinary Research Institute, being its largest single component, will be implicated.

The Department of Agriculture and Water Supply has been instructed by the Minister of Agriculture to investigate the possibility of establishing an ARC and to report back before the end of 1988 on its likely structure, probable personnel requirements and estimated financial implications. Sources of possible funding must also be provisionally explored. This is of course excellent news to me since I have been propagating this move for the Onderstepoort Institute by written word and verbally ever since I was in a position to do so.

It must be clearly appreciated that a parastatal body such as an ARC will of necessity obtain a considerable proportion of its funds from the State. The amount is, however, most unlikely to be increased annually, particularly in respect of running expenses. This means that it will be eroded by inflation, and an annual escalation in private funding will have to be sought by the ARC to compensate for this loss, not to mention providing for growth.

The most important message is that the products of research will have to be marketed in future in a format sought by the consumer.

In this case I am referring to the marketing of technology generated by research in a package which the market seeks. In the case of veterinary and other animal production-orientated research the potential market extends from "conception to consumption", in other words from the producer to the consumer. Into this reasoning can also be read that research will not stop at the farm gate, as has been the policy hitherto, although exceptions were made. This means that the farmer is not the only client for the products of agricultural and veterinary research, but that all the farming-orientated industries are also potential clients.

Corrollaries of this reasoning are that:

- more personnel may be appointed if the necessary funds can be found
- the ARC will be in a better position to compete for highly-qualified personnel
- there will be a shift away from the "publish or perish" concept to "publish and perish".
- it will consequently be more important to file a patent than to publish a paper
- there will inevitably be a shift away from fundamental to more applied research
- evaluation of the progress of research will feature much more strongly
- the consumer of research results will have much more say - researchers have hitherto enjoyed a remarkable degree of freedom from external or even internal pressures

It must be clearly understood, however that a parastatal body is no Utopia.

Probably the most important potential problem which will have to be firmly addressed is the fact that "he who pays the piper calls the tune". Special care will have to be taken that fundamental research, which is the backbone of long-term scientific progress, is not an eventual casualty of the system. Many of the big scientific breakthroughs come from "fortuitous observations" made during fundamental scientific research. For this reason, State funding can, in my opinion, never be entirely dispensed with.

FUTURE RESEARCH REQUIREMENTS FOR PROGRESS IN ANIMAL PRODUCTION

I think it can be positively stated that Theiler was aware of the fact that animal production and animal health cannot be divorced from one other. In other words, the ultimate objective of any research on diseases of animals must be to keep animals healthy so that they can produce optimally. In 1928 Theiler said:

"The Institute at Onderstepoort, South Africa which was founded and organised by me, did not deal with all the aspects of animal health as I propose should be done in Australia. It dealt almost exclusively with disease. ..... Animal health ..... is national wealth"[2]

The food requirements for a self-sufficient South Africa, a situation that would

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be expedient for strategic and economic reasons, for the coming century will be determined by its population growth. The latter can only be described as awesome. It has been predicted that the total human population will number about 47 million people by the year 2000, most of whom will have adopted a Western food consumption pattern. In the average Western diet, animal products provide 70% of the protein, 35% of the energy and most of the required minerals[3].

One expert has estimated that the increase in the requirement for beef will be 50%, for mutton 30%, and for dairy products 60% by the turn of the century[4], to name but a few products. Another predicts a 70% increase for beef and 75% for mutton[3]. Irrespective of which of these predictions is correct, it is clear that these goals can only be attained by a considerable increase in animal production.

Theiler's[2] view on South Africa's potential for beef production is clearly overoptimistic:

"The last hindrance to cattle farming in South Africa has now been cleared up and this country will now become one of the biggest producers of meat"[2].

It is obvious that we cannot increase our cattle, sheep, goat and game numbers dramatically because we already have a full house under extensive conditions. The potential for increase by greater intensification is, with the exception of poultry and pigs, also limited. A dramatic increase in the productivity of our ruminant livestock is the only alternative left to reach the abovementioned animal production goals. To reach a goal of 70% more beef, for example, we will have to slaughter 3,7 million cattle annually instead of the current 2 million head. How will we reach this figure?

There is considerable scope for the increase of animal production by merely improving the management of our national herd to obtain better nutrition, a quicker growth rate, increased fertility and better immunity against diseases. A key to much of this lies in persuading the South African farmer to keep fewer, but more productive livestock.

If the weaning rate of our national beef herd could be increased, for example, from the current estimated less than 50% to 65%, which is not unrealistic, 1,95 million instead of 1,5 million calves could be weaned annually. This means that both an increased fertility and a lowered mortality rate are required. A higher turnover of cattle (the current turnover is 26%) will be possible because 450 000 more cattle could be available for slaughter each year. Because the veld cannot accommodate more animals, better selection and earlier culling of females must result. Increased feedlotting has already ensured that the ratio of young to older animals being slaughtered is increasing, namely from 44% in the A category in 1983 to 53,5% in 1987 (R.T. Naude, ADSRI, Irene, personal communication, 1988). Some further growth in the feedlot industry would be essential to absorb the higher number of animals available for slaughter. This is again dependent on a low grain price structure. There is likewise much room for improvement of the current 70% weaning rate of sheep.

The government's soil conversion scheme, which involves the conversion of about one million ha of marginal cash crop lands to artificial pastures over a period of 5 years, can also make a contribution of about 300 000 LSU, consisting of both sheep and cattle, to the required shortfall. It is, however, likely that most of these pastures will be used initially to relieve the grazing pressure on already overburdened natural pastures.

It therefore seems unlikely that we will be able to reach a 50% increase in beef production, for example, by a more rapid turnover of animals. A 70% increase by this method seems a pipe dream. The same arguments would apply to mutton, etc.

To reach the required increases in the abovementioned commodities by the year 2000, increased production per animal by higher quality animals is indicated. Performance and progeny-testing are extremely useful tools in this regard. We don't need excessively large animals, but cows that each wean a calf weighing 200kg every year. Performance-testing, which is being run by the State at present, does not nearly meet the national requirement. For example only 25% of the beef breed bulls acquired for breeding purposes annually, are being performance-tested at present under the largely government-sponsored scheme. Privatisation of performance-testing seems unavoidable.

However, more rapid methods to increase the performance of our livestock than the relatively slow progress provided by conventional selection methods will have to be sought and exploited if we are serious about reaching the abovementioned animal production targets. Biotechnology at both the molecular and cellular levels of genetic manipulation offer the choicest fruits in this regard.

Although Theiler and his contemporaries could not have foreseen biotechnology as we know it today, their awareness of the importance of progress achieved by pure science is a measure of their intellectual greatness. The following quotations by Theiler (1905) and Schonland (1908), respectively, from Gutsche[2], illustrate this point:

"We may assert with confidence that the time is not far distant when South Africa will not be devastated by ravaging diseases. And this point will be won not only by the advance of our particular branch of science but by the advance of science in general".

"Your work" he told Theiler, "illustrates in a particularly happy manner the fact that progress in applied science must go hand in hand with progress in pure science.....".

The theoretical possibilities open to exploitation by the variety of powerful biotechnological techniques which have been and are constantly being developed, seem to be infinite. Our manpower and financial resources are, however, so limited, that it would be wise to concentrate them on those problems which are unique to South Africa, and for the rest to make as much use as possible of knowledge generated elsewhere.

I regard the following objectives as the highest priorities for the RSA:

1. A dramatic breakthrough in respect of ruminant digestion which will enable ruminants to utilise the millions of tons of available low grade roughage such as veld grass and crop residues more efficiently. This should enable us, for example, to market younger animals off the veld or other roughage, in a finished condition and to eliminate winter nutritional stress in females. Development by recombinant DNA technology of ruminal micro-organisms (super bugs) that can effect this miracle is, for example, no longer such a far-fetched idea.

2. Embryo transfer technology must be made freely available on a country-wide scale. This technology includes all the techniques associated with embryo transfer such as multiple ovulation, recovery and freezing of embryos obtained thus or from ova fertilised in vitro, embryo splitting, embryo fusion, sexing of embryos and gene transfer. England is already offering beef embryos salvaged as ova from abattoirs and fertilised in vitro as an alternative to AI. Moreover, Australia and New Zealand are importing Angora embryos, against our wishes, from South Africa for the benefit of their countries. Is this technology being exploited to multiply genetically superior small stock in South Africa to any significant extent?

3. Gene transfer is a technique which has great theoretical potential for use in Africa, and hence the RSA, because it will enable us to produce animals with specific adaptational genotypes that are tailor-made to make them highly productive under African environmental conditions. The genotypes concerned have already been provided by natural selection.

   I am thinking here of transgenic animals that are resistant to diseases such as trypanosomiasis and tick-borne diseases. Perhaps even more important is resistance to the plethora of species of African ticks. We have already determined that an indigenous Sanga breed such as the Nguni has large numbers of individuals that are highly resistant to our cattle ticks. This genetically determined characteristic would be most useful in faster growing breeds. Once established, such transgenic animals can be multiplied by the abovementioned embryo transfer technology. An Australian genetically engineered vaccine against the blue tick, *Boophilus microplus*, is on the cards and vaccines against other tick species are bound to follow suit. However, I am prepared to predict that ticks will find a way to circumvent the immunity thus induced.

   Their ability to manifest resistance to acaricides is an indication to me that there will also be individuals in a population endowed with the ability to avoid an immune response directed at specific antigens. The more far-sighted, longer term approach of developing cattle with transgenically induced tick-resistance should therefore not be neglected. In the meantime the use of tick-resistant breeds of cattle in the appropriate environment should be

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exploited much more fully.

The ultimate aim regarding worm and blowfly control in sheep should be genetically determined resistance. Resistance to chemical control by the parasites concerned, and the increasing pressure against pesticide residues in animal products and against pollution, will make this approach inevitable. Transgenic animals, and their multiplication by embryo transfer technology, again come into the picture as a means of bringing a resistance gene(s) into a breed more quickly than by classical selection for resistant animals.

Mice, equipped by gene transfer with a human growth hormone gene, grew more than twice as fast as litter mates. This has opened up the way for similar research in other species. I doubt, however, whether elephantine cattle or sheep will be an advantage production-wise under extensive South African conditions.

Transgenic fodder plants and grasses can also make an important contribution to increased animal production. A sulphur-containing lucerne cultivar which increases wool production has, for example, been developed in Australia. More digestable indigenous grasses, which are already drought resistant, or the introduction of drought-resistance genes into more nutritious grasses would be most useful as improved artificial pastures, for example, under the crop withdrawal scheme, or even natural pastures, which would amount to radical pasture improvement.

4. Recombinant-DNA technology has made it possible to produce vast quantities of growth hormone in vitro, which has been shown to substantially increase growth in pigs and sheep and to induce considerably higher milk yields in cattle. It still remains to be seen whether the product will eventually be released for general use. Public pressure against its use seems to be triumphing in Europe, and the USFDA appears to be dragging its feet too.

5. Genetically engineered vaccines against local diseases must feature strongly in any research programme aimed at increasing animal production. Particularly relevant are those diseases against which it has not been possible to develop vaccines, such as snotsiekte, jaagsiekte and cysticercosis of cattle, or instances where existing vaccines are either not very effective, or for various reasons, impractical to use or dangerous to produce. Important examples of the latter are vaccines against heartwater, redwater, anaplasmosis (current vaccines consist of infected blood, with obvious disadvantages), bluetongue (which is a live attenuated vaccine consisting of 15 serotypes, also with obvious disadvantages) and FMD (which consists of inactivated virulent viruses).

6. Recombinant-DNA technology will also provide a series of diagnostic probes for a variety of diseases and parasites which could revolutionise the diagnosis of diseases and carrier states. The detection of measles in live cattle; crush-side diagnoses of diseases such as heartwater, redwater, and anaplasmosis; detection of the carrier states of *Theileria lawrencei* in buffalo, jaagsiekte in sheep, bluetongue in cattle and sheep destined for export, equine viral arteritis and various other viral diseases in imported stock, biliary fever and horsesickness in horses destined for export, and heartwater infection in ticks, are a few examples which come to mind.

Biotechnology therefore has much potential for making a significant contribution towards increasing the productivity of our extensively-farmed livestock. It is, however, longterm research and consequently unlikely to have a dramatic effect before the year 2000. Therefore our imports of the commodities referred to initially, are likely to increase. It may well be necessary to fill in the balance with pork and chicken.

FUTURE EDUCATION REQUIREMENTS FOR PROGRESS IN ANIMAL PRODUCTION

I am convinced that much of the progress required in animal production will, in the medium and longer term, depend on research in which biotechnology in its various guises, will feature strongly. Suitably-trained manpower will have to be found for this purpose.

From the above exposition it is also clear that a veterinary qualification is not a prerequisite for any of the research work required. Whereas experienced veterinarians should be in their element with the required improvement in the management of livestock, and likewise those with appropriate post-graduate training with embryo transfer technology and all its permutations, the work can also be done by non-veterinarians. Much of the basic research on embryo transfer technology in this country is already in the hands of non-veterinarians who have been trained in a variety of biologically-orientated natural sciences.

Applicable research approaches for which there is currently the greatest need and which offer the greatest chances of success are:

- Biotechnology, which includes embryo transfer technology and all its ramifications, gene transfer, molecular biology, r-DNA technology, microbiology and immunology.
- Genetically-determined resistance to disease and parasites, which can be achieved relatively slowly by conventional methods or probably faster by means of gene transfer.
- Physiology, particularly that of ruminant nutrition and digestion.
- Chemical and molecular pathology, and pathogenesis of disease.
- Ecology, under which umbrella I include studies on the epidemiology of disease, ecosystems, pasture sciences and plant poisonings, livestock and game management, and pollution-orientated sciences, which would include the use of industrial byproducts to produce food and energy.

These research approaches all require a sound background knowledge of the basic, biologically-orientated sciences such as biochemistry and molecular biology, microbiology, physiology, biology, genetics and ecology.

Throughout his career, even before his association with the brilliant biochemist, Harry Green, Theiler had what can be described as a yearning for the "pure sciences", as is once again illustrated by this quotation from Gutsche[2]:

"Theiler concluded his address with a virtual expression of his own philosophy: Foster by all means the pure sciences. They are, in the hands of experts, the medium of solving the many economic problems of South Africa."

Veterinarians receive some training in the abovementioned subjects at the undergraduate level, but it is not nearly sufficient to equip them for a research career in which the abovementioned scientific approaches feature strongly. I have a problem with the concept of providing for these diciplines at the post-graduate level because it is like placing the cart before the horse. Moreover, it will be necessary to rope in expertise from all possible institutions, irrespective of whether the required tuition is offered at undergraduate or post-graduate levels.

In my opinion veterinarians would be wise to take note of recent developments in a sister profession. Members of this profession can be likened to the dinosaurs. Like the dinosaurs, they excelled in every respect. They eventually filled every niche and every cavity. They became so specialised that they could not adapt and, lo and behold, eventually virtually worked themselves out of a job. Now they have gone back to the drawing board to try to find a way out of their predicament.

If the basic sciences are neglected in favour of clinically-orientated ones, veterinarians will at best be at a disadvantage and at worst be unable to contribute towards the advanced research required to increase animal production. This will not only curtail the job opportunities for veterinarians, but also lower the high status that they have always enjoyed as researchers in this country. The technological revolution currently on our doorstep may even decrease the demand for veterinary services in the farm animal industry, because scientists with a more basic training would be in a better position to provide for the whole spectrum of sophisticated biotechnological techniques required to improve animal production.

Thus the veterinarian's slice of the animal production market is bound to shrink even further. Eventually the basket containing the currently fairly lucrative companion animal market may be virtually the only one left. May I remind you that the saying goes: Don't put all your eggs into one basket.

CONCLUSION

In conclusion I wish to say that the purpose of my talk was not to show that Theiler was prophetic. I used Theilerian quotations to give perspective, colour and spice to my views and arguments. I have no doubt, however, that Theiler was remarkably far-sighted, as was aptly diagnosed by Smuts (Gutsche[2]) when he unveiled the statue we all know so well in 1939:

"Theiler had had a great capacity for

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application but in addition he had insight into the nature of things which was given to very few people. Rutherford, Einstein and others like them had had that insight into the significance of the situation before them. It is the grace of God, genius - something you get in some unaccountable way''.

Let those of us who, quite naturally, sometimes have doubts about the revolutionary developments envisaged, take heart. Theiler would undoubtedly have given these changes his blessing.

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