quite apart from their intrinsic interest in the taxonomy of animals. Many fossil forms identified by their general features are likely to prove distinct if examined more minutely. *Lingula ovalis* has for many years been cited as a remarkable case of persistence of type from the Early Palæozoic down to the present day. The writer finds it hard to believe that this presumed (and widely accepted) identity between the ancient form and the modern would stand the test of scrutiny under the microscope.

(e) *Geochronology of the Pleistocene of Kashmir.*

There is a wide and fascinating field, largely untapped, for research in India on the lines laid down in the classical work of Baron de Geer and his school in Scandinavia, North America and other parts of the world.[15] The Karewas of Kashmir contain numerous outcrops of varved clays which would well repay examination. A whole team of field geologists can be employed in making, firstly, a general survey of all such occurrences, then a series of collections of varved columns which should be combined into a local chronological scale. It may ultimately be possible to make detailed correlations with the glacial and interglacial cycles in Scandinavia. The palæobotanist can help to complete the ecological picture by working out the pollen flora in the varved sediments, which should indicate local changes in vegetation and climate.[16] The important work of Dainelli, de Terra, Norin and others on the Pleistocene of Kashmir is a clear indication of the possibilities that lie before the Indian worker: obviously this is mainly a task for those who can apply themselves continuously to field work for some years at a stretch.

A considerable amount of work has been done by Puri[17] on the larger plant-remains in the Karewas. This work should be brought to completion, but at the same time it should be recognised that the pollen analysis of the Karewa Series, and of the sub-recent peat deposits of Kashmir, holds promise of even richer results for a close dating of climatic oscillations and orogenic movements in this area during the past few million years.

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INDIAN WOOL*

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ON account of its many scientific and technical aspects, wool has been a subject of close study in recent times. As a result we have a fairly good conception of the physical and chemical nature of wool, one of the oldest known protein fibres; and the knowledge has been fruitfully utilised in a number of technological developments pertaining to woollen textile industry. From the economic standpoint the quality of wool is of paramount importance to the country which has a large trade in this commodity. Assessment of wool qualities in terms which are physically definable is, therefore, necessary. This is generally done either by specific numbers or by some symbols which show a relation to the spinning quality expressed as "Counts". Ultimately, however, all such specifications which are made by the wool sorters merely by appearance and feel of the samples, are related to the absolute dimen-

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sion of the fineness of the fibres which is precisely measurable in physical terms. Laboratory methods have been, therefore, perfected and specifications drawn up to which various trade qualities of wool conform.

Indian and Foreign Wool

Of the four thousand million pounds of wool annually produced in the world, the major proportions are contributed by Australia and New Zealand (33 per cent.), and by America (25 per cent.). The European countries produce about 20 per cent., while Africa and Asia account for the rest almost equally (10 to 12 per cent.) between them.

India produces annually nearly one hundred million pounds of wool, which is 2·5 per cent. of the total world production, and is valued at fifty to sixty million rupees. Of this about half is exported, mostly for the manufacture of carpets. But, like cotton, Indian wool, in common with other Asiatic wools, is considerably coarser than those produced in other countries, notably Australia. Indian wool, consumed in this country and abroad, is useful only for coarse quality goods such as blankets, carpets, cheaper qualities of felts and as a lining material for clothings made from finer wools. Indian woollen mills, producing yarns and cloth for the worsted and clothing types of materials, mostly use foreign wools or blends of foreign and Indian wool of selected varieties from Kashmir and Tibet.

On the other hand, paradoxical as it may seem, India also produces the world's finest wool material, namely, the undercoat of fine hair of the famous Pashmina goat of the Kashmir frontier. The production of Pashmina wool is, however, extremely limited, and the question of increasing the population of this animal in its own habitat and in other parts of the country still needs a systematic investigation.

As the finer quality wools consumed by the woollen mills costing 10 million rupees and the fabric materials costing nearly 30 million rupees, are all imported the question may be asked, if it is not possible to produce better wool in this country. Before attempting to answer this question it is important to know the types of wool produced in India and their comparison with the foreign products. The following table gives the relevant information.

Fineness, Homogeneity, Medullation and Length

Fibre fineness is the main characteristic which determines the quality of wool, and it would be seen from the foregoing table that the first and second quality wools from other countries with finer fibres are much superior to Indian wools. However, as far as the fineness is concerned foreign wools of the coarser types (third and fourth qualities) are comparable with the two higher grades of Indian wool (Joria and Bikaner). Still, foreign wools with the same fineness as these two would be rated at a much higher value by the wool trader. Coarseness of the fibre is, therefore, not the only defect in Indian wool. It is the very uneven spread or distribution of the fineness, combined with what is known as medullation or hairy portion, indicated by the dead white appearance and non-resilient nature of the fibre that are responsible for the inferiority of the Indian wool. These defects result from the wild state in which the Indian sheep are allowed to breed. In the absence of selective breeding, they propagate their primitive coat of coarse hairy wool from generation to generation, without any improvement. This fibre heterogeneity and medullation are noticeable in some foreign breeds of sheep also, such as the Romney of New Zealand and the Blackface mountain sheep of Scotland, but these are rather exceptional cases, whereas in most of the Asiatic breeds both heterogeneity and medullation are common.

Commercial Classes of Wool in Various Countries

Wool type	Trade quality	Fineness (fibre diameter in microns)
INDIAN ;		
(i) Joria	40'S	38
(ii) Bikaner	36'S	40
(iii) Low East Indian ..	very low below 30'S	50
AUSTRALIAN ;		
(i) Super combings (Merino)	80'S	19
(ii) ,, clothing ..	70'S	20
(iii) ,, cross bred ..	58'S	26
(iv) Cross bred	46'S	35
S. AFRICAN		
(i) Super combing ..	80'S	19
(ii) Second combing ..	66'S	21·5
(iii) Coarse merino ..	below 60'S	Above 24
AMERICAN		
(i) Fine	80'S–64'S	19–22
(ii) Half blood	60'S–56'S	24–28
(iii) Quarter blood	50'S–46'S	31–35
(iv) Common bred	44'S–38'S	37–39
ENGLISH :		
(i) Southdown	58'S–50'S	26–31
(ii) Cheviot hog	44'S–40'S	36–38
(iii) Scotch black face ..	32'S–28'S	48–52

It would be, therefore, obvious that unlike foreign wools, specifications giving only the fibre fineness would not suffice for Indian wools. We need to have specifications for heterogeneity and medullation as well. These have to be established by suitable methods, heterogeneity by the evaluation of the co-efficient of variation in diameter from a large number of microscopic measurements on the individual fibres in a wool sample and medullation by the measurement of the medullated portions in each fibre, carried out along with the diameter measurements.

A clear idea of the position being considered would be obtained from the accompanying diagrams and photographs. Figs. 1, 2 and 3 show instances of homogeneous, moderately homogeneous and heterogeneous fibre distributions respectively in samples of shoulder wool from three different sheep. While Fig. 1 shows a uniform sample with high peak, the large variations in fineness (diameter) and the con-

sequent heterogeneity of the sample in Fig. 3 is at once apparent. Most of the Indian wool

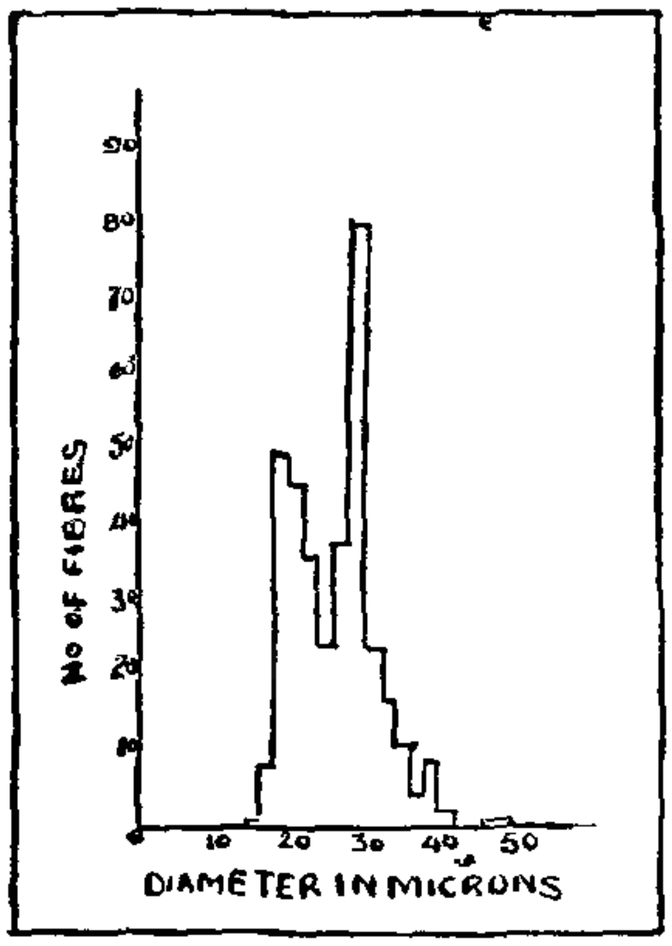

FIG. 1

is of this character, and this is conveniently shown by the corresponding value for the per-

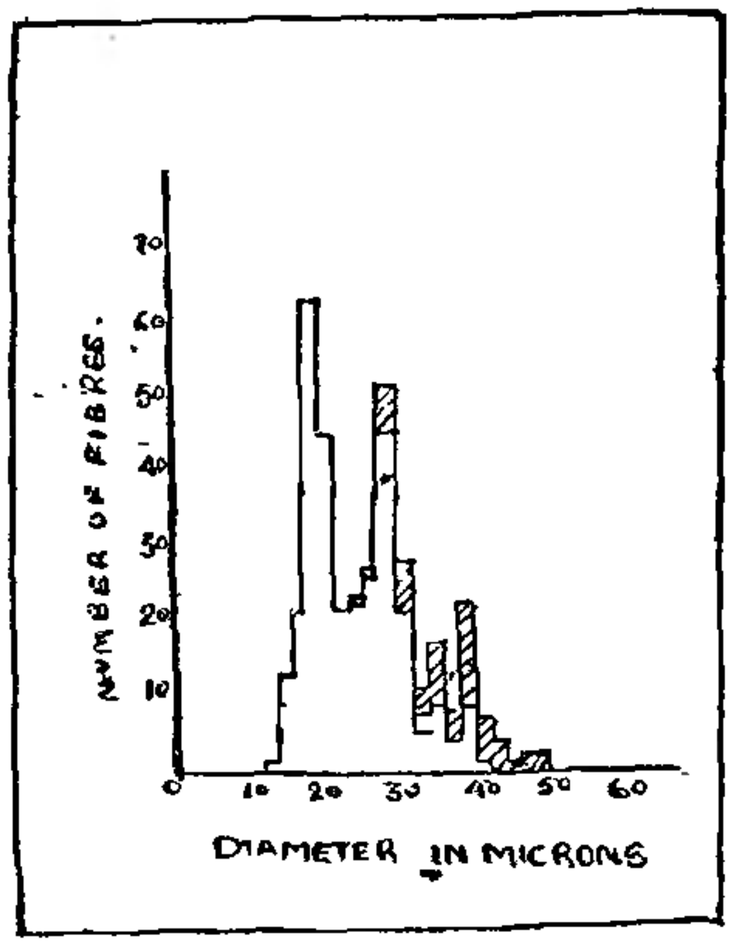

FIG. 2

centage coefficient of variation in diameter, designated as C.V. The proportion of medul-

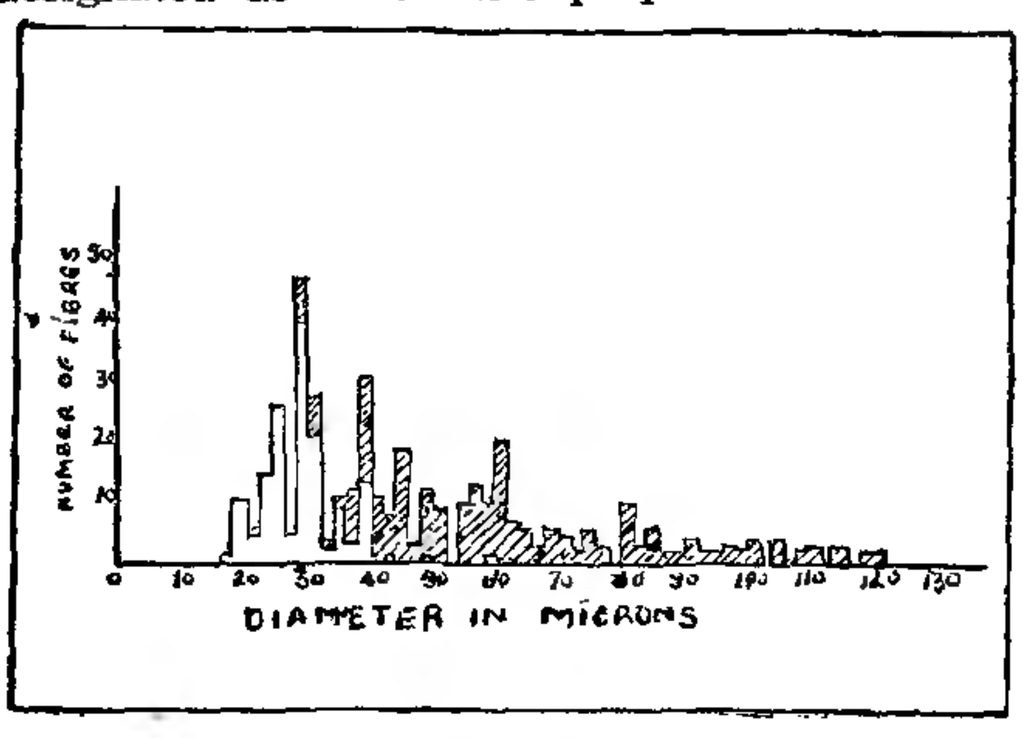

FIG. 3

lated or hairy fibres and their distribution is also shown in Figs. 2 and 3 by the shaded portions. Fine wool of Fig. 1 has no medullation. Photomicrograph in Fig. 4 shows wool fibres with clearly visible outer covering of scales. These are fine wool fibres free from medullation. The sample in Fig. 5 is a heterogeneous mixture of fine and coarse fibres. Such specimens have very high C.V. figures giving values above 50 per cent. Fig. 6 shows a very inferior type of wool, almost wholly hairy or medullated and very coarse.

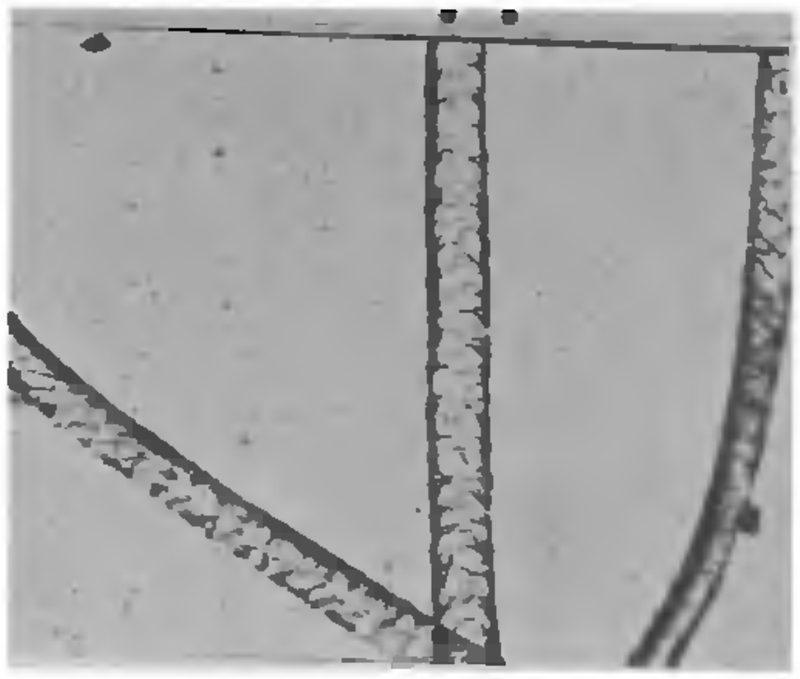

FIG. 4

Cross-sectional views of wool samples are still more helpful in arriving at an estimate of the wool quality, as all the necessary features—fineness, homogeneity and medullation—are strikingly brought out in one picture. Some

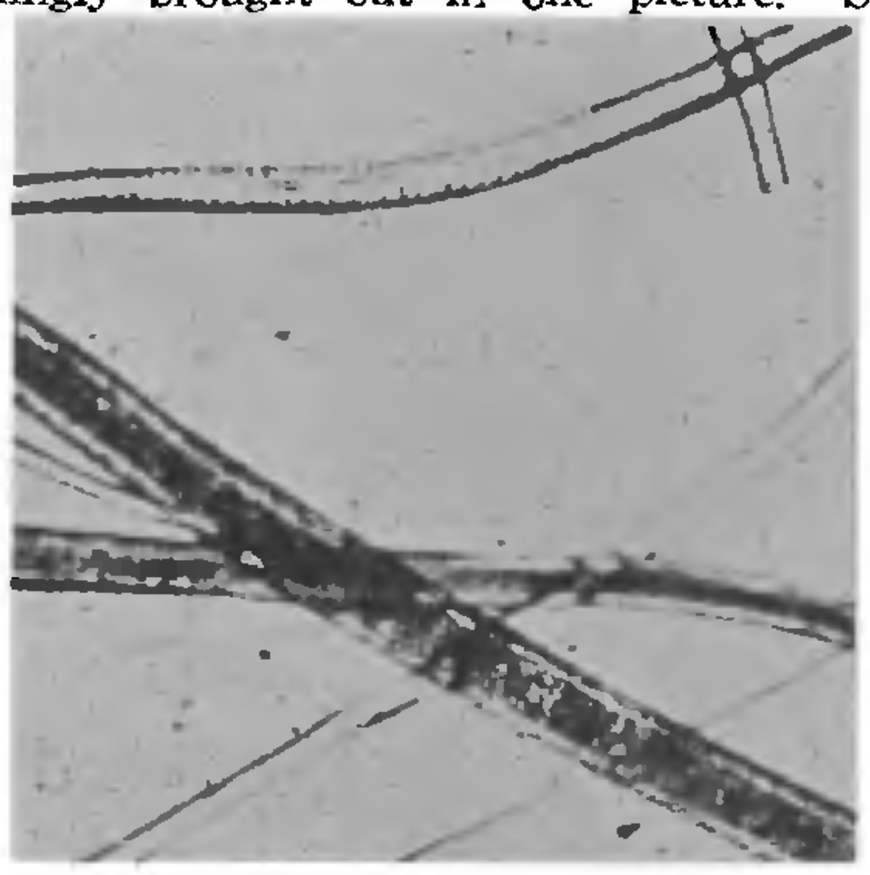

FIG. 5

typical cases are shown in photomicrograph Figs. 7 to 10. Fig. 7 is fine Merino wool, homogeneous with uniform fibre diameters and totally free from medullation. Fig. 8 shows the cross-section of a sample of Kashmir wool, coarser than Merino, but free from the defects of heterogeneity and medullation. Fig. 9 is a wool sample with none too homogeneous distribution of fibres. Medullation is marked in coarser fibres as central dark spots. Fig. 10 shows very coarse fibres—almost all hair, high-

ly medullated. As the photographs are obtained at the same magnification (× 110) the cross-

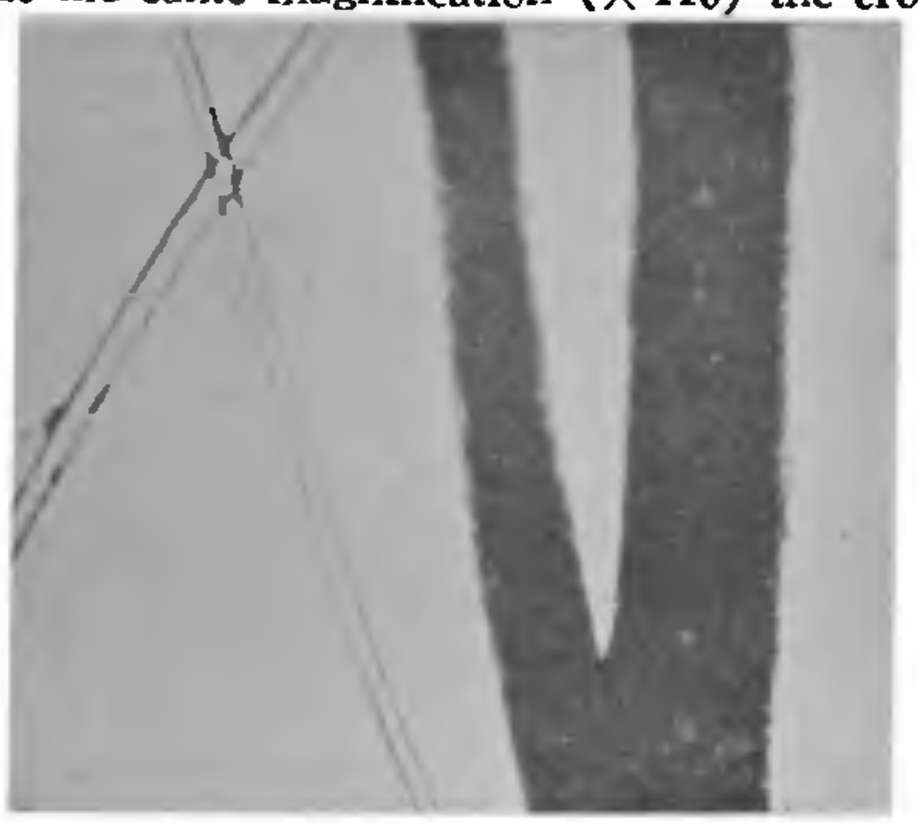

FIG. 6

sections give a good idea of the relative fineness of each type of wool. (Scale : 1 cm. = 90 microns.)

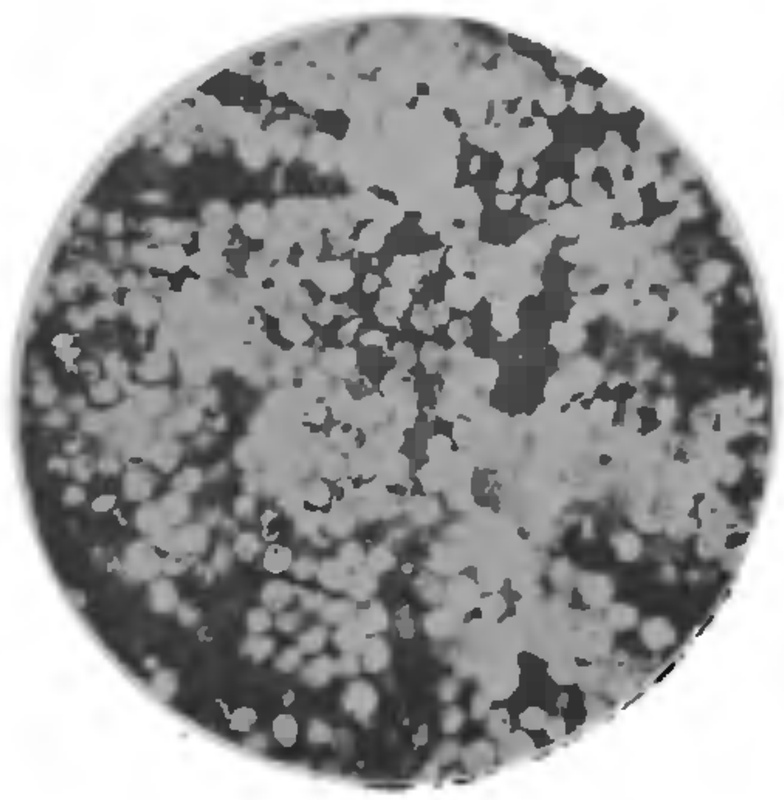

FIG. 7

A high coefficient of variation in diameter, with values above 40% and medullation above

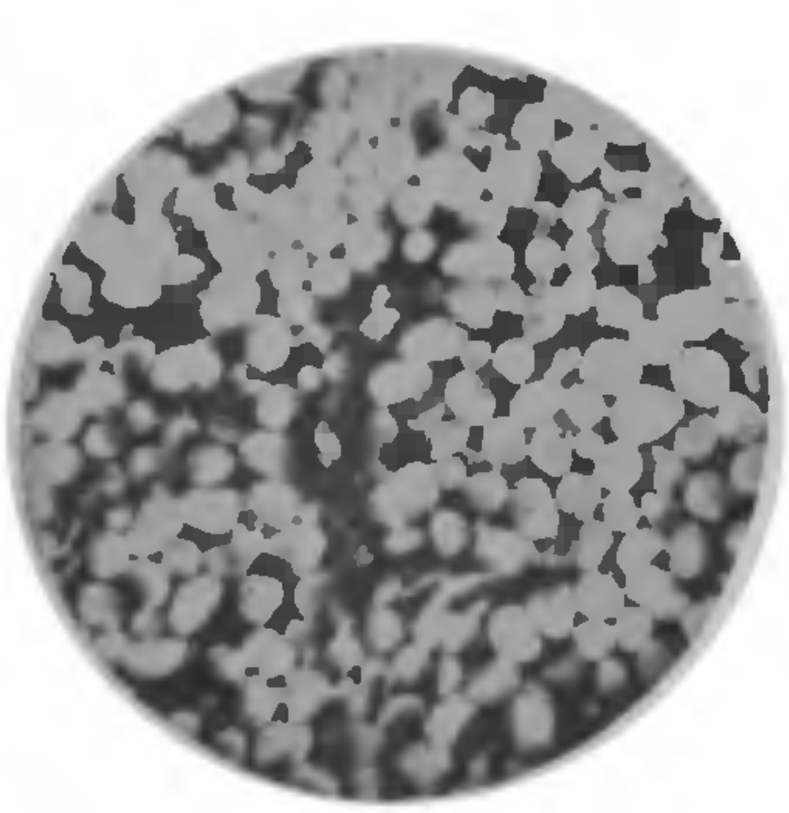

FIG. 8

30% definitely imparts a coarse and harsh feel to the wool sample under test, so much so that it is possible to lay down a quality scale of wool in accordance with the magnitude of these

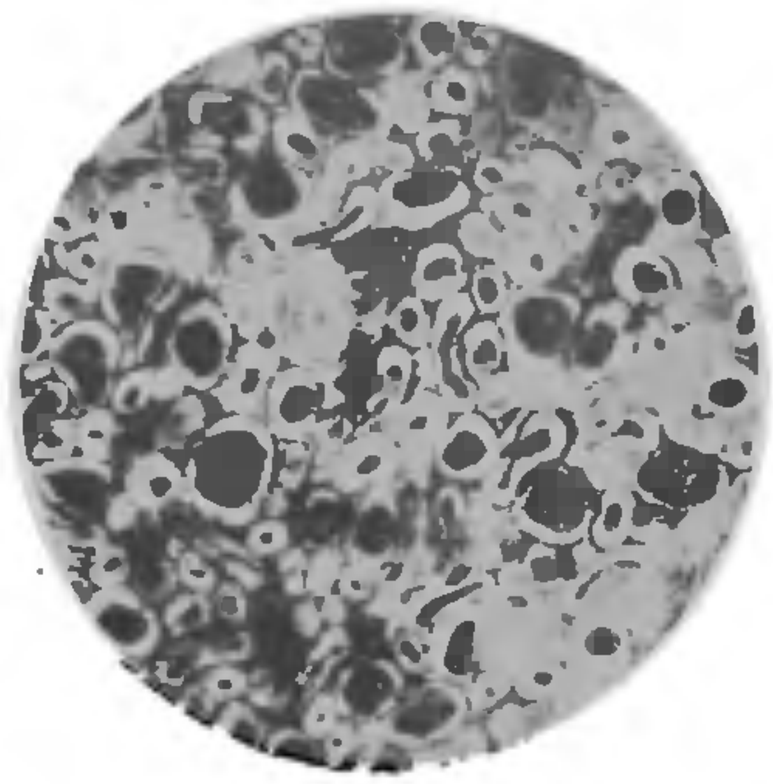

FIG. 9

defects. It would be thus apparent that assessment of any sample for its spinning qualities based solely on its average fibre fineness would lead to erroneous results, if heterogeneity and

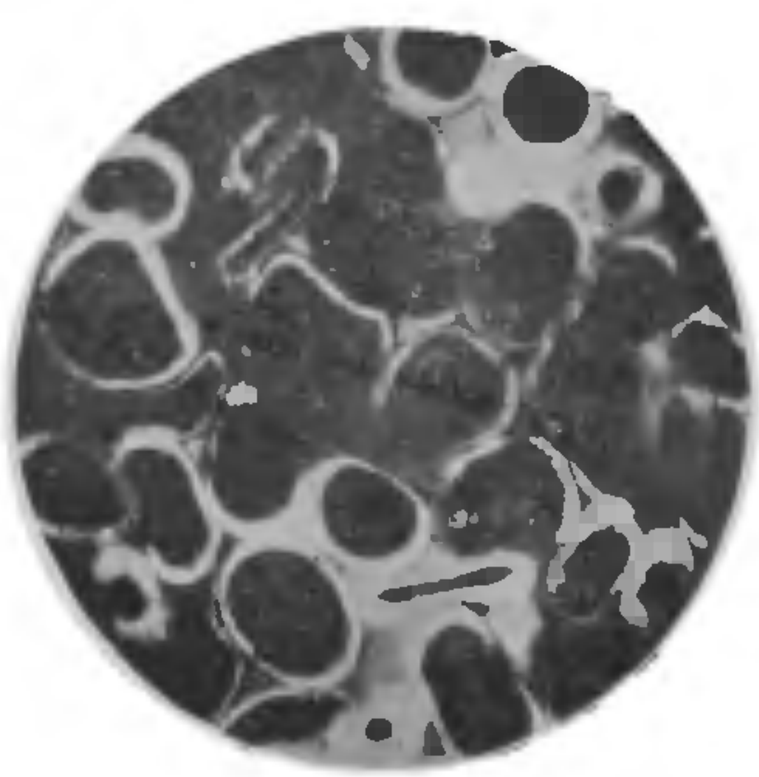

FIG. 10

medullation are left out of consideration. On the other hand with foreign wool this difficulty is not at all serious, and a direct correlation between the fibre fineness and spinning quality expressed as 'count' numbers has been laid down as shown in the following table.

The trader's specification of wool qualities is generally in terms of the count numbers mentioned here, which indicate the number of hanks, each 560 yards long, which could be spun from 1 lb. weight of wool. As the length of the yarn which could be obtained from a given weight of the fibrous material depends on the fineness of the individual fibres the practical advantage of this system of quality specification is obvious. It is similar to that adopted for cotton (840 yards in a hank). Judged from their average fibre-fineness values only the better types of commercial Indian wools like Joria and the Bikaner would hard-

ly be above the 50 count quality, though they are never assessed in these terms, for their extreme heterogeneity would considerably lower down this count values below 40.

Spinner's count	Fineness (Diameter in microns)
100	17·1
90	18·3
80	19·6
70	20·8
64	22·3
60	23·4
58	25·5
56	27·2
54	29·0
50	31·0
48	33·1
46	35·5
40	38·3
36	39·2

The length of the staple, so important for the cotton spinner, is also significant for wool as far as the manufacture of yarns for the worsted and finer clothing industries are concerned. Finer wools are generally short (2 inches), while the coarser varieties of non-medullated wool are obtainable in lengths upto 8-10 inches or more. However, for the medullated hairy type, length could be indefinite. As a matter of fact long hairy fibres are unsuitable for carpet and blanket manufacture and for this reason Indian wool with at least two shearings in a year (*Chaitra* and *Shravana*) in March (Spring) and September-October (Autumn), is not generally allowed to grow to a length of more than 3 inches. The climatic condition of the country also makes it necessary to have two shearings in a year.

Foreign Matter

Raw wool on the body of sheep is always contaminated with grease known as wool-fat, and suint or perspiration matters. Together with these natural accompaniments, vegetable matters and burrs, dirt and refuse also accumulate on the body, and are very often allowed to go to the market with the sheared wool collections. Even deliberate adulteration of dirt is resorted to in order to increase the apparent weight of wool, so that a given quantity may fetch a higher price than the non-adulterated lot. This ruse may or may not be successful but it certainly leads to heavier transportation charges and creates a bad impression in the public mind about the unclean nature of Indian wool. Such a practice together with the bad sorting for which Indian wool is known may, on the other hand, hit the producer and seller like a boomerang, for they may actually realise a higher price if it is based on what is known as the yield value, or the percentage weight of clean wool which could be obtained after it has been subjected to a thorough scouring process.

Scoured wool is seldom offered for sale, but sheep are generally washed before shearing. Even where the scouring practice is adopted the use is often made of cheap alkaline soap which tends to make wool felted and impart to it a harsh feel. In any case there is the necessity of marketing wool of any type only after its clean-scoured yield has been determined according to a standard method. The prices should then be based on: (1) the general qualities of the fibres and (2) the clean scoured yield. This procedure is followed in other countries. Reference cards are prepared for wool merchants showing at a glance the prices of each type of wool corresponding to all possible yield values. It is interesting to note in this connection that one of the progressive Indian States recently carried out an experiment on marketing well-sorted and scoured wool, which fetched a price 25 per cent. higher over the unwashed wool for the same variety, after deducting all the costs involved in the extra operations. The advantage of introducing standard methods of scouring and sorting is apparent.

Wool Production and Marketing

The annual production of wool in different parts of the country according to the 1940 figures is shown in the following table.

Annual Production of Wool in India

Area	Number of sheep (lakhs)	Annual yield of wool per sheep (greasy basis) lb.	Annual production of wool (lakh lb.)	Percentage to total production
Kashmir State ..	12·5	1·5	18·5	2·2
North-west Frontier Province including Agency and Tribal areas	8·4	3·4	28·3	3·3
Br. Baluchistan States	15·1	3·2	48·6	5·7
Sind and Khairpur State	7·8	4·0	30·9	3·6
Punjab	44·2	3·8	169·7	20·0
Punjab States ..	13·6	3·8	52·3	6·2
United Provinces and States	22·0	4·3	75·1	11·2
Rajputana States	53·2	3·1	164·5	19·3
Western India States ..	12·5	3·7	46·3	5·4
Bombay including Deccan States	21·1	1·0	21·1	2·5
Mysore State	26·0	0·85	22·1	2·6
Madras and States ..	121·9	0·56	69·4	8·2
Hyderabad State ..	59·4	0·56	34·0	4·0
Central Provinces ..	5·8	2·0	11·7	1·4
Bihar	11·5	0·81	9·3	1·1
Orissa	4·0	0·75	3·0	0·3
Bengal and States ..	5·1	1·1	6·0	0·7
Other areas	9·7	2·0	19·5	2·3
Total for India ..	453·8	1·9	850·3	(100·0)

According to their locations, several varieties of Indian wool are known in commerce such as Joria (Kathiawar), Bikaner (Punjab and Rajputana), Beawar (Rajputana), Fazlika (Punjab), Multan, Kandahar, S. Indian, etc.; and these are sold in bales roughly graded according to their appearance and feel when handled by experienced wool dealers. Feel

is, however, dependent on fibre fineness, their distribution and medullation as has been noted already; and it would be quite possible to have only three or four grades, clearly defined on these physical attributes of the fibres, rather than the confused and uncertain classification prevalent at present.

The principal market centres of wool in India are Peshawar, Lahore, Amritsar, Fazlika, Cawnpore, Bikaner, Jodhpur, Beawar, Karachi, Jamnagar, Bombay, Ahmednagar and Bijapur. Here sales are held twice a year (May and November), and most of the wool for export trade and for local consumption in mills and cottage industries is disposed off. These sales are very often not organised on proper lines, and it is not uncommon to find the middlemen getting most of the profit and the producer the least. It would be realised that gradations according to specified standards, stamping of the goods so classified by a recognised authority and sales on well organised economic lines so that the wool producer gets the maximum of benefits, are the necessary factors to improve the unsatisfactory state of affairs found at present in the wool industry.

Sheep Breeds of India

It is likely to be presumed from what has been said about Indian wool, that this country is incapable of growing fine wool, or that there is no scope in this country for developing good breeds of sheep with fine homogeneous and non-hairy type of wool. The fine-wooled Pashmina goat of the Kashmir frontier and the very limited supply of wool it gives, has already been mentioned. Data obtained during the course of recent work on the fibre characteristics of a number of Indian sheep breeds have amply shown that sheep types producing wool comparable with the Merino quality of the 56'S to 58'S class, do exist in this country. Such breeds of sheep are found in the North Western Frontier Provinces (Hashtanagri and Khagani breeds), in the Kashmir State (Karnah and Gurez breeds), in the Punjab (Hissar dale), in certain parts of Kathiawar, Kutch and Gujarat (Pattanwali) and in the North Deccan (Deccani). However it is only by chance that a few good individuals in each of these breeds survive, for no attempt has ever been made on a large scale to improve the number of good breeds. All the rest of the Indian breeds invariably produce coarse, heterogeneous and highly medullated wool. The few individuals of the better types are always in danger of being contaminated on account of the primitive conditions of indiscriminate breeding, ignorance of the breeders and migration of the flocks to more fertile parts of the country during seasons of pasture scarcity, often involving long journeys. These factors allow sufficient scope for the mixing up of pure breeds with good wool with inferior types. Sheep-breeding farms established by the Government and some States do help to identify, isolate, conserve and breed the good types of sheep; but they could not be expected to undertake large-scale breeding operations, which should be done under present conditions, by the wealthier class of landlords and by floating joint-stock companies. A step in this direction has been recently taken at Patan in Baroda State, where it has been found possible to produce commercially wool of good quality from the Pattanwali breed of Northern Gujarat. More efforts of this type are needed to develop and establish the good sheep breeds of the country, and make Indian wool comparable with class wool from other parts of the world.

The principal breeds of Indian sheep which have been recognised are listed in the table below, together with information on the wool fibre characteristics of some of the best individuals among them.

Sheep Breeds of India

Breed	Region	Fibre length (mm.)	Fineness (microns)	Homogeniety (C. V. in diameter)	Hairy portion (medullation %)
Karnah ..	Kashmir	87	26	22	0
Gurez ..	Kashmir	63	22	25	0
Hissardale ..	Punjab	73	24	19	0
Pattanwadi ..	Gujarat	98	30	27	0
Khagani ..	Hazara Dist.	62	33	34	0
Hashtanagri	N.W.F.P.	100	25	39	2
Deccani ..	Deccan	83	36	32	3
Lohi ..	Punjab	114	39	27	4
Masuda ..	Ajmer	33	32	31	8
Bikaner ..	Rajaputana	149	38	24	3
Damani ..	N.W.F.P.	38	35	34	18
Bibrik ..	Baluchistan	103	39	31	20
Bellary ..	Madras	103	52	36	60
Jalauni ..	Jalauni Dist. U.P.	66	69	43	58
Khasi ..	Assam	78	66	58	61

Comparing this table with the last one for commercial wools it is apparent that some of the sheep breeds at the top of the table are capable of giving fine wool of the type needed for the worsted and the clothing industry. However, although there may be a large number of animals in some or any of these breeds, those actually showing good fibre characteristics mentioned are very few. They are generally restricted to small regions or are confined to some experimental farms only, and need a hundred to thousandfold multiplication if the wool produced by them is going to be any industrial value. Thus the Hissardale breed which has been evolved by crossing the Merino and the Bikaner sheep, and which may, therefore, be called Indian Merino, has proved itself quite successful. However, its number is so limited that a large demand which exists from sheep-breeders for a supply of these animals in different parts of the country is not easily met with. The case with the good individuals from the best breeds of Kashmir is also very similar.

Improvements in Coarser Types of Wool

The experimental farms established by the Government ascertain the best conditions under which the good sheep breeds of the districts around may thrive, and undertake a programme of work, according to which inbreeding (in selected flocks) and cross-breeding (with recognised indigenous and foreign breeds) experiments are carried out with the idea of improving wool quality of known breeds and establishing new breeds with desirable fibre characteristics. The process is long, and several years may be required to increase the stock of good breeds sufficiently and to fix new types. Other genetical factors such as the best breeding season of the year and the number of

lambings in a year, have also to be considered. Whatever information is thus obtained on the good breeding of sheep is generally passed on to sheep-breeders in villages and towns for any use they could make of it.

Laboratory Analysis and Assessment of Wool

In any case, for judging the quality of wool, whether in testing the suitability of animals for particular types of experiments or in gauging the success of the experiments already undertaken or in distinguishing between the good and defective types of wools or even for trade requirements, laboratory tests for wool fibres are always necessary. Very little has been done in this respect in this country, but elsewhere definite standards and methods for the assessment of various grades of wool exist, and are recognised by the Government of the country. Accordingly, all wool for trade has to conform to standard specifications.

The most important physical characteristics of wool which determine its quality, as has already been mentioned are the length and the diameter of the fibres, considered together with the amount of individual variations in them. The latter are determined as coefficients of variations from a statistical analysis of individual fibre measurements thus giving a complete idea of the homogeneity or heterogeneity of a sample with respect to the particular characteristic measured. In some cases analysis of variance may have also to be carried out to find whether there is any correlation between the two variables of the fibres such as the length and the diameter. The variance test is also useful in ascertaining the amount of variations to be expected in the fibre characteristics of the individuals in a given breed of sheep. These methods are very helpful in arriving at suitable specifications for wool standards for different breeds of sheep and also for trade purposes in case of commercial wools.

The length is measured to the nearest millimeter by stretching the fibre on a black velvet board against a steel rule placed alongside. In a few cases where the samples have crimps, the unstretched lengths of the whole staple is measured, and the number or crimps per centimeter length calculated from the observed number of total crimps along the staple. About 500 measurements are thus carried out on one specimen, the readings being directly plotted on a sectional paper, so that at the end of an examination, the frequency distribution diagram is obtained. Mean length, standard deviation from the mean and coefficient of variation are calculated from the figures obtained.

For the fineness measurements, a bundle of about 500 fibres is cut up in very small lengths of about 0·3-0·5 mm. in a special type of microtome and a suspension of these is made up in thickened cedar wood oil. A drop of this suspension is placed on a microscopic slide and covered with a cover slip. With a microprojection apparatus the images of the fibres on the prepared slide are projected on a screen, and the width of each is measured with a transparent scale to the nearest half millimeter at least at three points along the length. The mean of these values gives the average width of a single fibre in the field of view. Several fields have to be examined in order to make up the required number of measurements. As the magnification is always maintained at 500 diameters, 1·0 cm. width of the projected fibre corresponds to a fibre diameter of 20 microns ($20\mu = 20 \times 10^{-3}$ mm.). The diameter readings which are correct to the nearest micron are plotted, as for length measurements, on a sectional paper so as to obtain a frequency distribution curve (Figs. 1, 2 and 3). From the measurements thus carried out, the mean, standard deviation and coefficient of variation are calculated.

Medullation, as has been observed before, is a property connected with coarse wool fibres and hairs of many animals. A medullated fibre may be generally distinguished from a wool fibre by its dead white appearance and non-resilient nature. A non-medullated wool fibre on the other hand is semi-transparent or translucent and possesses a good amount of elasticity. Under the microscope wool fibres appear covered with scales, while hairy or medullated fibres when freshly mounted in a non-alcoholic medium show long dark longitudinal marks in the central portion which may occur at intervals or run for the whole length of the fibre (Fig. 5).

It has been observed before that an undesirable feature of Indian wool is its high degree of medullation. One of the tasks of the Indian breeder, therefore, consists of producing wool free from medullation. A determination of the degree of medullation in a wool sample is thus important from the sheep-breeder's as well as from the commercial point of view. When the image of the wool fibres is projected on the screen for the measurements of diameter, the medullated portion in each of them is also recorded, and the percentage amount of medullation in the number of fibres measured, is calculated from the collective data obtained for any one sample.

Based fundamentally on these fibre characteristics, namely, (*i*) fineness, (*ii*) fineness homogeneity (C.V. in diameter) and medullation, it is possible to arrange various types of sheep breeds according to the quality of wool produced by them. The table on Indian Sheep Breeds has been thus prepared from the results which are known so far.

Wool Standards

From what has been said here about the Indian Wool it would be realised that the present need in this field is to know exactly the types of wool grown in this country. This has to be done for the large quantities of wool in the trade, as well as for the smaller quantities obtainable from the known pure breeds of sheep in the country. When the fibre qualities of each of these types have been established by laboratory tests, standard specifications in terms of physically measurable qualities such as length, fineness, homogeneity, hairiness may be laid down to which various grades of wool would conform. Such standards would be helpful to traders in wool as they can always rely on the specifications under which various types of wool is handled by them. Sheep breeders, on the other hand, would also gain much by the standard specifications as they would be able to judge any improvement in the qualities of wool produced by the specific sheep breeds against a system of standards.

The Indian Council of Agricultural Research through its Wool Committee is devoting its attention to the question of wool standards as well as to other neglected aspects connected with the Indian woollen industry, notably the methods of improving the production, grading and marketing of Indian wool.