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TABLE OF CONTENTS

THE CHIEF PREVENTIBLE BLINDING DISEASES OF CHILDHOOD

Dr. Elizabeth Matthai Lectures 1933-34 (Madras University).

BY

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The first of the series of three lectures on "The chief preventible blinding diseases of childhood" was delivered in the theatre of the Elliot School of Ophthalmology, Govt. Ophthalmic Hospital, Egmore, Madras, on the evening of Tuesday the 6th March 1934. The subject of the first lecture being 'Deficiency disease and Trachoma.'

In introducing the lecturer, the Surgeon-General, Sir Frank Connor, made some interesting remarks regarding the history of the Madras Eye Infirmary now named the Govt. Ophthalmic Hospital. He said: The first eye hospital in the English-speaking world was founded by Saunders in London in 1805. From this parent institution, now known throughout the world as "The Moorfield's Eye Hospital' the following eye infirmaries were founded :

Exeter	Eye Infirmary	Adams	1807
Madras	,, ,,	Richardson	1819
New York	Eye and Ear Infirmary	Delafield and Rogers	1820
Calcutta	Eye Infirmary	Egerton	1824
Bombay	,, ,,	Jeafferson	1824
Boston	Massachusetts Eye and Ear Infirmary	Reynolds	1824

He showed photographs of some of these pioneers of Ophthalmology.

LECTURE I

DEFICIENCY DISEASE AND TRACHOMA

The deficiency disease which is so largely responsible for preventible blindness in children in the Madras Presidency, as also in the greater part of India and other parts of the world, notably China, is the avitaminosis, known as keratomalacia.

Let us briefly consider some of the clinical features of keratomalacia with which most of you, lay and medical, are probably familiar. Its earliest manifestation is a symptom, night blindness, which is therefore not observed in the class of cases we are considering, namely, the young child. It is however the complaint which brings many older children and adolescents to the hospital. The next evidence of this progressive deficiency is the peculiar smokiness of the conjunctiva (illustrated at the lecture by paintings and actual cases). This is the earliest obvious sign just as the night blindness is the earliest symptom. One may meet either or both of these in a youth who is apparently healthy-looking in other respects. They are however danger signals and if it were possible for the baby to complain of the first, or for the mother to detect the second, the advance of the condition to a serious stage might be averted. When the early signs and symptoms appear, if nothing is done to augment the amount of essential food factors in the diet, the case rapidly progresses and marasmus sets in; the patient becomes wasted, the skin harsh and earthy-looking, the hair appears dull brittle and thin, the mucous membranes also show a diminished secretion and the more accessible membranes of the nose, mouth and throat are seen to be abnormally dry. It is generally somewhere about this stage that we have babies brought to the out-patients department. *Pari passu* with the wasting of the mucous membranes, there is an advance in the eye symptoms. As a rule the smoky conjunctiva becomes dry, wrinkled and greasy-looking, the cornea becomes dull and lustreless, and eventually opaque. Occasionally the changes in the eye are of a different type and instead of a dry greasiness, we find a wet, dull, red conjunctiva. In the one case there appears to be a suppression of the lachrymal secretion ; in the second it is excessive, but this does not obscure the essential changes. Little patches covered with a sort of white foam appear on the conjunctiva,—Bitot's spots—, they are generally situated at either end of the horizontal diameter of the cornea. The cornea eventually undergoes necrosis and ulceration and if untreated, the ulcer perforates, and the eye is ultimately lost. Should the condition be improved at the stage when both corneæ present large ulcers, the child may be restored to good general health, but remains blind on account of the dense scar tissue opacities (leucomata) of the corneæ. Certain of these children who show gross ulceration heal with the formation of thin, weak scars of the corneæ. Such cases may present themselves some years later with well-marked bulging (staphylomata) of the corneæ. If seen in this state for the first time it would be impossible to tell whether these staphylomata resulted from keratomalacia or other forms of ulceration in early childhood.

It is sometimes quite impossible for the mother to observe the condition of the baby's eyes when she brings the child to the hospital, as, by the time she has made up her mind to seek relief it requires an expert to open the lids and examine the state of the cornea ; but she has probably noted previously that there was something definitely wrong with the eyes and the progressive wasting of the infant drives her to seek relief. By the time the average mother brings the baby to the hospital, the skin is hanging in baggy wrinkles round the joints,—the so-called elephant skin,—the mucous membranes of the mouth nose and throat are wasted glazed and dry, the thin piping or hoarse croaking voice is hardly recognisable as proceeding from a human being. The alimentary tract is affected just as the mucous membrane of the respiratory tract, and diarrhœa of one type or another is present. When this condition of marasmus is reached, the child is, as a rule, blind, but in spite of the appalling general state, it is a relatively easy matter to restore it to comparative health again with cod liver oil. Even if the child is too ill to take cod liver oil by the mouth or to tolerate it in the intestinal tract, it is often possible to save the life of the child by wrapping it in a flannel binder soaked in cod liver oil. We are not here concerned with the general condition or even the tissue changes in the various mucous membranes. What we are considering is the state of the eyes, and, by the time numbers of babies reach our out-patient department, either one or both the eyes have been so damaged as to result in partial or complete blindness, even though health is restored. This is perhaps all that is necessary to say about the clinical aspect of the condition.

The degenerative condition thus designated is due in the main to a deficiency of vitamin A in the diet ; vitamins B, C and D are possibly also concerned so that one may perhaps regard it as a polydeficiency, but we need not now discuss what part these latter food factors play. The signs and symptoms observed in human beings who are suffering from keratomalacia are similar to those artificially produced in animals by withholding vitamin A from the diet, referred to by experimentalists as xerophthalmia. The clinical evidences of keratomalacia have probably been known for thousands of years although it is only recently that scientific research has enabled us to place the condition amongst the avitaminoses.

The treatment of certain affections of the eye by the same methods as are in use today for keratomalacia was known to the ancients. The fact that liver was used successfully in treating night blindness in ancient Egypt, Greece, parts of India, Russia, Japan, and elsewhere, strongly suggests that it was keratomalacia, of which night blindness is such a prominent symptom,—which was dealt with. If, for example, the treatment by means of roasted ox liver, recorded in the 'Book of the Eyes' of the Egyptian Papyrus of 1500 B.C. deciphered by Ebers in 1872, was for night blindness, —and this is likely in view of subsequent ophthalmological history—then it is not improbable that this treatment was for the night blindness of avitaminosis. A reference to the literature bearing on this subject shows that liver administration in various ways was handed down from generation to generation in many countries as a treatment for night blindness. It is unlikely that this would be so if the treatment was not relatively successful. There are records which show that such night blindness sometimes followed fasts and famine, was sometimes associated with xerosis, and sometimes went on to complete blindness, which sequence is true of keratomalacia. To those who have lived in keratomalacia-ridden countries, the old records indicate that the night blindness of retinitis pigmentosa and congenital stationary night blindness, which are permanent and not influenced by treatment, cannot have been the sole causes of the night blindness which determined a worldwide belief in a treatment which has been handed down to the present day, and which we now find in use in remote districts hardly touched by western medicine, as a specific for the condition we call keratomalacia. We may therefore argue, I think, that there is strong probable evidence in favour of the view that successfully treated cases included a high percentage of keratomalacia patients. Other varieties of temporary night blindness hardly enter into the picture, they are not even now

taken seriously by people who live in a primitive way unless some of the other evidences of avitaminosis make their appearance.

This degenerative condition which we recognise as due to a deficiency in essential food factors and treat with cod liver oil, and which the ancients recognised in part and treated with liver in various forms, is a disease complex characterised by a march of symptoms and signs, which in an advanced state includes a partial necrosis of the corneal tissues with softening, sloughing, ulceration, and resultant blindness; hence the name keratomalacia.

If untreated, death frequently affords a merciful release and indeed the deaths registered as due to malnutrition marasmus, and diarrhœa, very frequently record the terminations of the lives of infants, blind of that eye affection which is such a prominent feature of this deficiency in food factors essential not only to the nutrition of the eye but to the very existence of the organism. When one compares the records of the causes of preventible blindness in children in western countries and in the east, it is noteworthy that keratomalacia plays an insignificant role in the former. Its great importance in India was however pointed out in a paper which I published in the *Lancet* of April 11, 1931. In that paper it is stated that keratomalacia is almost certainly the chief cause of preventible blindness in children in India. I stressed the words 'almost certainly' and am now glad that I did so, as at that time we did not consider that the hereditary blinding diseases should be included in our survey, but as will be pointed out in the third lecture of this series, I am prepared today to include this group, which is of enormous importance and interest.

Another point may be noted here which goes to show that the responsibility of keratomalacia as a blinding disease may have been underestimated in so far as the publication quoted above is concerned. In the year's survey of cases attending this hospital on which the figures quoted were based, there were about 30 children totally blinded, and 35 more in which practical blindness resulted. But these figures did not include a number of cases in the same year which are recorded as leucoma or staphyloma of the cornea and which were partially or totally blind from this cause. It is not possible to estimate with any degree of accuracy the frequency of the various causes of leucoma and staphyloma of the cornea, but we know that the common causes are keratomalacia, small pox, the application of irritant remedies, and the ulcerations associated with acute and chronic diseases of the conjunctiva and cornea other than these. We may therefore include a certain proportion of the cases recorded as blind from leucoma and staphyloma in the kerotomalacia group. This would bring the figure of total and practical blindness (and by this one means partial blindness of such a degree as to seriously interfere with earning a livelihood), due to keratomalacia for that particular year to between 70 and 75 out of approximately 20,000 patients seen in this period. Approximately three per thousand of our hospital cases. We shall see later that the collective group of blinding hereditary diseases sometimes equals, but more often exceeds this figure. You must be content with this idea of frequency as I cannot give figures for the general population, or what percentage of the total blind at all ages is due to keratomalacia. Figures in this connection want the most careful analysis if they are not to lead us astray. For example one finds in a pamphlet on "Prevention of blindness," by a very eminent official, that the census return for blind in India is half a million, but his investigation makes it two millions. A statistician would almost certainly consider the Special Census Officer's figures to be more nearly correct than those of an individual founded at best on a selected and localised survey. We all feel at times that there are more blind in India than the Census return would indicate, but we are not entitled to found a generalised statement on very limited observation which a Special Census Officer could readily repudiate on statistical grounds. The population of the Madras Presidency was 47,193,602 and the number of blind 52,279 (1931 census); the population of England and Wales was 39,290,000 and the number of blind 46,822 (1927 census). These figures are given as a matter of interest as in these lectures we are not considering the total blind at all ages.

With regard to the treatment of the condition by cod liver oil, we have carried out a considerable amount of experimental work in this hospital for the last 12 years and tried numerous substitutes for cod liver oil,—some of which were more palatable—, but have not however found anything so efficient as crude cod liver oil. It is not necessary to administer it in large quantities. We have gradually reduced our dosage until now the average daily quantity of cod liver oil, administered in the form of

emulsion,—for small children is 7½ minims. Of course this does not apply in case the child is unable to take cod liver oil by the mouth. Irradiated ergosterol did not appear to have any better results than cod liver oil, nor did fresh liver, liver powder, etc. It would appear from our former work in this connection that vitamin A alone is not so effective in the treatment of the condition as when supplied in conjunction with other vitamins in the form of crude cod liver oil. One hears a great deal about the anti-infective nature of vitamin A, and apparently many experimentists regard the condition they produce by withholding vitamin A from the diet as productive of a condition in which the organism is more liable to invasion with pathogenic bacteriæ. As I have explained elsewhere there is no suggestion of this in clinical keratomalacia. I imagine that most of the experimentists have little experience of keratomalacia in bulk as we have. Far from there being any suggestion of an increased liability to organismal invasion the response of the body of an infant almost dead of this deficiency to treatment with cod liver oil contradicts the idea that organismal invasion holds sway. As the alimentary tract may be affected very severely by the bacteria which habitually attack this area, it is sometimes suggested that keratomalacia may follow on dysentery. This seems in our view a mistaken idea and we consider it is the converse which is true, that bacillary dysentery may attack the individual more readily when the tissues are damaged by avitaminosis. With this possible exception there is no evidence that the sufferer from avitaminosis is more liable to invasion by pathogens than other delicate children. The pathogens which have already settled in the conjunctiva, cornea, nasal mucosa, throat, lungs, and intestinal tract no doubt diminish as the patient improves on cod liver oil, but these pathogens have for weeks perhaps been leading a saprophytic existence in the very situations where they might have been expected to cause destruction of the individual earlier had they exercised their specific role, e.g., pneumococci in the respiratory tract.

Prevention.—As suggested in the title of these lectures, this is a preventible disease; it is also an easily treated disease. In spite of this it is probably responsible for more blindness in young children in India than any other single condition. Why then should it not be prevented? Simply because the economic conditions do not permit. The question of prevention of keratomalacia and the blindness due to keratomalacia primarily concerns medical men to the extent of elucidating the nature of the blindness, the cause and treatment of the disease, and the method of its prevention. Having pointed this out to the community at large and the administration responsible for the public health, they cannot do more than relieve the limited number of cases which come their way, instruct others in methods of relief and so try to avoid individual suffering. The disease will gradually become eliminated as better conditions of life become established.

Trachoma

I have linked trachoma with deficiency disease more for convenience in spacing the subject-matter of these lectures than anything else. It shares with the latter the distinction of having been well-known to the ancients, but unfortunately hundreds of years of study by the medical profession has not thrown much light on the ætiology or treatment of this affection.

Trachoma is a chronic inflammatory affection of the conjunctiva which sometimes appears to follow an acute onset, but frequently sets in insidiously. Its clinical evidences in the early stages are unrecognisable with certainty. All the vaunted criteria for recognising this affection in its beginnings fail again and again so that I personally do not feel justified in teaching students or post-graduates to do anything more than record that a suspicious case is 'trachoma-like.' This, to my mind, is a safer procedure than labelling a doubtful case trachoma and subjecting the patient to some of the appalling forms of treatment recommended for this disease which may do such damage in a non-trachomatous affection as to produce changes in the tissue which may well be mistaken for the latter stages of the disease itself; if indeed the disease has not been grafted on to the individual during numerous attendances with other sufferers at some overcrowded dispensary. Another diagnosis which, in my opinion, should never be made is that of 'granular lids.' It is a method of hedging adopted by some members of the profession when uncertain as to what conjunctival condition they are dealing with. This pseudo-diagnosis gives a sort of moral support which enables the doctor to proceed at once with methods of treatment

which are calculated to transform a relatively simple affection into a condition of misery for the patient. The general public has a sort of horror of 'granular lids,' whatever that term may mean, and patients are contented to suffer much at the doctor's hands when so diagnosed. I regret to see that the term is still used in anti-trachoma propaganda literature by a distinguished medical pamphleteer. One of the most frequent errors in this connection is mistaking trachoma for that form of chronic conjunctival irritation associated with inspissation of the contents of the solitary glands of the mucous membrane, in which small yellowish seedlike elevations of the conjunctiva make their appearance; But one need not particularise; practically every variety of conjunctivitis has been labelled granular lids at one time or another and treated for trachoma.

Ætiology.—An enormous amount of work has been done, and is still being done in connection with the determination of the cause of this disease. There are distinguished ophthalmologists who consider that they can recognise the disease even in its earliest stages by the appearances of the tissues under the microscope; others who believe it is due to a specific micro-organism which they can isolate, but many who remain sceptical as to the possibility of early diagnosis. I must confess to belonging to the latter class. Some years ago the distinguished Rockefeller bacteriologist, Noguchi, felt certain that he had isolated the organismal agent of trachoma. His B. granulosis isolated (in pure culture) from trachomatous Red Indians, produced a conjunctival condition in chimpanzees very similar to the earlier stages of trachoma in man. In 1927 I was privileged to examine some of Noguchi's chimpanzees and felt sanguine that at last the causative agent had been discovered; for although the clinical evidences in these animals did not include the later stages,—the absolutely certain stages,—of humans, one felt that this might be due to a difference in soil. Laborious work since then all over the world has failed to confirm Noguchi's conception. In Madras, we failed to transmit the disease to animals although with the co-operation of Col. Cunningham, at the King Institute, Guindy, we were enabled to undertake numerous animal experiments.

You may ask, 'but how do you know you are dealing with a pure trachoma case when doing experimental transmission experiments?' We do not know, and this element of uncertainty amongst observers as to what constitutes true trachoma makes investigation difficult. Experienced observers do not agree amongst themselves as to the diagnosis of the early stages of the disease and the very late stages are so complicated by other factors as to make ætiological investigation well nigh impossible. Differences of opinion also make statistics inaccurate and the classification of clinical stages almost hopeless. It almost makes one blush for shame to pick up a modern review of the current work on trachoma. No fair-minded reader can assume anything but that the most hopeless confusion exists in various parts of the world in the fields of histopathology, bacteriology, clinical signs and most of all, treatment.

Of course there are clinical pictures about which nearly all experienced observers would agree as to a diagnosis of trachoma even before the advanced stages. In such cases it is possible to so treat the conjunctiva (by washing) as to free it from all detectable organisms. Thereafter if some of the affected tissue is removed, and transferred to the healthy conjunctiva of man or animals, one might reasonably expect to reproduce the disease, because long experience has led us to believe firmly that the condition is contagious. Certain well-known ophthalmologists, careful observers, have recorded that they developed trachoma from a splash of infective material. It is said that the incubation period is relatively short—under a fortnight. Still experience supports the view that under good hygienic conditions the affection is contagious with difficulty. It is of course quite likely that in this conjunctivitis complex we are dealing with more than one affection, and that in the late stages of one or other of these conditions the picture is complicated by still other infections. In 1932 we tried to find out something about the infectivity of the disease. A case was selected in this hospital in which a number of observers agreed that trachoma was well established, but not too far advanced. With due bacteriological precautions, material was transferred from the patient's conjunctiva to that of a blind volunteer in which the conjunctiva was normal. Six days afterwards the patient developed what might well have been the early evidences of trachoma in the eye which had received the implantation. Three days later material collected from this eye failed to give a culture of B granulosis when examined at the King Institute, Guindy. Nine days after the first eye showed

signs, the second eye became infected. At no time subsequently did gross changes appear in the cornea of either eye, (although microscopic vascularisation was observed), which would justify a diagnosis of trachoma. The eye remained in what one might term a 'trachoma-like' condition for a while and then spontaneous improvement took place till in six weeks the patient was apparently normal again. A year later his conjunctivæ were normal. The case is an isolated one and therefore of no real scientific value, but it shows that even a deliberate implantation is not necessarily successful in reproducing this disease under favourable experimental conditions, whilst it is apparently readily transmitted from man to man in almost epidemic form under other conditions e.g., old time warfare. There is no doubt that there are many factors which influence the spread of this disease, the relative importance of which it is impossible to estimate. If we assume an infective agent, either a filter passing virus or a microscopic culturable organism, we must admit that its conditions of spread are peculiar. A world distribution map of the disease showing approximate percentages of population affected gives you some idea as to its prevalence. It is a rough guide to the possible association with race, religion, social conditions, food supply, density of population, humidity, temperature, elevation, general health etc. In so far as we are concerned in India it would appear to be a disease more of Mohammedans than Hindus; in South Indian Hindus it is more common in Brahmins. In my experience of Mohammedans it appears to be commoner in women; the same view is shared by certain competent observers in the north. Col. Kirwan, Professor of Ophthalmology, Calcutta advises me that it is relatively uncommon amongst Bengalis. The percentages of trachoma amongst the total eye cases treated in several widely scattered ophthalmic teaching centres furnished to me are approximately :—

Lucknow (United Provinces)	...	24% (treated for trachoma) Of the other eye cases seen between 20 to 30% also have trachoma.
Lahore (Punjab) ...	...	50%.
Bombay (Bombay presidency)	...	14·5%.
Madras (Madras presidency)	...	3·5%.

Rangoon (Burma) ... ... 75%. (I cannot but feel that this figure is greatly in excess of the frequency of trachoma in Burma where I visited practically every important station.)

I must here thank Professors N. M. Dick, J. N. Duggan and B. G. S. Acharya for their communication regarding blinding diseases in their areas of work.

It is associated with overcrowding, indoor living, dark, confined unventilated housing, and the purdah, rather than with poverty *per se*. It is more frequent in urban than rural populations. It is not necessarily a disease of hot countries; it is about as common in the cold, wet, dark slums of Dublin as in hot, humid, poverty-stricken areas of Madras. It appears to be more common in Indian groups who habitually drape the head and face with clothing. It is of interest to observe here that in some parts of India where there is no real cold season the disease is not so prevalent. In such localities the poor rural inhabitants are of cleaner habits; they go practically naked instead of wearing layers of dirty clothing, they lose no opportunity of getting into water and washing, although unfortunately for many of our South Indian people the water may be green and putrid, and contaminated with the causative agents of all manner of bowel infections and infestations. You are all familiar with its frequency in Mongols and Jews; possibly race has a determining influence, we do not know. There are many points in common however between the wretched conditions of life in the lowest strata of society in China, Palestine, the Slav countries and Egypt. It is not a disease of the better classes of Anglo-Saxons even though exposed again and again. It is a disease of the great unwashed, who fug in frouzy overcrowded dwellings, at least these types and conditions appear to mark reservoirs of the affection.

For purposes of these lectures trachoma does not concern us in India to the same extent as some of the other affections dealt with, as its blinding effect in small children under school age is relatively small. It is more a disease of adolescence and middle life and it is in the later age groups that it produces its main effects on the total blind rate. Still we must regard it as

one of the responsible causes of preventable blindness in young people. We may now ask ourselves, is it preventable, and if so, what are we doing to prevent it in India. The answer to the first question is 'yes,' the answer to the second, 'nothing of any consequence.'

The difficulties of prevention in a country like India would be enormous and uneconomical. The chief methods of prevention are inspection with segregation, and control of immigration. However feasible such measures may be in islands like Great Britain and Japan, or in a concentrated but strictly controlled population, e.g., the armies in the great war,—they are out of the question here where the frontiers (N.W., N. and N.E.) are uncontrollable. Pending a sound knowledge of the cause of the disease, the conditions which favour its spread, and a State preventive policy based on these, we, Government medical servants, play at prevention here and there and from time to time, by means of propaganda through the medical and educational departments, leaflets and posters, lectures, inspections of school children, etc.; similar activities are carried on in a tentative way over localised areas by the Blind Relief Association (Bombay), the Junior Red Cross and other similar organisations. Mysore is perhaps most progressive. Dr. B. K. Narayana Rao, Professor of Ophthalmology, Minto Ophthalmic Hospital, Bangalore, advises me that compulsory medical inspection of all students in all grades of education is legislated for, together with adequate arrangements for the treatment of cases in suitable centres, and financial help to the needy and deserving for the purpose.

Relief is carried on meantime. The organisations dealing with treatment are the thousands of hospitals and dispensaries maintained by the various local Governments and Native States and a few unofficial organisations such as the Blind Relief Association (Bombay). Such treatment, however humanely intended, can hardly affect to any appreciable degree the total amount of damage to the eyes due to this disease. I will not discuss treatment except to say that our experience goes to show that unless an efficient follow-up system is established, cases which have been brought to a stage of practical cure, relapse when they are lost sight of. One of the most general and effective forms of treatment is by means of the application of copper sulphate; it is of interest to note that it is one of the ancient methods of attempting to cure this disease. Trachoma is one of those unfortunate diseases which the patient only gets once, as it is never absolutely cured as far as we know even though a practical cure may be effected. In January I was asked by the Chairman of the International Association for the Prevention of Blindness to attend their meeting in Paris in May, and also the meeting of the International Organisation against trachoma held simultaneously, and to send a brief report summarising the public health and administrative measures adopted in India versus trachoma. I regret that I am unable to attend the meeting but the report is a very easy matter and may be summarised in one word 'nothing', except as stated above, school legislation in Mysore.

It will be seen from the foregoing that the position with regard to trachoma is very unsatisfactory in India. The Government organisations and the voluntary organisations practise relief in the form of treatment. At school-going age, when the disease first becomes a serious problem, we find the beginnings of an attempt to stir up an interest in the affection in the sporadic reports of inspecting medical officers and others and the activities of the Junior Red Cross Society, but for all practical purposes the matter ends there. The diagnosis is uncertain and the statistics inaccurate, but nevertheless it appears to be one of the most serious menaces to adult sight in certain areas, notably the Punjab and the United Provinces. It is perhaps as well at the present time that large amounts of money should not be diverted to doubtful measures for the control of trachoma in India even if this were likely to appeal to our financial experts. The curtailment of trachoma will probably follow on better conditions of housing, feeding, social education, e.g., the emancipation of women (notably in Mohammedan races). In brief, its eradication is largely dependent on a betterment in the general care of the public health, and the beginning of its prevention must originate in the progress made in this important function of the State.

LECTURE II.

Venereal Disease.

Venereal diseases, the sequelæ of corneal traumata, and acute corneal ulcerations not included under previous headings.

Ophthalmia neonatorum (Gonorrhœal conjunctivitis of the new-born)

The venereal disease which has the greatest interest in connection with preventible blindness is ophthalmia neonatorum, sometimes referred to as Blenorrhœa or ' baby's sore eyes.' It is an acute conjunctivitis due to infection with the gonococcus which gains access to the child's eyes at the time of delivery. When the maternal passages contain this organism it is always possible for the newly-born infant to become infected if precautions are not taken. Should this happen the newly-born child's eyes soon become red and œdematous and a thin purulent discharge exudes from between the swollen lids. This acute conjunctivitis is liable to be associated with ulceration of the cornea, perforation, and loss of the eye ; or, as is more frequently the case in this part of India, the ulceration may be milder and eventually heal with more or less opacification of the cornea. The condition is easy to diagnose clinically, but should always be confirmed by detecting the gonococcus in the discharge when examined microscopically. Other forms of blenorrhœa of the new-born are met with which are clinically very similar to the gonorrhœal affection, but in which the gonococcus is not found. They too are severe and likely to produce great damage if not treated.

This disease has been known and dreaded by accoucheurs for many years and its seriousness as a blinding affection has been fully recognised by both obstetricians and ophthalmic surgeons. In western countries it is said to be the greatest single cause of preventible blindness. In England and Wales it is held to account for 10 per cent of the total blindness. Now this is a very interesting point because it is certainly not the greatest cause of preventible blindness even in children in India. Why this should be so is not quite clear, but I have elsewhere advanced the suggestion that here in Madras at any rate we are dealing with a strain of gonococcus which is not so virulent as that which is responsible for the disease in England. At one time we thought that perhaps the rate of occurrence was much less than elsewhere, and we were advised that it was very seldom seen in our sister institution, the Government Hospital for Women and Children. Careful investigation showed that this was not the whole truth. In one year we collected quite a large number of cases amongst babies born in the Hospital for Women and Children. Many of them did not give the clinical appearance of classical ophthalmia neonatorum, but microscopic examination proved their true nature. This was not because of the nature of the prophylactic treatment, for different methods had been used, and some children had no prophylactic treatment at all. It was apparently due to the fact that the affection was mild in nature, and a possible explanation is, as mentioned above, a difference in the strain of the infective organism. It is highly probable that the condition is more prevalent in the mofussil villages where skilled medical attention is not available than in cities such as this. Even so, the mofussil cases which we do see here tend to be mild. Taking figures for our ophthalmic hospital population we find that its incidence for ten years averaged 42 per annum in an annual hospital population of 20,000, that is about 2·1 per 1,000. This, as you will remember from our first lecture, is a far lower incidence than that of keratomalacia. The relative significance is also affected by the frequency of other conditions such as the effects of small-pox, and irritant remedies, which now-a-days are not prominent causes in England and Wales. As time passes and the general social conditions and public health of a country improve, the picture of eye disease changes. One has only to look at Dalrymple's atlas of eye diseases published in London in 1852 to realise that the affections depicted as prevalent at that time in London, and now much rarer there, are common in our Madras out-patient department to-day. If we consider the relatively small number of cases which we do see, it is also noteworthy that very seldom indeed does the disease produce blindness. This, perhaps, is largely because of the energetic treatment given, but even cases which come late rarely go on to blindness, so that we have come to form the opinion that ophthalmia neonatorum is not nearly such a potent cause of blindness in India as it is in

the West. This does not mean that we should relax our efforts to prevent infection. As you may imagine a condition which is said to be the greatest cause of blindness at all ages in England and Wales, and which is definitely preventible, has stimulated a great deal of effort there in connection with its prophylactic treatment. It was recently found that in spite of a known efficient prophylactic treatment the rate of incidence still remained about where it was a number of years before. It was therefore regarded so seriously that exceptional measures have been adopted to stamp it out. The Council of British Ophthalmologists recommended the Ministry of Health to establish ophthalmia neonatorum centres all over the country, and to make it compulsory for nurses, district nurses, midwives and medical students to attend at one of these centres for practical instruction.

For many years it has been known that a prophylactic treatment known as Credé's method is a certain way of preventing the disease if properly carried out. This, or some equivalent modification, is adopted in most of the lying-in-hospitals of England and Wales and those elsewhere in Europe. It may be of interest to give the details of Credé's own directions :—

'As soon as the umbilical cord has been cut, the child is to be freed from the vernix caseosa with the adherent blood and mucous in the usual way, and then placed in a bath. The eyes are to be washed with a clean cloth, or better absorbent cotton, not with the water of the bath, but with other clean ordinary water. Then, before the baby is dressed, each eye should be opened a little by means of two fingers, and a single drop of 2 per cent solution of silver nitrate brought in contact with the cornea and allowed to drop upon it. No further attention is to be paid to the eye. The instillation must not be repeated if during the next twenty-four or thirty-six hours, there should be a slight redness and swelling of the lids with a mucous secretion.'

It would probably be easier and safer to instil the drop of silver nitrate by letting it fall from a dropper upon the conjunctiva at the inner angle of the eye or in the gap between the lids without touching the cornea rather than try to follow the detail of the original description. One per cent silver nitrate is more generally recommended now-a-days by British ophthalmologists than 2 per cent. The chief thing is that it should be employed in all cases unless it is absolutely certain that neither the mother of the child nor the father has had gonorrhœa. It would be only reasonable to insist that neither doctors or midwives be qualified to practise in India until the medical authorities are satisfied that they have had a practical experience of the prophylactic treatment of ophthalmia neonatorum as suggested by the British Council of Ophthalmologists.

(To be continued)

THE LAWS OF INDIA: SHOULD THEY BE SCRAPPED?

BY

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The principles of Hindu Law were enunciated more than three thousand years ago. It is indeed a matter of joy and pride to every Indian that Indian intellect and Indian talents had the vision and wisdom to produce a set of rules and laws for the proper conduct and guidance of Indian society at a time when the other nations of the world were non-existent, or if they did exist, were barbarous or semi-barbarous and the notion of any law was remotest from their minds. But splendid as was the lead in law that India gave to the world thanks to the genius of Manu, the mightiest of law-givers that ever trod on ancient Indian soil and his stalwart successors, Gautama, Sankha and Parasara—to mention but a few names—and thanks also to the Vedas, Mantras and Sutras—the 'uttered thoughts' of India's inspired seers, and the immemorial 'usages' of the peoples of India, it is greatly to be pitied that to-day, judged by modern standards, the laws of India are comparatively crude, out-of-date and primitive and are better fitted to be consigned to a first-class museum as a glorious relic of India's antiquity than put into use to meet the needs and requirements of a race such as the Indian race which certainly is not the same to-day as it was in the day of Manu and which has progressed vigorously in every walk of life and thought during the past fifty years to a degree that makes Hindu law nothing short of an anachronism simply allowed to be in force because there has not emerged yet a modern Manu who would have the courage to denounce it in the same way as Manu of old propounded it. India to-day does not crawl on chariot wheels or double bullock carts but gallops on Fords and Rolls Royces. Indians do not shun the forbidden seas any more but cross them with an easy conscience by means of motor vessels, some of them even resorting to aeroplanes; the wireless, telegraph, trans-oceanic telephones, talkies and television have brought the world to India's very door. The annihilation of space and distance by means of express locomotives throughout the length and breadth of India has brought the divergent castes and communities of India incredibly closer. A keen sense of patriotism resulting in a national upheaval and a common aim and aspiration in regard to the political, social and economic welfare of India, have made the disjointed warring India of old with millions of internal problems and disturbances, a solid, united nation. Territorialism and communalism are slowly disappearing and in all things that matter India's outlook on life and things to-day is a world outlook compared with her erstwhile narrow and provincial outlook. Indian schools and colleges modelled on Western lines and the tremendous influence of the West and particularly that of Great Britain are spurring India on towards ultra-modernism. India's superstitions and ignorance, her racial differences and communal animosities will all be soon things of the past and by quick degrees, whether she likes it or not, India will be 'modern' in every sense of the term like her sister nations of the world.

The question now arises—and it is a very important question—has Hindu law kept abreast of the tremendous strides India has made towards advancement in recent times? Has the progress of Hindu law been commensurate with the growth of modern India? Is not Hindu law obsolete and must therefore be scrapped?

The answer to these questions must necessarily depend on what the Hindu law is to-day and what India is to-day. We have seen in the foregoing paragraph that India is tending to be modern, and is already quite modern in many respects. Can the same be said of Hindu law? Emphatically 'No'. The origin of Hindu law goes back to several centuries before Christ—to roughly about 1280 B.C. The Hindus claim that it is mainly divine in its origin, being the revelation of inspired seers and the institutes of revered Sages handed down by word of mouth from generation to generation. It is also human in this that at a later stage the approved and immemorial 'usages' of the people supplemented the divine law of India. It was on these lines that Manu and Yajnavalkya propounded Hindu law nearly three thousand years ago. The principles underlying them are indeed sound and even remarkable when one considers that they were the results of human thought as early as 3,000 years ago. In a law such as this there would be indeed no holes to pick if Indian society had remained stationary these 3,000 years, but time has considerably altered the whole fabric of Indian society and Indian thought and the application of Hindu law to 'New India' is like putting new wine into old bottles or hitching the 'Flying Scot' on to a goods wagon. If Manu were only to come back to life and see for himself aeroplanes and motor cars sweeping past him, the extraordinary change in Indian manners and customs, the miraculous linking up of places and communities, the incredible merging of races and castes, and the astonishing tolerance and laxity in religion, he would surely offer profuse apologies for conspiring with the other law-givers of his time to bind hand and foot Hindu society by a set of rules known as the Hindu law which while on the one hand helped to solve legal problems at the time, has on the other tended to enslave Hindu society for ever. The Hindu is a born conservative and being a zealous stickler for religion he prizes the Hindu law which is based on Hindu religion as a priceless gift from God, and would sooner die than in any way attempt by word or deed to belittle the Hindu law—to do which, according to him, would be nothing short of blasphemy. True he is himself modernised every day, but out of respect for his religion and a sneaking regard for all that is 'ancient' he would far rather let himself be judged by the antique law of India than submit himself even in the slightest degree to any departure from it. This is indeed the reason why all these 3,000 years the Hindus have silently suffered themselves to be judged by a law which at its best is a 'curiosity' and at its worst a 'hindrance' to the progress of India. It is for the same reason too that no modern Manu in the shape of a law reformer has dared to come yet on the scene.

It may be asked in what respects the Hindu law as administered to-day is defective and unsuited to modern thought and requirements. It is a question that by its nature necessarily involves a thorough discussion from line to line and page to page of all the standard treatises on Hindu law, beginning with the sources right up to the recent 'decided cases' and the latest legislative enactments. In an article such as this, it is not possible to delve deep into the subject and the only way it can be answered is by a sweeping generalisation of a few glaring defects which might afford sufficient thought for the budding jurists to ruminate upon and the powers-that-are to ponder over. The main purpose of this article is to set up a healthy controversy over the subject of Hindu law and create such an interest among the legislators, judges, politicians and students of India that it might inevitably result in the administration of a more modern law than that which is at present in vogue.

First and foremost the Hindu law is defective in point of time. Three thousand years have made a world of difference to India and it seems ridiculous at the present age to try to conform to modes and methods, faiths and beliefs, and customs and manners of centuries before Christ. India has moved since then and moved so swiftly that should the graves by some freak of nature give up in flesh and blood the ancient authors of Hindu law, they would slink back to their holes with fright at the sight of a land and peoples that they could not recognize.

The next most baffling and bewildering thing about the Hindu law is its different schools and the consequent lack of uniformity. It was all right in those days when a province was a separate unit with no earthly chance of contact with the neighbouring provinces. Now they are all interlinked by means of rapid transport and communication with the result that the different schools have overlapped to such an enormous extent that the maintenance and preservance of different schools intact, and the application of special and exclusive laws to separate and different provinces have tended to cause confusion which is being made worse every day by inter-racial and inter-communal marriages, immigration of peoples from one province to another, the births of new religions, the adoption of new customs and manners, and the increasing change in the daily outlook on life. It is time the Bengal, Mithila, Benares, Bombay, Madras and the Punjab schools were completely scrapped and the broad divisions that they fall under, namely the Mitakshara, Dayabhaga and Mithila, were further reduced to one common uniform school to which the whole of India could easily conform without confusion.

In regard to the law of succession and inheritance, there is a great deal of confusion and ambiguity. It often arises with regard to tracing relationships from the propositus. The method of determining relations such as Sapindas, Sakulyas, Samanodakas, Sagotras, Samana Pravaras and Bandhus by means of what is known as the 'funeral oblations' or 'Pinda Theory' must go and

an up-to-date and modern method must be substituted. The Hindus are gradually discarding their caste marks and most of them are even giving up their daily 'Pujas'. The 'Pindas' therefore are also bound to go if they are not already gone sooner or later. How then relationship is going to be determined in the future? In a country like India where there are no such things as baptismal registers to record names or ages and where parents do not bother to record in writing the names of their own children for future reference or guidance, it is extremely difficult to trace one's relations up to the seventh or fourteenth degree as required by the Hindu law for purposes of inheritance, marriage, mourning or adoption and the genealogical tree affords great scope and temptation for an ambitious adventurer or 'impostor' to creep into the family tree as an agnate or cognate. It is such frauds, ambiguities, confusions and uncertainties that have unquestionably made India the most litigous country in the world. As for women, there has been no attempt to improve their lot either as property holders, inheritors, wives, mothers or widows, and all the way through they play a passive part rather than an active part, and in many respects treated more as chattels than human beings with a will of their own. Talk of 'equality of sexes' and 'fair play' for all, it is all moonshine according to the Hindu law and till the Law that has doomed them to eternal serfdom and slavery is reformed there seems to be no hope at all for the women of India.

The joint family system deserves condemnation. It makes idlers in the family more idle and the ones with initiative and courage, less enterprising by its restrictions and cautious and meagre distribution of funds for domestic or business purposes. In modern parlance it is a sort of 'dole' which encourages 'unemployment' and breeds sluggish ways among its component members. The young man grows up to be a 'ninny' with his eyes always fixed on the 'family property' and actually collapses when it is wrested away from him or he is wrested away from it. It is a system which often encourages the living of fifty or more members of one family in a small ill-ventilated, insanitary dwelling place with no privacy or seclusion and with no earthly chance for thinking, studying, or developing one's individuality. The only 'recreation' of the members consists of quarrelling or squabbling over their respective shares. Can you wonder why the Indians have not had much time or opportunity for mechanical or industrial invention.

The Hindu law as we have seen is based primarily on religion. In as much as religion is not uniform in India, there are bound to be irregularities in the law which originates from it. Superstitions in many instances have assumed the garb of religion and stealthily crept into it; customs of an objectionable nature have also found their way into it. Take for instance the question of sonship: There are fourteen kinds of sons! Son by a concubine, son born of an unmarried girl, and son born in secret are all embraced in the generous arms of Hindu law. It is not the morality of it that worries one but the confusion arising when property has to be 'inherited'. Similarly there are 'approved' marriages and 'disapproved marriages' and one of the 'approved' forms of marriage consists of the giving away of the girl in lieu of fees to a bridegroom who officiates as priest in a sacrificial ceremony. Yet another 'approved' form of marriage consists of the giving away of the girl by the father to a bridegroom in return for a pair of cattle! Of the 'disapproved' forms of marriage which are not actually invalid two may be mentioned, namely: (1) The sale of a daughter and (2) the capture of a girl after her relatives have been killed or wounded. Polygamy, concubinage and child marriages are instances of further evils in Hindu law that must be eradicated. The forbidding of inter-racial or inter-caste marriages and the deliberate tendency to keep down the Sudras and the depressed classes are also instances of injustice that are highly to be deprecated in the Hindu law. The effect of all these, it may be noted, has been to split the Indian race into hundreds of sects, castes and divisions and keep them always apart in such a manner as to make them a disunited, disjointed nation incapable of combining or uniting for the common welfare of India. It is a thousand pities that India's backwardness and slow progress have after all got to be traced to its own self-imposed laws which have gripped her as it were in a vice and enslaved her these many centuries.

The jurists who have justified the existence and continuance of Hindu law from time to time have argued that Hindu law is never stationary but always advances with the times with every legislation and every decided case. It is a poor consolation to satisfy oneself on these lines because the legislature does not often

dare interfere with the religion or the customs and manners of the peoples of India and what interference there has been from this quarter is totally negligible. As for 'decided cases' being a source of law and a help towards modernising the Hindu law, they have certainly helped to increase the quantity of the Hindu law but not the quality which is the same as it was in the days of Manu. The bench have scrupulously clung for ages to the principles inculcated by Manu and his followers and the result is that apart from the fact of the law being stated more clearly in 'decided cases' there is no radical change so far as the law itself is concerned and the tendency of the bench to cater for the religious, customary and superstitious idiosyncrasies of Hindu law have been singularly marked and definitely pronounced. And what is more the heaps of decided cases which are often in conflict with one another and which have helped to swell the bulk of Hindu law to a ridiculously monstrous size have added new difficulties and made confusion worse confounded. For instance for every 'decided case' that a counsel for the appellant cites before their Lordships of the Privy Council in order to substantiate a point of law, the counsel for the respondent perhaps cites two or more 'cases' in support of his contention which are diametrically opposed to that quoted by the counsel for the opposite side, which only go to prove the conflicting nature of the 'decided cases' and their lack of uniformity. They are certainly no help to the judges or the counsels and if anything they are a source of annoyance to the bench and the bar.

What then is the remedy?

I say emphatically—modernise the Hindu law, simplify it and standardise it. Scrap the unnecessary elements retaining only those that are absolutely useful and necessary. Purge it of all ambiguities and superstitions and customs and manners that are objectionable and let legislation play a free hand at giving it a perfect trim. Codify the 'Case Law' and reduce its bulk to the absolute minimum commensurate with legal requirements. Make it more secular and less religious. Strive at uniformity all over India and abolish all things that are out-of-date and obsolete that tend to retard India's progress. In a word pull 'Hindu law' out of the rut into which it has fallen and give it a new start on modern lines, that it may be of real service to the India of to-day.

Perhaps a commission of legal experts can devise ways and means to draw up a scheme for modernization and standardization of Hindu law. Why not bring such a commission into existence at once? It would be splendid if at the same time as the Supreme Court comes into being in the future Federal Constitution of India that the new Hindu law is also brought into effect. There is no question that the reformation of the Hindu law is an urgent necessity and India awaits with eagerness the advent of a modern Manu.

GAMMA RADIATIONS AND ATOMIC NUCLEI

BY

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During the last four years our stock of information concerning the relation between radiations and atomic nuclei has considerably increased. This can easily be seen when we compare what we actually know, with what was known in 1930, when the standard book on the matter: 'Radiations from Radioactive Substances' by L. Rutherford and collaborators, was published. This volume constitutes a real landmark in the history of the researches on atomic nuclei: not only has it gathered all the main results and what led to it, up to that time, but it also pointed the way to future researchers by emphasising some theories just cropping up at that time, as well as by suggesting original explanations for some up to then unexplained facts. Some of these suggestions have by this time become almost a matter of course, which shows the insight and foresight of the authors, as well as it goes to prove the thesis that new theories most naturally follow upon and are but the outcome of newly discovered facts, which although at first suggested by the older theories, when examined in detail are found not to square exactly with them.

This article claims no originality, except in so far that it brings together facts and theories which are only found scattered in a multitude of articles in different reviews.

I. RADIOACTIVE DISINTEGRATIONS

'We have little if any definite information on the internal structure of nuclei to guide us', thus wrote the authors of the above cited book (p. 524). Even now, it must be confessed, we have little definite information on this subject, yet undoubtedly a wealth of experimental data has been accumulated concerning the interactions between atomic nuclei and γ radiations.

Up to 1928, all what was known about these radiations, was that in the radioactive disintegrations they proceed from the nuclei themselves and do not originate from a change in the levels of the outer electronic structure. It was also known that many of the β particles originating in these same disintegrations, were due to these very γ rays, which projected the outer electrons out of the atom by a process similar to that of the photoelectric effect. This discovery afforded an excellent method of studying the γ radiations by their β ray spectra. For α and β radiations can easily be studied, because, being electrically charged, they can be deflected by means of a strong magnetic field. In this way from the curvature of their respective paths for a given field, the intensities of the different radiations can easily be studied. γ radiations, being of an electro-magnetic nature, cannot be studied in this way. However since they give rise to β rays and to β rays of different energies, as can easily be understood from the analogy with the ordinary photoelectric effect, it was found possible to determine the energy of the different γ radiations by examining and measuring the β ray spectrum they produce.

That such measurements go not without many difficulties and complications, can easily be gathered from the masterful exposition of this topic in the already referred to book of Rutherford. By dint of patient labour much information has thus been gathered and is still being acquired concerning the various γ radiations emitted by different radioactive substances.

Besides the method just referred to and known as the excited corpuscular method, which is an indirect method, there exists another direct method, the crystal method, where the wavelength of the γ radiations is measured in a way similar to that used in X-ray spectrography. However the difficulty in the case of γ rays was much greater because of the extremely small glancing angles required for such high frequencies as those of the γ radiations. Thus the Frenchman Frilley measured a γ ray of wavelength about 16 X. U., (X. U. $= 10^{-11}$ cm.), which radiation has a glancing angle of less than 10 minutes and is but feebly scattered by the crystal. However these experiments were extremely useful because they showed the reliability of the relatively easier but indirect way of the excited corpuscular method. At the same time these last experiments constitute a corroboration of the Einstein photoelectric equation as well as of the above given explanation of the β rays emission in radioactive disintegrations.

Having in this way obtained a lot of information about those γ radiations, the next question was to explain their origin. As we have said, it has been proved that they must originate in the nucleus itself. Several explanations have been proposed, of which the latest was simultaneously proposed by Gamow and by Gurney and Condon. This theory, based on the Wave Mechanics, has proved very useful, at least in its general outlines. It was devised to explain the origin of α particles from radioactive nuclei, and in particular to interpret some contradictory conclusions deduced from measurements on the scattering of α particles by heavy radioactive substances on one side and from measurements of the energy of the α particles emitted by these same substances. For it was found that the values for the size of the uranium nucleus as deduced from these two sets of experiments do not agree. These contradictory results were difficult to reconcile on the basis of the classical theories, however the new Quantum Mechanics afforded a ready explanation. In this theory, it is supposed that the atomic nucleus is made up of a heavy central core surrounded by lighter elements, mainly α particles with a few neutrons and possibly a proton. The whole of this aggregate having only a radius of the order of 10^{-12}, all these elements are very closely packed and must be kept together by still unknown forces. The stability which is thus brought about, is rather to be compared with that of a waterdrop, inside which the various forces neutralise each other, whilst all around they constitute a kind of protecting sphere. These internal forces are attractive forces, varying inversely as the fourth or fifth power of the distance from the centre. Superposed on to these forces, is the ordinary repulsive Coulomb force, whose effect is prominent at farther distances from the centre. There will therefore be a critical distance R_0, for which both forces will have equal absolute values; this is the potential barrier of the nucleus. Suppose an α particle is fired at the nucleus, possessing sufficient energy to overcome the repulsive force even at its strongest, then it will cross the potential barrier, and once inside, it will be strongly attracted towards the centre. The same holds good for an α particle which is originally inside: unless it possesses sufficient energy to overcome the strong attractive forces, it will not be able to cross the potential barrier. At least this is the conclusion according to classical Mechanics, but according to

Wave Mechanics, we can only with a certain degree of probability foresee the position of a particle in a given field of forces, such as the one that prevails inside the nucleus. This probability depends on the momentum of the particle and on the intensity of the field at that point. Hence it follows, that there is a certain probability for the particle of being found in regions where according to classical Mechanics it could not possibly exist. On the score of this, Gamow calculated the probability for a given α particle of escaping from a given nucleus with a given potential. He thus found back the empirical relation of Geiger Nuttal, which connects the probability of disintegration of an atom with the speed and hence the momentum of the emitted α particle. This theory was then further expanded by Gamow to explain certain unexpected phenomena, which had been discovered concerning these α particles emitted during the radioactive transformations.

Until very recently it was believed that each radioactive substance emitted but one characteristic mono-kinetic α radiation, that means that all the particles are expelled with identical speed. In fact the magnetic spectrum method by which these radiations were studied, showed only one characteristic line for each substance. However the resolving power of the instruments used was rather limited, so that small differences in the α radiations could not have been detected. Only a few rare observations seemed to contradict the above statement. As far back as 1910, attention was drawn by Miss Blanquies on some abnormalities in the Bragg's absorption curve of α particles from AcC, which, she suggested, might be explained by admitting α particles of various ranges. In 1916 Rutherford and Wood, definitely observed long range α particle emitted by ThC. Since then many experiments were carried out investigating this point, so that finally all doubts about it were removed and it was definitely established that these long range α particles are of nuclear origin like the others.

It is interesting to read in Rutherford's book a first tentative explanation of this phenomenon, much of which was in fact taken up in Gamow's interpretation: "we may suppose that the long range particles do not exist in the nucleus with their abnormally high energies, but that they are particles of the normal groups which have received in some way, just before their ejection, an extra supply of energy" (p. 94), although the main idea is similar to that of Gamow, yet it may also be said that Gamow's explanation is just the other way about, in so far at least that for him the long range particles alone show the real energy possessed by all the α particles when they are inside the nucleus in the normal state. Gamow was led to his theory by the more refined researches on the velocities of the emitted α particles. One way consisted in improving the magnetic spectrum method, this was done chiefly by Rosenblum and collaborators with the help of the large Paris electro-magnet, which gave constant fields over relatively large areas. (Journal de Physique, I, p. 438). He used and perfected the focussing method and thus succeeded in obtaining sharp and well defined lines. In this way he discovered what has been called the fine structure of the magnetic spectrum of α particles. Rutherford and collaborators used a counting method, depending on the linear magnification of the ionisation current, due to a few millimetres of the track of an α particle. The momentary current, amplified by means of valves, was recorded on a photographic film by a special oscillograph. By using a double ionisation chamber, it was found possible to record only those α particles which were stopped in the shallow ionisation chamber. (Proc. Roy. Soc., 131, p. 702, and 129, p. 217). In later experiments (Proc. Roy. Soc., 139, p. 617), Rutherford combined the focussing method of the magnetic spectrum with a direct electrical counter amplified by means of thyratrons. The experiments were conducted with the greatest accuracy, so that a high precision could be claimed for the measurements, evaluated at 1/5000.

All these experiments as well as many other varying in technical details, have led to the conclusion that at least many of the radioactive substances emit several groups of α particles of different velocities. These differences in the velocities, were carefully studied by Rosenblum in the case of ThC, and before Gamow published his theory, he had the idea of comparing the different energies of the α particles with those of the γ radiations emitted by the mixture Thc $(C+C'')$, he had thus found some striking connections between the two kinds of radiations. However Gamow was the first to suggest a well defined explanation of this relation between the two radiations apparently emitted at the same time.

According to Gamow, and contrary to Rutherford's suggestion quoted above, initially all the α particles exist in the same fundamental state inside the potential barrier proper to that nucleus. When disintegration occurs, as explained above in Gamow's theory, this may take place in two different ways. In the first case, the α particle is simply emitted, and then its kinetic energy, which will be that of a long range particle, corresponds to the energy it possessed inside the nucleus in the normal state. In the other case, a secondary intra-nuclear change has first taken place: before the emission the nucleus is excited, for instance by the emission of a β particle, and all the α particles are no longer in the same energy state, so that in this case the α particles emitted will have various energies. Since the nucleus cannot remain long in an excited state, by returning to the normal state, it will emit its surplus of energy in the form of a γ radiation. The energy of this last radiation will of course be equal to the difference in energy between the two or more kinds of α radiations which the nucleus emits when in the excited state. (Proc. Roy. Soc., 136, p. 752). This theory of Gamow therefore explains the relation between α rays and γ rays in the same way in which the spectra of optical and X rays are related to the outer electronic structure of the atoms.

As was said, upto these last months, many and varied experiments have been carried out to study the fine structure of the α radiations, and along with these, as soon as Gamow's theory showed the relation between this fine strcture and the γ rays, a whole series of experiments was started to study the energy as well as the intensity of the various γ rays emitted by the radioactive substances that emit γ particles, in order to test quantitatively the truth of Gamow's theory.

In certain cases, the fine structure of the α particles was discovered first, and afterwards the γ radiation, which should accompany it, was looked for, and, when discovered, its measured energy was collated with the calculated value. In other cases it was the γ radiation or radiations that were first discovered and then the corresponding fine structure of the α radiations was looked for. The experiments however were not always successful, the reason being that at times the intensity of the expected radiation when compared with the principal radiation, is so

small that it is almost impossible to detect it. A few examples out of many will show this very clearly.

Lewis and Wyn-Williams had found that the α rays from actinon were complex, consisting of two groups differing in energy by about $3'5 \times 10^5$e-volts, about 16% of it being emitted in the lower velocity group. (Proc. Roy. Soc., 136, p. 349). Rutherford and Bowden, on receiving this information, by means of an ingenious experiment looked for and found the γ radiation corresponding to this complexity of the α rays emitted by actinon (Proc. Roy. Soc., 136, p. 407). From absorption measurements they derived a value for its energy of the right order to be expected from the difference between the energies of the α particles. However very accurate measurements could not be made, because the sources of actinium available were not strong enough.

Already in 1930, Bothe and Becker, during their famous researches which finally led to the discovery of the neutron, were led to examine whether polonium does not emit a γ radiation. They succeeded in discovering it, however its intensity is very small so that it is not astonishing that so far the corresponding fine structure of the α rays emitted by polonium has not been observed. (Zeitschrift fur Physik, 66, p. 313.)

The most interesting example in this series remains that of Th(C + C″) which in fact led to Gamow's theory, and which was therefore studied in great detail by many different researchers. Thorium C, as is well known, disintegrates in two different ways. Only one of these interests us here, the one in which by emitting an α particle it becomes ThC″, which then by emitting a β particle becomes lead. Since ThC″ is very short-lived, it is very difficult to examine the disintegration of it separately, so that it is difficult to verify, what was generally admitted, that the totality of the γ radiations emitted by the mixture Th (C+C″) is exclusively due to the disintegration of ThC″. Rosenblum by his refined methods discovered that not only ThC′, but also ThC emits several groups of α rays. Gamow from this inferred the existence of a corresponding number of nuclear α particle states, and concluded that ThC also should emit γ radiations. To test the truth of this a priori statement many researchers set to work, especially Ellis at Cambridge and Meitner in Germany. Ellis examined the β ray magnetic spectrum of the recoil atom of ThC″, thus separating them from the mixture Th(C+C″) and compared this spectrum with the similar spectrum of the mixture. By discussing the absence of some lines in the latter spectrum as well as the difference in intensity of some of the lines present in both spectra, he came to the conclusion that some of the radiations giving rise to these lines were produced immediately after the disintegration of Th C and before the disintegration of ThC″, in agreement with Gamow's theory. However Meitner as a result of her experiments, concluded at first to the contrary. This was at the end of 1931 but in 1933 Meitner and Philipp measured again the magnetic β ray spectrum of an intense source of ThC″, isolated from ThC', and found that some of the lines due to Th (C+C″) are absent in the spectrum of Th C″ ; hence this time they arrived at the same conclusion as Ellis, corroborating Gamow's a priori deduction based on Rosenblum's discovery of the fine structure of the α rays emitted by ThC.

These and similar researches have led to admit at least as a working hypothesis the theory of Gamow that the penetrating γ radiations emitted by radioactive substances are due to different states of the α particles in an excited nucleus. As Ellis remarks (Proc. Roy. Soc., 136, p. 751), the above theory is based on the assumption that the principle of the conservation of energy applies to the nucleus, or better, to that part of the nucleus which is associated with the emission of α particles and the emission of γ rays. In both cases, what has been established, is the equivalence of the total amount of energy emitted when this energy can be divided. Either an α particle carries away all the available energy, or if it takes only part, the remainder is emitted in the form of γ rays. A more detailed explanation is still to come. In particular how to account for the excitation of the nucleus, which seems to be due to the emission of a β particle, whilst the emission of an α particle hardly produces any change, except at times a shift of an α particle from a lower to a higher energy level accompanied by the emission of a γ radiation of corresponding energy.

In connection with this problem it may be interesting to mention a recent attempt of Gamow to explain the γ excitation of the nucleus in the case of a β disintegration (Nature, 131, p. 57, January 1933). He assumes that every nucleus is built up of α particles, neutrons and, for elements of odd atomic number, one

proton. All the α particles are placed on the same energy level, two on each. Suppose now that for one reason or other one of the nuclear neutrons is unstable, and, releasing an electron, is transformed into a proton. This will rather happen to a neutron in the higher levels, because here less work will be required to extract the electron from the nucleus. The proton thus formed, being on a high level will fall towards the centre, and in doing so will emit a γ radiation. This would explain why the β disintegration is often accompanied by the emission of hard γ rays.

Of late some more precision has been obtained about the different energy levels of the α particles inside an excited nucleus, by extending to these levels, considerations at first applied only to the outer electronic structure of the atoms. As we have said, the γ radiations emitted by radioactive substances are often photoelectrically absorbed in one of the electronic shells of the atom, and thus produce the β ray spectrum characteristic of the energy of the exciting γ ray. The probability that the γ ray will be absorbed by one of the planetary elements of the atom is called the internal conversion coefficient of that γ ray. If we call a this coefficient, and A the probability per unit time of the emission of a γ ray by the nucleus, then the number of electrons ejected per unit time is Aa, and the number of quanta escaping unabsorbed is A (1-a). What is actually measured by experiment is the ratio A/(1-a), from which a is then deduced. Ellis and Aston have obtained such values of a for certain γ rays from RaC and RaB. In December 1932, two theoretical calculations of this conversion coefficient were published by Hulme and by Taylor and Mott respectively. Hulme considered the radiation field of an excited nucleus as that of an oscillating dipole, that is the field emitted, according to Quantum Mechanics, by a radiating system in transitions in which the quantum number j, specifying the total angular momentum, changes by unity. Hulme made use of the accurate relativistic wave equation and thus succeeded, much better than previous authors, in deducing theoretical values of the conversion coefficient which agreed fairly well with the experimental values. However for some radiations, the agreement was less good. To account for these, Taylor and Mott repeated Hulme's calculation for quadripole radiation from the nucleus. A radiating system emits the field of a quadripole in transitions where the quantum number j changes by two, or in certain cases by zero. (P.R.S., 138, p. 665). The authors showed also that octopoles, etc. were extremely improbable. For some rays they obtained values of α quite similar to those obtained experimentally.

This interpretation was made use of by Rutherford, after he had analysed in great detail the long range α particles from Ra C′ by means of an annular ring magnet capable of focussing groups of α particles after these have traversed a semi-circle of 40 cms. radius (P.R.S., 142, p. 347). He thus discovered 12 different groups of α particles. Calculating the corresponding energy levels of the excited nucleus, he found that all the γ rays emitted by Ra C′ can be correlated with these levels, if four other levels are added, which do not correspond to any observed α particle groups. Yet on measuring the relative intensities of the various groups, he found that the excess energies of many of the calculated α particle levels do not correspond to the strong β ray groups of the γ ray spectrum. A satisfactory explanation was found in the theory of the above quoted authors, which classifies the γ rays into dipole and quadripole. Consequently quantum numbers were assigned to the nuclear levels of the RaC′, as had already been done by Ellis and Mott for nuclei of the Thorium series. The internal structure of the nucleus is, in this way at least, made to resemble very closely that of the outer electronic structure of the atom. However the great difference remains that for the nucleus all the particles, α particles, proton and neutrons are packed very closely, and the forces at work there must be quite different from the Coulomb forces in the outer structure.

Thus gradually more information, theoretical as well as experimental, is obtained concerning the excited nuclei of the heavy atoms. A fully detailed and in all points quite satisfactory explanation has not been proposed yet. The reason no doubt is the difficulty of making accurate and reliable measurements which should supply the theorician with data sufficient to build up his theory as well as to verify it by the conclusions he derive thereof.

II. Artificial Disintegrations

Some 15 years ago Rutherford conceived the idea of artificially disintegrating the elements from an attentive stud

of the spontaneous disintegrations which nature is continually displaying before us. In the same way the above theory of Gamow, first excogitated to interpret the radioactive disintegrations, was then most naturally extended so as to interpret some unexpected phenomena which occurred during the artificial disintegrations, and was thus made to throw some light on the internal structure of the nuclei of non-radioactive elements. Sir Hopkins said in picturesque language, at the anniversary meeting of the Royal Society, November 30, 1932 (P.R.S., 139, p. 12): 'The atomic nucleus for a long time had seemed to be an impregnable fortress, but missiles of high destructive power have been gradually contrived by almost magical skill in the army of attack, and the fortress, in spite of its formidable potential barrier is crumbling. It is interesting for the spectator to realise how much is learned by the commanders of the attack from the nature of the missiles (part of itself) with which the fortress replies to the bombardment.' This last consideration is in fact of the highest interest, it is precisely this point we want to expose somewhat more in detail.

Rutherford by directing a beam of powerful α particles in a vessel filled with nitrogen, observed the emission of protons, which he ascribed to the disintegration of the nuclei of this element. This was then further extended to other elements, and it is now known that the nuclei of all the elements from boron to potassium, with the exception of carbon and oxygen, manifest the same disintegration phenomena, when bombarded with powerful α particles. The observations of Blackett with the Wilson expansion chamber made it clear that the emission of protons was really due to the disintegration of the nuclei of the corresponding elements. By accurate measurements of the length and the direction of the tracks of the various particles resulting from the disintegrations, Blackett proved also that the track of the recoil atom after the collision with the α particle, corresponded to a new nucleus resulting from the absorption by the old nucleus of the α particle accompanied by the emission of a proton.

Since the velocities as well as the directions of the various particles before and after the inelastic collisions could be measured with sufficient accuracy, it was natural to apply to them the general laws of such collisions, to see whether the principle of the conservation of energy holds good in this case. Of course the relativistic principle of the equivalence of mass and energy has to be assumed. Hence the equivalent masses of the kinetic energies of the travelling particles had to be introduced into the equations expressing the balance between the energy and mass changes during the disintegration processes. In dealing with such and similar changes, the kinetic energies of the travelling particles as well as the energies of the electro-magnetic radiations, if there are any, are now almost universally expressed in terms of the kinetic energy gained by an electron falling freely between a difference of potential v. in volts. To pass from these expressions to the atomic mass scale (where $O_{16}=16$) it is enough to know that a change of mass 1 on the atomic scale corresponds to 933 million electron volts; reciprocally 1 million electron volts corresponds to $1'07 \times 10^{-3}$ mass units. Similarly the energy of a free electron or a free proton is equivalent to about 311,000 and 964 million e-volts respectively. Since in artificial disintegrations there takes place a breaking up of the old nucleus followed by the building up of a new one, the energy equation will also contain a term referring to the 'packing effect' of the different nuclei, or the mass defect, as it is more commonly called nowadays. In analogy with the radioactive nuclei it is now generally admitted (or at least assumed) that all nuclei heavier than helium, consist of α particles, neutrons and at times a proton, the number of α particles being as large as possible. To bring and keep so closely together four protons and two electrons to constitute one helion, and similarly to make one single compact nucleus with several helions and other particles, strong binding forces are needed. These are got from the constituent particles, the mass of which has slightly diminished. This constitutes the packing effect, and the mass defect is precisely the difference between the sum of the masses of the constituent particles of the nucleus when free and their masses combined into one nucleus. It was calculated that the mass change of a proton from 1'0072 in the free state to a mass exactly 1, involves a change in energy corresponding to 6'7 million e-volts. The mass of an helion being 4'0011, whilst the mass of the four constituent protons and two electrons is 4'0301, the mass defect 0'029 corresponds to an energy loss of 27 million e-volts.

Taking all these data, obtained for a great part from the accurate measurements of Aston with the mass spectrograph, having besides measured accurately the kinetic energy of the various moving particles which take part in the non-elastic collision, Rutherford computed the energy equation to test accurately the balance between the energy and mass changes in the disintegration. This would show whether the principle of the conservation of energy is verified also in the actual case. He applied it in particular to the case of the disintegration of fluorine, for which accurate data were at hand. He found that the mass of the resulting nucleus (a neon isotope of mass number 22) could not be greater than 21'9937, whilst the value for the same nucleus found experimentally is about 22'0048. The agreement was not at all satisfactory and the difference was far beyond the range of error of Aston's measurements. Rutherford extended his calculations to other nuclei and thus discovered that not only there appears an energy change during the artificial disintegrations, but that this change is not even constant for the same kind of disintegration. In collaboration with Chadwick he found that the protons emitted by aluminium when bombarded with α particles, had ranges varying from 12 cm. in air to 70 or 80 cm. If we assume, as is probable, that the range of an α particle is proportional to the cube of its velocity, this corresponds to a variation in the energy of the emitted protons from 0'33 to about 1'1 or 1'2 of the energy of the α particles producing it. Hence in some cases there was loss of energy, in others gain. There appeared to be no other compensating energy change. An explanation had to be found. Rutherford at first suggested that the mass or energy either of the bombarded or of the new 'integrated' nucleus was not constant, or perhaps even both were variable, he suggested that this could be tested by experiments with the mass spectrograph. On the score of his hypothesis of the α particles gravitating inside the nucleus on various levels in a way similar to the outer electrons, he explained the slight variation in energy or mass for the different nuclei of the same element, by saying that the energy levels of the α particles inside the nucleus are not well defined. However such a suggestion seemed difficult to reconcile with the modern views on the nuclear structure and on the energy levels in general. This was perhaps the reason why in Rutherford's book, after the above suggestion, there follows another suggestion or rather a consideration, which, as a matter of fact, contains already much of the explanation now universally adopted. It is therefore worth while to quote it at length: 'In this discussion of the energy relations in the disintegrations it has been assumed that all the energy is associated with the three particles the α particle, the nucleus, and the proton and that no other particle or radiation is emitted in the process. The best evidence that no positive particle is emitted is provided by Blackett's experiments, which refer only to nitrogen, but the emission of an electron or of radiation by the nucleus would most probably not have been detected in any of the observations which have been made. If one quantum of γ ray energy were emitted in each disintegration, the detection of the γ radiation would be a matter of some difficulty even if polonium, which does not itself emit γ radiation, were used as the source of α particles. The above discussion of the energy relations is therefore subject to certain reservations.' (p. 309.) How appropriate their reservations were, the authors realized it even before their book was completely printed, for at the end they added an appendix where they admit that their discussion on the artificial disintegration by α particles needs some revision in the light of recent work (p. 572). The work they alluded to is that of Chadwick, Pollard and Constable, which they shortly expose in that appendix, and which appeared at full length in P.R.S., 130, p. 463. Chadwick and collaborators had undertaken to examine in detail the artificial disintegration produced by α particles, they wanted in particular to measure very accurately the range of the protons emitted. For this they devised a detecting instrument of great sensitivity, thanks to the use of valves. Their work therefore was somewhat similar to that of Rosenblum on the fine structure of the α particles emitted by radioactive substances. We shall see that, like in Rosenblum's case, here also the measurements led to the a priori conclusion that those artificial disintegrations must be accompanied by the emission of γ rays. This was afterwards verified experimentally.

The Cambridge researchers found on bombarding many different elements with α particles, that in all cases, except for fluorine and sodium, the disintegration protons consisted of different groups having each a different velocity. They therefore

suggested that the particles and protons subsist in different well-defined energy levels inside the nucleus. When disintegration occurs, an α particle is captured and f.i. remains in a given energy level $-E_a$, at the same time a proton is emitted from a determined energy level E_a. Supposing that the kinetic energy of the bombarding particle is e , we see that the emitted proton will possess an energy $e_p = e_a + E\ - E_p$, neglecting the small amount of kinetic energy taken by the nucleus. In case there are different energy levels for the α particles and protons, we shall find different values for e_p, the energy of the emitted proton, and this will explain the experimental results, what we might call the fine structure of the emitted proton's spectrum. Chadwick and collaborators suggested also another kind of disintegration, in which the α particle is not captured by the bombarded nucleus, it only disturbs the nucleus so much that a proton is being emitted. Of course to produce such a disturbance, the α particle will have had to give up part or even the whole of its kinetic energy. In this case then the energy of the emitted proton will be given by any value ranging from $e_p = 0$ to $e_p = e_a - E_p$, according as the α particle has lost in the process more or less of its energy. Since in this case the α particle is not captured, the term E_a is naturally missing. Hence it follows, that in the first case, disintegration with capture, we must have a definite group of fixed values for e_p, that is a kind of line spectrum for the energies of the emitted protons. In the second case, disintegration without capture, we shall have a continuous spectrum, since all the values between the two given limits, are possible. These two kinds of spectra were found experimentally by Chadwick, Constable and Pollard, for different substances. We should still a moment more consider the equation $e_p = e_a + E_a - E_p$: we can put it in the form $Q = e_a - e_p = E_p - E_q$. In the first assumption we might have said $e_a - e_p = 0$, neglecting the change in energy inside the nucleus, but, as we have seen, this cannot be neglected. In disintegration processes a change in energy Q, either positive or negative, always occurs. This is precisely the reason why it was concluded that α particles and protons are contained in the nucleus on different and definite energy levels. In some cases of disintegration, notably for boron, the authors had to admit that it could take place in two different ways. For they had observed two kinds of capture disintegrations for boron, in both of which the isotope B_{10} is transformed into a C_{13} nucleus. However in one case this is accompanied by an energy change of $0'2 \times 10^6$e-v., and in the other case there is an energy change of $3'2 \times 10^6$ e-v. The authors therefore supposed that the disintegration with smaller release of energy gives rise to an excited nucleus, which very shortly afterwards changes into the stable nucleus corresponding to the disintegration with the greater release of energy. This explanation was extended to similar disintegrations with different releases of energy, as was the case with aluminium, as already observed by Rutherford. In both cases the final stable nucleus is produced relatively seldom in a single step, hence the long range protons will be relatively much rarer than the short range protons. It looks therefore as if a nuclear transformation is more likely to take place in a series of small steps with corresponding small energy changes, rather than in a single step.

We said that in the case of disintegration with small energy changes, the excited nucleus very soon changes into the stable nucleus, this of course cannot be done without a corresponding release of energy. The authors supposed that this energy might be emitted in the form of γ radiations, for which therefore the frequency could be calculated, since it could be known to what amount of energy it should correspond. This was but a suggestion of those authors, however not devoid of experimental support, since at that time already, Webster at Cambridge had obtained evidence for the production of a penetrating γ radiation, when aluminium was bombarded with α particles from polonium. It should be remembered that it was precisely in the case of the disintegration of aluminium that Rutherford had first found variable values for the energy changes.

Already in 1930, before Chadwick and collaborators published their results, Bothe and Becker from Charlottenburg, had examined carefully the artificial excitation of nuclear γ radiations, as they called their researches (Z. Phys., 66, p. 289). By means of a Geiger counter, taking many precautions, they had thus been able to detect the presence and also to measure the energy of the γ radiations emitted from different elements when bombarded with α particles. Along with the statement of their experimental results, they outlined an interpretation of these, which is very similar to the one published later on by Chadwick, as explained above. They based themselves on Gamow's theory of the atomic nuclei of radioactive elements, and extended it to non-radioactive elements, examining all the different possibilities for a fast α particle to enter a nucleus and excite or even disintegrate it and thus produce an emission of γ rays. Just as Gamow had examined the various cases for an α particle which is inside the nucleus, to get out of it, with the possible emission of γ rays which might follow upon it.

Bothe and Becker found that in the case of boron, the energy of the emitted γ radiation, $2'8 \times 10^6$e-v., was in fairly good agreement with the energy difference between the two kinds of protons emitted in the disintegration of this element, as was said before. They found many more concordances of this kind.

Webster published his results only in 1932, in the meantime he had been able to improve considerably the accuracy of his measurements. Making a thorough discussion of all the possible causes of error, he calculated his final values, taking into account the various corrective terms. (P.R.S., 136, p. 428.) On many points he confirmed the observations of Bothe and Becker, and thus also the above theory about the internal structure of the nuclei of non-radioactive elements, in every point similar to that of the radioactive elements, except that in the case of the former, the probability for an α particle of escaping spontaneously from the nucleus, is practically nil. Webster also confirmed Bothe and Becker's discoveries on another important point, which was the beginning of a great discovery. Like them, he found that the energies of the γ radiations emitted from the different elements varied very widely, ranging from a few hundred thousand to several million e-v. However it was difficult to be very precise on this point, owing to the various corrections which had to be applied, as well as to the feeble intensity of the radiations observed. Beryllium and boron were found to emit γ radiations of very great penetrating power, in fact higher than that of any γ radiation known so far. Beryllium also was the element which emitted a relatively large amount of those radiations, so that researches on this element were somewhat easier and also more reliable.

For these very penetrating radiations, the above interpretation did not yield values quite in agreement with the experimental results.

In the meantime, I. Curie (daughter of the famous Mme. Curie) together with her husband F. Joliot, had taken up the experiments of Bothe and Becker, observing the emitted radiations by passing them through an ionisation chamber, mounted over a very sensitive Hoffmann electrometer (J. de. Phys., iv, p. 21). As α particles-source they used one of the most intense sources of polonium ever used so far: 100 millicuries, emitting some 2×10^6 α particles per second. A magnetic field could also be applied, normally to the axis of the cylindrical ionisation chamber. In this way they examined the radiations emitted by beryllium, boron, lithium, when bombarded with α particles. They first confirmed the discovery of the hard radiations: they found that the Po + Be radiation is only half absorbed by 4'5 cm. of lead, that of Po + B by 3 cm. They found the penetrating power to be intermediary between that of the ordinary γ radiations and that of the penetrating cosmic radiations. Hence the interest of the discovery: on one side it might throw some light on those mysterious cosmic rays, on the other side it tended to fill up a gap in the now very extended gamut of electro-magnetic radiations. The energy of these new radiations being so great I. Curie and Joliot thought that perhaps they would be powerful enough to produce transmutations in the lighter elements, just like α particles. Therefore they interposed on the path of those rays to the electrometer, screens of different substances. The idea was that in case of phenomena of transmutation, the particles, α or H, thus emitted from the nuclei would increase the ionisation in the chamber above the electrometer, this ionisation being added to that due to the γ radiations. They found on using screens of many different substances, such as Pb, Ag, Cu, Al, paraffine, that only a noticeable increase in the ionisation occurred when the substance interposed contained H atoms. In particular in the case of paraffine, they found that the ionisation current was doubled. By absorption methods and with the magnetic deflection method, it was easy enough to determine that the new ionising particle expelled by the photon from the paraffine was an H particle. However from this they did not conclude that some transmutation had taken place, since to produce H particles, it was necessary to put on the path of the radiations a substance containing already such H particles. It was then examined whether other nuclei could also be expelled

by this method. Experiments were made with helium first and then with other substances. It was found that in general all atomic nuclei are expelled by these penetrating Po + Be or Po + B radiations. The expansion chamber was used so that the phenomenon might be made visible. These experiments then showed clearly that the expulsion of nuclei is due not to an ionising corpuscle, for there was no luminous track of droplets from the top of the chamber up to the point where a short track is suddenly seen to start and which is due to the expelled proton or other nucleus. These tracks suggested the idea of an effect similar to that of the Compton effect: in the actual case, a γ radiation of great penetrating power, by impinging on an atom, would strike off an electron; the ejected particle whether H or α, or any other, would constitute the recoil atoms, whose ionising tracks were observed in the Wilson chamber. However the conclusions derived on this assumption seemed difficult to reconcile with the experimental results. Therefore Chadwick decided to examine in detail the properties of those radiations excited in beryllium. The ionisation current amplified by a series of valves, passed in an oscillograph, and gave then a deflection proportional to the ionising power of the expelled particles, which passed through the chamber. He definitely called these particles the recoil atoms, and observed them for different gases, thus confirming Curie's discovery that the radiation ejects particles presumably from all elements. From measurements of the energies of these expelled particles, he concluded that it is impossible to ascribe the ejection of these particles to a recoil from a quantum radiation, at least if energy and momentum are to be conserved in the collisions. Indeed he found that for the ejection of an H particle the radiation required should possess a quantum of energy of about 55 million e-v., for the ejection of a N particle 90 million, and thus larger and larger quanta as the mass of the struck atom increases. It should be remembered that Bothe and Becker had measured for the energy of the quantum a value of some 14 million, whilst Webster taking into account various corrections, concluded to a value still considerably lower. Chadwick had the genial idea of using a suggestion made by Rutherford in 1920 as to the possible existence of a neutron. From the above considerations he concluded that all the difficulties disappear, both with regard to frequency and transfer of energy, if we suppose that the Po+Be radiation is not of electro-magnetic nature but is of corpuscular nature, consisting of particles of a mass nearly equal to that of the proton. To explain their great penetrability, which makes them so similar to γ rays, it is further necessary to assume that these particles have no net charge. We may suppose that such a particle is made up of a close combination of a proton and an electron, the 'neutron' as foreshadowed by Rutherford in his Bakerian lecture of 1920. The proton and electron are so closely combined that even in the immediate proximity of the particle, their respective charges cancel each other's effect. Such particles will of course be able to pass very close to the nuclei without being affected by the electric charge of those nuclei, hence like the photons they will have great penetrabilities. In the same way the ionisation they produce will be very small and thus is explained the fact that their path is not visible in the expansion chamber until they collide with a nucleus.

It is superfluous to expose more in detail the well-known researches of Chadwick, Feather, Dee and others on the neutron and its various properties, in particular its disintegrating powers, as clearly shown by Feather's photographs with the Wilson chamber. All this is too well known and also would not be directly to our point. It is however necessary to remark here that Bothe and Becker's suggestion as to the electro-magnetic nature of the radiation they discovered, in their experiments, is not to be abandoned, as might be concluded from the neutron theory. These same German scientists in 1932, succeeded in showing that with their detecting apparatus (a Geiger counter) the radiation they observed in the case of boron, was undoubtedly of electro-magnetic nature and must be connected with the two kinds of protons emitted by boron, as explained. In the case of beryllium, they admitted that the radiation observed by them, was mainly made up of neutrons. (Z. Phys. 76, p. 1616.) Later on they showed that by varying their experimental arrangements, they could at will measure either the neutrons or the γ radiations.

I. Curie and Joliot, besides confirming these conclusions (J. de Phys., iv, p. 278) observed that in the case of beryllium, the emission of neutrons is accompanied by very hard γ rays. From those observations Chadwick concluded that the emission of γ rays and neutrons are not independent and are probably

related in a manner similar to that in which the γ rays emitted by boron are related to the protons emitted at the same time. This supposition was confirmed by the experiments of I. Curie, Joliot and Savel (Comptes Rendus Acad. Sc. Paris, 194, p. 2208). They observed that the protons emitted from paraffine by the Po+Be radiation had different ranges, these could be separated mainly in a stronger group of range about 28 cm. and a weaker group of range 70 cm; this corresponds to a maximum velocity for the neutrons of $2'9 \times 10^9$ cm/sec. and $3'8 \times 10^9$ cm./sec. respectively. The proposed explanation is that two kinds of disintegrations may take place: either there is emission from the Po+Be source of a neutron with the higher energy, or the transformation takes place in two steps, there being first the production of an excited nucleus with the emission of a neutron of lower energy and soon after the excited nucleus changes into the normal nucleus with an emission of a γ ray of energy corresponding to the change in energy. At the end of his discussion on this point, Chadwick concludes that the evidence now available is yet inconclusive. (P.R.S., 142, p. 1.)

The experiments on the artificial disintegrations with neutrons are of some interest for our subject, since here again the question of the emission of γ rays has been raised when more accurate observations became possible. It is in particular N. Feather who studied the collision of neutrons by stereoscopic photography of the tracks produced in an expansion chamber filled successively with different gases. His first studies went only to confirm the neutron theory, but after that he studied in detail the nature of the collisions. Of this he published a preliminary account (P.R.S., 142, p. 689) in November 1933, wherein he mainly states the data as obtained by direct experiment, without much discussion about the general problem of the nature of these collisions. There are however some explanatory suggestions in one of which, to obtain an exact balance of mass and energy in one kind of nuclear reactions, he requires the emission of a high energy γ radiation, accompanying such a disintegration.

We have already so often come across such a suggestion whenever more accurate measurements are at hand, that the extension of it to the case now considered, is quite natural, as Feather also concludes: 'experiment appears to show that the emission of energy in the form of radiation is a feature common to the different types of capture disintegration of light nuclei'. However so far no good experimental evidence has been obtained in the present case.

The truth of Feather's remark can be seen in the case of quite another kind of artificial disintegration, initiated only of late by Cockroft and Walton, where the elements are bombarded by fast travelling protons. As Cockroft declared it (J. de Phys. iv, p. 421) the idea of such a method of disintegration could never have been thought of in the classical Quantum Mechanics, because according to this theory no sufficient energy could be communicated to a proton to make it cross the potential barrier of the nuclei. But with the ideas of Wave Mechanics applied to the atomic nucleus as done by Gamow, for a proton endowed with energy as can be communicated to it in our laboratories, there is still a certain probability of penetrating inside the nucleus, this probability increasing of course with the energy possessed by the proton. As is sufficiently known, artificial disintegrations were thus produced, just as with fast travelling α particles, since the discovery of the heavy isotope of hydrogen, even these diplons have been used to bombard elements and thus to disintegrate them. (P.R.S., 137, p. 229; 141, p. 259 and 141, p. 722). The interest of these experiments for our subject is that here again and quite naturally the question arose of possible γ rays emitted during these disintegration processes. Oliphant and Rutherford (P.R.S., 141, p. 274) having examined more in detail the transmutation of boron by fast protons, suggest that the B'' isotope on capturing a proton, breaks up into three α particles. This means a release of about 11 million e-v. of energy, whilst in their interpretation the total energy released is only some 9 million. There is then again the possibility of the surplus energy being emitted in the form of a γ radiation, the authors say that so far they had no time to search for it.

In their first report (P.R.S., 137, p. 229) Cockroft and Walton had already suggested an emission of such γ rays, to account for the short ranges which they found, when lithium is bombarded by protons. Later even Traubenberg claimed to have detected one γ ray quantum for each disintegration. However this is questioned by Oliphant, Rutherford and Kinsey (P.R.S., 141, p. 729).

More recently still, February 1934, Rutherford and Kempten (P.R.S., 143, p. 724) published a short study on the bombardment of the heavy isotope by α particles. These experiments were conducted to test whether the diplon can be broken up into a neutron and a proton, for this would reveal its internal constitution. No certain evidence has been obtained. It is remarkable that to interpret these negative results, another transformation was suggested in which one diplon would with two helions make three lithiums; here again, by considering the masses of the atoms, it was concluded that a liberation of some 3 million e-v. energy should take place, which, it was supposed, would be emitted in the form of γ rays. So far no evidence of such an emission has been obtained when heavy water is being bombarded with particles.

These last instances go at least to show how the idea of γ ray emission accompanying disintegration processes, has become quite familiar, and how its consideration helps much towards the understanding of the internal structure of the nuclei.

III. Anomalous Absorption of Hard Gamma Radiation

Besides the natural and artificial production of γ radiation accompanying nuclear disintegration, such radiations may also be produced without the destruction of the emitting nucleus. Already in 1921, Slater (Phil. Mag., 42, p. 904) claimed to have found a small amount of penetrating radiation from tin and lead bombarded with particles from radon. Subsequent attempts always failed to detect this phenomenon. In the meantime the subject was tackled along quite different lines, when researches on the absorption of γ rays led to the discovery of a new kind of nuclear γ radiation. To introduce our subject it will be useful to review some points concerning this absorption of γ rays.

Being of electro-magnetic nature and extremely small wavelength, the γ rays have a degree of penetrability much higher than the α or β rays. Their nature was investigated, as we have said, by means of the β ray spectrum they produce. However at first they were studied by means of their absorption coefficient, when passing through matter; in this way a first discrimination could be established between the γ radiations emitted by the different radioactive substances, for it was soon observed that their respective powers of penetrability varied widely. Up to 1930, it was supposed that this absorption was due to two different phenomena only: the scattering or Compton effect and the photoelectric effect. γ rays are found to vary much in quality with the angle of scattering, which corresponds to the Compton effect in the case of X rays. On the other hand like X rays, γ rays manifest the photoelectric effect, in which process the whole energy of the quantum radiation is given to the electron which is emitted as a result of the impact of the photon on the atom. On the contrary in the first mentioned effect, only part of the energy of the quantum radiation is imparted to a recoiling electron, whilst the remaining part is emitted in the form of a γ radiation of smaller frequency. Hence the absorption coefficient of a γ radiation will be made up of three terms at least: two of which represent the conversion of radiating energy into corpuscular energy by the photoelectric and Compton effect respectively, and the third term represents the energy of the deflected radiation. However we shall usually speak only of two terms; $J+\sigma$, the first referring to the photoelectric effect, the other to the scattering effect.

For the ordinary X rays it was found that the photoelectric absorption coefficient per atom is proportional to the fourth power of the atomic number and the third power of the wavelength $J = C\ Z^4\lambda^3$. In the case of the γ radiations, no such simple relation has been found. With regard to the wavelength, it appears certain that the power of λ lies between two and three. L. H. Gray (Proc. Camb. Phil. Soc., 27, p. 103) found an empirical relation between the absorption coefficient and the wavelength, this relation is now universally used to obtain at least a probable value of the wavelength of the γ radiation which is being studied. Since the photoelectric absorption varies approximately as the fourth power of the atomic number, for the same radiation of a given wavelength, the absorption due to the photoelectric effect in a light element, say aluminium will be negligible compared with that in a heavy element such as lead. This is the principle of the method for measuring the absorption coefficients. The absorption in aluminium giving practically the scattering coefficient, which being deducted from the value found in the case of lead, will give the photoelectric absorption coefficient for that radiation in lead.

The binding energy of the outer electrons being negligible in comparison with that of the incident quantum radiation, it is generally assumed that the scattering from each electron is independent of the atom to which the electron belongs. Hence it is usual to calculate the scattering coefficient per electron; this of course, when multiplied by the atomic number will be equal to the scattering per atom.

Like in the case of the photoelectric absorption, many attempts have been made to deduce a theoretical formula for the scattering coefficient per electron in the case of the γ rays. There was first the Compton formula, based on classical Mechanics, which was afterwards replaced by Dirac's formula based on the new Quantum Mechanics: both formulæ gave practically the same results. They were superseded by the Klein Nishina formula, which made use of Dirac's relativistic interpretation of Quantum Mechanics. Whilst in the case of the ordinary X rays, the three formulæ yield almost the same results, in the case of the γ rays, the latter formula gives values double those obtained by the other two formulæ. Hence the numerous experiments and observations to test the accuracy of the Klein Nishina formula. From what we have seen, it appears sufficiently how important it is to have a reliable formula to deduce from absorption measurements the wavelength of the various γ radiations which arise in nearly all the experiments on nuclear disintegration.

It should be noticed that the two ways mentioned in which part of the energy of the γ radiation is absorbed on passing through matter, refer only to interactions with the outer electrons of the atom, the nucleus not taking any part in it. We shall see how experiments to verify the accuracy of the Klein Nishina formula led to the conclusion that the nucleus may also be excited by γ rays and made to emit characteristic γ rays different from the incident rays.

Like several other researchers, G. P. Tarrant undertook to test the Klein Nishina formula and in 1930 he announced that the scattering coefficient as given by the Klein Nishina formula is accurate within the limits of precision of the experiments for a number of elements, yet for some other elements, especially the heavy elements, some abnormality was found in the absorption, which, he suggested, might be explained by an interaction between the hard γ rays and the nuclei of these elements. (P.R.S., 128, p. 346.) Tarrant experimented with the γ rays from Thorium C″ using rather large filter thicknesses, only the hardest radiation, of energy $2'65 \times 10^6$ e-v., could traverse the filter, and thus the observation of the absorption referred practically only to this radiation. The γ rays were made to pass through small cylinders of different substances, and the amount of radiation transmitted was measured by means of an ionisation chamber placed directly above the absorbers and filters. Several measurements were made for each substance. A natural leakage had to be taken into account together with a small portion of the softer radiations from the ThC″, which were not absorbed, and also and chiefly the scattering correction, because some of the scattered rays will also enter the chamber, in spite of the small angle it subtends: separate experiments were made to find the value of all these corrections. Finally account had to be taken of a certain amount of photoelectric absorption, a probable value for this was calculated for the different substances and subtracted from the absorption coefficient as obtained from the experiments. It was found in this way that the absorption co-efficient per electron, which, as we have said, is assumed to be constant for all atoms, was differen for the different substances. In Tarrant's first experiments, i was found to vary irregularly with the atomic number, howeve in general it was greater for the heavier elements.

We have seen that Tarrant had to calculate a probable valu for the photoelectric absorption coefficient, since this coefficien for γ rays is not known with certainty, his calculations showe therefore some indefiniteness. This was one of the reasons wh L. H. Gray, also at Cambridge and at the same time, decided t investigate more directly the scattering of hard γ rays (P.R.S 128, p. 361). Contrary to Tarrant, Gray did not measure the part of the radiation which is simply transmitted through th absorber, but he measured the amount of radiation which wa scattered by the absorber in directions making a given angl namely between 16° and 90°, with the incident radiation. Fo this the ionisation chamber was of the annular type, so that th directly transmitted radiation passed through the inner cylind without entering the chamber. In this case also he measur directly the scattering coefficient, without having to bring

corrections for the photoelectric absorption. However to obtain sufficient intensity in the scattered radiation no source of ThC″ strong enough was available, so that Ra (B + C) was used. Experiments were made with aluminium and sulphur, a light and a heavy element. No certain difference in the scattering power per extra-nuclear electron could be observed. The results with lead were not very reliable, owing to large corrections to be applied for reabsorption. It must however be remarked that the γ radiations from Ra (B + C) are on the whole softer than those from ThC″, so that Gray's negative results led only to the conclusion that with γ rays from Ra (B + C) and within that degree of sensitivity as his experiments allowed, there is no difference in the scattering absorption per electron of light and heavy elements. Both Tarrant and Gray, at the end of their respective reports, announced that soon they hoped to obtain much more accurate results by means of an ionising chamber containing gas at a pressure of some 80 atmospheres.

Independently and almost simultaneously, experiments similar to those of Tarrant and Gray were reported by several researchers. Meitner and Hupfeld (Naturw., 18, p. 534) and Beck, arrived at the same conclusion as Tarrant. Chao (Phys. Rev., 36, p. 1519) besides reporting the observation of the anomalous scattering and its interpretation on the score of a nuclear interaction, mentioned that he had observed the emission of a secondary radiation, emitted by the elements, which show an anomalous scattering coefficient. He noted further that this radiation seemed to be almost monochromatic, and of the same quality in all directions, that is isotropic. Another observer, Jacobsen, like Gray, first reported negative results, but soon after, like Gray also, he corroborated the statement of the other researchers.

In the meantime Gray was studying the actually scattered γ rays in the forward direction, by means of a high pressure ionisation chamber, containing oxygen at a pressure of 85 atmospheres. In this way the ionisation due to the scattered γ rays traversing the chamber, was considerably increased, whilst on the contrary the disturbing effect of the ionisation due to the α particles markedly diminished. From the previous experiments it seemed now certain that in the case of the heavy elements there is a departure from the proportionality between the scattering power of an atom and the number of its extranuclear electrons. This might be due either to the fact that the binding energy of these electrons has some influence on the scattering, or else that there is some nuclear reaction taking place, at least in the case of the harder γ rays. In the first assumption, that is the Compton scattering, as already noted, the greater the angle of scattering, the smaller the energy of the quantum radiation, hence in this process the greatest amount of energy will be radiated in the forward direction: nearly half the total energy scattered in this way falls within the angular range 10° to 30°, whilst only some 6% would be measured within the same range in the case of an isotropic radiation. If then the difference in absorption with different absorbers was due to the extranuclear electrons, by measuring the scattered radiation within the cited angular range for different scatters, a difference should be noted. Gray measured this for several elements, light as magnesium, aluminium, and heavy such as lead: no difference was perceptible either systematic or irregular. Hence the assumption that the scattering depends only on the number of extranuclear electrons can be kept. The other supposition, that of nuclear interaction, had now to be tested: owing to the greater sensitiveness of his ionisation chamber, Gray was able this time to take measurements for γ radiations from ThC″ as well as from Ra (B + C). However even with the actual improvements the ionisation due to the scattered γ rays from ThC″ was still so weak that it was of the same order as that due to the 'penetrating radiation'; this gives an idea of the precautions to be taken, besides the many corrective terms to be added. Such were the partial reabsorption of the scattered radiation, the absorption of the direct beam and of the radiation scattered from the walls of the lead cylinder which canalised the radiations from the source, after these had been filtered through a few cms. of lead. To calculate the values of these absorption coefficients, the author used the Klein Nishina formula for the scattering and the empirical photoelectric relation discovered by himself already referred to, which expresses the relation between the photoelectric atomic absorption coefficient and the wavelength of the radiation. In this way Gray observed and measured the relative scattering power per electron for different substances, especially for the hard γ rays from ThC″, and less accurately for those from RaC. In the case of ThC″, he found a gradual increase of about 2% on passing from magnesium to lead, and an irregular decrease of the same amount in the case of RaC. From this he concluded that his empirical formula for the photoelectric absorption coefficient, could only account for part of the difference between the absorption coefficients of the hard γ rays from ThC″ in light and heavy elements. There seems therefore to be an additional absorbing mechanism besides the Compton scattering and the photoelectric effect, which is operative only in the case of very hard γ rays, such as those from ThC″. The author on discussing his results, concludes that the slight variation found, being only 1 or 2 %, although it is not probable, yet might possibly be attributed to some faulty estimation of corrections, such as those based on the empirical photoelectric relation. He concluded to the necessity of further investigations.

The researchers went on gathering more experimental data about this abnormal absorption and scattering of the hard γ rays. Thus Tarrant (P.R.S., 135, p. 223) measured the absorption coefficient for γ rays from ThC″ by means of a pressure ionisation chamber containing nitrogen at pressures between 100 and 120 atmospheres. As usual due account was taken of the different corrective terms, and finally the absorption coefficient per electron for different absorbers was compared with the results of other researchers. In general there was good agreement. It was found that on passing from the light to the heavy elements, these absorption coefficients vary quite closely as the square of the atomic numbers. Apart from the electronic scattering, there is the photoelectric absorption, and the supposed nuclear absorption. It is therefore the sum of these two last effects which was measured and found to vary approximately as the square of the atomic number. How each one separately varies is not known, because their effects cannot be separated. It was further noted that even in the case of light elements the scattering coefficient per electron as calculated by the Klein Nishina formula, is about 3 % less than the measured value. Hence the nuclear interaction with hard γ rays seems to be common to all elements.

In his report published in 1930 (Phys. Rev., 30, p. 1519) Chao had already noted that the anomalous scattered radiation besides being isotropic is also almost monochromatic; he found its wavelength to be about 22′5 X. U. (i.e. about $0'6 \times 10^6$ e-v.). In a discussion on penetrating radiations at the Royal Society in May 1932, Tarrant stated that the energies associated with the scattered radiation are about 1 and 0′5 million e-v., hence more complicated than what Chao had first observed.

In the case of the emission of a new radiation of wavelength different from the incident radiation, this is probably due to a disintegration or an excitation of the nucleus followed by the emission of one or more quanta radiations. It was therefore natural to search for the excitation or disintegration potentials of the various nuclei. The difficulty here was to find a source emitting γ rays of a continuous range of wavelengths. This was secured artificially by Chao, who used the scattered γ rays from the homogeneous hard γ rays from ThC″, falling on a light scatterer and thus by the ordinary Compton effect, giving scattered radiations varying continuously in wavelength with the angle of scattering. The incident beam of wavelength 4′7 X. U., gave in this way a range of wavelengths varying from 4′7 to 53′2 X. U. The greatest difficulty in this experiment was again the very weak intensity of the scattered radiation. However the difficulty was overcome by the use of a differential method, in which were compared the differences in the scattering coefficients per electron for a heavy and light element, the difference between the two he called the extra-absorption. In this way the errors were minimized. He found that on plotting the corrected values of these differences against the wavelength of the corresponding primary γ radiation, there was a sudden jump in the curve between 5′9 and 6′6 X. U. Hence there seems to be at this point an excitation or disintegration potential. This agrees well with Gray and Tarrant's results who found that in the case of RaC, the rays responsible for the nuclear scattering have a value of 2′2 and $2'5 \times 10^6$ e-v. However because of the error limits in Chao's experiments, the occurrence of a sudden jump was not quite conclusive and further investigation along this line was required.

Gray and Tarrant jointly investigated more in detail the secondary radiation emitted by various substances when irradiated with hard γ rays (P.R.S., 136, p. 662). They arranged their experiment in such a way that the secondary radiations reaching the ionisation chamber, proceeded from the radiators in a direction making an angle $125° + 15°$ or $145° + 15°$ with that of the primary radiation. In this way the disturbing effect of the ordinary Compton radiation was much reduced. The calculations made were based on the assumption that the secondary radiation is spacially isotropic: the actual experiments together with previous experiments of Gray and of other researchers, showed that this is very probable. The experiments were carried out with the hard γ rays from Th″C, and Ra (B + C), the radiator specially studied was lead. Experiments were also made where the radiator was tin, iron or water in a glass vessel. It was found that in all cases the two same kinds of secondary radiations (about 0′92 and 0′47 million e-v.) were emitted by the various radiators, when irradiated with γ radiations of quantum energy greater than 1′8 million e-v. (λ = 7 X.U.) This was obtained from an accurate study of the effect with the Ra (B + C) radiations, in good agreement with Chao's results obtained by a quite different method, which was explained above. A third method, different from these two, also led to the same lower limit. This last method consisted in comparing the absolute number of quanta of the various γ radiations emitted per second by ThC″ and RaC of equivalent activity. In the case of Th″C only the hard radiations are effective and these constitute one-third of the total number of quanta. However these radiations produce an effect 2′2 times stronger than that from RaC, hence only about one-seventh of the total number of quanta from RaC is effective. On inspecting the numbers of quanta of the various γ radiations from RaC, it was found that no radiations of energy quantum below 1′8 million e-v. could be effective, otherwise more than one-seventh of the total incident radiation would have been effective.

Another interesting question was to investigate the magnitude of the reemitted radiation, in particular from lead. For this the unfiltered intensity of the irradiating hard rays was measured from the ionisation they produce after passing through a given thickness of lead, knowing the absorption coefficient of these radiations. Assuming that the secondary radiation is emitted isotropically, the integrated energy of the radiation emitted by one nucleus, could be calculated and compared with that of the incident radiation producing it. The ratio of the two in the case of γ radiations from ThC″ was measured for several elements. Whilst at first it was found to be only about 0′52, in later and more accurate experiments (P.R.S., 143, p. 708), the authors found that within 10 to 15 per cent, the whole of the incident energy absorbed by the nucleus was reemitted in the form of secondary radiations. Since the main part of it are radiations of energy rather less than 0′5 million e-v., it follows that in general from four to six quanta of low energy radiations are emitted for each quantum of high energy absorbed. However whilst the total energy reradiated, like the abnormal absorption itself, varies approximately like the square of the atomic number, the proportion of the harder rays decreases much more rapidly with the atomic number. The theoretical interpretation of these results, suggested at that time by Gray and Tarrant, was that these secondary radiations are characteristic of the emitting nucleus. Following the analogy of electronic transitions in the outer structure of the atom, to explain the ordinary radiations, they suggested that here also when radiation of energy quantum higher than 1′8 million e-v. falls on the nucleus, a certain number of particles in the nucleus are in an excited state. The transitions of each particle separately to the ground state, corresponds to the emission of a γ radiation of 0′5 million e-v. The simultaneous transition of two particles will correspond to the emission of a one million e-v. radiation, this however will be a much rarer event than the first case, whilst there is hardly any likelihood for a simultaneus transition of 3 particles, which would give a 1′5 million e-v. radiation, hence it is never observed. There still remains an excess of energy of about 0′5 million e-v., how this is disposed of by the nucleus, cannot be explained yet, but probably it is not emitted in the form of γ radiation, because its effect would have been observed.

It had been suggested by Meitner and Hupfeld (Naturw., 19, p. 775) that the secondary emission might perhaps consist merely of part of the unmodified γ radiation simply transmitted, mixed with some γ radiation scattered according to the ordinary Compton law. Such a mixture would in fact explain the results deduced from their experiments. Gray and Tarrant undertook to examine this question, by a special series of experiments and they arrived at the conclusion that very little if any of the primary radiation is present in the secondary emission from lead.

At most this could account for 2 per cent of the total intensity of the secondary radiation.

The same conclusion was arrived at by Ketelaar and Stahel (J. de Phys. iv, p. 457), they proved by their experiments in an unambiguous manner that the radiation emitted by the radiators is characteristic of the irradiated substance and is markedly softer than the primary γ radiation. In general the results of their experiments agreed with those of Gray and Tarrant, whose experimental arrangement they followed approximately, they were however to add some precisions on a few points. In the case of lead, by studying in detail the shape of the absorption curve of the secondary radiation, they found that the hard radiation of λ = 16′7 X.U., as mentioned above, is approximately isotropic at least with regard to the energy, but with regard to the total energy, there seems to be a greater amount emitted in the direction closer to that of the primary radiations. The total integrated energy of the hard component being about 1/5 of the energy of the secondary radiation taken as a whole. There is another softer component of λ = 31′2 U.X., representing about 45 per cent of the total, and then there remains another 35 per cent which may possibly be ascribed to the ordinary Compton scattered radiation. The wavelengths of the secondary radiation were also studied in detail for other radiators than lead, and contrary to Gray and Tarrant's results, it was found that the hardness of this radiation was increasing with the atomic number of the radiators. Thus for Al, the inclination of the absorption curve for the secondary radiation was hardly less than that for the ordinary Compton radiation (λ = 32 and 41′9 X.U. respectively). As the atomic number increases, the slope of the corresponding absorption curve gradually becomes less steep. In the case of iron the corresponding wavelength was found to be 23′4, for tin 21′9, for lead 16′7, for uranium 18′6. This with regard to the quality, or wavelength of the secondary radiation, if however we consider the total energy of the secondary radiation, then it is found to decrease with increasing atomic number. This is easily understood, since the greater the atomic number, the greater the portion of this secondary radiation which will be reabsorbed in the radiator itself. This last point led to an interesting modification in the method of experimenting: in fact it was found that on starting with very thin radiators and then gradually increasing the thickness, the intensity of the diffused radiation at first increases proportionally to the thickness, but for the greater thicknesses, the intensity tends towards a limit, because the radiations emitted at a certain depth, are practically fully reabsorbed before reaching the surface. It was noticed besides, as could be expected, that for increasing thicknesses the proportion of the hard component was increasing. Hence the idea of using very thin radiators so as to find the real proportion of hard and soft components emitted by each nucleus. By means of a simple theory and subsequent experiments, the conclusion was thus arrived at that in the case of lead the ratio of the initial energies of the soft and hard components is 4′5 whilst for great thicknesses, when saturation is reached, it is only 2′25. The authors therefore concluded that for each hard quantum, about eight soft quanta are emitted.

Quite recently Gray and Tarrant published the results of their latest experiments (P.R.S., 143, p. 681), which consisted for a great part in obtaining confirmatory evidence for their previous results and those of other reasearchers. At times also they concluded to the necessity of altering their previous results, because some points had been overlooked, this was the case for the measurements concerning the fraction of the γ rays' energy absorbed by the nucleus and reemitted, as we have mentioned it. They arrived at these results from an accurate study of all the corrective terms to be applied and of all the details of the experimental procedure so that definite conclusions might be reached as to the reliability of experimental data and the theoretical interpretation thereof. They discussed in particular the various absorption curves of the secondary radiation emitted by the different radiators. These curves could be decomposed into several straight lines corresponding to various radiations, of which the complex secondary radiation was made up. The authors showed that a very great degree of certitude concerning the energy of the component radiations obtained in this way, could not be expected. In the case of the primary radiation from RaC, they even showed that the curve could be very well interpreted by assuming besides the two ordinary components, a third softer one. In general however the results seem to conclude to the same energy for the hardest secondary radiation, of which however the total energy decreases rapidly with decreasing atomic

number. With regard to the softer component, there are slight variations with the different radiators, chiefly when the primary radiation is from RaC. However no regular variation was found as in the case of Stahel and Ketelaar's experiments.

Since the theoretical explanations proposed so far, are not quite satisfactory, as we shall soon explain, the authors examined the question whether those secondary radiations were really of electro-magnetic nature and not particles. For this they measured the ionisation produced separately by the hard and soft components in nitrogen and hydrogen and found the ratio of the two to be 4′5 which is practically the value obtained with γ rays of the same wavelength, whilst in the case of neutrons the ratio is 0′3. They experimented also with a Wilson chamber: the photographs failed to indicate the presence of any radiation other than the γ radiations as explained.

Additional evidence was also obtained concerning the isotropic distribution of the secondary radiation. By this time the radiation had been measured almost in all possible directions by various researchers. The authors undertook some additional measurements on the angular distribution of the radiation between 64° and 114°. Although each experiment taken separately is liable to considerable experimental error, when taken together the various experiments afford sufficient evidence for the conclusion of an approximately isotropic distribution, as had already been stated by Chao in 1930.

From the accurate and in general concordant results obtained so far by themselves and by other researchers, the authors conclude that it is not possible to hold the theoretical interpretation suggested by themselves as well as by several others, which interpretation assumes that the nucleus first excited by the primary radiation, on returning to its stable state, emits the characteristic radiations. It is concluded that if this were so, in case the excitation is produced by a quantum of energy higher than the critical excitation potential (about 2 million e-v.), the surplus should be emitted in the form of a Raman scattered radiation. We have seen that secondary radiations are produced by the hard γ rays from ThC″ and RaC of mean energy values 2′6 to 2 and 2′2 to 2 million e-v. respectively. Hence there should in each case be a different scattered Raman radiation. It might be suggested that in the case of ThC″ this corresponds to the softer *component and in the case of* RaC, *to the third and softest* component of energy 0′3 million e-v. But the theory of the Raman effect requires only a very weak emission of this scattered radiation: about 0′2 to 2′6 or 8 per cent of the emission. Whilst in fact at least for the soft component from ThC″, this radiation represents nearly half of the total emission. Another interpretation is therefore suggested, which was first proposed by Blackett and Occhialini, immediately after the discovery of the positive electron in connection with cosmic radiations. It was soon after found by several researchers that such positive electrons are also emitted by lead and other substances when irradiated with the hard γ rays from ThC″. It is therefore natural to look for a connection between this emission of positive electrons and the abnormal absorption of hard γ rays accom-*panied by the emission of a secondary radiation.* A tentative explanation based on this, is proposed by Gray and Tarrant, but already before them a more detailed interpretation along similar lines was proposed by I. Curie and Joliot (J. de Phys., iv, p. 494). These last authors had observed that the distribution curve of the energies of the positive electrons emitted from lead bombarded with the hard γ rays from Th C″, shows a sudden diminution at about 0′8 million e-v. On many of the photos taken with the Wilson chamber, they found paired tracks, one corresponding *to a positive electron, the other to a negative one*; at times even both tracks were seen to start from the same point. They suggested that one quantum radiation of high energy, on meeting a heavy nucleus, is transformed or rather 'materialized' into two electrons of opposite sign. This materialization of course will require an expense of energy, found to correspond to about 1′02 million e-v. What is left of the initial quantum energy, is communicated to the electrons as kinetic energy, and perhaps also part of it might be emitted as a diffused quantum. In the case of the 2′65 million e-v. incident quantum, a couple of electrons, of opposite sign will be emitted having kinetic energies of about 0′8 million e-v., as found experimentally. It follows also from this that at any rate no radiation of quantum less than 1′02 million e-v. can produce positive electrons, since so much is required for the materialization alone. This last conclusion agrees with the observation of Gentner that the abnormal absorption of γ rays becomes noticeable for radiations

of energy above 1′1 million e-v. In these transformations the nucleus itself does not seem to take any part, except in so far that its presence is indispensable, almost like a catalyst in some chemical reactions. This suggestion will of course have to be submitted to experimental tests, to be verified quantitatively in all its consequences.

The great difficulty in the above explanation, is that the secondary radiation in the case of abnormal absorption, is, at least mainly, of electro-magnetic nature. Perhaps the hypothesis of Gray and Tarrant may explain this, since according to them the primary rays, on being absorbed, are transformed into positive electrons, which in their turn soon after are annihilated with a negative electron in free space, and, as a result of this, two quanta are produced of about half a million e-v. each, as found for the soft component. Or also, but more rarely, the positive electron may become annihilated in such a way that a massive particle, say the nucleus, carries away the recoil momentum; in this case it can be shown that a quantum radiation corresponding to that of the hard component is emitted. However Gray and Tarrant find that such a hypothesis encounters a number of difficulties when confronted with experimental data. Perhaps, a combination of both the above explained theories will have to be considered.

Like in our study of the spontaneous and artificial disintegrations, we arrive once more at the same conclusion, that the experiments of the last years have thrown much light on what is going on inside the atomic nucleus. It will require a certain time and much painstaking work to explore the newly discovered field. Then only will it be possible to obtain a coherent view of the whole. Once this reached, it will of course lead on to further inquiries and discoveries. This unending process seems to be a characteristic feature of scientific research, and quite naturally so, since we know the natural phenomena only from the outside, from the way they appear to us, and not as they are in themselves.

ECONOMIC DEPRESSION IN THE MADRAS PRESIDENCY (1820-1854)

'Long lines of cliff breaking have left a chasm:
And in the chasm are foam and yellow sands.'
—TENNYSON.

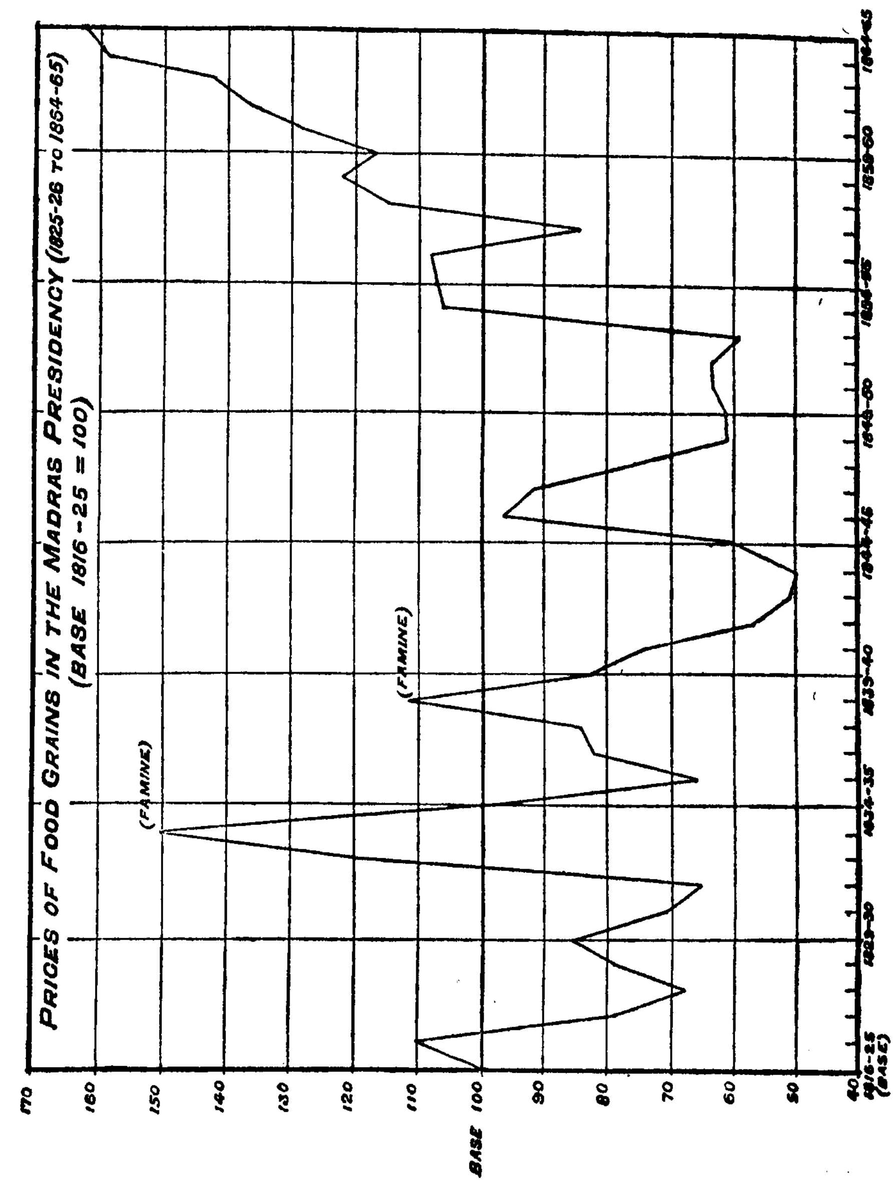
I

Exactly a hundred years ago, there was an economic depression of great magnitude in India. It commenced about the year 1820 and continued its chequered course till about 1854. It seems to have prevailed in all parts of India, but was perhaps most pronounced in the ryotwari provinces of Madras and Bombay. Madras Presidency was formed in the early years of the 19th century, and soon afterwards it found itself in the grip of a fell slump which seriously affected public and private economy and produced a great deal of suffering all over the Presidency. The following index numbers were constructed by taking into account the prices of foodgrains [paddy (2 sorts), cholam, ragi, varagu, and cumbu], with the period 1816-25 as the base:—

Years	Average Price per Madras Garce in Rs.				Index Nos.
	Paddy 1st sort.	Cholam	Ragi	Cumbu	
1816-25 Base	111·1	137·5	114·4	111·1	100
1825-26	122·6	152·2	130·0	124·0	110
1826-27	92·5	103·0	91·8	87·0	79
1827-28	80·6	84·6	78·5	77·0	68
1828-29	92·3	105·3	89·6	86·8	79
1829-30	97·3	109·5	100·6	99·8	85
1830-31	83·0	99·5	75·6	82·0	71
1831-32	71·8	85·8	74·0	72·5	65
1832-33	120·7	171·3	146·5	154·1	120 (Famine)
1833-34	156·2	203	174·5	177·3	150
1834-35	99·7	122·7	113·5	124·5	98

Years	Average Price per Madras Garce in Rs.				Index No.	
	Paddy 1st sort.	Cholam	Ragi	Cumbu		
1835-36	80·4	87·8	80·4	74·5	**66**	
1836-37	97·8	111·6	103·0	95·8	**83**	
1837-38	98·5	113·1	109·8	95·1	**84**	
1838-39	*122·6*	*153·5*	125·8	126·0	**111**	(Famine)
1839-40	97·4	110·6	102·6	86·8	**82**	
1840-41	85·1	100·2	85·8	80·6	**74**	
1841-42	63·8	70·7	67·3	63·4	**56**	
1842-43	67·6	61·7	66·2	57·1	**51**	
1843-44	67·0	60·0	66·3	55·7	**50**	
1844-45	76·9	78·4	80·4	64·0	**60**	
1845-46	110·7	128·7	121·3	119·1	**96**	
1846-47	106·5	125·7	117·0	121·2	**91**	
1847-48	79·6	110·8	96·7	92·2	**76**	
1848-49	72·3	82·4	77·0	68·4	**61**	
1849-50	75·5	81·2	74·2	75·7	**61**	
1850-51	70·6	86·5	68·8	76·4	**63**	
1851-52	68·7	83·8	66·8	71·2	**60**	
1852-53	68·7	85·0	67·5	74·1	**60**	
1853-54	111·7	151·0	123·8	127·3	**106**	
1854-55	119·8	146·8	125·7	122·5	**107**	
1846-55 (10 years)	88·5	106·7	97·5	94·3	**81·3**	
1856-65 (10 years)	143·7	165·1	158·4	146·3	**121·5**	

Between 1825 and 1854, prices were constantly on the decline; but the most acute fall occurred during the period 1840-45 when the index number stood at 58.20, thus recording a fall of 41.80 per cent from the basic period. The year-to-year variations of prices shown above are much larger than we are accustomed to in modern times, but that must have been chiefly due to the lack of communications and the caprices of



weather. These circumstances have changed since, owing to the growth of irrigation and cheapening of transport.

In many ways, the depression of 1820-54 is analogous to the recent price slump which commenced in 1920 and is still continuing. The analogy is perhaps least in regard to causes, and greatest in regard to course and effects. Both depressions embarrassed Government by reducing revenue and disorganising trade; agriculture suffered most under both and the agriculturist's burdens increased, owing to the rigidity of his dues—revenue, rent, interest, and other fixed charges. It was to combat the depression of 1820-50 that Government slightly modified its laissez-faire policy and interested itself in irrigation and road-making and agricultural improvement; the burdens of the tax-payer were also lightened by a more liberal policy of land revenue settlement. Indeed conditions have largely changed in the last 100 years; none the less the experiences of the depression of 1820-50 must be of some value in combating the present depression.

Although this was perhaps the greatest depression of the 19th century in India, the attention of economists has not been sufficiently directed to this important event in Indian economic history. In fact, the only information available to the student is contained in two or three paragraphs in Mr. Srinivasaraghava Aiyangar's able *Memorandum on the Progress of the Madras Presidency during the last 40 years* (1892), and in a short note by Peddar. Lately, the original documents connected with the subject have been explored and a work is being prepared by us. In this paper, it is only proposed to enquire into the causes of the depression.

II

Causes of the Slump

Mr. Srinivasaraghava Aiyangar attributed the depression of 1820-54 to local causes, as he did not realize that the depression was not confined to India. It prevailed in England and over all Western Europe and was one of those secular price movements which affect nearly the whole world. Ever since the influx of American silver into Europe in the 16th century, there have been several long-period movements of prices in Europe, and as different parts of the world have become connected by trade, these movements transmitted themselves to distant parts of the world.

Thus, even in the 16th and 17th centuries, when India's connection with Europe was far from intimate, prices in India rose simultaneously with prices in Europe, and it is said that the successive enhancements of the Moghul land revenue were due to these increased prices.[1]

Without entering into the still unsettled controversy on the cause of trade cycles, it may be said that in those days, at any rate, monetary causes were more potent than non-monetary. In recent times, the relation between gold and prices has become rather remote, but in the 19th century and to a larger extent in the previous centuries, the relation between prices and the precious metals had been much more direct. As credit had not developed in those days and as even paper money was scantily used, money then meant the metallic circulating medium.

Writing about the depression of 1820-50 in Europe, Sir Walter Layton, who has carefully analysed these secular price movements, says: 'Prior to 1810, Europe had received the greater part of its supply from the Spanish colonies of Central and S. America. But during the wars of the French Revolution the colonies threw off the yoke of Spain and 15 years of civil war and internal disorder followed during which period the mines were practically deserted and a great slump occurred in the output of the precious metals'.[2] According to the estimates of Del Mar, the output of gold and silver from Spanish America which amounted to £7,200,000 a year before the French Revolutionary wars, fell to £5 million in 1825 and £4 million in 1829; and this was the potent cause of the depression in Europe.[3]

The scarcity of precious metals affected India even as it affected Europe. As India did not have any considerable local supply of gold or silver, she had to get both the metals from outside, and what affected their supply outside affected the supply in India as well. In those days, as now, a general fall of prices meant a diminution in the supply of money or an increase in the demand for it or both. After 1800, the

[1] *Fifth Report*, Vol. II, p. 186 (1883 Edition).
[2] Layton, *An Introduction to the Study of Prices*, p. 38.
[3] Del Mar, *History of the Precious Metals*, chapter xviii.

supply of money in India diminished owing to various causes, while the demand for money increased considerably. We will see how this happened.

III

Supply of Money

The supply of money during the period diminished owing to (1) the outflow of bullion, and (2) to the Indian Currency Act of 1835, which resulted in the demonetization of gold and the discarding of a good deal of the silver currency.

India has always been regarded as the sink of precious metals. That was because she always had valuable merchandise to sell to other countries, but had little to buy from them, thus necessitating payment in bullion. This disturbed the minds of the financiers of the Roman Empire, and the drain of specie to India is generally regarded as one of the chief causes of Rome's downfall. Early European traders had the same experience. Sir Thomas Roe expressed it in the epigram, 'Europe bleedeth to enrich Asia'[1]. Hence the stringent regulation of the export of bullion to India from European countries. In England laws already existed against the exportation of coin and bullion, and in the time of James I, this was regarded as so heinous an offence against the country that the king found himself helpless in raising revenue by selling pardons.[2] Indeed subsequently, such bullionist ideas changed in England and in the first half of the 18th century bullion formed 75 per cent of the total imports of the Company into India. However, when the Company acquired territorial possessions in India, bullion exports to India became unnecessary, and even the Company's trade with China came to be managed with Indian bullion.

Thus the current changed. India which absorbed bullion for centuries had to disgorge part of it. This is what repeatedly happened in the past and one is even tempted to formulate a law of bullion movements. For centuries, India would absorb gold and silver; and then would come an efflux which would partly deplete the hoards. Such a rhythmic movement is observable in the bullion transactions of India from the earliest times to the present day, and it is curious to note that generally

[1] Quoted in Moreland, *From Akbar to Aurangzeb*, p. 53.
[2] See H. M. Robertson, *Rise of Economic Individualism*. (1933), p. 62.

the outflow of gold occurred when there was a shortage for it in Europe. During the 16th and 17th centuries, the flow was inward, but after 1757, the outflow commenced, and this became pronounced in the first three decades of the 19th century, but it diminished after 1840. When the Company became an important territorial power in India as a result of the battle of Plassey, it obtained large revenues from its possessions. Handsome gifts and tributes were also made by the country powers to the Company and to its servants. Several of the Company's employees made large fortunes: Bolts admits having made £90,000 in six years. The Company had also to meet large dues in England, and this it did, not only by sending merchandise but by exporting bullion and specie. Bullion from India was also transported to China for the 'investments' of the Company there, and that bullion never returned to this country. The result was that, year after year, not only bullion but coin went out of the country and the amount of currency in circulation diminished. Indeed this could have been avoided by the use of bills of exchange, and bills were known and used then in India not only by the Company, but by Indian bankers also; but owing to various circumstances, they could be used only to a limited extent.[1] From the very beginning the Company realized the economic evils of such a growing drain of coin from the country, but they were unable to remedy it for a long time.

The declining importance of India's staple exports also contributed to the efflux of bullion from the country. When the European nations first traded with India, the principal articles of Indian export trade were pepper and calico, and these two constituted the great bulk of the homeward cargo.[2] But towards the close of the 18th century, both these exports declined in quantity and value. The demand for pepper diminished because thanks to the agricultural improvements of 'Turnip' Townsend and Jethro Tull, it became possible to keep cattle during winter with the new fodder crops, and the system of killing and pickling beef and mutton in autumn thus died away, and with it the importance of pepper also passed away. As for the trade in calico, Great Britain transformed herself about the beginning of the 19th century from an importer of

[1] Parshad, *Indian Foreign Trade*, pp. 57-58.
[2] Thomas, *Mercantilism and East India Trade*, Chapter I.

cotton textiles to an exporter—and the principal exporter—of that commodity, and this was the result of the Industrial Revolution. The spinning jenny and the power loom cheapened the processes of spinning and weaving cotton in England, and enabled her to become the home of the world's cotton industry, and not only did England capture the market in Europe but soon her cheap calicoes and muslins came into India and successfully competed with the hand-made and expensive calicoes and muslins of this country. Indeed the high tariffs imposed on Indian textiles in England also hastened the decline of Indian exports, but that decline was bound to come by the superiority of the machine over the human hand.

In this way, the character of Indian export trade, which remained fairly steady for at least a thousand years, underwent a radical change, and dwindled in quantity as well as value for some time. The textile exports diminished after 1800, and their fall was rapid after 1820. In the last decade of the 18th century, cotton goods worth £2 millions on an average were exported to England, but in the decade 1820-30, the exports came only to £500,000 on an average and in the following decade fell below £300,000.[1] The Charter Act of 1833 gave a fillip to the importation of English textiles into India, and after that, the textile exports of India died away rapidly.

So long as the East India Company carried on trade, there was some encouragement given to Indian manufacturers, owing to its annual 'investments', but that ceased when the Company's trading rights ceased. Subsequently, there arose a growing export trade from India in primary products, but that involved a radical change in the nature and direction of Indian trade. Partly owing to this change and partly to other causes, the imports of bullion diminished for a time, and from some parts of India there was a large net exportation of bullion and specie. To facilitate the efflux of treasure, the Government of England permitted the transportation of bullion belonging to the Company's Governments in India in H. M.'s ships at the same rates as those paid for the transport of treasure belonging to the Crown.[2]

[1] McGregor, *Commercial Tariffs*, Digest Vol. IV, pp. 434-40.
[2] Despatch of the Court of Directors to Madras, (Finance) 10 April 1838, No. 4.

Unfortunately, we have not got accurate statistics of the export and import of bullion during the period. The figures given by authors are often based on guesswork. However, we have enough to conclude that much more bullion was exported than imported during this period. Sir George Wingate has estimated the efflux of bullion from India during the period 1800-1858 at £100 millions, and Montgomery Martin, reckoning at compound interest, computed the outflow of bullion in the period, 1800-1830, at £700 millions. Sir John Shore and M. E. Grant have not given figures but hold that the amount was large. Professors Hamilton and Dodwell consider these estimates exaggerated, but have not given any specific counter-estimates. Hamilton pushed the scepticism furthest, and Dodwell doubted 'whether he (Hamilton) allows quite enough weight to the popular belief as displayed by Shore and Grant'.[1]

IV

Supply of money—the Peculiar Features of Madras

The general view of Indian trade and bullion movements dealt with above is fully borne out by the experiences of Madras in the period, 1820-54. Nay, more. Various peculiar features of the trade of this Presidency aggravated the causes of the bullion outflow and prolonged it more than in other presidencies. We have been able to gather from Madras archives fairly adequate statistics of the trade and bullion movements of the period and we find that the outflow of bullion which commenced from the year 1825 continued almost uninterruptedly till 1850.

The special features which intensified and prolonged the outflow of bullion may now be dealt with: In the first place, during the period under survey the export trade of Madras changed drastically both in content and destination. Until about 1830, the export trade of Madras was chiefly in manufactured textiles and this went to those countries which generally paid for our goods in bullion (e.g., Straits of Malacca, West Coast of Sumatra, Manilla, Pegu, Persian

[1] *Journal of Indian Economics*, 1921-22, p. 236.

Gulf and Arabia); and those countries were the most regular source of supply of precious metals for the Madras Mint.[1] But when cheap British textiles outsold the Indian piecegoods in those countries the export trade rapidly fell away and bullion ceased to flow into the Presidency. Indeed, our export trade with China and Britain increased, but they did not send us bullion and this was partly due to the bill transactions of the Court of Directors which will be dealt with below. The following tables will bring out the change in the Export trade both in character and destination between 1824-34 and 1840-50.

STATEMENT SHOWING AVERAGE ANNUAL EXPORTS OF MERCHANDISE FROM MADRAS BETWEEN THE YEARS 1824-34 AND 1840-50

[Compiled from the Mint Master's Reports.]

Countries	1824-34 (average of 10 years)		1840-50 (average of 10 years)	
	Piecegoods Rs.	Total Rs.	Piecegoods Rs.	Total Rs.
Straits of Malacca ...	14,58,488	16,13,512	7,60,994	10,22,264
West coast of Sumatra ...	1,43,373	1,59,102	5,329	8,213
Manilla	1,70,644	1,72,899	*Nil*	*Nil*
Pegu	1,35,000	2,75,000	1,10,000	{ Little decline
Gulf of Persia, and Arabia	5,46,000	13,70,000	1,68,000	12,00,000
China	,,	6,50,000	,,	14,50,000
Great Britain ...	16,00,000	29,75,000	5,75,000	50,00,000
Bengal	2,00,000	9,00,000	4,75,000	14,75,000
Bombay	12,50,000	50,00,000	9,75,000	73,00,000
Ceylon	6,75,000	14,50,000	7,50,000	29,75,000

During this period the export trade of Madras in manufactured goods diminished by about 40 per cent while the

[1] Mint Master's Report, 16th December 1851, para 17.

export of primary products increased largely, as will be clear from the table below.

AGGREGATE EXPORTS FROM MADRAS DURING THE DECENNIAL PERIODS 1824—34 and 1840—50.

Articles.	From 1824—25 to 1833—34	From 1840—41 to 1849—50
Piecegoods	619,89,315	382,73,194
Cotton and cotton wool ...	82,45,741	426,93,304
Grain	239,42,294	377,96,556
Sandalwood	23,18,755	12,29,660
Spices	86,50,691	111,68,595
Sugar	*Nil*	95,73,161
Oils	*Nil*	6,77,141
Oilseeds	*Nil*	2,44,363
Dyes, indigo, etc.	70,90,670	216,52,303
Turmeric	*Nil*	3,68,614
Coffee	3,29,043	18,44,784
Salt	17,47,514	12,66,079
Hides	3,42,830	19,14,624

Evidently the void created by the decline in manufactured goods was more than filled by the growing export trade in raw materials. This subsequently increased to much larger proportions until nearly the whole of our exports became primary products. The outflow of bullion from Madras was an inevitable result of this transition from an export trade composed chiefly of finished goods to one mainly of primary products. And naturally the transition was a painful one and it dislocated the price level and caused one of the greatest economic depressions ever known in the country.

2. It may be asked why the increased export trade with China and Great Britain did not result in an influx of bullion into the Presidency. But here we have to explain another important factor which made bullion movements unfavourable to Madras. When money was due to the Presidency from Britain or China or other countries which were Britain's

debtors, the Court of Directors settled such accounts by means of bills drawn on the Indian treasuries. The result was that bullion which ought otherwise to have found its way to India in the natural course of commerce was prevented from coming in. The first large issue of Company's bills began in 1834 but its importance rapidly increased as can be seen below:

AVERAGE VALUE OF BILLS DRAWN BY COURT OF DIRECTORS FOR THE 5 YEARS ENDING

	Rs.
1834—35	31,610
1839—40	14,31,685
1844—45	13,87,586
1849—50	39,21,580

3. There were also various political causes tending to work in the same direction. 'The employment of our troops in foreign warfare, their maintenance in time of peace beyond its frontier, and the necessary contribution of this Presidency to the general charges of the empire have constantly required the export of large sums on the public account, far in excess of the imports'.[1] For instance, Madras sent a considerable amount of specie to Malacca in 1832 for the payment of the Company's troops there; expeditions to Burma and China were also financed by sending specie from Madras.[2] Another political factor was the arrangement under which the revenues of Malabar and Canara amounting annually to Rs. 20 lacs on an average were sent directly to Bombay in the form of specie. According to a contemporary estimate the net export on Government account alone for the 30 years from 1820-21 to 1849-50 amounted nearly to Rs. 15 crores. The cumulative effect of all the factors described above was the pronounced and prolonged outflow of specie as may be seen from the following table carefully drawn up from the documents preserved in the Madras Record Office.

[1] Selections from the Records of the Madras Government. No. III of 1854, p. 82. Para 7.

[2] Despatch of the Court of Directors, 10th August, 1836. No. 11 (Finance; see also *Calcutta Review*, Vol. XVI (1851), pp. 473-74.

STATEMENT OF BULLION AND SPECIE IMPORTED INTO AND EXPORTED FROM MADRAS PRESIDENCY DURING THE YEARS 1819-20 TO 1849-50.

YEARS.	ON PRIVATE ACCOUNT.		ON GOVERNMENT ACCOUNT.		TOTAL.	
	Imports. Lakhs.	Exports. Lakhs.	Imports. Lakhs.	Exports. Lakhs.	Imports. Rs.	Exports. Rs.
1819-20	...	...	...	...	78,29,021	36,90,066
1820-21	...	...	...	...	43,69,643	27,28,191
1821-22	...	...	...	...	40,05,731	51,27,222
1822-23	42·80	2·72	*Nil*	27·00	42,80,641	29,72,596
1823-24	...	...	...	...	84,56,782	84,41,771
1824-25	44·90	4·42	23·31	79·76	68,21,445	84,18,825
1825-26	37·05	5·38	0·28	124·34	37,33,958	1,29,72,242
1826-27	32·74	8·98	11·21	50·04	43,95,076	59,02,914
1827-28	36·28	10·12	0·99	44·67	37,27,185	54,79,102
1828-29	26·31	9·91	*Nil*	47·69	26,31,476	57,60,109
1829-30	22·40	12·65	*Nil*	86·39	22,39,768	99,04,006
1830-31	20·39	7·85	*Nil*	25·70	20,39,237	33,55,028
1831-32	26·33	17·80	*Nil*	67·98	26,33,040	85,77,796
1832-33	25·43	26·93	1·44	31·88	26,86,649	58,81,220
1833-34	26·76	23·67	35·12	29·55	61,88,856	53,22,401
1834-35	33·42	11·06	*Nil*	17·59	33,42,091	28,65,642
1835-36	32·65	8·41	1·58	58·12	34,23,070	66,53,208
1836-37	33·28	8·49	12·35	48·97	45,63,525	57,46,898
1837-38	25·35	17·25	26·16	39·08	51,51,626	56,33,301
1838-39	35·28	15·66	6·52	48·74	41,80,785	64,40,920
1839-40	27·88	11·10	5·66	91·97	33,54,590	1,03,07,711
1840-41	30·32	10·02	10·00	95·40	40,32,845	1,05,41,605
1841-42	28·89	3·33	*Nil*	83·50	28,88,803	86,83,339
1842-43	28·68	2·82	*Nil*	71·19	28,68,744	74,01,161
1843-44	49·08	18·33	9·00	27·50	58,08,323	45,82,816
1844-45	65·43	7·42	*Nil*	70·40	65,43,643	77,82,901
1845-46	66·01	9·06	*Nil*	32·80	66,01,711	41,86,753
1846-47	49·60	31·30	*Nil*	29·30	49,60,828	60,60,098
1847-48	37·00	35·52	*Nil*	71·00	37,00,280	1,06,52,343
1848-49	26·75	22·38	*Nil*	77·00	26,74,852	99,38,403
1849-50	42·36	9·10	*Nil*	59·79	42,36,514	68,79,637

[Compiled from the Statements by the Collector of Customs, Madras, In Consultations dated 2nd August, 1832, and by the Reporter of External Commerce dated 23rd September, 1851, and from Reports of the Mint Committee.]

The Government of Madras at the time was fully alive to the gravity of the growing efflux of bullion from India, and in 1830, commenting upon the view expressed by certain district Collectors and the Board of Revenue that the efflux of specie was a major cause of the fall of prices, the Government of Madras wrote:—

'With regard to the observations of the Board—having reference apparently to the late extensive remittances of bullion to England—on the subject of the draining of the precious metals from this country by the combined operations of its political relations with Great Britain and its external commerce, the Right Hon'ble the Governor in Council is fully sensible that the continued exportation of the precious metals from a country which does not possess sufficient trade or manufactures to recall them must be attended with impoverishing and distressing consequences. But the real question which the Supreme Government and this Government had lately to consider was whether the Company should be exposed to great difficulties at home from the want of those metals which were in the treasury here and relieving them to the full extent of their power, deprecating at the same time the repetition of that demand and endeavouring by all other means to mitigate the evil consequences of such an exportation upon the public credit and the public finance in India.'[1]

The Court of Directors have also admitted that there was a considerable net export of bullion in the thirties.[2]

Several writers have inveighed against this export of bullion on the ground that it was a drain of wealth from the country, but we are not concerned with that aspect of the matter here; nor do we think that even mercantilists will be alarmed when a country which for long periods of time imports precious metals exports a part of it subsequently. What we are concerned with is the effect of these transactions on the currency system of the country. We have to note in this connection that the treasure exported in those days consisted almost entirely of specie.[3] It is true that the imports—small as they were in quantity—were also largely specie, but as they were currencies of foreign countries, they could not get into circulation unless recoined in the local mint. And as for such recoinage we have definite evidence that the 'uncurrent coin' tendered to the mint during the period diminished considerably from year to year, although no seigniorage was charged on recoinage. The following figures taken from the Report of the Mint Master at Madras will make this clear.

[1] *Ceded Districts Handbook*, Ed. by P. Macqueen, I.C.S., Vol. 4590, pp. 247-49. Also extract from Board's Proceedings, dated 9th Sep., 1830, paras 18-21.

[2] Despatch of the Court of Directors to Madras, dated 30th Aug., 1834 (No. 13). (Finance).

[3] The imports and exports of silver on private account were all in specie with very rare exceptions—see Board's Consultations, 25th December, 1859. On the Government account, on the other hand, all the exports had been 'wholly in specie,' as clearly pointed out in the Proceedings of the Board of Revenue, 5th January, 1860, para 3.

STATEMENT SHOWING THE AMOUNT VALUE OF MERCHANTS' BULLION AND UNCURRENT COINS, RECEIVED INTO THE MADRAS MINT FROM 1841-42 TO 1849-50.

Year.	Merchants' Gold and silver outturn value.			Gold and Silver Uncurrent coins outturn value.			Total.		
	RS.	A.	P.	RS.	A.	P.	RS.	A.	P
1841-42 ...	7,81,951	0	11	22,53,676	6	9	30,35,630	7	8
1842-43 ...	9,39,328	2	9	8,07,270	9	8	17,46,598	12	5
1843-44 ...	11,93,612	11	11	36,17,818	7	4	48,11,431	3	3
1844-45 ...	4,00,059	15	11	22,06,815	3	6	26,06,875	3	5
1845-46 ...	5,39,034	3	8	25,51,078	11	0	30,90,112	14	8
1846-47 ...	2,11,739	9	5	55,55,400	7	8	57,67,140	1	1
1847-48 ...	1,12,676	11	0	28,90,539	8	9	30,03,216	3	9
1848-49 ...	1,77,895	12	7	12,11,847	7	7	13,89,743	4	2
1849-50 ...	2,44,319	1	7	9,46,903	8	6	11,91,222	10	1

* *Report on the Proposed abolition of the Madras Mint: App. 8 to the Report dated 11th April 1851.*

It is clear from the above table that the bullion tendered for coinage fell off considerably during the period 1841-42 to 1849-50. This was perceptible after the year 1834. The average annual amount of bullion tendered to the mint previous to the year 1834 was Rs. 32½ lakhs. It gradually declined until in 1847-48—the year of the great commercial panic and crisis—it came down so low as Rs. 1 lakh.[1]

The result was that the currency of the country became progressively inadequate to meet the local needs. The suspension of the Madras Mint aggravated this state of things in the thirties and to this fact C. R. Cotton, Special Commissioner, appointed to enquire into the financial stringency of the Presidency, attributes the distress of the time.[2] Indeed the Madras Mint was reopened under orders from the Court of Directors dated 10th May 1839 (Despatch No. 12), but as

[1] Mint Master's Report: 11th April, 1851, para 23.

[2] Cotton's Report (MSS), 1840, para 82.

above pointed out, that did not materially improve the currency situation of the Presidency.

V

Currency Legislation

It may be remarked, by the way, that the influx of gold into England must have been a matter of some convenience at the time to the Bank of England, which was then engaged in building up a gold reserve for the support of its currency system. England adopted the gold standard in 1816, and as this meant the redemption of all notes in gold, every effort was made by the Bank of England to build up a gold reserve. It was therefore natural that the Government of that country should have offered special facilities for the transportation of bullion by the East India Company.[1] This measure had its repercussions on the Indian currency system. Gold became undervalued, and the gold mohur rose from Rs. 16 to Rs. 18. This shook Indian bimetallism to its foundations and made it essential to reorganise Indian currency on a new basis. A reform on the English model was deemed unsuitable. Giving evidence before the House of Commons Committee in 1832, Mr. Horsley Palmer, Governor of the Bank of England, said: 'Gold neither does nor will circulate to any extent as current coin in India whose silver forms the actual currency and is legal tender. . . . . I should be directly opposed to an opinion of the propriety of introducing gold into India as the current coin of the realm'.

Accordingly, India in 1835 gave up its crude bimetallism and adopted the silver standard. There were too many kinds of rupees in circulation, and of this the Arcot Rupee was accepted as the standard coin by Act XVII of 1835. That Act also laid down that gold shall not henceforth be legal tender on payment in British India, and thus demonetized all the gold coins which hitherto passed current in the country. Indeed the bulk of the gold coins had either been hoarded or had gone out of the country, except in the Northern Circars where a considerable number of gold coins seems to have been in circulation.[2] By adopting the Arcot Rupee as the standard coin

[1] See Despatch dated 10th April 1838.
[2] Dodwell, *Indian Journal of Economics*, 1920-22, p. 201.

Government did away with the currency confusion that then prevailed, and thus laid the foundations of a stable currency system; but the immediate result was not quite favourable. By demonetizing gold and discarding the numerous varieties of rupees, there arose a shortage of legal tender money in the country and this aggravated the fall of prices. Referring to the Act of 1835, Sir J. C. Coyajee says: 'The progress of uniformity of currency though ultimately beneficial brought much immediate and wide hardship on the people, for the withdrawal of debased currency led to a reduction of the circulating medium for a time and led to great fluctuations of prices.'[1]

Not only were the innumerable denominations of currency within British India discarded, but the Indian States and Principalities that came under British suzerainty had also to give up their coinage rights, and this meant the abolition of several mints which hitherto met local needs. Even petty poligars possessed mints of their own.

Paper currency could not make up the deficiency of the circulating medium created by the Act of 1835, for, although the Madras Bank was allowed to issue bank notes, that power was hemmed in by various restrictions in regard to cash reserves and so forth. In 1838, the maximum amount of issue was fixed and the Bank was strictly forbidden from exceeding that limit.[2] Thus the issue of notes was rigidly fixed without any reference to the currency needs of the country. In 1840, Mr. C. R. Cotton reported that a more elastic paper currency controlled by Government was essential, but that question was not taken up till 1860.[3]

Nor are we sure that a more plentiful issue of paper currency would have remedied this state of affairs at the time. Whatever may be the amount of currency coined by the Mint, unless all such currency finds its way into the pockets of the people, it would not really affect prices. In the period under survey, the Company's trade transactions and the Bill policy of the Court of Directors prevented the influx into India of all the monies due to her on trade account; and owing to the parsimonious policy pursued by the Company's Government with regard to public works in Madras, and the abolition of

[1] *The Indian Currency System* (Sir William Meyer Lectures), p. 6.
[2] Despatch of the Court of Directors, 16th May 1838, No. 8 (Finance).
[3] Cotton's Report, 20th Feb., 1840, para. 83.

the Company's textile establishments in various parts of the Presidency, all the currency coined in the country did not get into circulation. The Mint Committee of Madras estimated that although the 'corpus' of the currency was about Rs. 4 crores, more than half of it was locked up in the Government treasuries.[1]

Thus the supply of money in India during the period diminished (1) by the efflux of gold and silver and (2) by the diminution of the circulating medium in India resulting from the Act of 1835.

VI

Demand for Money

At the same time the demand for money increased chiefly by the replacement of barter by money economy and by the growth of business transactions in the country. The demand for money is measured by the extent of the use to which money is put; and when money economy expands and transactions increase, prices are bound to be affected. With the inauguration of British rule in India, the system of cash payments was introduced (a) in land revenue and (b) in other civil and military transactions. In pre-British times, the land revenue in India had been collected sometimes in cash and sometimes in kind. The East India Company insisted on collecting revenue only in cash, and this created some inconvenience to the tax-payers. Nor was time opportune for introducing such an innovation. In the District of Tanjore, a fixed money rent came into vogue during the time of the Amani rents of 1804-07 and was encouraged during the triennial lease of 1807-10. It was finally established in the course of the later Olungoo settlement. Indeed, in the beginning, no compulsion was imposed on the ryots, but Government placed various inducements before them to make the system acceptable. For instance, in 1808-10, with a view to make the Teerwai system acceptable it was decided to revive the ancient village system, for which the Mirasidars had a distinct preference. Vigorous rules were also promulgated for making it difficult for the tenants to continue the system of grain rents, and gradually

[1] Report of the Mint Master, 28th January, 1854, para 50.

the whole district conformed.[1] Similar difficulties arose in other districts also during the period when money assessments were sought to be established.

This transition to money economy cannot be smooth, unless the circulating medium of the country expands according to needs. But with a rigid currency system, with a currency contracting rather than expanding, prices were bound to fall.

Under the Moghuls, both the military and civil establishments were paid chiefly in kind, and the system of giving jaghirs of land was also widely prevalent. The first steps taken by the British Government were to substitute the 'regularly paid and disciplined troops, located in military stations, for the rural militia of the native feudatories and a staff of European and native officials receiving fixed salaries in place of the former mamlatdars and revenue farmers with their followers who paid themselves by perquisites and other indirect gains, but received very trifling emoluments from the treasury of the State'.[2]

To what extent did the growth of cash payments influence the fall of prices? On this, a difference of opinion is possible. A writer in the *Bombay Quarterly Journal* in 1857 opined that the slump was entirely due to 'the extraordinary demand for money occasioned by our collecting the land assessment in cash and conveying it away from the agricultural district to our large military stations for the payment of troops located there.[3] This is an exaggerated view of the situation. No doubt, the use of cash payments did cause a great inconvenience, but a part of what Government collected as land revenue came back to the people's pockets, and to attribute the whole slump to this would be to distort facts.

The demand for money is also affected by the supply of goods exchanged and the number of transactions into which they enter. In other words, if production increases and trade expands the demand for currency will thereby increase, and that by itself will depress prices, other things remaining the same. We have therefore to see how these factors influenced the demand for money.

[1] Tanjore District Gazetteer, chap. xi, p. 172.
[2] *Bombay Quarterly Journal*, April 1857.
[3] The paper is extracted in Aiyangar's *Progress*, p. xxxiv.

In the opinion of Mr. Peddar, these factors had a powerful influence. He says in the course of a note on prices in the *Report on the Moral and Material Progress for* 1882-83:— 'After the general introduction of British rule, a heavier "duty" was thrown upon the circulating medium by the extension of trade. . . . . . With peace and settled government there was a great extension of cultivation and consequent increase of production'. Our enquiries do not confirm this view. That the first experiments in ryotwari revenue settlement were not conducive to the increase of production is now fairly admitted. The first assessments were pitched too high and when the prices fell subsequently, agriculture ceased to be paying, and many ryots gave up their holdings. Mr. Mellor, Collector of Cudappah, wrote in 1845: 'The universal complaint and request of ryots is to be allowed to reduce their farms, a convincing proof that cultivation is not profitable. Land has never been saleable. Ryots, formerly substantial and capable of laying out their capital on lands and liquidating their sirkar demand, reserving their produce until they could get a favourable price, are now sunk in debt bearing heavy interest, entirely subject to their creditors; and were it not for the aid of the Collector, through the revenue subordinates, one-half or at least one-third of the highly assessed lands would have been thrown up.'[1] So widespread was the discouragement to cultivation that Lord Harris, the Governor, wrote in 1856 that the area under cultivation in Madras was only one-fifth of the whole, and had no tendency to increase.[2] The land revenue demand in 1825-26 was for Rs. 330 lakhs, but in 1829-30, it fell to Rs. 284 lakhs, and by 1833 to Rs. 275 lakhs. The fall was so heavy that it perturbed the minds of the Court of Directors and at their instance an enquiry was made into the 'defalcation' of revenue in Madras. No doubt the fall may be due also to annual remissions of revenue, but this large remission year after year indicates that agriculture was depressed. Indeed in certain years, there must have been bumper crops, and that must have suddenly depressed prices.

While production was thus slackening, population went on increasing. The population of the Presidency was estimated

[1] Letter to the Board, 25th July, In Consultations, 7th December, 1846.
[2] J. M. Ludlow: *British India*, Vol. II, p. 42.

at 13.5 millions in 1822, but rose to 22 millions by 1851, in spite of the famine and mortality due to epidemics in the thirties. This necessitated importation of rice, and at that time imports came from Arakan, which then enjoyed special facilities for the production and exportation of grain. These imports came to an annual value of about 9.5 lakhs between 1834 and 1844, and were largest during the years 1836-42.[1] These imports seem to have influenced prices considerably. The greatest fall of prices occurred immediately after years of large importation. For instance, grain worth nearly Rs. 19 lakhs was imported in 1840-41 and in the following year the index number of prices fell from 74 to 56.

Nor was there during the period any considerable expansion of trade, whether external or internal. The stagnation of internal trade was the dominant characteristic of the time, and this was due to the lack of roads and other means of communication, and to the numerous impediments to free movement of trade, in the form of inland duties.[2] There were very few 'made' roads in the country, and therefore wheeled transport could not have developed. During the summer, communications were easy enough for men, but during winter, it was impeded by swamps and unbridged rivers. Even where there were roads and bridges, communication was impeded by the vexatious exactions of tax-collectors, which were particularly oppressive in Madras, where the inland duties were farmed out by Government.[3] Cotton states in his report that 'the trade of India had been depressed and all classes of the people harassed and discouraged by our mode of taxing the inland traffic'.[4]

As for external trade, it had even a more melancholy tale to narrate. When pepper and calico were in great demand abroad, export trade flourished, but with the loss of external markets in those, trade languished and the weavers lost their employment and some became agricultural labourers or mendicants. In the 18th century, Indian ships plied between the coastal ports and carried on a brisk trade. Masulipatam, Negapatam, Tuticorin and Cochin were then important ports,

[1] Official Memorandum from the Collector of Sea Customs, Madras, 8th July, 1845, Enclosure No. 1.
[2] Transit Duties (Sayer) were abolished by 1844.
[3] Hamilton, *Trade Relations between India and England*, p. 219.
[4] Cotton's Report (MSS.), 1840, para 76.

but with the establishment of British dominion, India came under the Navigation Acts, and therefore indigenous enterprise in trade and shipping had a setback.

At least upto about 1840, foreign trade remained depressed and this caused loud complaints from the Court of Directors in London. Customs revenue was most affected, as is clear from the following figures[1] :—

Year	*Land Customs*	*Sea Customs*
1828–29	Rs. 41,89,703	Rs. 10,55,917
1833–34	Rs. 33,97,200	Rs. 6,80,523

Since 1840, the foreign trade seems to have somewhat recovered, but the slowness of the recovery is clear from the fact that the total export trade only increased by Rs. 50 lakhs between 1834 and 1850. Bengal and Bombay fared much better in this respect.

VII

Conclusion

We will now bring together the different aspects of the problem. A general fall of prices must be due *either* to the diminution of the circulating medium, *or* to the increase of the demand for that circulating medium, i.e., an increase of the transactions to be performed by that medium, or to both. In the present case, we know (1) that the circulating medium diminished in quantity during the period 1820-1850, (2) that the available circulating medium had more duties to discharge, seeing that cash payments had increased and that external trade had expanded to some extent. Both influences were working simultaneously, and that led to the steep and prolonged fall of prices, but the more potent cause was on the supply side. Owing to various causes detailed above, there arose an inadequacy of currency in the country, and this resulted in one of the greatest depressions in the economic history of India.

After 1850, these tendencies changed. The discovery of gold mines in California and Australia resulted in an unprecedented supply of the yellow metal, and pushed up prices in the world's markets to great heights. This gave a great

[1] Despatch, 30th August, 1837, (Finance) paras. 4 and 7.

impetus to productive activity in India as well as in other countries. The construction of railways, the opening of plantations and the establishment of industries financed by British capital in India brought into the country much money from outside, and the growing demand for Indian jute and coffee and tea in Europe made bullion to flow once again in the direction of India. The cotton famine in Lancashire in the sixties gave India an opportunity to expand her exports beyond all proportions and the opening of the Suez Canal further strengthened that opportunity. From 1854, prices went on rising, and not even the Great Depression of Europe in 1873-96 affected India, thanks to the steady fall in the exchange value of the rupee during that period.

KING JAMES I AS MAN OF LETTERS

BY

MR. V. SRINIVASAN, M.A.

I

'Oh', cry'd the goddess, 'for some pedant reign!
Some gentle James, to bless the land again;
To stick the Doctor's chair into the Throne,
Give laws to words, or war with words alone,
Senates and courts with Greek and Latin rule,
And turn the Council to a Grammar School.'

—A. POPE: *Dunciad*. iv. 167–172 (Globe Edn.)

'*The comic offspring of the tragic union of Mary, Queen of Scots with Lord Darnley.*'

It is interesting to speculate as to what would have happened to James VI of Scotland had not a strange fate called him to play the role of king for the British Isles. The present writer has not read Prof. Hearnshaw's *Ifs of History* and is not aware if the matter has come up for the consideration of that eminent historian. None the less, information at our disposal warrants the inference that the Scottish king would have happily died a man of letters.

His literary output was considerable even at the time of his accession to the English throne. And at a later date we find him bewailing sorely[1] that 'being of riper years, my burden of state is so great and continuall without anie intermission', that his affaires and fasherie 'would not permit him to devote himself to literature.' 'Yea scarcelie but at stiller moments have I the leisure to blank upon any paper.'

He was something of a prodigy in his youth when, it is said, he could, at the age of ten, turn a chapter from the Latin Bible into French and from the French to English. He was well read, was exceptionally well-informed in theology and was well-versed in foreign politics. Awfully fond of the chase, he was a mighty hunter and an excellent horseman. A malignant fate placed him

[1] Preface to *Exercises at Vacant Hours*.

on the throne of England. He was least fitted for the job and he proved to be only a nervous drivelling idiot. He had a high opinion of his kingly duties, was, according to Warburton the first to assume the title of Sacred Majesty and believed in the divinity that hedged a king. Such a monarch was quite unacceptable to post-Tudor England. 'If only he had been a canon of Christ Church or a prebendary of Westminster,' the words are Macaulay's[1], 'he would have left a highly respectable name to posterity, and distinguished himself among the translators of the Bible and regarded by a literary world as no contemptible rival of Vossius and Casaubon'.

It was an age of great authors, of Ben and his tribe who had all received their education and apprenticeship in the palmy days of good Queen Bess. Jonson was the preferred poet of James himself and as he wrote, he had

> Eaten with the beauties and the wits
> And braveries of court, and felt their fits
> Of love and hate.[2]

The king knew Shakespeare well and according to an anecdote given by Oldys on the authority of D'Avenant, wrote him a complimentary letter in his own hand.[3] The great dramatist's works were very much in favour at the court and we learn that eight of the fourteen plays put on boards between the 1st November 1604 and the 31st October 1605 were his.[4] The king was no Puritan and was extremely friendly to the stage. A series of entertainments were got up for him during his first visit to Oxford in 1605 and the visit gave a great stimulus to theatrical activity which lasted for some time afterwards.[5] The King Majesty's Declaration, issued to his subjects in 1618, 'concerning lawful sports to be used' gave permission for dancing in the

[1] *Essay on Lord Bacon*, 1837.

[2] *Underwoods*, lx. quoted in Jusserand's *Literary History of the English People*, Vol. II, p. 386.

[3] Shakespeare did not forget the king's compliments. The lines in *Macbeth* (Act IV, Sc. i, ll.119-121) are said to refer to James:

> 'And yet the eighth appears, who bears a glass,
> Which shows me many more; and some I see
> That twofold balls and treble sceptres carry.'

The passage extracted has obtained a celebrity which reminds one of the 'fair vestal throned by the west' in *A Midsummer Night's Dream* (II. i. 158) said to refer to Elizabeth.

[4] *Essay on English Poetry* prefixed to Thomas Campbell's *Specimens of the British Poets*. See p. lxxii, note.

[5] *Cambridge History of English Literature*, Vol. VI, pp. 316-19.

church and after evensong.[1] He patronised men of letters and assisted in the publication of the plays written under French inspiration by Sir William Alexander, Earl of Stirling. The year 1611 saw the publication of the Authorised Version of the Bible. The period when James lived and reigned, was thus an epoch of plenteous crop in literature and this is an admirable feature of a reign of disrepute.

The king was much interested in the cause of education. He established the St. James College and granted a charter for the founding of an institution at Chelsea to maintain priests that would answer the adversaries of religion.[2] He took upon himself to teach Latin to Car, Earl of Somerset. When, at a later date, the Grand Duke of Tuscany complained of a book—Dallington's *Tuscany*—James ordered the book to be publicly burnt in the cemetery of St. Paul's and the author suffered imprisonment during the Grand Duke's pleasure.[3] We have it also on record that Gondamar, a Spanish ambassador in the court, would speak false Latin to him on purpose, to give him the pleasure of correcting it whereby he wrought himself into his good graces. All of which went to show how much he was interested in learning and scholarship and what a fetish he made of both.

But he himself wrote tolerable verses and some prose which did not lack vigour. He had thus his share in the Renascence movement of the age. In his days Huguenots from France found a refuge in England and the king's hospitality extended to the nationals of other countries as well.

Yet it remains to be told that all that learning could do for him was to make people think of him as a pedant. He was prodigiously conceited, posed himself as being intellectually high above the ordinary level of humanity and held views which he found it difficult to harmonise with the nascent love of freedom that was slowly asserting itself in the country. No wonder he found his path beset with difficulties at every step.

II

The first compositions of James in verse were collected and published in 1584 with the title 'Essays of a Prentice in the

[1] *Cambridge History of English Literature*, Vol. IV, p. 339.

[2] This institution was a failure Laud called it 'Controversy College' and Charles II sold the site to the Royal Society.

[3] Lewis Einstein: *Italian Renascence in England*, p. 121 (*n*).

Divine Art of Poesie'. This volume opens with a dozen sonnets wherein the writer, invoking the blessings of deities like Jove, Apollo, Phœbus, Neptune, Pluto, Mars and Mercury, solicits their encouraging benedictions in his ventures in the realm of poetry:

> 'You all forenamed gods I pray
> For to concur with one accord and will,
> That all my works may perfect be alway:
> Which if ye do then swear I for to fill
> My works immortal with your praises still.' (*Sonnet* 12)

Then follows a poem *Phœnix* treating of the piteous story of the Arabian bird which meets with its end under circumstances extremely tragic—being burnt to death. The death of the grey old fowl grieved the writer and in an envoi he beseeches Apollo to bring her to life: in which case

> 'My tragedie a comike end will have.'

The piece is in good form and runs in rhyming octaves to 37 stanzas.

There is also in this collection a small poem on Time—equally well done. Here is an excerpt:

> 'For what hath man bot tyme into this lyfe,
> Which gives him dayis his God aught to knaw:
>
> . . . . .
>
> Bot sin that tyme is sic a precious thing,
> I wald we should bestow it into that
> Which were most pleasour to our heauenly king.
> Flee ydilteth, which is the greatest lat,
> Bot sen that death to all is destinat,
> Let us imploy that time that God hath send us,
> In doing weill, that good men may commend us.'

Towards the close of the collection the author has put down another sonnet wherein he commends his exercises to the reader.

> 'From fountains small great Nilus flood doeth flow:
> Evin so of rawnis do mightie fishes breid.
> Therefore, good Reader, when as thow dois reid
> These myne first fruictis, dispise them not at all,
> Who watts, both these may able be indeed
> Of fyner poemis the begynning small.'

The pieces included in this publication abound in allusions

which testify to his range of study not only in the literature of his own age and country but also in the classics of antiquity.

A table of some obscure words with their significations after the order of the alphabet is appended to the book and there is, at the end, an extract from Pliny on the Phœnix, which has been inserted, explains the author, 'for filling up of the pages'.

Reference may now be made to a sonnet that James wrote in the year of the Armada. He was too shrewd to ignore how intimately the fate of Scotland was involved in the English resistance to the Spaniard, and commemorated the deliverance from that 'foreign and godless fleet' as he termed it:

> 'The Nations banded, 'gainst the Lord of Might,
> Prepar'd a force and set them to the way:
> Mars dress'd himself in sick and aweful plight,
> The like whereof was never seen, they say:
> They forwards came in monstrous array,
> Both sea and land beset us everywhere,
> Brags threatened us a ruinous decay.
> What came of that? The issue did declare:
> The winds began to toss them here and there,
> The seas began, in foaming waves, to swell;
> The number that escap'd it fell them fair,
> The rest were swallow'd up in gulfs of hell.
> But how were all these things miraculously done?
> God looks at them out of his heavenly throne.'[1]

God's name was ever on his lips. The sonnet was considered 'sweet' in his own day and impressed his contemporaries.[2]

One more volume of verses appeared subsequently and was titled 'His Majesty's Exercises at Vacant Hours' (1591-94). These included a translation of the *Furies* of du Bartas, a French contemporary (about whom, more anon) and a poem *Lepanto*, together with a French rendering thereof prepared by du Bartas himself.

[1] 'The same sonnet is extant in Latin by Metellanus, Lord Chancellor of Scotland'. See Earl of Essex's *Ghost. Harleian Miscellany.* Vol. V, p. 235.

[2] In Henry Petowe's *England's Caesar* written in 1603 on the occasion of James's coronation we come across these lines of compliment to the king:

> 'Nor tongue, nor poem, nor witte can truly sing
> His wondrous worth and matchless dignity.
> I meane His glory of the English King,
> Which wraps my muse in all felicite.'

See *Harleian Miscellany.* Vol. X. pp. 342-3

The works mentioned so far were composed while James was reigning in Scotland as James VI. Montgomerie was dead and the Makari epoch was at an end. At a time when an abrupt end was apprehended for Scottish poetry, James's court provided a centre of literary activity and made it possible for Scottish national literature to put forth fresh leaves. Under his distinguished patronage throve several of the better-known figures in later Scottish poetry and his inspiring presence had much to do with the output of writers like Faber, Stewart of Baldines, John Burel and others.

III

We now proceed to consider James's critical code as set forth by him in a short treatise in eight chapters which he attached to the *Essays of a Prentice*. The writer seems to have exerted himself in preparing a body of *Rules and Cautelis* to be observed and eschewed in Scottish poetry: 'I tuke earnist and willing panis to bloke it' says he in the preface.

Invention, says James, is the chief virtue of a poet[1] and comparisons, epithets and proverbs constitute the special ornaments of verse.[2] James then tells us how themes like love are handled in verse and then enjoins the poet not to insert in his works 'a long rable of mennis names, or names of townis or such other names because it is hard to make many long names all placed together to flow well.' He dreads polysyllables and among feet allows only the iamb laying down the rule that the feet, i.e. syllable must be even and not odd. The syllables are divisible into three classes[3] "Ye man understand that all syllables are divided in three kinds . . . . some schort, some lang and some indifferent . . . . By indifferent I mean they which are either lang or schort". James also advocates a cæsura or some kind of sharp division in the middle of a line.

In the last chapter (VIII) we have an interesting description of the various kinds of verses and their respective uses:

(i) Rhyme, which 'serves only for long historie';
(ii) the heroicall stanza of nine lines rhymed *aab aab bab* fit for describing manly feats of arms;
(iii) 'ballat royal' (octavo rima) fit for high and grave subjects;

[1] Chap. vii. [2] Chap. iiii [3] Chap. ii.

(iv) 'the Troilus verse'—the Rhyme Royal, for tragical matters and plaints;
(v) 'Rouncifals' or jumbling verse (doggerel alliterative) useful for purposes of invective;
(vi) sonnet verse of fourteen lines and ten feet in every line for 'compendious praising of any books or the authors thereof or any arguments of other histories where sundry sentences and change of purposes are required;'
(vii) the Common Verse (octosyllabic couplets) to be pressed into service in treating of themes of love;
(viii) finally, all other sundry kinds of 'broken or cuttit' verse—'Hall Verse'.

This is the resume of the matters covered by the Schort Treatise. James was a student of Gascoigne and an ardent disciple of Buchanan. Particular note has to be made of his remarks regarding the sonnet and of the restricted use he would put it to. He ignores all uses of that form of verse save for the compendious praising of books or their authors and for the prefatory presentation in brief summary of the topic of any long treatise.[1] Note too must be made of the insistence on the hard and fast sections in verse and his allowance among feet of only the iamb. In these could be traced the influence of French literary models where the iamb had long been the only foot. The dread of polysyllables was however something common to the writers of the age.

Prof. Gregory Smith has remarked that a shame has ever clung to the vernacular prose of Scotland that it is the vehicle for unconsidered scraps and pedantries which could not be conveniently or comfortably done into verse.[2] To this class belongs King James's Short Treatise. Thus in his opinion, the *Rules and Cautelis* is a book of small pretence. But at the same time it is hard to overlook or ignore the value of the publication which indicates to us moderns the canons of poetic taste and style that prevailed in England just before the advent of

[1] The latter usage was very rare in England. Shakespeare experimented with it by casting in the sonnet form the prologues before the opening acts of *Romeo and Juliet*. See Vol. VII, of the works in the Shakespeare Head Edition. (The Variorum puts the 2nd choral sonnet towards the close of the first act itself.)

[2] G. Gregory Smith: *Scottish Literature*, p. 121.

Spenser and Sidney. The unusual shrewdness and acumen exhibited in this treatise certainly make it a document of value. In the words of Prof. Saintsbury it is an honest and by no means unintelligent attempt to make English prosody[1] and hence its publication is to be considered besides Webbe's *Discourse* and Puttenham's *Arte* to be a notable milestone in the progress of Renascence criticism.

IV

> 'Of late yon God declared his wondrous will
> That Uranie should teach this prince most rare:
> Syne she inform'd her Scholar with such skill,
> None could with him in poesie compaire.'
>
> —WILLIAM FOULER, Sonnet prefixed to the *Essays of a Prentice.*

Of the King's translations we have to refer but to three:—

(i) The CIV Psalm of David made out of the Latin version in the edition of Emmanuel Tremellius (1510-1580) a celebrated Hebrew scholar of Jewish extraction.

(ii) a paraphrastical rendering of some of Lucan's verse.

(iii) *The Uranie* translated from du Bartas (by far the best and the most important of the translations).

Reference has already been made to the stream of French influence on the literary ideals of James I. But French influence was even then only a recent phenomenon. It was not much in evidence in the poetry of Dunbar and became more and more marked only with the accession of Mary Stuart. French poetry was the queen's chief reading, Ronsard and du Bellay grew into raptures over her superb beauty and the verses she made had admirers on the other side of the channel. And her son could not be beaten in his ardour for French poetry.

As for the English people, they had much sympathy for the Huguenot movement and many a refugee had found shelter under their hospitable roofs.

Thus began the process by which French ideals began to exercise a more and more increased influence on English life extending at a later stage to the field of diplomacy as well.

[1] G. Saintsbury: *Criticism and Literary Taste in Europe*, Vol. II, pp. 177-178.

Gillaume de Salluste Seigneur Du Bartas (1544-1590) was the most important figure in the Huguenot intellectual movement who affected the imagination of the English people. The honours that Shakespeare's generation paid him excelled those bestowed on any foreign contemporary of that epoch. Even Ronsard's star waned in his presence.[1]

James was the person who discovered Du Bartas for England. A perusal of the Frenchman's *Uranie* made him an enthusiast and he set himself to the task of introducing him to the English people. The offshoot of this was a translation of the *Uranie*. At that time translations were few and the king's performance furnished a model for imitators.

In his prefatory remarks, James explains why he took to translating the French poem. Nature had not been overbountiful to him, he says and he lacked 'lofty and quik ingyne' to imitate the 'divine and illustrious poet' whom he admired. Hence he began to translate his poem, that having appeared to him as the best form his homage could take under the circumstances. He was not unconscious of his limitations and set the original side by side with the translation. 'I have put in the French on the one side leif and my bloking on the other, noght thereby to give proofe of my just translating but by the contrairy to let appear more plainly to the reader wherein I have err'd, to the effect that with lesse difficulty he may escape those snares wherein I have fallen.'

The sincerity and the modesty animating the preface, as indeed all of James's prefaces, is something which is peculiar and indubitable.

Continuing the thread of his relations with Du Bartas we may refer to his very strenuous efforts directed towards bringing him into vogue in England. Under his direction, a translation was prepared (1584) by Thomas Hudson, of *Judith* an epic of Du Bartas. Before the latter made its appearance, Du Bartas published *La Semaine* which James read with much avidity. *La Semaine* was an encyclopædic poem and by far the best and the most famous of his works. Goethe admired it and made

[1] Du Bartas was frequently referred to in the literature of the age, books of travel not excepting. The celebrated Welshman, translator, and traveller, James Howell refers to him: "Being come to France, there be some French poets will afford excellent entertainment specially Du Bartas"—Sect. 3, *Instructions for Forraine Travell*. 1612. (p. 25 in Arber's Reprints, Vol. viii).

a profound and deep impression on the British Solomon. He invited its distinguished author to visit England; which he did. On his return to his native land Du Bartas amply requited James's hospitality by publishing a French version of his *Lepanto* and by eulogising its royal author in the preface. Thus something like mutual laudation passed between the two.

James was not the only admirer of Du Bartas; a host of English writers fell under the magic spell of the Frenchman's influence. His works were translated by Sidney and Sylvester; Donne's satires and Drayton's scriptural tracts bore the impress of his unmistakable influence and even the *Paradise Lost* has been acclaimed to be a distant offspring of *La Semaine*. For about a century Du Bartas's fame remained a fixed star in the literary firmament.

The eagerness with which the Elizabethans greeted him is indeed an inexplicable curiosity in the history of literary criticism. Perhaps public opinion towards the close of the sixteenth century was defective in judgment and was inclined as Sidney Lee surmised[1], to set what was second-rate and third-rate above what was first-rate.

Antoine de Montchretien, a Norman poet of humble parentage, was yet another Frenchman whom James patronised heartily. Montchretien was the author of several tragedies modelled on Seneca and had in his best drama, *L'Escossaise* told the last days of Mary Stuart with pathetic accuracy. King James naturally was grateful for the portrayal of his mother and sheltered him when he had to flee from France for his Huguenot credo. Sometime after, James successfully pleaded with Henry IV and procured the refugee's pardon.

V

A third person has to be referred to before we pass on to the other well-known works of James,—namely, *the Demonologie* and the *Counter blaste*. This was John Florio, a Protestant refugee from Italy. Florio was a Florentine and taught at Oxford and at London and eventually was appointed Italian reader to Anne of Denmark, the wife of James[2]. He was a

[1] S. Lee: *French Renaissance in England*. p. 340. Bk. V. Chap. ix.
[2] Lewis Einstein: *Italian Renascence in England*, p. 102. Also S. Lee *ibid.* 170.

familiar figure at the court and was noted for his translation of Montaigne's essays. He did much to popularise Italian amongst the gallants of the city and his pupils included the Earl of Southampton, the patron of Shakespeare.

Next to France Italy exerted on Elizabethan civilisation an influence which might be traced back to the days when Chaucer sojourned in the peninsula. Even Shakespeare alludes to the fashions introduced into England of his day:

> fashions in proud Italy,
> Whose manners still our tardy apish nation
> Limps after in base imitation.[1]

Italian crimes furnished the subject-matter of the tragedies written during the reigns of Elizabeth and James and again it is well-known that—thanks to Wyatt and Surrey—, the sonnet too came from Italy.

VI

Plays with witches formed an important branch of the drama of the age, and the *Witch of Edmonton* by Rowley, Dekkar and others is a well-known production in this class of literature: the witch represented in the play being supposed to refer to one actually executed.

When Reginald Scott, an Englishman had the temerity to deny the existence of witchcraft, James rebutted his arguments. This he did in the dialogue—*Demonologie*—which was published in 1597.

The King believed in demons and spirits but held with Roger Bacon that the infernal world was not beyond God's dominion.

His essay partakes of the nature of a manual, and recapitulates with ample quotations the various theories held by previous demonologists. Digressions there are, on philology and ecclesiasticism, but these do not detract from the value of the book which is marked by a fulness of detail that does credit to the writer. It is a scholarly performance on the whole and is referred to in Boswell's *Life of Johnson*.

Some of the recommendations contained in James's paper inspired Parliament to enact a law condemning witches to death. *Basilikon Doron* or "Instructions to his dearest

[1] *Richard II*, Act II, Sc. i, ll. 21-23.

sonne ", Charles, (written about 1599 and published secretly, the edition being limited to seven copies) is another important work of James wherein are enshrined his real thoughts. It is in this work that James first indicated his predilections towards the system of Government by Bishops over which so much trouble was to brood during the reign of his successors. The work inspired Sir Walter Raleigh to prepare " for his son and to posterity " another book on the same lines.

A French version of *Basilikon Doron* was published at Paris in 1603 by Vielliers Hotmann, one of the earliest instances of a book being translated from English into French.

VII

The *Counterblaste to Tobacco* was perhaps the first production of James to be published after his accession to the English throne. Raleigh is credited with the introduction of " tobacco drinking " into the kingdom. It had developed into a vicious national habit[1] and tobacco pamphlets became a part of the social literature of the land. King James who like his contemporaries, Shah Abbas of Persia and Jehangir of our own history, considered it a noxious drug, wrote his famous attack.

In a brilliant preface he has told us how much perturbed he has been by the alarmist growth of the tobacco drinking habit which held, octopus-like, the whole English nation in its tentacles. He upbraids the people for their sluggishness. ' Our peace hath bred wealth, and peace and wealth hath brought forth a general sluggishness which makes us wallow in all sorts of idle delights, soft delicacies, the first seeds of the subversion of all great monarchies. Our clergy are become negligent and lazy, our nobilitie and gentes prodigal and solde to their private delights, our lawyers covetous, our common people prodigal and curious, and generally all sorts of people more careful for their private ends than for their mother, the Commonwealth.' This was unworthy of the English people. ' It is the king's part to purge society of all these diseases by medicines meet for the same, to maintain peace, to make them ashamed of sluggish

[1] Ben Jonson's *Every Man In his Humour* (1596) has a reference to the habit See Act. III. Sc. ii. Also Spenser : *Faerie Queene*. III. v. 32.

> ' There, whether yt diuine tobacco were,
> Or Panachaea or Polygony she found.'

delicacies, to waken the clergy to be more diligent in their offices and all these generally by the example of his own person by removal of abuses and by the due execution of good laws.' "And

> surely in my opinion there cannot be a more base and yet hurtful corruption in a country than in the ill use (or abuse) of taking tobacco in the kingdom which hath moved me sharply to discover the abuses thereof in the following little pamphlet. '

Having elaborated in this manner the *raison d'etre* of his brochure James severely rebukes the Englishman for his addiction, to his own destruction, to a habit which was but an antidote amongst primitive society to a filthy malady. After some quaint and vigorous descriptions of the disgusting habits of the smoker we have a detailed refutation of the arguments advanced in favour of the use of the herb. Suffimigation does no good either to the mind or to the body and the encomiums bestowed on the herb[1] says James, are all meaningless. The drinking habit has nothing to recommend it. It is but a branch of the sin of drunkenness which in turn is the root of all sins. You are only disabled and rendered effeminate on account of a custom,

> 'so lothsome to the eye, hateful to the nose, harmful to the brain, dangerous to the lungs and in the black stinking fume thereof nearest resembling the horrible Stygian smoke of the pit that is bottomless."

So ran James's thesis.

Not content with this tirade he issued in October 1604 a proclamation—Commissio pro tobacco—augmenting the customs duties on the article, and directed the High Treasurer of the Realm to actively co-operate with him in the campaign against the obnoxious habit.

[1] *Cp.* this extract from a poem written by an enthusiast in an Ovidian style :

> ' The faire mother of all fragrant flowers :
> From which first love aglorious Sample springs,
> Beloved of heavenly gods and earthly kings.
> ....
> The sweete and sole delight of mortall men,
> The cornucopia of all earthly pleasure,
> Where bankrupt Nature hath consumed her treasure,
> A worthie plant springing from Floraes land
> The blessed offspring of an uncouth land.'

It was in this strain that the pamphleteers of the time wrote of the Promethean virtues attributed to tobacco.'

Many a writer took the cue from the sovereign[1] and ere long tobacconists fell into ridicule. It is wonderful to reflect on the extent to which the theme proved to be a favourite whetstone for the wits of the age.

VIII

James published in his reign several other works most of which however were tracts deserving little more than mention. Such are: (1) Triplici Nodo Triplex Cunens. 1605. (2) A Premonition to all the Mightie Monarchs, Kings, Free Princes and States of Christendom. 1609. (3) A Remonstrance for the Right of Kings. 1615. (4) A Meditation of Revolutions.

Interesting particulars could be found in the Second volume[2] of Rowland Gardiner's *History of England* during the period 1603-1642, of the circumstances under which James, by interfering in a controversy between the Spanish Court, Henry IV of France and the Pope, contrived to transfer the dispute from the sphere of diplomacy to his favourite field of literature. Thus was written *the Apology for the Oath of Allegiance* (1609) wherein he attacked the two breves and indicated the right of temporal authority against the ecclesiastical power.

IX

More remarkable than these is "*The True Law of Free Monarchies*" which has an abiding interest to all students of history. It forms a part of the literature on the Divine Right of Kings about which a battle royal has been waged. James had ever had an exalted sense of duty: witness, for instance, his solicitude for the welfare of his subjects which finds expression in the preface to the *Counterblaste.*

The king, according to James, was the fountain of honour, justice, and the mainspring of all power, civil and military, and as such ought to be looked to as the hope of public-spirited conduct in the realm. He was the supreme Trustee of the nation—that was the claim forwarded by James in the *True Law* under reference. He believed—and sincerely—that the divine right of succession lodged in the ruler was not capable of alteration by

[1] As for instance Richard Braithwaite the author of '*The Smoking Age*' 1617.
[2] Pp. 27-28.

any human authority: much the same thing that Shakespeare put in the mouth of his *Richard II*:

> 'Not all the water of the rough rude sea
> Can wash the balm off from an anointed king.
> The breath of worldly men cannot depose
> The deputy elected by the Lord.'[1]

Any attempt to act up to such a political philosophy was doomed to fail in Renascence England and it is not surprising that many of James's and his son's undertakings in which they endeavoured to execute what they held to be their trusteeship, miscarried and miscarried disastrously.

X

But there is no mistaking the sincerity with which James bolstered up the arguments in support of his views. In a different age the position he took up would have been acknowledged as substantially correct. It was his misfortune that times were too far out of joint for him.

James was an indifferent writer but a clear one. He is forcible and knows how to drive home his points. His speeches were scarcely less vigorous: that is evident from all contemporary accounts.

A certain promptness of wit, much solid judgment and acute critical ingenuity are certainly his and the claim as man of letters can no more be denied him than the question whether Pope was a poet be decided against the sage of Twickenham.

Viewing the Bodleian once, he is said to have exclaimed: 'Were I not a king I would be an University man, and if it were so that I must be a prisoner, if I might have my wish I would have no other prison than this library and be chained together with these good authors.'[2] A mere nincompoop could not have expressed himself thus. Literary conscience compels one to conclude that James was a zealous votary of literature and that posterity has scarcely been charitable to him. It is unfortunate that a dispassionate judgment of the man could not be divorced from unfavourable notices of the ignominious foreign policy of the reign. And it has to be conceded that he was a captain of arts though but a clerk of arms.

[1] Shakespeare: *Richard II*. Act. III. Sc. ii. ll. 54-57.
[2] Isaac D'Israeli: *Curiosities of Literature* Vol. I, p. 466.

THE OOGENESIS OF *EMERITA ASIATICA*[1] MILNE-EDWARDS

BY

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The present paper contains an account of the reproductive organs and the history of the cytoplasmic inclusions, particularly their share in vitellogenesis, the chromosomal history being reserved for a subsequent contribution. The work was carried out in The University Zoological Laboratory, under the guidance of Professor R. Gopala Iyer, the Director, and I wish to thank him for his unfailing help and advice. I am indebted to the Madras University for awarding me a research studentship and thus enabling me to pursue this work.

The history of the cytoplasmic inclusions in oogenesis has claimed the attention of a number of cytologists in the past few years, as a result of which the oogenesis of a number of animals belonging to almost all the major classes of the animal kingdom has been investigated.[2] Among the crustaceans, with which alone we are concerned in the present paper, *Oniscus asellus, Carcinus mænas, Lygia oceanica, Calanus finmarchicus, Scylla serrata, Palæmon lamarrei,* and *Paratelphusa spinigera* are the forms that have been studied. Since the later papers contain good summaries of previous work I shall merely give below a tabulated statement of the most important of their conclusions, namely,

[1] The name *Hippa* was changed into *Emerita* in 1900 by J. E. Benedict and the latter has been accepted by all American Carcinologists.

[2] For a summary of work done till 1931 see the article on Zoology by Prof. MacBride and Hewer in *Recent Advances in Microscopy*—Biological. Edited by A. Piney, 1931.

those relating to the role of the various inclusions in yolk formation.

Name of form	Albuminous yolk.	Fatty yolk
Oniscus ...	Mitochondria swell and become converted into albuminous yolk.	Golgi elements swell and become fatty yolk.
Carcinus ...	By the deposition of material in the Chromophobe part of Golgi elements to which is added extruded nucleolar matter.	Arises *de novo* in the cytoplasm.
Lygia	Arises from the Golgi apparatus	Do.
Calanus ...	Formed in the mitochondria by the transformation of part of their own substance and the deposition in them of substances derived from the nucleolus and the cytoplasm.	*nil.*
Scylla ...	Nucleolar extrusions may indirectly influence the synthesis of proteid yolk.	Golgi elements swell and form fatty yolk
Palæmon ...	Mitochondria swell and become albuminous yolk.	Do.
Paratelphusa.	Nucleolar extrusions grow directly into yolk.	Do.

The table brings out quite clearly the important fact that even in the same class of animals the origin of yolk has been noticed to be different in different species. This is particularly so in the case of albuminous yolk, in the formation of which all the cytoplasmic inclusions, namely, Golgi elements, mitochondria, and nucleolar extrusions take part either individually or collectively.

Material and method.—The work was mainly carried out during the months of March, April, May and June, when ovaries contain eggs in different stages of growth. For purposes of fixation freshly secured animals were opened in the living condition and small pieces of ovary were cut off

and transferred directly to the different fixatives. Bouin's fluid was used as a general fixative. For the study of the nucleolus the above fixative followed by iron hæmatoxylin gave very satisfactory results. Material fixed in corrosive acetic and stained in Mann's methyl-blue eosin was also very useful. For the detection of chromatin Feulgen's 'Nucleal-reaction' was adopted. Staining in pyronin-methyl-green furnished information for chromophility. Methods for mitochondria included Flemming without acetic and iron hæmatoxylin, Chamy-Kull and Kolatchev-Nassonov. The last mentioned method gave the most satisfactory results for the demonstration of Golgi elements also. Ludford's modification of the Mann-Kopsch method was tried, but was not very useful. It may be of interest to note here that for both of the above methods the necessity of an incubator was not felt since the atmospheric temperature of the place in the hot months in which the work was done comes very nearly up to what has been recommended. Osmication for five days in the Kolatchev-Nassonov method produced excellent impregnation of the Golgi apparatus, which were jet black in sections. The method of Da Fano was very unsatisfactory though the material was left in the fixative and silver nitrate solution for varying periods. It should therefore be mentioned here that all the observations on the Golgi elements recorded in the subsequent pages are based mainly on the results of the above mentioned chrome-osmiun method.

In addition to the above methods absolutely fresh tissue was frequently studied in a drop of sea water. Pieces of ovary stained post-vitam in janus green (strength about 1 in 30,000) and osmicated in 2 per cent osmic acid were also studied; fresh and formalin fixed material stained in Sudan III was made use of to detect the presence of fat. In view of the unreliability of the action of neutral red solution as demonstrated by Gattenby and others on various kinds of cells, (8) no attempt was made to study material stained by this dye intra vitam.

Observations

Ovary: Fig. 1. The ovaries lie partly in the thorax and partly in the abdomen. The anterior end of each ripe ovary is a flattened structure, consisting of two main lobes, one extending forwards and the other to the sides.

Each lobe is again divided into smaller lobes. The posterior part of the flattened portion of each side is connected by a transverse bridge of ovarian tissue lying above the pyloric part of the stomach. Behind the transverse connection each ovary is cordlike, lying in close contact with each other, over the midgut. In the sixth thoracic segment the two fuse to form a common median portion which extends to the fifth abdominal segment usually along the left side of the alimentary canal.

The oviducts are short straight tubes arising on each side from the hind end of the middle portion of the ovary. They run down and open on the inner side of the coxopodite of the sixth thoracic leg.

Syncitium and Early oocytes. Figs. 2 and 3. The germinal tissue is in the form of a syncitium. The nuclei are small, oval bodies containing a faintly staining recticulum and a few nucleoli. Groups of these nuclei which are destined to give rise to the oocytes then enlarge and undergo the early prophase changes of the reducing division. At first the chromosomes appear as a network of threads which stain well in hæmatoxylin. Although in all fixed preparations the early stages of the oocytes are so crowded together as to make the detection of cell boundaries impossible, it seems probable that at this stage they become cut off from the syncitium. These early oocytes have very little cytoplasm around the nuclei. Some of the nuclei are represented in Bouin iron hæmatoxylin preparations in the form of dark grey masses in which a number of black-granules are imbedded (Fig. 3 deg. n). They are probably degenerating nuclei. The spireme is followed by a synizesis stage from which emerge the bivalents. The bivalents show a tendency to move towards the neculear membrane. In the further stages of growth of the oocytes the bivalents gradually become extensively branched and stain more and more feebly. At the commencement of this change each of these oocyte nuclei has assumed the appearance of a typical germinal vesicle more or less round and several times bigger than the syncitial nuclei. The chromosomes seem to remain in this diffused condition throughout the subsequent stages of

growth. Many of these older oocytes are surrounded by several nuclei (Fig. 2) which may be concerned in the nutrition of the oocytes.

Chromatin.—After Feulgen's test the syncitial nuclei are bright purple in colour with very little unstained space in them. In the nuclei of the early oocytes the spireme and the bivalents are well stained but the other parts of the nuclei are uncoloured, thus showing that all the chromatin is concentrated in these threads. In the later process of diffusion undergone by the bivalents a progressive dimunition in the intensity of staining takes place, till in about a half grown oocyte hardly any staining is noticeable.

Nucleolus.—The nuclei of the syncitium contain a few basophil granules. A small oxyphil nucleolus appears at about the time of the formation of the bivalents (Fig. 3). It stains bright red in Mann's methyl-blue eosin and pyronin-methyl-green. It is uncoloured after Feulgen's test and hence appears to be a plasmosome. Usually it occupies an excentric position inside the nucleus. It grows along with the oocyte but does not change in position markedly. Even in the young oocytes a few small irregular bodies staining identically with the nucleolus occur inside the nucleus (Figs. 6,7) some of which are occasionally found near the nuclear membrane. These are the early nucleolar extrusions which may ultimately find their way into the cytoplasm.

As the oocyte grows the activity of the nucleolus seems to increase, attaining a maximum in those which are about a third of the mature oocyte in size and in which albuminous yolk has not yet appeared. In the nucleus of such an oocyte small irregular masses of nucleolar matter are scattered about, some occasionally remaining in contact with one another (Fig. 4). Many are seen closely pressed against the nuclear membrane. Though no particles resembling nucleolar extrusions could be seen in the cytoplasm, minute black granules are seen sticking to the outside of the nuclear membrane in sections stained with hæmatoxylin (Fig. 5). The condition in which they come out, whether as entire bodies or as a fluid is not clear. It may be, as Hilton has remarked, that the granules on the outside of the nuclear membrane are due to the condensation of fluid matter during fixation.

The appearance of the nucleolus undergoes considerable alterations during this period of activity. At first it was homogeneous, staining red in methyl-blue eosin and pyronin-methyl-green and black in hæmatoxylin. But as the process of extrusion of matter progresses the colour becomes fainter and fainter. At the same time a large central vacuole surrounded by several smaller ones appears in it. The appearance varies slightly in material prepared according to the Champy-Kull, Kolatchev-Nassonov and Ludford techniques. In some a central vacuole can be seen which is practically colourless (Fig. 11). The rest of the nucleolus is of a pale yellowish green colour in which a number of dark green minute vesicles are present. In others only these smaller vesicles are noticed (Fig. 12).

During the later growth of the oocyte the nucleolus remains comparatively inactive, since the nuclei of these oocytes contain very few extrusions. The ultimate fate of the nucleolus has not been traced.

Golgi apparatus.—No trace of a Golgi apparatus could be discovered in the syncitium. In the earliest oocyte also a clearly defined apparatus was not visible in any of the preparations. Nor was the method of osmication of fresh tissue in 2 per cent osmic acid successful. In a slightly grown oocyte represented in Fig. 6 on one side of the nucleus there are two or three bodies which are darker than the surrounding greenish yellow mitochondrial material in Kolatchev-Nassonov preparations. These bodies might represent the feebly impregnated Golgi elements. In a still older oocyte, however, unmistakable Golgi elements in the form of more or less round vesicles with intensely black rims and pale interiors are present (Fig. 7). As the oocyte grows these increase in number and spread out in the cytoplasm. As the elements spread they grow in size to some extent. In some preparations there were a few irregular elements (Fig. 8). These are believed to be imperfectly impregnated and collapsed ones. Ultimately they become uniformly distributed in the cytoplasm. In the later stages they show some amount of resistance to fixatives containing acetic acid, as some of them have been noticed in material fixed in corrosive acetic and as indicated by the appearance described below,

noticed in material fixed in strong Flemming (with acetic).

Even while the Golgi elements are gradually spreading, some of them grow, though not very much, and a gradual accumulation of fat takes place inside them (Fig. 8). These vesicles do not at any stage attain to the enormous size that has been noticed in other animals. These fatty vesicles have their interior also blackened to the same extent as the rim. In preparations of material fixed in strong Flemming (with acetic) and mounted after dissolving away the paraffin an appearance represented in Fig. 18 can be noticed. The smallest Golgi vesicles are in the form of black granules. Some of the larger ones which have withstood the action of canada balsam are uniformly black while the majority are decolorised and look like empty vesicles with dark grey rims. Irregular and crescentic forms are also present, but the latter seem to be optical sections of vacuoles. If the same sections are examined after immersion in turpentine for an hour and a half all except the smallest appear as empty vacuoles with grey rims. In stained slides only empty spaces are left, probably due to the dissolving action of alcohol.

Older oocytes prepared according to the Flemming without acetic method and mounted unstained contain several Golgi elements in the form of irregular black bodies wedged in between the albuminous yolk globules (Fig. 19). Some appear in the form of vacuoles with dark grey rims while others are crescentic. Such appearances are very rare in the Kolatchev-Nassonov pereparations. Since the crescentic structures are not met with in younger oocytes devoid of albuminous yolk globules and in Kolatchev-Nassonov preparations they seem only sections of the vesicular Golgi bodies. Granules uniformly black or light grey are also present, the latter of which being osmicated fatty yolk globules decolorised by canada balsam.

Examination of fresh tissue mounted in a drop of sea water proved highly useful for studying the formation of fatty yolk. In a very young oocyte the Golgi elements were not visible. In another of the size represented in Fig. 14, however they can be clearly seen in the form of highly refractile tiny vesicles of varying sizes and gray granules mostly confiend to one side of the nucleus. This corresponds more or less to the stage shown in Fig. 8 in which the Golgi elements have not spread to all parts of the cytoplasm. The bigger vesicles are of a pale greenish yellow colour, while the smaller ones appear grey. In a third and bigger oocyte (Fig. 15) they have spread still more and at the same time the number of greenish yellow vesicles has increased very much. As shown in Fig. 15 these lie mostly on the outer half of the cytoplasm. In still more advanced cells (Fig. 16) they are present in all parts of the cytoplasm. When a drop of Sudan III solution was run under the coverglass all the larger vesicles turned a deep reddish orange in less than a minute while the smaller ones showed varying shades of yellow. The granules could not be seen. It is therefore clear that the vesicles are really Glogi bodies in which fat is being gradually deposited, raising their refractive index and visibility.

In the ripe oocytes most of the Golgi elements have become globules of fatty yolk. In osmic acid tests these did not go black in a few minutes but became completely black only after osmication was continued for several hours. The smaller ones were browned to varying degrees. The smallest had black rims and pale inside.

Mitochondria.—All of the fixed preparations were unsuitable for the study of the early oocytes due to extreme crowding. The syncitium does not show any substance resembling mitochondria. In some preparations stained with iron hæmatoxylin a grey structureless mass was occasionally noticed lying at one end of the nucleus of the very young oocytes (Fig. 13). A corresponding body stained pink in Champy-Kull material. This mass soon expands and forms a ring around the nucleus (Fig. 6). At this stage it is clearly visible after any of the methods for mitochondria mentioned above. In Flemming without acetic followed by iron hæmatoxylin it is deep grey, pink by Champy-Kull and greenish yellow in Kolatchev-Nassonov (unstained).

Gradually the circumnuclear ring expands outwards without breaking away from the nuclear membrane (Figs. 7 and 8) In this expanding mass definite granular mitochondria can be made out. Finally in an oocyte which is little more than

a fourth of a mature one in size the mitochondria are evenly distributed in the cytoplasm. They are extremely numerous minute spherical granules staining dark grey in iron hæmatoxylin.

As growth progresses they become bigger and show more affinity for stains. Soon albuminous yolk begins to appear. Usually the first-formed yolk masses are near the periphery, though occasionally they seem to arise in any part of the cytoplasm (Fig. 9). Each of these globules under high magnification is seen to consist of a clump of enlarged mitochondria (Fig. 10). In some sections prepared by the Kolatchev-Nassonov method various stages in this process can be seen. Each of them lies in a clear area of the cytoplasm.

In later stages of growth yolk formation becomes more rapid and takes place in all parts of the cytoplasm (Fig. 11). Many of these later yolk droplets are smaller than the earlier ones. Some are formed by a few mitochondria, while others arise by the direct transformation of individual mitochondrial granules. During the process of formation most of the yolk spheres, except the smallest, show numerous vacuoles or in stained preparations granules inside them (Fig. 11). Structures showing such internal differentiation have been noticed by Bhatia and Nath among the swollen mitochondria of the oocytes of *Palæmon lamarrei*. Most of these vaculoles disappear in the fully formed yolk granules, many of which have now become irregular in shape (Fig. 12). A fully grown oocyte is packed with these yolk masses, between which are found the fat globules and unmodified Golgi bodies (Fig. 17); the cytoplasm having shrunk to a narrow layer around the nucleus which is usually found at one pole.

In Kolatchev-Nassonov preparations the initial stages of the albuminous yolk globules are of a pale greenish yellow colour. But the older ones are dark and sometimes even black. In Ludford material all except the smallest ones are black. The blackness can be removed by keeping the slides for three to four hours in turpentine. It would seem therefore that the time of osmication, namely five days in the former and three in the latter is slightly longer than is necessary for this material.

Cytoplasm.—In the youngest oocytes the cytoplasm is strongly oxyphil and is stained bright red in pyronin-methyl-green and methyl-blue eosin. With the growth of the oocyte the cytoplasm gradually becomes basophil. The yolk masses are faintly green in pyronin methyl-green, but stain purple in methyl-blue eosin. In the growing globules stained by the latter method a number of dark granules are present. They are however absent in the smallest as well as the fully formed yolk droplets. The cytoplasm gets much vacuolated in later stages (Fig. 11) the process beginning long before the onset of albuminous yolk formation. In some of the early oocytes a comparatively large vacuole was noticed on one side of the nucleus, which seems to disappear in older oocytes.

Discussion.—The account given above contains few points of outstanding importance requiring detailed consideration here. So far as the nucleus is concerned the absence of chromatin in the older oocytes as revealed by Feulgen's test is the most interesting point to be noted. This phenomenon has been noticed by Koch (20) in the oogenesis of Chilopods, and his conclusion was that the chromatin undergoes some chemical change during the growth of the oocytes. Ludford (21) could find scarcely any chromatin in the oocyte nuceli of *Limnæa stagnalis*. Some however were noticed to have a faint purple coloration. While recognising the probability of chemical change, he is inclined to believe that the chromatin may be so finely distributed as to render its demonstration impossible by this method. Gresson also records a similar disappearance of chromatin from the oocytes of saw flies and adopts Koch's (20) explanation for the phenomenon. The same may hold good in the case of *Emerita* also, since the changes outlined above are essentially similar to what the latter author has noticed.

The process of yolk formation is initiated comparatively very early in the present form. The origin of fatty yolk from Golgi elements has been previously observed in several invertebrate animals, viz. in *Oniscus, Scylla, Palæmon* and *Paratelphusa* among Crustacea; *Luciola, Periplaneta, Dysdercus, Culex* and saw flies among Insecta; in the scorpions; in the scolopendrid *Otostigmus;* in the spiders; in the mollusks *Helix, Patella* and *Pila*. The process of fatty yolk formation

in *Emerita*, as described above, is similar to what takes place in these animals, namely, the gradual enlargement of the Golgi bodies and the accumulation of fat inside them, though in the present case the increase in size is not considerable.

Whether the process of transformation is simply a case of condensation of neutral fats inside them due to their own activity or whether it is really a chemical change in which some portion or the whole of them gets converted into fats is not quite clear. Bell (1) has described a direct transformation of groups of Golgi granules into neutral fat in the spermatids of the dog and adduces chemical evidence in support of his view that the Golgi elements consist of phospholipins. In a recent paper, after reviewing the evidence furnished by the osmic acid, Scharlach R and Sudan III tests on the Golgi elements and fatty yolk of a number of animals, Nath (24) comes to the conclusion that the osmiophilic part of these bodies 'consist of unsaturated lipoids and the osmiophobic part of very nearly fully saturated lipoids'. At some stage in oogenesis in several animals these lipoidal elements, which at first do not stain in the two latter dyes, are converted into fats when they are stained brilliantly. It may be quite probable that a portion of the Golgi elements undergoes chemical change in the formation of fatty yolk. But the presence of rims around fully formed fatty yolk as noted above, seems to indicate that secretion of fat may be taking place at the same time.

The transformation of mitochondria into albuminous yolk has been noticed in some other animals also besides the Crustaceans mentioned previously. Brambell (7) has recorded it in *Helix* and *Patella*, Gardiner (9) in *Limulus* and Hirchler (18) in *Ciona*. The mitochondria in all these cases swell and become albuminous yolk.

In several cases nucleolar extrusions have been noticed, and are believed to take part in the formation of yolk.

The following facts of observation lend support to this view.

i. The phenomenon of nucleolar extrusions has been observed by almost all workers on oogenesis. (For a summary of work on nucleolus see Gresson 11.)

ii. The period of maximum activity of the nucleolus is her just before the commencement of vitellogenesis as in *nerita,* or coincident with the latter as in *Calanus.*

iii. Gardiner has proved that in the oocytes of Limulus e nucleolar extrusions convey some substance rich in phos- ıorus from the nucleolus to the cytoplasm, which is used the synthesis of yolk.

iv. In several animals these nucleolar extrusions have ɜen noticed to give rise to albuminous yolk directly. (*Sac- ıcirrus, Luciola, Dysdercus, Periplaneta,* Saw flies and *Para- lphusa.*)

The observations of Hilton (17) and Harvey (15) in *Calanus* nd *Carcinus* respectively seem to furnish direct evidence for combination of nucleolar matter with yolk. The former oticed a darkly staining cloud around groups of mitochondria t some stage in oogenesis and attributes it to an accumula- ion of nucleolar material. Harvey noticed the presence of central chromophil core in some of the large peripheral yolk ;lobules similar to the plasmosomal granules scattered in the ytoplasm. The core gradually expanded and finally the yolk ;lobule stained brilliantly.

In view of the above facts and the activity of the nucleolus ;ketched in the section dealing with it, it is possible that ılbuminous yolk is formed in *Emerita* by the deposition of ;ubstances derived from the nucleolus and perhaps from the ;ytoplasm inside the swollen mitochondria, which themselves might undergo some chemical change in the process.

SUMMARY

1. The germinal tissue is in the form of a syncitium. Groups of these nuclei enlarge and undergo the early prophase of reducing division, during the course of which they become cut off as definite oocytes.

2. During the growth of the oocytes the chromatin of the nuclei gradually diminish and finally disappear as revealed by Feulgen's test.

3. The nucleolus is a plasmosome. Nucleolar extrusions begin very early, but become most marked a little before the commencement of albuminous yolk formation. It is suggested that they contribute some substance in the synthesis of yolk.

4. In the syncitium no Golgi elements appear to be present. The youngest oocytes also did not reveal their presence by any of the usual methods. In slightly older oocytes a few vesicular elements make their appearance. These gradually increase in number, spread in the cytoplasm and eventually most of them become fatty yolk.

5. Mitochondria are absent in the syncitium. In the young oocytes they form a structureless mass on one side of the nucleus. Gradually the mass grows and becomes a circum-nuclear ring, which then spreads outwards, ultimately becoming evenly distributed in the cytoplasm in the form of innumerable minute granules.

6. The granular mitochondria swell, clump together and give rise to albuminous yolk. After some time the process becomes more rapid and takes place in all parts of the cytoplasm. At this stage the mitochondria may collect into small groups and give rise to yolk droplets or may directly become separate yolk globules.

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ABBREVIATIONS.

al.y.	...	albuminous yolk.
b.f.g.	...	blackened fat globules.
biv.	...	bivalents.
bq.	...	bouquet stage.

PLATE I.

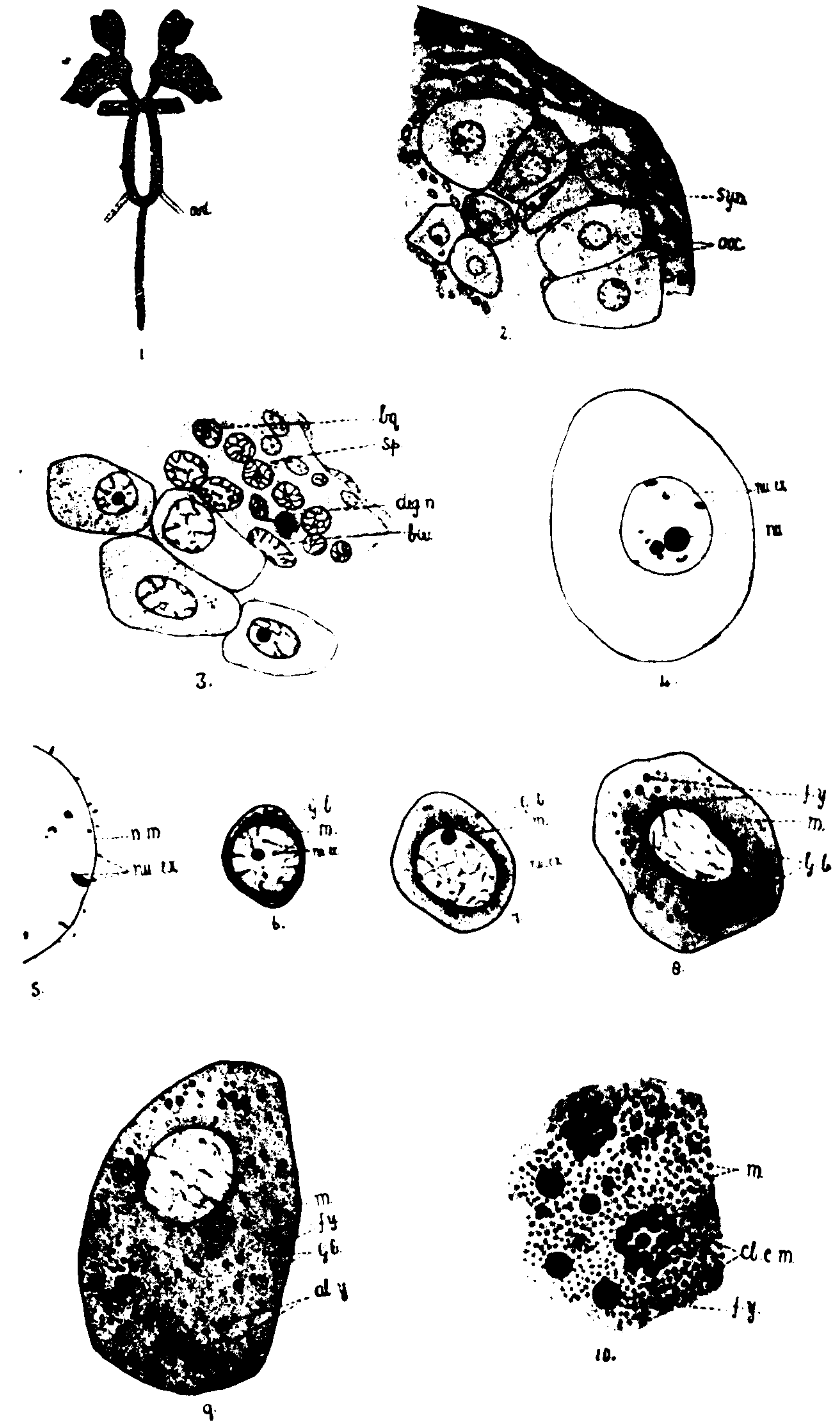
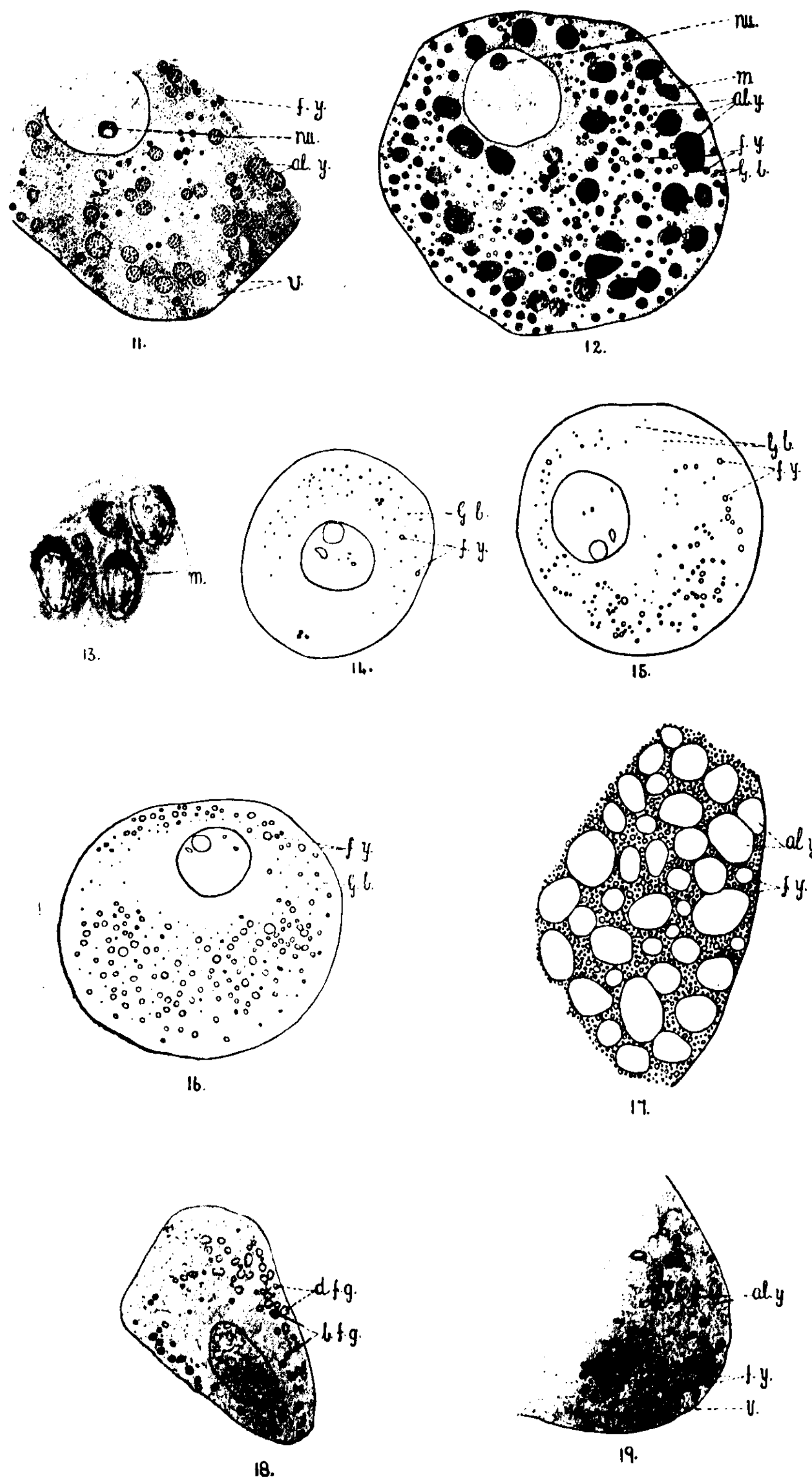


PLATE II.



cl.e.m.	...	clumps of enlarged mitochondria.
d.f.g.	...	decolorised fat globules.
deg.n.	...	degenerating nucleus.
f.g.	...	fatty yolk.
G.b.	...	Golgi bodies.
m.	...	mitochondria.
n.	...	nucleus.
nu.	...	nucleolus.
n.m	...	nuclear membrane.
nu.ex.	...	nucleolar extrusions.
ovd.	...	oviduct.
sp.	...	spireme.
v.	...	vacuole.
K.N.	...	Kolatchev-Nassonov.
Ch.K.	...	Champy-Kull.
F.W.A.I.H.	...	Flemming without acetic followed by iron hæmatoxylin.
B.I.H.	...	Bouin's fluid and iron hæmatoxylin.
Cor. Ac. M.M.B.E.	...	Corrosive acetic and Mann's methyl-blue eosin.

FIGURES.

1. Mature ovary. Nat. size.
2. Germinal tissue with older oocytes. B. I. H. × 130
3. Syncitium and the earliest stages of the oocytes. B.I.H. × 325.
4. A young oocyte showing nucleolar extrusions inside the nucleus. Cor. Ac. M.M.B.E. × 650
5. Nuclear membrane showing granules of nucleolar matter sticking to the outside and inside. B.I.H. × 650
6. Very young oocytes showing circumnuclear mitochondrial ring and Golgi bodies at one pole. K.N. Unstained. × 650
7. Oocyte slightly older than the former. K.N. Unstained. × 650
8. Still more advanced Oocyte. K.N.I.H. × 325
9. Oocyte in which albuminous yolk formation has commenced. K.N. Unstained. × 325
10. Mitochondria highly magnified to show how they clump together and form albuminous yolk droplets. K.N. Unstained. × 1625
11. Older oocyte in which albuminous yolk is formed in all parts of the cytoplasm. Ch. K. × 325
12. Advanced oocyte. K.N. Unstained. × 325
13. Youngest oocytes with indistinguishable cell boundaries showing mitochondrial mass at one side of the nuclei. F.WA.I.H. × 650

14, 15, 16. Fresh oocytes showing the gradual enlargement of the Golgi bodies to become fatty yolk. × 325

17. Portion of a fresh oocyte, almost ripe, slightly pressed under coverglass. × 325
18. Young oocyte showing blackened and decolorised fat globules. Strong Flemming with acetic, unstained. × 325
19. Portion of an older oocyte in F.W.A.I.H. Preparation showing distorted Golgi bodies and blackened fat droplets. × 325

THE UNIVERSITY

THE HON'BLE SIR K. RAMUNNI MENON

On 21st May, the Hon'ble Sir Konkoth Ramunni Menon, *Kt.*, M. A. (Cantab.), retired from the Vice-Chancellorship of the University after holding that high office for six years. He has served the University in various capacities since 1912, and during this period of 22 years, he has taken an active part in the affairs of the University. The Journal may therefore be permitted on this occasion to publish a short sketch of his life and work.

Sir Ramunni Menon was born on 14th September 1872, at Villyadom near Trichur in the well-known Nair family of Konkoth. His father, Mr. Idichanadath Krishna Menon, was a cultured and able public servant of his time. He was the pet of his uncles who educated him, and after their death, he has admirably discharged the duties of the *karanavan* of that prosperous Tarwad. In 1899, he married Miss V. K. Kalliani Amma of Kurupath, one of the aristocratic families of Trichur.

Sir Ramunni Menon had a brilliant academic career. He received his early education at Trichur and Ernakulam, and at both places he distinguished himself as a student of unusual gifts. In 1893, he passed his B.A. from the Presidency College, topping the list of candidates in English and Zoology in the Presidency. He then obtained the Gilchrist Scholarship and proceeded to Christ's College, Cambridge, where he was subsequently elected to another scholarship—an unusual distinction for an Indian student, even in these days. He took a first class in both parts of the Tripos (in 1896 and 1897) and soon after returning to India, entered the Madras Education Department. In 1910, he became Professor of Zoology in the Presidency College, and he held that post till his retirement in 1927.

As Professor at the Presidency College, he built up an efficient Department of Zoology. He was a brilliant teacher and understood the difficulties of his students, and those who have had the privilege of attending his lectures will always remember with gratitude the great pains he took in making the subject interesting and instructive. A strong disciplinarian himself, his students soon learned to adjust themselves to the rather severe atmosphere of his lecture hall. Of him it may be truly said that he radiated discipline without actually enforcing it. A keen and careful observer, he trained his students in habits of accurate and systematic work and thus fostered qualities which have stood many a young man in good stead in after life.

In 1928, he was appointed Vice-Chancellor of the University, and was reappointed again in 1931. Since the reorganisation of the Madras University in 1923, the duties of the Vice-Chancellor have become heavy and varied; and in order to discharge them efficiently, not only academic eminence but great administrative ability and a capacity to master minute detail have become essential. It will be generally admitted that Sir Ramunni Menon brought to his task administrative ability of a high order, and as for his capacity for detail, it has become a by-word. The most important task during his term of office was the reorganisation of the University administration to meet the requirements of the Amendment Act of 1929, and he addressed himself to this task with great earnestness and unremitting industry. The statutes of the University were carefully overhauled, proper academic standards were prescribed for the affiliated colleges, and suitable arrangements were laid down for the housing and functioning of the newly established research departments of the University. He administered the laws of the University with great fairness and his dealings with the affiliated colleges were characterized by tact, impartiality and a real desire to maintain standards, both intellectual and moral. His greatest success was perhaps in the financial sphere. It was during his term of office, and largely under his initiative, that an adequate financial system was evolved for the University. He husbanded the resources of the University with great care, put his finger on every item of waste, and all avenues to economy were thoroughly explored and effectively utilized. Thanks to such a jealous guard of the purse, the finances of the Madras University are to-day in a prosperous condition, and all those who know University finances in these days, whether within India or outside, will recognize that this is a great achievement.

Perhaps the establishment of the Research Institutes of Zoology, Botany, and Bio-Chemistry will be regarded by future generations as his greatest achievement as Vice-Chancellor. He planned them long and well, and by the time he laid down the reins of office, the three Institutes were firmly founded.

Sir Ramunni Menon took great pains to foster social life in the University. He enthusiastically pushed through the scheme of a University Union, taking particular care that it should benefit the students of the Colleges in the City. The frequent entertainments that he organised at the Senate House not only brought together the teachers of the different Colleges, but also served as opportunities for the contact of academic people with persons engaged in other walks of life.

It is not sufficiently known that Sir Ramunni Menon is an ardent lover of art and literature. In the striking Convocation Address delivered by him in 1927, he emphasised the importance of the study of literature and throughout his career, he has used every opportunity to impress upon the people around him the value of general culture. He is the founder of the Stone Prize for English in the University and of the Bilderbeck Prize for the same subject in the Presidency College. He also instituted a prize for Sanskrit at Christ's College, Cambridge. Nor is his conception of culture a narrow one. He is a keen lover of pictures, and it may be remembered that the Faculty of Fine Arts and the Diploma in Music were established during his regime. He has instituted a Medal for fine arts in the Ernakulam College (which is awarded for Drawing and Music in alternate years), and just on the eve of his retirement from the Vice-Chancellorship, he founded a Lectureship in the University for the advancement of the study of aesthetics.

This is not perhaps the time to dwell on the sterling qualities that have contributed to his success, but this account cannot be complete without a bare reference to his great sincerity and equanimity, the austerity of his personal life, his hatred of sham and ostentation, and his ardent devotion to duty.

It remains for us only to wish him success in the new sphere of activity which he has entered upon. If the Council of State is to reflect the 'sober second thought of the Nation', it should contain persons of mellowed wisdom and sound judgement, persons who are capable of giving wise counsel on economic and constitutional questions, uninfluenced by political shibboleths and party interests. The Council of State has secured such a person in Sir Ramuni Menon, as already the Council debates have shown. May he live long in the service of King and Country!

UNIVERSITY NOTES

(January to July 1934)

CHANGES IN PERSONNEL

The term of office of the Vice-Chancellor, Sir K. Ramunni Menon, Kt., ceased by efflux of time on the 21st May 1934, and Mr. R. Littlehailes, C.I.E., M.A., one of three persons recommended by the Senate, was appointed Vice-Chancellor of the University for a term of three years from the 21st May, 1934.

During the period, 8th February to 20th May, when Sir K. Ramunni Menon was on leave, the Rev. F. Bertram, S.J., a member of the Syndicate, was appointed to officiate as Vice-Chancellor.

The following changes took place on the Syndicate:—

Mr. M. A. Candeth died on the 28th March 1934 and in this vacancy Mr. C. J. Varkey, Professor, St. Aloysius' College, Mangalore, was elected by the Senate.

Mr. Quadir Hussain ceased, by efflux of time, to be a member of the Syndicate from the 7th May 1934, and Mr. A. Gopala Menon, of Trivandrum, was elected to the Syndicate by the Academic Council.

Lt.-Col. C. Newcomb, I.M.S., resigned his nominated seat on the Syndicate in May, when he went on leave, and Lt.-Col R. E. Wright, C.I.E., I.M.S., Ag. Principal, Madras Medical College, was nominated by the Chancellor to the vacancy.

COURSES OF STUDY

Recommendations for revision of higher research degree courses and draft revised regulations for the Matriculation and Intermediate examinations which were placed before the Academic Council were referred back to the Syndicate for reconsideration and report with reference to certain details and directions given.

Regulations for the new B.Sc. (Veterinary) Degree course and examinations were adopted.

TEACHERS AND RESEARCH DEPARTMENTS

The services of Dr. P. J. Thomas were lent to the Government of India as one of the two Indian Economic Experts appointed to work with Dr. Bowley and Mr. Robertson in connection with the Economic Survey. He was away on this duty from 2nd January to 31st March 1934.

Mr. P. S. Lokanathan, Reader in the Economics Department, who went on study leave to England in July last returned to duty in February 1934 after qualifying for the D.Sc., Degree of the London University, the thesis submitted by him for the degree being 'Industrial Organization in India.'

The proposal for the institution of a Department of Anthropology was approved by the Syndicate and the Academic Council and the details of the Scheme are now under consideration by the Board of Studies in the subject.

Mr. Sundararama Sastri, M.A., M.Sc. has been appointed to the vacant Lectureship in Statistics.

PUBLICATIONS

The following are the latest publications of the University:—

1. *The Challenge of the Temporal Process.—Principal Miller Lectures, 1933*, by Dr. A. G. Hogg.
2. *Vijianagara.—The Origin of the City and the Empire* by Dr. N. Venkataramanayya.
3. *The Unadi Sutras in various recensions.* Edited by Mr. T. R. Chintamani, Parts II. and VI.
4. *Brhati.*—Part I. Edited by S. K. Ramanatha Sastri.

LECTURES

The following endowment lectures were delivered during the period:—

Principal Miller Lectureship. By Rev. John Mackenzie, Bombay, on 'Purpose and Progress.'

Dr. Elizabeth Mathai Lectureship. By Lt.-Col. R. E. Wright, C.I.E., I.M.S., on 'The Chief Preventible Blinding Diseases of Childhood'.

Mr. Ghulam Yazdani of Hyderabad who was appointed to deliver the Sir William Meyer Lectures for the year 1934 expressed his inability to do so and the Syndicate has appointed Mr. K. N. Dikshit to deliver the lectures in History next year.

Rao Bahadur K. V. Rangaswami Ayyangar, of Trivandrum, was appointed to deliver the Sir William Meyer Lectures in Economics for this year.

ENDOWMENTS

The following new endowments were accepted by the Syndicate:—

(i) The Rt. Hon. Sir George Stanley Lectureship instituted by Diwan Bahadur Sir K. Ramunni Menon, *Kt.*, former Vice-Chancellor, in the name of the Rt. Hon. Sir George Stanley, Governor of Madras and Chancellor of the University, the subject of the lecture being Aesthetics to be delivered once in three years.

(ii) Dr. A. Lakshmanaswami Mudaliar Medal instituted by Diwan Bahadur Sir K. Ramunni Menon, *Kt.*, former Vice-Chancellor, in the name of Rao Bahadur Dr. A. Lakshmanaswami Mudaliar to be awarded to the candidate who qualifies for the degree of M.B., B.S., and gets the highest number of marks in Midwifery.

(iii) Mr. G. A. Natesan Prize instituted by his friends out of subscription received in connection with his *Srashtiabdapurti* (sixtieth birthday) ceremony. The Prize is to be awarded for proficiency in Indian Music either in B.A., or in the Diploma in Indian Music.

OBITUARY

THE LATE MR. M. A. CANDETH.

It is with deep regret that we have to record the death of Mr. M.A. Candeth, one of the most distinguished educationists of the day in Southern India. The spontaneous expressions of regret from his innumerable friends, acquaintances and old students give but a feeble indication of the loss that was so widely felt in the many spheres of activity with which he was associated. No one who had come into touch with the late Mr. Candeth

would have failed to realise what a dynamic personality he was, and how richly gifted he was, with some of the finest qualities of head and heart which people appreciate in any individual.

After a brilliant scholastic career, both here and abroad, he soon found himself in the robes of a teacher and here he had an opportunity to show to the fullest extent the depth of his learning, and the width of his tastes. To the students who had the good fortune to sit at his feet, and imbibe the great lessons of life which he was preaching in his homely style, he was not only the teacher in the class-room, but in reality a friend, philosopher and guide, whose sane advice amidst the many witty sarcasms he used to indulge in, was of permanent and abiding value. Mr. Candeth's intellectual vigour could not possibly keep him tied down to his desk or to the immediate group of students under his charge. He threw himself heart and soul in the wider spheres of activity connected with education in general and students in particular. As a member of various university bodies for several years, Mr. Candeth proved himself an invaluable leader of sound educational ideas and of high academic aims. It could be truly said of him as of Goldsmith that he touched nothing that he did not adorn. Whether in the boards of studies, or in the Academic Council, or in the Senate, his intervention in any debate was welcomed on all sides, because he had the rare gifts of clear thinking, of precise thought, lucid expression, persuasive eloquence, and sweet logic, so that even when he demolished the arguments of his opponent, he did it with such grace that there was little of heat or passion generated.

His work on the chief executive body, the Syndicate, was even more solid, if somewhat less spectcular, and his colleagues would bear testimony to the influence he wielded on all important matters of policy and administration. He was ever anxious to pursue the narrow path of duty, careless of the smiles and fearless of the frowns of the multitude, and was not one of those who dare not be in the right with two or three.

Mr. Candeth was a great patriot and his patriotism took the solid shape of some material contribution for the development of true citizenship. His name will ever be associated with the inception and progress of the Madras University Training Corps, and his influence for good was tremendous and well-known to all interested in the future of that body. He did not, however allow his patroitism to be swayed by sentimentalism or warped by the passing phases of popular fancy, and had almost a contempt for those spectacular displays of evanescent frenzy which sometimes swayed large groups of adolescents and adults.

In society Mr. Candeth was always a centre of attraction. Endowed with brilliant conversational abilities, with a mind peculiarly agile and gifted with a wide knowledge of men and manners, he was well able by his vivacious wit and sparkling humor to enthrall any audience in a drawing room. And many are his friends who have come away from his company cheered and relieved and in a robust frame of mind.

Mr. Candeth had a great future before him. It was well-known that he would have risen to the highest rung of the ladder as an educationist and he was himself looking forward with real pleasure to the work that lay before him immediately as the Principal of one of the premier colleges in the Presidency. His death is a great loss to the educational world and we of the University are panticularly sorry that we have been deprived of such a wealth of talent. To the members of the bereaved family we extend our heartfelt sympathy. May his soul rest in peace.

A. L. M.

REVIEWS

THE MAHABHARATA, Southern Recension, critically edited by Vidyasagar P. P. S. SASTRI, Vol. IV, Aranya Parvan, Part I. V. Ramawsami Sastrulu & Sons, Esplanade, Madras.

Six volumes of this critical edition of the Southern Recension of the Mahabharata in eighteen volumes have already been published by Messrs. Ramaswami Sastrulu & Sons. The first part of Aranya Parvan comprising volumes IV and V, which was held over, has now been issued. A welcome feature in the get-up of this volume is the light coloured printed wrapper which protects the cover.

Dr. Sukthankar in his Bhandarkar Institute edition of the Mahabharata, while admitting the great value of Prof. Sastri's critical work has challenged his whole method of editing. In the introduction to this volume Prof. Sastri examines and refutes the criticism. As pointed out by Prof. Sastri, it would not be possible to examine *all* the manuscripts of the Southern Recension, and record *all* their variations. While such a method may be desirable in the case of other works, it would be neither practicable, nor profitable in the case of the Mahabharata. The best that could be done has been done by Prof. Sastri, namely, to choose which pass the tests of belonging to the Southern Recension, and adhere to them in the main, recording the departures therefrom scrupulously. We do not think that Dr. Sukthankar is justified in charging Prof. Sastri with arbitrariness in fixing the chapters 'in order to reach an imaginary norm.' Surely, the scheme in the Parvasangraha is not 'an imaginary norm', and it is entirely reasonable on Prof. Sastri's part to attempt a conjectural reconstruction of it, not in an arbitrary manner, but basing his division on one or other of the manuscripts available.

R. V.

BOOKS RECEIVED

Everyday Law for Women	By Helena Normanton.
Trial of A. A. Rouse	,,
Trial of Norman Thorne	,,
India in England	,,
Kingship through the Ages	By P. S. Ramakrishna Iyer.
Groundworks of Economics	By R. D. Richards (*Tutorial Press*).

PERIODICALS

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Monthly Summary of the League of Nations.
The Nagpur Agricultural College Magazine.

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2.	**Sources of Vizianagar History,** by Dr. S. Krishnaswami Ayyangar. Available from the Superintendent, Govt. Press, Mount Road, Madras... ... ... each	4	8	0
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