the inclination of the body; but this is introduced into the portable form of the instrument shown in fig. 29, the basal portion of which (fig. 30) can be used, like that of the preceding model, as a simple microscope, and, by a most ingenious construction, can be so folded as to lie flat in a shallow case (fig. 31) that holds also the upper part with the objectives of both the simple arm and the compound body. M. Nachet now connects his objectives with the body of his microscopes, not by a screw, but by a cylindrical fitting held in place by the pressure of a spring-clip against a projecting shoulder. This method not only allows one objective to be removed and replaced by another much more readily than does the screw-fitting, but also renders the centring of different objectives more exactly conformable. It may be safely affirmed that a very large proportion of the microscopic work of the last half-century, which has given an entirely new aspect to biological science, has been done by instruments of this simple Continental type.

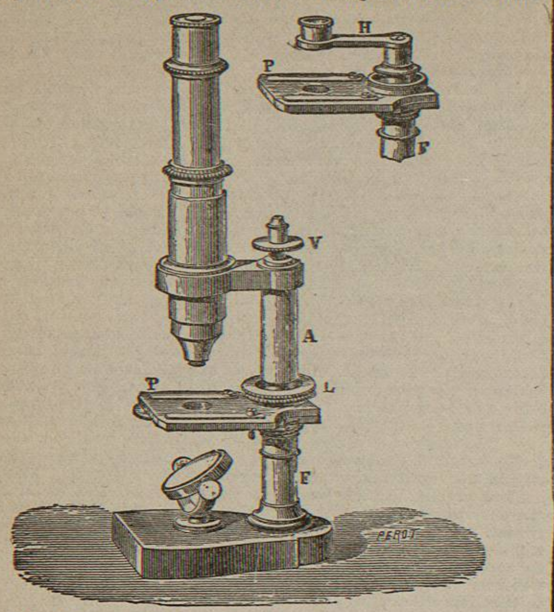

FIG. 28.—Nachet's Combined Simple and Compound Microscope.

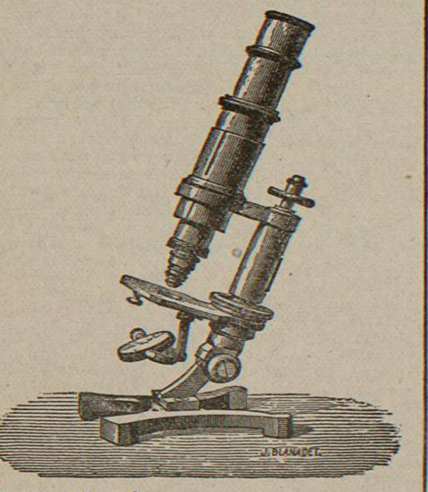

FIG. 29.—Nachet's Portable Compound Microscope.

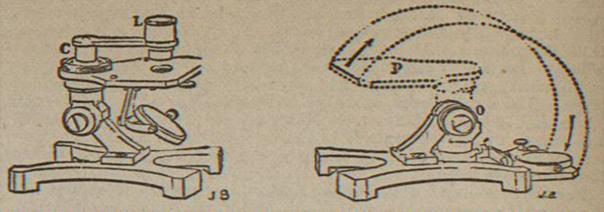

FIG. 30.—Nachet's Portable Dissecting Microscope; on the left as set up for use, on the right as having the stage P turned back upon the joint O, so as to lie flat on the bottom of the case.

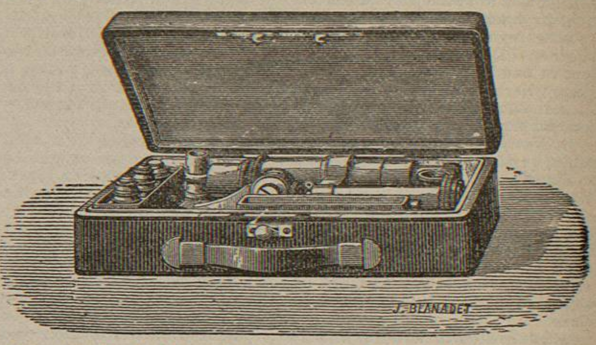

FIG. 31.—Nachet's Portable Compound and Dissecting Microscope, as packed in case.

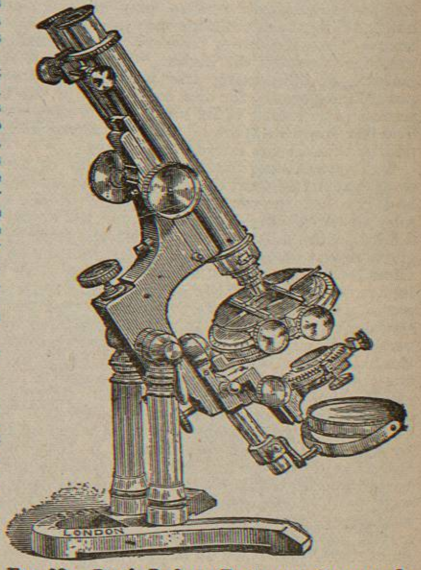

FIG. 32.—Ross's Jackson-Zentmayer Compound Microscope.

A larger model, however, was from the first adopted by English opticians; and, as a typical example of the general plan of construction now most followed both in England and in the United States, the improved Jackson-Zentmayer microscope of Messrs Ross (fig. 32) may be appropriately selected. The tripod base of this instrument carries two pillars, between which is swung upon a horizontal axis (capable of being fixed in any position by a tightening screw) a solid "limb," with which all the other parts of the instrument are connected,—a plan of construction originally devised by Mr George Jackson. The binocular body, having at its lower end (as in fig. 24) an opening into which either of the Wenham prisms can be inserted, and at its top a rack movement for adjusting the eye-pieces to the distance between the eyes of the observer, is attached to a racked slide, which is so acted on by the large double milled head in the upper part of the limb as to give a "quick" upward or downward motion to the body; while the "slow" motion, or fine adjustment, is given by means of the vertical micrometer screw at the back of the limb, which raises or lowers a second slide behind the rack.[1] The stage is supported upon a firm ring, which is immovably fixed, not to the limb, but to a strong conical pivot which passes through the limb, to be clamped by a screw-nut at its back,—the purpose of this being to allow the whole stage to be inclined to one side or the other at any angle, so that a solid object may be viewed sideways or from below, as well as from above. Upon this ring the stage rotates horizontally, its angular movement being measured by a graduated scale and vernier at its edge; and it can be fixed in any azimuth by a clamping-screw beneath. Rectangular movement is given to the traversing platform which carries the object by two milled heads on the right of the stage, the whole construction of which is adapted to allow light of extreme obliquity to be thrown upon the object from beneath. On the strong pivot by which the stage is attached to the limb (the axis of which passes through the point at which the object-plane is intersected by the optic axis of the body) is hung the swinging tail-piece invented by Mr Zentmayer of Philadelphia, which, carrying the whole illuminating apparatus, may be so set as to give to the axis of the illuminating pencil any required degree of obliquity. To the upper part of it is attached a rack-and-pinion movement carrying the "substage," which is provided with two milled-headed screws for centring it precisely with the microscope-body. Into this may be fitted the achromatic condenser, parabolic illuminator, polarizing prism, or any other kind of illuminating apparatus; whilst at its lower end it carries the mirror, the position of which may be varied by sliding its fitting up or down the "tail-piece," or by turning the arm which carries it to one side or the other; while, if direct illumination from a lamp should be preferred, it may be turned altogether aside. By swinging the tail-piece round above the stage, oblique light may be reflected from the mirror, through the condenser, upon the upper surfaces of objects. The condenser usually fitted to this instrument is of about $\frac{1}{10}$ inch focus, with a large back lens; behind which are placed an iris-diaphragm for reducing the light to the central rays, and a diaphragm-plate with apertures of the various forms most suited for the resolution of lined objects by oblique rays.

No instrument, in the writer's judgment, is better adapted than this for the highest purposes of microscopical research. It works admirably with every power from the lowest to the highest, and is capable of receiving any one of the numerous pieces of apparatus which have been devised for special researches of various kinds. The detailed description of these not being here admissible, it will be sufficient to indicate the polariscope and the spectroscope as the most important of these accessories.

Micrometry.

The microscopist has constant need of some means of taking exact measurements of the dimensions of the minute objects, or parts of objects, on the study of which he is engaged; and the accuracy of the operation will of course be proportioned to the correctness of the standard used, and the care with which it is applied.

The instruments employed in microscopic micrometry are of two kinds, the measurement being taken in one by the rotation of a fine screw with a divided milled head, whilst in the other a slip of glass ruled with lines at fixed distances gives a scale which forms a basis of computation. Each of these has its advantages and its disadvantages.

The stage-micrometer constructed by Frauenhofer was formerly much used by Continental microscopists, and has the advantage of indicating the actual dimensions of the objects to be measured; but it has the two special disadvantages that a sufficiently small value cannot be conveniently given to its divisions, and that any error in its construction and working is augmented by the whole magnifying power employed. This instrument has now, however, almost entirely given place to one of those to be next described.

The screw-micrometer ordinarily used in astronomical measurements (see MICROMETER) can be adapted to the eye-piece of the microscope in a manner essentially the same as that in which it is applied to the telescope,—its two parallel threads—of which one is fixed and the other made to approach towards or recede from this by the turning of the screw—being placed in the focus of the eye-glass, and being therefore seen as lines crossing its field of view. The object is so focussed that its image is formed in the same plane; and, the latter being brought into such a position that one of its ends or margins lies in optical contact with the fixed line, the screw is turned so as to bring the movable line into the like coincidence with the other. But the distance between the lines, as given by the number of divisions of the micrometer, will here be the measurement, not of the object itself, but of its magnified image; and the value of these divisions, therefore, will depend upon the amplification given by the particular objective used. Thus, suppose each division of the micrometer to have an actual value of $\frac{1}{10000}$th of an inch, and the visual image to have one hundred times the linear dimensions of the object, the theoretical micrometric value of each division would be $\frac{1}{100}$th of $\frac{1}{10000}$th, or one-millionth, of an inch,—a degree of minuteness, however, not practically attainable. It is necessary, moreover, to determine the micrometric value of the divisions of the micrometer, not only for every objective, but for variations in the conditions under which that objective may be employed, as regards the length of the tube or "body" of the microscope, which is varied not only by the draw-tube, but also, in many cases, in the working of the fine adjustment or slow motion, and also, in the case of the large-angled powers furnished with adjustment for thickness of the covering-glass, for the degree of separation of the front- from the back-glasses of the objective, which makes a very sensible difference in its magnifying power. This determination is made by means of a divided glass stage-micrometer put in the place of the object, so that the lines ruled upon it at fixed intervals shall be projected upon the field of view. The stage-micrometer is usually ruled either to 1000ths of an inch or 100ths of a millimetre; and it is convenient that one of the divisions of its image should be made to coincide exactly with a certain number of divisions of the screw-micrometer. This may be done by lengthening the draw-tube, so as to increase the amplification of the scale until coincidence has been reached; and the exact amount of this lengthening should be noted,—as should also the precise position of the milled head of the slow motion (if it acts on the objective, instead of on the body as a whole), and of the adjusting screw-collar of the objective itself. Thus, if two lines of the stage-micrometer separated by 1000th of an inch be brought into coincidence with the two threads of the eye-piece micrometer, separated by forty divisions of the screw milled head, the value of each of those divisions is $\frac{1}{40000}$th of an inch. If the above conditions be precisely recorded for each objective used in micrometry, the micrometric value of the divisions remains the same for that objective, whenever it is employed under the same conditions.

The errors to which micrometers are subject arise (1) from inequalities in the ruling of the stage-micrometer, (2) from irregularities in the screw of the eye-piece micrometer, (3) from "lost time" in its working, and (4) from the thickness of its threads. In order to eliminate the first and second, it is well to determine the relation of the divisions of the two micrometers by the comparison of a considerable number of both; the third proceeds from an imperfection of workmanship which, if it shows itself sensibly, entirely destroys the value of the instrument, while the fourth can be rectified by the exercise of skill and judgment on the part of the observer. For, if the micrometer is so constructed as to read zero when one thread lies exactly upon the other, its divisions indicate the distance between the axes of these threads when separated; and the dimensions of any object (such as a blood-corpuscle) lying between their borders will obviously be too great by half the thickness of the two threads, that is, by the entire thickness of one thread. When, on the other hand, the measurement is being made (as of the distances of the striæ on diatoms) by the coincidence between certain lines on the object and the axes of the threads of the micrometer, the dimensions indicated by the divisions of the screw milled-head will be correct.

The costliness of a well-constructed screw-micrometer being a formidable obstacle to its general use, a simpler method (devised by Mr George Jackson) is more commonly adopted, which consists in the insertion of a ruled-glass scale into the focus of an ordinary Huygenian eye-piece, so that its lines are projected on the field of view. This scale (ruled, like an ordinary measure, with every fifth line long, and every tenth line double the length of the fifth) is fixed in a brass inner frame, that has a slight motion in the direction of its length within an outer frame; and this last, being introduced through a pair of slits into the eye-piece just above the diaphragm, and being made to occupy the centre of the field, is brought exactly into focus by unscrewing the eye-glass as far as may be requisite. When the image of the object to be measured is brought by the focal adjustment of the object-glass into the same plane, a small pushing-screw at the end of the micrometer (whose action is antagonized by a spring at the other end) is turned until one of the long divisions of the scale is brought into optical contact with one edge of the image of the object to be measured, and the number of divisions is then counted to its other edge,—the operation being exactly that of laying a rule across the real object if enlarged to the size of its image. The micrometric value of each division of this eye-piece scale must be carefully ascertained for each objective, as in the case of the screw-micrometer, the error arising from inequality of its divisions being eliminated as far as possible by taking an average of several. The principal point of inferiority in this form of micrometer is that, as its divisions cannot be made of nearly so small a value as those of the screw-micrometer, an estimate of fractional parts of them often becomes necessary, which is objectionable as involving an additional source of error. To meet this objection, Hartnack has introduced the diagonal scale used in mathematical instruments before the invention of the vernier.

Another mode of making micrometric measurements, which for some purposes has considerable advantages, is to employ a stage-micrometer in combination with some form of camera lucida attached to the eye-piece of the microscope, so that the image of its divisions may be projected upon the same surface as that on which the image of the object is thrown. By first using the ruled stage-micrometer, and marking on the paper the average distance of its lines as seen in the central part of the field, and then ruling the paper accordingly, the micrometric value of the divisions so projected may be exactly determined for the objective employed and the distance of the drawing-plane from the eye-piece,—so that, when the image of any object is projected under the same conditions, the dimensions of that image or of any parts of it can be exactly measured upon the divided scale previously projected, and the true dimensions of the object thus easily ascertained. If, for example, the lines of a stage-micrometer ruled to the thousandth of an inch should, when thus projected, fall at a distance of an inch apart, then the application of an ordinary scale of inches (divided into tenths) to the image of an object projected by the same objective

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[1] In the older form of construction still retained by some makers the fine adjustment acts directly on the objective, the fitting of which is made to slide up and down within the nose of the body; but this plan is attended with many disadvantages.

and on the same plane would give its real dimensions in thousandths of an inch, while the tenths of the inch scale would represent a real dimension of as many ten-thousandths. It is often desirable to make such measurements from careful tracings of the outlines of objects, rather than from the visual images,—this plan being especially advantageous when the exact dimensions of many similar objects have to be compared, as in the case of blood-corpuscles, precise measurements of which are not unfrequently required in judicial inquiries. It was by the use of this method that the late Mr Gulliver made his admirable series of measurements of the average and extreme dimensions of the blood-corpuscles of different animals. And more recently Mr Dallinger has shown,—by first making a very fine camera lucida tracing of *Bacterium termo* under an amplification of 2000 diameters, and measuring the breadth of its body in the mode above indicated (which gave it as $\frac{1}{20400}$th of an inch), and then by magnifying his tracing from five to ten diameters, and comparing, by means of the screw-micrometer, the breadth of the flagellum with that of the body (which last proved to be just ten times as great),—that, although the theoretical limit of resolving power for closely approximated lines is $\frac{1}{146528}$th of an inch, a semitransparent filament whose breadth is not greater than $\frac{1}{200000}$th of an inch may be clearly discerned, and even measured with a close approximation to accuracy (*Jour. of Royal Micros. Society*, vol. i., 1879, p. 169). (W. B. C.)

MIDAS, king of Phrygia, is one of those half-legendary heroes in whom religious legends have gathered round a real person. The name Midas the king, ΜΙΔΑΙ ϜΑΝΑΚΤΕΙ, occurs on a very ancient tomb in the valley of the Sangarius, the legendary seat of the Phrygian kingdom (*Iliad* iii. 189). The Phrygian monarchy was destroyed by the Cimmerians about 670 B.C., and the last king Midas committed suicide by drinking bull's blood. The name Midas became in Greek tradition the representative of this ancient dynasty, but all that is told of him is religious myth. He is a figure in the cycle of Cybele legends, the son of the goddess and her first priest. He is also closely connected with the cultus of Dionysus, like the two heroic personages Marsyas and Silenus. The Midas legend was known on Mount Bermius in Macedonia, and must at one time have existed in Greece; two cities Midea, in Argolis and in Bœotia, recall the Phrygian city Midæium.

See Herod. viii. 138; Xen., *Anab.*, i. 2, 13; Paus. i. 45, &c.

MIDDELBURG, in Holland, the ancient capital of the province of Zealand, situated in the middle of the island of Walcheren, is mentioned as early as 1153, and receives the title "town" in a charter granted it in 1227. It has all the characteristics of an old and worn-out place. The population (25,000 in 1739) had sunk to 12,000 or 13,000 by the beginning of the 19th century, and has only begun recently to increase again, being 15,939 in 1882. The dwelling-houses, which in 1739 were about 3800, are now but 3000, and of these about 600 are unoccupied. The vast warehouses and imposing mansions once belonging to wealthy families, which have either died out or left the place, call up the memory of that prosperity which Middelburg enjoyed before its extensive trade, with the East and West Indies, with England and Flanders, was ruined by the war with England and the French occupation. By the opening of the railway (1872) and of the ship canal (1873) to Flushing Middelburg was lifted out of its isolation, and, with the assistance of the chamber of commerce, manufacturing industries (iron, machinery, furniture, oil, cigars, &c.) were established; but the prosperity anticipated for Flushing, and consequently for Middelburg, remains unrealized. One of the chief sights of Middelburg is the splendid town-house, for the most part erected in 1512–13, with its front gable adorned with twenty-five statues of counts and countesses of Holland and Zealand; it contains the archives, and a most valuable antiquarian and historical collection. The abbey, begun in 1150, has frequently been the residence of royal visitors (Maximilian, Philip the Fair, Charles V., and so on down to Napoleon I., and William I., II., and III.); part of it is now an hotel, and part of it is occupied by the provincial authorities. The great hall of the building, in which the states of Zealand assemble, is adorned with beautiful tapestries by Jan de Maecht, representing the heroic feats of the men of Zealand in the contest with Spain. What was formerly the nave of the abbey church is now the New Church, and the ancient choir constitutes the Choir Church. The former contains a fine pulpit resting on an eagle, the monument of William, king of the Romans (d. 1256), and the tombs of Jan and Cornelis Evertsen, two naval heroes who fell in the war against England in 1666; the latter has the monuments of the learned Hadrian Junius and of Jan Pieterszoon. The provincial court, the corn exchange, the Hof St Joris and the Hof St Sebastian (formerly buildings belonging to the guilds of archers, and now places of amusement) deserve mention. The great museum of Zealand antiquities, collected by the Zealand Society of Arts and Sciences (founded at Flushing in 1769 and transferred to Middelburg in 1801), shows that the town is the intellectual centre of the province.

The principal facts in the history of Middelburg are the sieges by the Flemings in 1288, 1296, and 1303 (the last resulting in the capture of the town by Guy of Dampierre); the recovery of the town from the Spaniards in 1574, after an investment of nearly two years; the frequent disturbances among the townsfolk in the 17th and 18th centuries; the surrender to the English in 1809; and the arrival and departure of the French in 1809 and 1814.

MIDDLEBOROUGH, a town of the United States, in Plymouth county, Massachusetts, 34 miles south of Boston. It h a handsome town-hall and a public library, manufactures woollen goods, straw goods, shovels, shoes, carriages, &c., and in 1880 had 5237 inhabitants.

MIDDLESBROUGH, situated near the mouth of the Tees, on its south bank, in the North Riding of Yorkshire, has now become the principal seat of the English iron trade. It is a municipal and parliamentary borough, locally governed by a mayor and corporation, and returns a member to parliament. The earlier history of the place is meagre. Where Middlesbrough now stands (Graves's *History of Cleveland*) there were at one time a small chapel and priory founded by Robert de Brus of Skelton Castle. These were dedicated to St Hilda, and with some lands were given by De Brus to the abbey of St Hilda at Whitby in 1130. The priory fell into ruins at the time of the Reformation, and no trace now remains beyond some stones built into the wall of a brewery. The mayor's chair also is made from a fragment. In 1801 there were upon the site of Middlesbrough only four farm-houses. In 1829 a company styling itself the Middlesbrough Owners bought 500 acres of land, and commenced building the town. In 1830 the Stockton and Darlington Railway was extended from Stockton to Middlesbrough; four years later the town was lighted with gas; and after six years more a public market was established. The census of 1831 showed the population to be 154; that of 1841 showed 5709. In 1842 the opening of the docks gave additional importance to the town. First containing an area of 9 acres, they were extended in 1872 to 12 acres, with 1700 feet of quays. Vessels of 3000 tons burden can be accommodated. From the year 1851, when J. Vaughan discovered the presence of ironstone in the Eston Hills, the town advanced with rapid strides. When the jubilee of the town was held in 1881 (a year late) the population had risen to 55,934, the area to 2731 acres, and the rateable value to £140,000, the population of the parliamentary borough (area 4715 acres) being 72,145. In the district there are upwards of

130 blast furnaces, besides large iron and steel works; and the Thomas-Gilchrist process of making steel promises for Middlesbrough importance in the future as a steel entrepôt. The make of pig-iron in 1880 was 1,991,032 tons. There are also shipbuilding, potteries, chemical works, and a salt trade. Middlesbrough is well laid out, nearly all the streets lying at right angles to one another. Many of the churches and the exchange are handsome buildings, while the station of the North Eastern Railway is probably the finest in the north of England. A splendid park of 72 acres, the gift of the late H. F. W. Bolckow, adds greatly to the amenity of the town.

MIDDLESEX, an inland county in the south-east of England, lying between 51° 25′ and 51° 40′ N. lat., and between 0° and 0° 36′ W. long. On the south it is divided from Surrey and Kent by the Thames, on the east from Essex by the Lea, on the west from Buckinghamshire by the Colne, and on the north from Hertfordshire by a partly artificial and very irregular line. Although with the exception of Rutland it is the smallest county in England, its population is exceeded by that of Lancashire only. Its total area is 181,317 acres, of which 2592 acres are common or waste lands. The longest straight line that can be drawn in the county is one of nearly 28 miles from the north-eastern extremity near Waltham Abbey to the south-western at Staines. From north to south in the broadest part the distance is about 15 miles.

Surface and Geology.—The greater portion of the county is flat, although there are sufficient undulations to allow of a proper drainage of the land. A range of hills runs along the Hertfordshire border by Barnet, Elstree, Stanmore, and Pinner, averaging 400 feet in height; another range occupies the ground just north of London by Hornsey, Highgate, and Hampstead; Harrow occupies an isolated eminence between the two ranges.

The county lies entirely within the basin of the Thames, and the London Clay extends over a large portion of the surface. This formation stretches from the mouth of the estuary of the Thames to the neighbourhood of Marlborough. It attains its greatest breadth (little short of 30 miles) in the neighbourhood of London, and extends northward until it is lost beneath the drift of Suffolk and Norfolk. The following is a table of the various beds of rock which occur at the surface, with their greatest thickness (in feet) in the district:—

Alluvium (recent river deposits)	15
Post-Pliocene Tertiaries.	
Post-glacial beds (brick-earth, gravel, &c.)	50
Glacial drift (boulder clay, gravel, &c.)	80
Eocene Tertiaries.	
Lower Bagshot sands	100
London Clay	420
Woolwich and Reading beds	90
Cretaceous.	
Chalk with flints	300

Chalk comes to the surface in so very few places that it is scarcely worth mention. It is seen near Harefield and on the north-west side of South Mimms. The depth from the surface to the chalk varies greatly in different parts of the county. This has been proved by the borings for wells; thus at Isleworth the depth is 400 feet and at Hampstead 378, while at Ruislip it is 76 feet and at Pinner only 60. The Reading beds (plastic clays) are brought to the surface at Windsor. They follow roughly the course of the river Colne from the north of Uxbridge along the flank of the hills north-eastward, but are sometimes cut back southward along small side valleys. An outlying mass is exposed at Pinner. The Bagshot sands, consisting of gravel and sand permeable to water, once stretched over the whole extent of the London Clay, but they are now to be found only on the high grounds at Hampstead, Highgate, and Harrow. A corner of the main mass enters the south-west corner of the county near Littleton. Beds of brick-earth occur in the drift between West Drayton and Uxbridge.

Several deep borings in the London basin prove the existence beneath the chalk of beds which do not crop out in Middlesex. Three of these are in the county; and the most interesting is that at Meux's Brewery, Tottenham Court Road (about 1146 feet), which passes through the following formations:—gravel and clay, 21 feet; London Clay, 64 feet; Reading beds, 51 feet; Thanet sand, 21 feet; chalk, 655 feet; Upper Greensand, 28 feet; gault, 160 feet; Lower Greensand, 64 feet; Devonian, 80 feet.

Rivers and Canals.—The Thames is very tortuous in the 44 miles of its course from Staines to Blackwall, and makes a remarkable bend at the eastern limit of the county where it forms the so-called Isle of Dogs. The width at Staines is 200 feet, at Chiswick opposite Barnes 340 feet, at Hammersmith 525 feet, at Fulham 820 feet, at Westminster Bridge 1100 feet, but at London Bridge it is less than 800 feet; above the junction of the Lea at the Isle of Dogs the width is 1350 feet. The ordinary rise of the tide at London Bridge is 16 feet, and the tide-way ends at Teddington. The port of London begins below London Bridge, and the channel for from 2 to 3 miles is called the Pool.

The Colne from Hertfordshire enters Middlesex at the north-western corner of the county. It then runs south, joining the Thames at Staines, and in its course divides Middlesex from Buckinghamshire for 15 miles. After the river leaves Uxbridge it divides out into several small channels. The Lea from Hertfordshire enters Middlesex at the north-eastern corner of the county near Waltham Abbey. It runs south, dividing Middlesex from Essex for 15 miles, and falls into the Thames at Bow Creek. Several branches flow off from the river during its course. The Brent from Hertfordshire enters Middlesex near Finchley. It takes a circuitous direction southward through the middle of the county by Hendon, Kingsbury, Twyford, Greenford, and Hanwell to the town of Brentford, where it unites with the Thames. Where the river crosses the Edgeware Road (about 3 miles south of the town of Edgeware) it is expanded by artificial means into an extensive reservoir. The Cran (or Yedding Brook) rises in the district between Harrow and Pinner and flows under Cranford Bridge; it crosses Hounslow Heath, and bends round to Twickenham and Isleworth, where in a divided stream it falls into the Thames.

There were several other small streams in the neighbourhood of London which have left their mark in the names of places, but which are now merely sewers, such as the Wallbrook, the Westbourn, the Tyburn, the Fleet river, &c. The last-mentioned, which runs into the Thames near Blackfriars Bridge, was formerly navigable as far as Holborn Bridge; but, the Fleet Ditch, as it was then called, having become in the last century a dangerous nuisance, the lord mayor and citizens were empowered by Act of Parliament to arch it over. The work was commenced in 1734, and in 1737 Fleet market, occupying the site of the space from Holborn Bridge to Fleet Bridge, was opened to the public. The New River, an artificial water-course constructed by Sir Hugh Myddelton in the reign of James I. to supply London with water, runs through the county from north to south a little to the west of the river Lea. It derives its waters from the springs of Amwell and Chadwell, increased by a cut from the Lea, in the neighbourhood of Ware, and enters Middlesex from Hertfordshire about 2 miles north of Enfield. It passes Enfield, Tottenham, Hornsey, and Stoke Newington, and is received into the reservoir in Clerkenwell known as the New River Head.

The Grand Junction Canal leaves the Thames at Brent