With the Authors Compts

ON

INFLAMMATION

AND

TUBERCLE.

EXPERIMENTAL AND PRACTICAL RESEARCHES

ON

INFLAMMATION,

AND ON THE

ORIGIN AND NATURE

OF

TUBERCLES OF THE LUNGS.

BY WILLIAM ADDISON, F.L.S.,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS; OF THE COUNCIL OF THE WORCESTERSHIRE NATURAL HISTORY SOCIETY; AND SURGEON TO H.R.H. THE DUCHESS OF KENT, MALVERN.

"In these days of various research actively pursued in so many countries, it would require more reading than is compatible with actual practice to collect together all that has been done on these subjects; nor would a single volume suffice for the mere references needful to such a work."—DR. HOLLAND.

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EXPERIMENTAL AND PRACTICAL RESEARCHES

ON THE ORIGIN AND NATURE OF

TUBERCLES IN THE LUNGS.

I. *Human Blood Corpuscles.*—1. *Red Corpuscles* 2. *Colourless Corpuscle.* 3. *Molecules and Granules.* 4. *Fibrine.*
II. *Pus Corpuscles.*
III. *Blood Corpuscles, and Lymph Globules of the Frog.*
IV. *Inflammation.*
V. *Cells.—Vegetable: Flower, fruit, leaf, pollen grains, spores. Animal: Vesicles of the liver, epithelium, animalcules, colourless blood corpuscles.*
VI. *Aëriferous Structure of the Lungs.*
VII. *Tubercles.*

THE researches forming the subject of the following memoir were commenced, and many of the results committed to paper,* previously to the perusal of Dr. Martin Barry's "Memoirs on the Corpuscles of

* *London Medical Gazette,* December, 1840, and January, 1841, "On the Colourless Globules in the Buffy Coat of the Blood."

the Blood," printed in the *Philosophical Transactions* for 1840 and 1841. According to the statements of this observer, he has found every tissue which he has examined "to arise out of corpuscles having the same appearance as the corpuscles of the blood."

From the nature of the subjects especially engaging my attention, viz., tubercle, tubercular infiltrations, and hepatization of the lungs, I have pursued a course of investigation different from that of Dr. Barry. I find all the varieties of epithelial cells and pus corpuscles to arise out of the *colourless* corpuscles of the blood, so far confirming Dr. Barry's conclusion; and I further find, that the morbid deposits above mentioned appear to have the same origin.

Before I proceed to give an account of my own researches, it will be necessary to make a few preliminary remarks upon the terms used by Dr. Barry to designate the minute objects seen in the interior of the blood corpuscle, which he calls "dark objects," "the foundations of future cells," but for which I have retained the terms "molecules" and "granules." The microscopic powers I have used magnify 250 and 500 diameters linear; and all subsequent descriptions have reference to objects as they appear with the former power, unless the contrary be expressly stated.

Black spots (*a*, plate 1, fig. 1) on a white ground, having a diameter of only $\frac{1}{500}$in., are distinctly visible to a person with a good sight, when held at the shortest distance for distinct vision. There are objects in the blood, in the blood corpuscle, and in all organized tissues, visible as similar black spots when magnified 250 times; hence their actual measure cannot be greater than $\frac{1}{100,000}$in.: for these objects I have used the term "molecules."*

There are other objects in the blood, in the blood corpuscle, and in all organized tissues, which, with the same magnifying power, are visible as bright points bounded by a dark circle: these I have called "granules."†

I am aware that globules of fat come under this definition of a granule; nevertheless, for reasons which will appear in the progress of this paper, I have deemed it necessary to keep in view a distinction between the smallest visible *dark points* and the smallest visible *bright ones,* by terms having no reference to their exact nature. A human blood corpuscle of mean dimensions has a diameter of $\frac{1}{2800}$in., and it takes usually four or five granules to reach across it; hence the measure of a granule is about $\frac{1}{11,000}$in. or $\frac{1}{14,000}$in. There can, however, be no precise measurement adapted for these minute objects, which vary in their size.

Molecules are the objects called by Dr. M. Barry "dark objects," "dark globules," and "foundations

* Wagner; *Icones Physiologicæ,* Fasciculus 1, table 1, fig. 5; table 6, fig. 1; and Fasciculus 2, table 13, fig. 2, B.

† Wagner; *Icones Physiologicæ,* Fasciculus 1, table 6, fig. 5 and 6; table 3, fig. 16. Fasciculus 2, table 13, fig. 1, D., and fig. 2, A., for granulated corpuscles.

of new cells;" and granules are synonymous with the "discs" of the same author. "The object called by me 'disc,'" he says, "is synonymous with the basin-shaped granules of Vogel, and the spherical molecules of Gulliver, seen in globules of pus."*

Dr. Barry has noticed my remarks on the colourless corpuscles in the buffy coat of the blood; and he calls these corpuscles "parent cells."†

I. ON THE BLOOD CORPUSCLES OF MAN.

1. Human blood corpuscles, examined by the microscope, exhibit an appearance of two circles, one within the other. The area of the inner circle is sometimes seen brighter (plate 1, fig. 1, *b*), sometimes darker (*c*), than that of the outer one; and sometimes the shading of the two circles causes the corpuscles to appear as if they were slightly hollowed out from the circumference towards the centre (*d.*) These variations of light and shade may be produced by gently approximating the corpuscles towards or by removing them from the focus of the microscope. When the corpuscles are crowded together, they become elongated and compressed into various shapes, and the outline or figure of the inner circle is equally affected with that of the outer one, but the matter of the two circles is never seen to mingle; and when the pressure is removed, both of them regain their pristine form. (Plate 1, fig. 2.)

Blood corpuscles therefore appear to consist of

* *Philosophical Transactions*, part ii., 1841, p. 223, par. 105.
† *Philosophical Transactions*, "On Fibre," pp. 107 and 109.

two elastic vesicles, one within the other, and to possess the following structure:—1st, an external and highly elastic tunic, forming the outer vesicle; 2nd, an inner elastic tunic, forming the interior vesicle; 3rd, a coloured matter, occupying the space between the two tunics; and 4th, a peculiar matter, forming the central portion of the corpuscle. I am aware that this description of the structure of the human blood corpuscle does not accord with that usually given by physiologists. My experiments lead to the conclusion that there is a central portion in the interior of the red corpuscle gradually increasing in size and development, and perfectly distinct from the coloured portion; but whether it be inclosed in a distinct tunic or not, is immaterial as regards the argument founded on the following investigations.

2. *Two very distinct kinds of Corpuscle may be distinguished in the Blood.*—A spot of recent blood, just withdrawn from the skin by a puncture, having been pressed into a thin film between two slips of glass, the surfaces of which fitted evenly on each other, was examined by the microscope. During the examination the glasses were frequently pressed together gently with the point of a finger, so as to put the corpuscles in motion, and the eye was thereby directed to several remarkable corpuscles which retained their circular form, and appeared harder or of a firmer structure than the rest; for the softer corpuscles, urged by the gentle motion given to the glass, passed to and fro around them, losing their figure; the softer corpuscles adhered together in rows and irregular masses, but the others had

no disposition so to do. (Plate 1, fig. 3.) The corpuscles thus discriminated were somewhat larger than the rest; the inner vesicle or central portion was larger, and numerous minute dark points or molecules were distinctly visible in it. By gently altering the focus of the microsope to and fro, they presented a peculiar and characteristic pearly aspect, and exhibited refractions of the light which could not be produced in any of the softer corpuscles. These are the colourless corpuscles of the blood.* By repeating this experiment with blood just drawn from any inflamed surface, as a pimple or the base of a boil, they are found very abundant; and in blood taken from the skin of a patient in scarlet fever, or from the spots of any cutaneous disease, they are remarkably numerous and conspicuous. It is impossible to form an accurate estimate of the depth or tone of the colour of the red corpuscles, viewed singly as microscopic objects; hence the distinctive character of the colourless blood corpuscle, seen in this way, does not arise so much from any obvious or striking difference of colour, as from its greater resistance to pressure, from the greater relative size of the central portion, from the dark points or molecules visible in it, and from the peculiar manner in which it refracts the light. In making this experiment I have met with three very distinct and characteristic conditions of the red corpuscles: sometimes they are banded together in rows; at others, they appear completely fused together in patches; and again they are sometimes seen having

* *Medical Gazette*, December, 1840; January, 1841.

no disposition to cohere. The firm colourless corpuscles may, however, always be easily detected.

3. *Of the Red Corpuscles.*—When the red corpuscles have been kept a day or two they lose their elasticity and are found in various altered forms; if caused to roll over during examination their thin edges and flat circular faces are alternately presented to view; during these movements the inner vesicle or the central portion of the corpuscles may be seen as a bright cylinder within the outer tunic (plate 1, fig. 4, *e*); or as two bright granules connected together by a straight or curved dark (*f*) or bright (*g*) line. Sometimes two strong lines are seen at one part of the circumference of the corpuscle (*h*); and frequently the corpuscles assume a permanent crescentic shape, the central portion projecting from the inner or concave aspect of the crescent (*i*.) Many of these phases may be seen successively in single corpuscles during their movement; and occasionally, by accurately watching them, I have seen the central portion exhibit independent movements, dividing into granules which afterwards coalesced. The red corpuscles frequently exhibit a very remarkable spontaneous change. When making the experiment (par. 2) we may almost always observe the central portion of many of them divided into molecules, which are attracted to the circumference of the corpuscle, forming the beaded border so accurately described by Dr. M. Barry, in the memoirs before referred to. I have several times counted from six to ten molecules, or even bright granules around the circum-

ference (plate 1, fig. 5); I have also repeatedly observed, when making the experiment (par. 2), that the corpuscles, after adhering together in rows for a little time, separate and become smaller, contracting their dimensions so much, that they are not more than one half or a third their former size (fig. 5, *j*); and those corpuscles which exhibited the beaded border lose it.

4. *Of the Colourless Corpuscles.*—The pale or colourless corpuscles, although they may readily be distinguished in every drop of blood, by the experiment (par. 2), are most conveniently obtained for microscopical examination from the fluid or liquor sanguinis, at the surface of buffy blood before the fibrine coagulates. These corpuscles vary in size and appearance; they are seldom less than the red corpuscle, frequently much larger. The central portion or inner vesicle is clearly defined; its outline appearing like a delicate filament just within the outer tunic of the corpuscle. (Plate 1, fig. 6, *k*.) The interval between the outline of the central portion and the outer circumference of the corpuscle is very small and without colour; sometimes there is no interval between them, and then the corpuscles have an uniform molecular aspect. (Plate 1, fig. 6, *l*.) The central portion has at all times a molecular or minutely granulated aspect, and frequently one, two, or more granules, during the observation, become distinctly visible in it. The colourless corpuscles of the blood have been seen under various circumstances by many previous observers, and described under the deno-

mination of lymph globules, pus globules, the white globules of the blood, blood corpuscles of the second form, and *exudation* corpuscles.

5. *Of the Molecules, Granules, and Fibrine.*—During the examination of the colourless corpuscles in the liquor sanguinis of buffy blood before it coagulates, a great number of isolated molecules and granules, not inclosed in any corpuscular tunic, may be seen; they are mingled with the colourless corpuscles, but can never be confounded with them on account of their minute size. (Plate 1, fig. 7 and 8.) They are frequently seen in separate groups, which have sometimes a circular outline, appearing as if the corpuscular tunic had been dissolved away from around them. After a short time the fibrine may be seen coagulating. Exceedingly delicate and perfectly cylindrical fibres or filaments, having a diameter even less than the molecules, first appear crossing the field of the microscope; they gradually increase in number, intersecting each other in various directions, and at length form a complete network, in the meshes and angles of which the colourless corpuscles and the molecules and granules are entangled and drawn together, forming, with variable proportions of included serum, the entire mass of the buffy coat of the blood.* (Plate 1, fig. 8.)

I have never seen the fibrine evince the slightest tendency to form either molecules, granules, or corpuscles of any kind, though I have repeatedly seen it coagulating into thick films under the microscope; nor have I ever seen an *exudation* corpuscle, if what is meant by this term be a corpuscle formed by the

* *Medical Gazette*, March, 26, 1841, and April 15, 1842.

fibrine whilst coagulating. The elements of the blood therefore visible by the microscope, without any addition or manipulation, are, 1st., the red corpuscles; 2nd., the colourless corpuscles; 3rd., molecules and granules in the interior of the colourless corpuscles; 4th., molecules and granules not inclosed in any corpuscular tunic; 5th, the fibrine.*

6. *On the effect of Water, the Dilute Acetic Acid, and Liquor Potassæ (Brandish's Alkali), on Blood Corpuscles.*—If a drop of *water* be added to recent human blood, its effect upon the red and the colourless corpuscles is very different. If the proportion of water to blood be small, the tunic of the red corpuscle is dissolved, and the colouring matter dispersed, leaving the central portion enlarged, with a molecular or finely granulated aspect, faintly visible (plate 1, fig. 9); or the corpuscles contract to one-half or a third their former dimensions, without any dissolution of their structure, and they remain with a stronger outline than before. (Plate 1, fig. 5, *j*.) If the proportion of water be greater, the corpuscles are entirely destroyed, leaving an indistinct hazy matter in the field of the microscope, which cannot, without the highest powers, be resolved into molecules. The *colourless corpuscles,* on the addition of water, do not experience any sudden change; they, therefore, stand out promi-

* Mr. T. Wharton Jones, in his "Observations on the Blood," first published in the *British and Foreign Medical Review*, for October, 1842, thinks that I have overlooked the fibrine in my account of the "Colourless Globules of the Buffy Coat of the Blood," in the *Medical Gazette;* but a reference to the articles published in this periodical for March 26, 1841, and April 15, 1842, will show that he is wrong in his idea.

nently amid the faintly visible central portions of the red corpuscles. They very soon, however, begin to alter their aspect, exhibiting various internal movements, during which the outline of the central portion of the corpuscle disappears. (Plate 1, fig. 10, *m.*) Bright granules and dark molecules may frequently be seen moving in the interior of the corpuscles, and sometimes they form a border at the circumference. (Fig. 10, *n.*) During these changes the corpuscles increase considerably in size by imbibition; the molecules and granules also become larger and more distinct; at last, the corpuscles burst, and the molecules and granules are dispersed. (Fig. 10, *o.*)

A drop of serum just coloured by the red corpuscles was examined by the microscope. Most of the corpuscles were shrivelled and irregular in outline; there were several rows of them. (Plate 1, fig. 11.) A drop of water, in which a little gum had been previously dissolved, was cautiously added. The red corpuscles became slowly distended by imbibition, without being ruptured; the rows of flattened corpuscles were seen moving; and the central portions of them, which could not be distinguished at first, became visible, apparently drawn to one side. After a short time the central portion was enlarged, and became separated from the side appearing in the centre as usual; many of the corpuscles became double the magnitude of others, and the strength of outline and the refractive pellucidity of the central vesicle varied exceedingly.* (Plate 1, fig. 11.)

* *Vide* a Paper in *Guy's Hospital Reports*, "On the Structure of the Blood Corpuscle," by Dr. G. O. Rees and Mr. S. Lane.

If a thin pellicle of coagulated fibrine be removed from the surface of buffy blood with the point of a needle, and a tea-spoonful of the fluid beneath it, free from red corpuscles, carefully skimmed off and put into a phial, previously nearly filled with an ounce and a-half of spring water, the mixture will become of a pale whitish colour, nearly opaque. If at the end of a quarter of an hour the mixture be examined by the microscope, numerous colourless corpuscles will be found in it, containing molecules and granules in their interior. There will also be found multitudes of isolated molecules and granules mingled with irregular masses composed of films and shreds, the remnants of ruptured corpuscular tunics. At the end of two hours a white sediment will be found at the bottom of the phial; this sediment is composed of similar objects mingled with fibres of fibrine. Here, then, a pus-like matter, composed of granulated corpuscles, isolated molecules and granules, and ruptured corpuscular tunics, may be obtained by the action of water on the elements of the buffy coat of the blood. The white colour is evidently owing to the great number of free molecules and granules.

If *dilute acetic acid* be added to recent blood corpuscles, its action upon them is similar to that of water, but more energetic. The *red corpuscles* are usually rendered darker and then dissolved (plate 1, fig. 12, *p*); frequently, however, several corpuscles appear enlarged, but very pale; they retain their usual figure, and the inner vesicle or the central portion is exceedingly obvious. (Fig. 12, *q*.) The *colourless corpuscles* lose somewhat of the regularity of their outline, and large granules appear within them. In a short time several corpuscles appear to be ruptured, and the molecules and granules are set free. (Plate I, fig. 13, *r*.) The acid sometimes produces an appearance of two dark lines inclosing a bright space, which seems to require dividing to form the granules.* (Fig. 13, *s*.)

7. The effects of *liquor potassæ* on blood corpuscles are very remarkable. In order to witness them a drop of recent blood, or of the liquor sanguinis from buffy blood, should be spread out on a slip of glass, and another slip of glass, somewhat smaller, placed upon it; a drop of the alkali added at one of the edges of the upper glass will gradually diffuse itself between them, and by a little management its progress may be followed by the microscope. At the first contact of the alkali, numerous corpuscles disappear in a moment; others explode and are dissolved. The *red corpuscles* are rendered darker, and the central matter becomes quite invisible. (Plate I, fig. 14, *t*.) I have met with many singular contortions of the corpuscles before they burst, and twice I have seen the central portion suddenly protrude itself beyond the outline of the outer tunic, and then it appeared to be drawn in again; immediately afterwards, the corpuscle for a moment regained its circular appearance, and then burst open and disappeared. (Fig. 14, *u*.) The way in which the red corpuscles discharge matter on the application of liquor potassæ, and then regain their

* See also Dr. Martin Barry's Memoirs, *l. c.*, plate 17, fig. 23, γ; and plate 20, fig. 63, γ; *Dujardin's Observateur au Microscope, avec Atlas,* plate 3.

form, is very curious, and may be well observed in the blood of a frog.* (Plate 2, fig. 25.)

The *colourless corpuscles* may be completely dissected by liquor potassæ or liquor ammoniæ, and the nature of their contents unequivocally displayed. Instantaneous changes occur in their interior, where numerous molecules and granules may frequently be seen in active motion. In a short time the corpuscles burst open or explode, and discharge ten, fifteen, or more molecules and granules, which either disappear quickly by dissolution in the alkali or remain for a longer time visible, according to the strength or quantity of alkali by which they have been acted on. Frequently, when the liquor potassæ is acting with diminished energy, the corpuscles give a sudden jerk, and in a moment enlarge to double or three times their former size, without losing their circular outline; the molecules and granules within them are more widely separated from each other, but not dispersed; and they are seen held together or attached to the tunic of the corpuscle by delicate connecting filaments. This singular and instructive change does not, of course, last long; the alkali continuing its action, ruptures the tunic of the corpuscle, dispersing and dissolving its contents. (Plate 1, fig. 15.)

These experiments lead to the conclusion that the colourless corpuscles are highly organized vesicles or cells, circulating in, and forming an essential portion of, the blood.

* *Dujardin's Observateur au Microscope*, plate 3, exhibits corpuscles very nearly divided in this manner by the application of a syrup.

II. ON PUS CORPUSCLES.

8. The colourless blood corpuscles appear to form pus corpuscles. An *abscess* was opened in the hand; five days afterwards the wound was discharging a colourless and transparent lymph, in which numerous corpuscles, isolated molecules and granules, and fibrinous filaments, were detected by the microscope. The corpuscles were slightly shrivelled and somewhat irregular in their outline, appearing as if a part of their fluid contents had exhaled, (plate 2, fig. 16, *v*); otherwise they had all the characteristics of the colourless corpuscles of the blood. A cautious application of the liquor potassæ caused them at first to swell out and become round, rendering the molecules and granules in their interior very distinct; they then burst open, and discharged their contents (plate 2, fig. 16,) which consisted of about ten or twelve granules and a number of smaller molecules. I may here observe, that liquor potassæ acts upon the free molecules and granules of the blood in the same manner as it does upon those which are turned out of the colourless blood and pus corpuscles. A little pus was mixed with serum of the blood; the corpuscles imbibed the fluid and became very large; numerous molecules and granules were visible within them, and they had very much the appearance and character of pollen grains which had been subjected to the action of water. (Plate 2, fig. 17, *w*.) In ten or fifteen minutes the tunics of the corpuscles partially gave way, and the molecules and granules were seen escaping. (Fig. 17, *x*.) I observed several of them enlarge suddenly with a jerk, and

the molecules and granules were seen attached to the tunic or wall of the corpuscle by delicate filaments.* (Fig. 17, *y*.)

Slight Chronic Cough.—In the mucus from the back part of the throat I found a multitude of free molecules and granules; small corpuscles with a few molecules in them; pus corpuscles of all sizes gradually passing, on the one hand, into large granulated oval or round corpuscles, and on the other, into flattened epithelial cells. Water and liquor potassæ produced upon all the granulated corpuscles the effects I have just described. (Plate 2, fig. 18.)

Chronic Scrofulous Abscess, which had existed some weeks.—The discharged matter, after having been mixed with a little water, was found to contain large corpuscles filled with molecules and granules; there were also groups of molecules and granules rather widely separated from each other, but retaining a bond of union by delicate filaments, and isolated molecules and granules, possessing vivid molecular motion. (Plate 2, fig. 19.) Pus corpuscles readily elongate themselves to pass through a narrow channel and regain their figure afterwards; I have frequently noticed this in the little currents almost always produced in the fluid, when the corpuscles are examined by the microscope between two slips of glass.

Ulcers of the Cornea and inflamed Tarsi.—In a tear from the corner of the eye a great number of corpuscles were found, in which the outline of the

* I have not always succeeded in this experiment; should it fail, add a drop of water and observe again.

inner vesicle or central portion was particularly strong and well marked; they were somewhat irregular in shape, and seemed puckered or shrivelled; in all other respects they exactly resembled the colourless corpuscles of the blood. On adding a little water they became circular and plump, and in a few minutes attained to nearly double their former size, presenting a molecular or finely granular aspect (plate 2, fig. 20); with liquor potassæ, many of them were instantly destroyed. When the first effect of this application had passed off, I observed, as the alkali slowly gained access to them, several singular changes of form and internal motions among the contained molecules, many of which became granules; afterwards, the corpuscles burst open or exploded, each of them discharging from ten to twenty molecules and granules. (Plate 2, fig. 20). Some of these corpuscles opened very gradually, and the tunic bent itself back, becoming concave the other way. (Fig. 21). A drop of blood was taken from the skin of the same person, and several colourless corpuscles were detected in it; on adding a drop of water to the blood, the red corpuscles experienced the changes before mentioned, but the colourless ones stood out prominently; previously to the addition of the water, their central portions were distinguished occupying very nearly the whole area of the corpuscles, but immediately afterwards their central portions appeared to fill the corpuscles, which became much enlarged and exhibited the same appearances as those I had taken from the corner of the eye; on adding to them a little liquor potassæ, they exploded and discharged a number of similar molecules and granules.

Shingles.—One of the transparent vesicles was pricked, and in a drop of the effused fluid a great number of colourless corpuscles were found ; some of them were remarkably large and contained several bright granules, which on close inspection were evidently moving ; that is, granules disappeared in one part of the corpuscle and became visible in another part. These appearances were repeated several times, as if from the working (writhing) or undulation of a fluid within the corpuscle, which, by dividing, coalescing, and then again dividing, formed the granules, which alternately appeared and disappeared.*

A little water was added to the corpuscles from the point of a lancet, and I observed the usual effects which have been already amply described. (Plate 2, fig. 19 and 20.) A drop of liquor potassæ was then applied, and I saw the corpuscles dehisce

* The following extract from the *Journal Universel des Sciences*, may assist in explaining these singular appearances :—

" M. Plateau entretient l'Académie d'une série de faits qui l'ont conduit à considérer, comme beaucoup plus générale qu'on ne l'avait cru jusqu'ici, la propriété en vertu de laquelle certains corps mouillent d'autres corps. On savait que les solides sont en général mouillés par las liquides et par les gaz. Or, l'auteur arrive à cette conclusion que les liquides sont aussi mouillés par les autres liquides avec lesquels ils ne peuvent se mêler ; que les liquides sont également mouillés par les gaz, et qu'enfin réciproquement les gaz sont mouillés par les liquides.

" C'est-à-dire que, par exemple, lorsqu'une masse liquide est plongée dans un autre liquide avec lequel elle ne peut se melée, elle maintient à sa surface une mince pellicule de ce dernier qu'elle êntraîne avec elle dans tous ses movements. La même chose a lieu à l'égard d'une bulle gazeuse qui se meut dans un liquide et enfin à l'égard d'une goutte liquide qui se meut dans un gaz. Il n'y à d'exception que pour les gaz entre eux, parce que, comme en sait, ils one after another, giving at first a sudden start or jerk, and enlarging to twice their former dimensions before bursting open and spreading out; discharging from twelve to fifteen bright granules, and many molecules, which slowly disappeared. (Plate 2, fig. 17, 19, and 20.)

Cancer of the Breast extending to the Axilla.—The whole arm, on the affected side, had been œdematous for two months, occasionally becoming very red and painful, and the skin had been punctured several times to relieve the swelling. From one of these punctures, at the back of the hand, a clear transparent fluid had been discharging in considerable quantities for some time, and I frequently collected and examined the fluid by the microscope. On every occasion, corpuscles, resembling in every particular the colourless corpuscles of the blood, were seen in it, accompanied with a fibrinous network. When the arm had been for a few days cool and free from pain, the fluid

ne peuvent demeurer en contact sans se mêler."—*Journal Universel des Sciences*, 1*ére*, sec. No 447.

Of the same nature is the following:—We may often remark in the vicinity of falling water, and even in liquids while filtering, that spherules of the liquid run along the surface, and remain a considerable time in a state of isolation without mixing; in these instances there can be no doubt that the spherule is covered with a film of air which it carries with it in its movements, and which prevents it mingling with the mass from which it has thus become temporarily separated. The central portion of the corpuscles, spoken of in the text, *was alive*, and by virtue of this vitality it exercised certain movements, by which a division into parts ensued; and the divisions or granules were wetted with the fluid of the outer part of the corpuscle, which prevented them for a little while from coalescing, and so on; so that the phenomena observed were due to the alternate actions of an inherent vitality, and a general physical law.

discharged was as colourless as spring water, but there were always corpuscles in it; and after standing for a few hours, a delicate network of fibrinous filaments could always be drawn out with the point of a needle; the filaments of this network were so fine, and the meshes so intricately disposed, that a very large globular mass of water only appeared to be suspended on the point of the needle. Under the microscope the network was seen studded with corpuscles and with isolated molecules and granules, which had been gradually collected, or drawn together, by the contraction of the filaments of fibrine. When the arm became red and painful, the fluid discharged from the puncture had the ordinary straw colour of serum; there were many more corpuscles in it, and the fibrinous network was more dense. On the addition of water the corpuscles imbibed and swelled, and on subjecting them to the test of liquor potassæ they dehisced and discharged molecules and granules. It is evident then that the fluid of œdematous swellings differs materially from the serum of the blood, remaining after the formation of the clot in an ordinary venæsection; for it contains both colourless corpuscles and fibrine. The corpuscles discharged from the open cancerous sore possessed the usual characteristics of ordinary pus corpuscles, and their behaviour, on the addition of water and liquor potassæ, was precisely similar.

The conclusions to which these experiments lead are, that pus corpuscles of all kinds are altered colourless blood corpuscles; and that all limpid, colourless, abnormal discharges are effusions of the liquor sanguinis, containing more or less of the fibrine, and corpuscles in varying proportions. No new elementary particles are formed by any inflammatory or diseased action.*

III. ON THE BLOOD CORPUSCLES AND ON THE LYMPH GLOBULES OF THE FROG.

9. The colourless or lymph globule in the blood of the frog is analogous to the colourless corpuscle in the blood of man.

If an incision be made in the skin of a frog, a clear liquid will be effused, which, when examined by the microscope, will be found to contain two kinds of corpuscles; the one the red corpuscle, the other the lymph globule. The effect of water on the lymph globules is precisely similar to that which it produces on the colourless corpuscles of the blood of man: they imbibe the fluid, and increase in size, molecules and granules being distinctly visible in them. If a little liquor potassæ be added, it immediately causes a commotion in the molecules and granules, and in a few moments the globules burst open one after another, and discharge from thirty to fifty molecules and granules, which increase in size previous to their dissolution in the fluid. (Plate 2, fig. 25, *d.*) After a little time the alkali becomes weaker in its effect, appearing to have only strength sufficient to burst the globule; the granules consequently remain for a long time visible, separated a

* Müller, "On the Nature and Structural Characteristics of Cancer," pp. 24, 25, and 32, 1840.

little from each other, but still held together by delicate filaments. (Par. 7.)

The great number of molecules and granules which are turned out of the lymph globule of the frog by liquor potassæ is quite amazing; the rapidity with which they imbibe the fluid, and their subsequent destruction and disappearance, are eqnally singular. I have no doubt that higher microscopic powers than I have been able to use would show an equal amount of molecules and granules from the colourless corpuscles of man; but these are so exceedingly minute that their actual number escapes notice, the larger ones only being accurately defined.

10. This lymph globule appears to be the inner vesicle or central portion of the red corpuscle.

In blood just taken from the vessels, the inner vesicle or central portion of the red corpuscle is not visible, though there is considerable difference in this respect in different corpuscles. (Plate 2, fig. 22, a^1.) In a very short time, however, and especially if the blood be allowed to dry on the glass, the inner vesicle becomes very distinct, having the oval figure of the outer one; its outline is irregular, and there are indications of a tendency to divide into granules. (Plate 2, fig. 22, b^1.) The effect of water on the recent and on the dried corpuscles is different. When it is added to the recent red corpuscles its effect upon them varies; and it would be almost impossible to particularize all the appearances they present. Some of the corpuscles are but little altered, a few are rendered circular and dark, but the majority become circular and pale, the inner vesicle also appears globular and very distinct. In some instances this inner vesicle has a finely granular appearance; in others it is evidently composed of granules, when it strongly resembles the lymph globule. (Plate 2, fig. 23.) If the dilute acetic acid be added to the recent red corpuscles, the outer vesicle is rendered very pale, and the inner vesicle becomes remarkably distinct. Having added a drop of the dilute acid to corpuscles which had previously been rendered pale and globular by water, I observed the pale outer vesicle enlarge suddenly, and at the same time numerous molecules and bright granules became visible in the globular inner vesicle, giving to it the most perfect resemblance in all points to the lymph globule. (Plate 2, fig. 24.)

A drop of frog's blood having been spread out on a slip of glass and allowed to dry, the corpuscles were examined by the microscope and the inner vesicles were found very distinct. I selected seven corpuscles lying together (plate 2, fig. 26, e^1); a little water was added to them, and the outer vesicles were instantly destroyed and disappeared, but the inner vesicles or central portions of the corpuscles remained, and began to enlarge by imbibing the fluid (fig. 26, *f*); and I counted from twelve to twenty molecules in them, which with higher power (500) appeared as bright granules with a dark refractive central spot. Some of these inner vesicles were round, and resembled the lymph globule, others retained an oval shape. (Plate 2, fig. 26, f^1.) On adding to them, very cautiously, a little liquor potassæ, they enlarged suddenly with a jerk, their outline remained for a moment or two faintly visible, and they had all the appearance of a network of granulated cells. (Fig. 26, g[1].)

These experiments appear to show that the lymph globule of the frog is the inner vesicle or central portion of the red corpuscle, and that its structure is similar to that of the colourless blood corpuscle of man. Hence, then, we have strong ground for concluding that the colourless blood and pus corpuscles of man are formed from the central portion of the red corpuscles; this central portion becoming developed, and increasing gradually in size by absorbing or assimilating the colouring matter.*

IV. ON INFLAMMATION.

11. It is well known that the lymph globules of the frog are disposed to adhere to the sides of the vessels along which they are passing, and that the red corpuscles pass by them, losing their figure.†

The following experiments will show that this disposition is very much increased in vessels that have been irritated or excited, when the lymph globules become so numerous as to line the whole interior of some of the vessels, while the current of the red corpuscles passes over them.

* I may observe, that Professor Owen's account of the blood corpuscle of the Siren, (*Penny Cyclopædia*, Art. "Siren,") fully bears out the view above given of the nature and structure of the central portion or inner vesicle of the red corpuscle of the frog; and strengthens the probability of the lymph globule being this inner vesicle arrived at maturity.

† Wagner; *Icones Physiologicæ*, Fasciculus 2, table 14, fig. 5, *a*, *a*, *a*.

The circulation in the web of a frog's foot was watched at intervals for half an hour, and only a few lymph globules were seen. A crystal of salt was applied, and the examination continued: its first effect was to quicken the rate of the circulation; this soon ceased, and the blood became stationary, the vessels being red and congested. In the capillaries contiguous to the congested vessels, the blood was oscillating to and fro; a little further off, the circulation was very quick. In half an hour the number of lymph globules had increased considerably, and the circulation in the congested vessels was resumed; but the corpuscles passing through them sometimes oscillated to and fro, sometimes retrograded, and at others hurried or darted through the vessels with the utmost velocity. The current of the red corpuscles, in some of the veins, appeared to be confined to the centre of the vessel, and not to touch the circumference, which was occupied by a great many lymph globules.* On the following morning the whole interior of the inflamed vessels appeared to be lined with lymph globules. By gently altering the focus of the microscope they were seen below the red current, and many of them appeared to lie externally to the boundary of the vessels.† (Plate 3, fig. 27.) Every now and then lymph globules were detached from their situation, rolling slowly onward with the red current, fresh ones taking their place.

* "Report on the Results obtained by the use of the Microscope in the Study of Human Anatomy and Physiology," by Mr. James Paget; *British and Foreign Medical Review*, Art. 15, c. Capillaries; 3, Functions, &c.

† Wagner; *Icones Physiologicæ*, Fasciculus 2, table 14, fig. 3, 4, & 5.

The circulation in the web of a frog's foot was watched for a quarter of an hour, and only six lymph globules were seen: the foot was then placed in water, at 94° F., for 30 seconds. After the immersion the circulation was proceeding at very different rates in different capillaries: in some it was quicker, in others slower, than before; the lymph globules gradually increased in number, and in some of the veins the red current appeared as if passing over a bed of marbles; one capillary was particularly noticed, nearly filled with lymph globules, oscillating to and fro, while at the same time red corpuscles were threading their way between them, passing *through* the vessel: occasionally these red corpuscles stopped suddenly and retrograded, yet no motion whatever could be detected in the wall of the vessel.

Several other experiments afforded, similar results. In repeating these experiments it is necessary to observe, that any rough handling in securing the foot to the plate produces an effect on the circulation, and that lymph globules will accumulate in the vessels, from the irritation excited by this operation.

12. The lymph globules seen in the blood in these experiments were not all of the same dimensions: some were nearly twice the size of others; molecules could readily be detected in many of them, and both molecules and granules in others. During some of these experiments the islets of tissue between the capillaries became distinctly cellular, and appeared as if overspread with irregular shaped lymph globules* (plate 3, fig. 27, b^2), and the

* Wagner; *Icones Physiologicæ*, Fasciculus 2, table 14, fig. 3.

various rates of circulation, which were seen in the same field of view, were very remarkable, showing that local causes may not only retard, but greatly accelerate, the motion of the blood over limited areas. Red corpuscles were frequently observed following each other with the utmost rapidity through vessels large enough to admit three or four abreast, and yet no movement whatever was discernible in the sides or wall of the vessel. It was frequently noticed, that red corpuscles were seen to be detached from a mass of blood almost stationary in a capillary, and after darting through three or four vessels, to arrive at another slowly moving mass; the intermediate movements being much quicker than those at the points either of departure or arrival.

The phenomena observed in the foregoing experiments corroborate the views of those distinguished physiologists who entertain the opinion that the capillary distribution of the blood is situated in channels of the tissue, and not in vessels with a distinct membranous coat.* Wagner observes, in speaking of the capillaries in the web of the frog's foot, that they are bounded by distinct walls, "*Parietibus distinctè circumscripta sunt,*" but he does not explain their nature or character.† These walls, bounding the capillary currents, become much more evident and more strongly defined in the inflamed vessels; they appear, however, to consist of parallel fibrinous fibres (par. 5), which gradually amalgamate with

* *Müller's Physiology*, vol. i., 229.

† *Icones Physiologicæ*, Fasciculus 2, table 14, description of fig. 2.

the structure of the tissue, as they recede from the currents of the blood; and it is among these fibrinous looking fibres that the lymph globules are seen to accumulate.* (Plate 3, fig. 27.)

13. It may perhaps be questioned whether the term inflammation be applicable to cold-blooded animals. Dr. Martin Barry has shown that various altered forms of blood corpuscles accumulate in the minute vessels engaged actively in the function of nutrition;† and he has used the term "vital turgescence" to express a peculiar condition of the vessels in which this accumulation has taken place.

My experiments have shown that the colourless forms of blood corpuscles accumulate in the minute vessels engaged in inflammation: hence I conclude, that "vital turgescence" and "inflammation" are terms expressing analogous actions; for blood drawn during pregnancy, where there is an extensive vital turgescence, exhibits the buffy coat; and so it does in pneumonia and rheumatism.

A vital turgescence (the modelling process of Macartney) consists in a normal accumulation of colourless corpuscles for the purposes of growth, nutrition, or reparation; and the various degrees of inflammation are states of abnormal turgescence, in which the corpuscles, over and above what are required for normal purposes, form pus corpuscles. (Par. 8.)

* The structure and formation of blood vessels out of filaments of fibrine, inclosing elongated or spindle-shaped colourless blood corpuscles, may be demonstrated in the transparent membranes of a very young embryo.

† *Philosophical Transactions*, part ii., pp. 47 and 48, &c., 1840; and part ii., p. 106, 1841.

V. ON CELLS.

14. In the lower orders of vital structures, where there is no circulating current, the granulated cells of the tissue are parent cells, exercising a reproductive function. Dr. Barry, in his *Researches in Embryology*, has described, in the interior of the cells of the impregnated ovum, "minute objects," the "foundations of future cells," which, escaping from the original or parent cells, form additional new ones.*

The minute objects, visible in the interior of the colourless blood corpuscles, and termed by me, as before mentioned, molecules and granules, have been investigated by Dr. B. under the denomination of blood discs; he believes that the colourless blood corpuscles are parent cells, and that the objects (discs) contained in them being discharged into the blood become young blood corpuscles.† There can I think be no doubt, in the higher order of animals, where there is a circulating current of cells, that the reproductive function, or the formation of new cells, and the first stages of their development, are performed in and confined to the circulating fluids, the chyle or the blood; and that the tissue or epithelial cells have not the power of reproducing their kind.

The term "parent cell," therefore, if at all appropriate to the colourless corpuscles of the blood, is not applicable to those which, having been withdrawn out of the circulating current in the manner

* *Philosophical Transactions*, 1839 and 1840.

† *Ibid*, 1842, part i., par 109.

already adverted to, become pus corpuscles (par. 8); nor, as I shall endeavour to show, to those forming the normal tissue cells, which retain the molecules and granules in their interior, not, as I believe, for the purpose of forming new cells, but to assist in some special function, to the reproduction of which they are essential elements.

15. Before proceeding to show that the colourless blood corpuscles form the tissue or ephithelial cells which elaborate the various secretions, I shall make a few remarks in support of the following propositions:—1st, that each cell performs its own function quite independent of those by which it is surrounded; 2nd, that the magnitude of a cell, the thickness of its wall, and the size of its nucleus, have no necessary connexion with the sensible qualities of the secreted matter, but that it is the molecules and granules, in its interior, which give special qualities to the secretion, or to the contents of a cell.

The isolated character and independent function of the cells of vegetable structures, might almost be inferred from the variety of products found not only in the same plant, but in the different parts of a similar structure, *e. g.*, the flower and the fruit. If a succulent fruit be bruised, a change of colour in the injured part almost immediately ensues, even although the cuticle remains entire. The injury ruptures the cells of the interior pulp, and causing their contents to mingle, produces rapid changes, ending in decay.

If the cuticle be removed from one of the surfaces of a coloured petal, the parenchyma, after having been moistened with a drop of water and examined by the microscope, will be found elaborately formed of cells, the size and figure of each cell varying in the different species of plants. (Plate 3, figs. 28, 29, and 30.) These cells are composed of a delicate transparent membrane, having a notched, waved, or undulating outline. Affixed to the angles or projecting points of the membrane, or irregularly distributed within the cells, are numerous molecules and granules, varying in number, but seldom less than fifteen or twenty. In a parti-coloured petal—for example, the *Garden Pansy*—(plate 3, fig. 28), each cell may be seen to possess its own colour, without the least intermixture with that of the adjoining ones. Cells filled with a purple pigment are in juxta-position with others filled with a brilliant yellow; and cells with these colours may be seen in apposition with others of a pale primrose, or with others devoid of colour. It is evident, from this examination, that the differences of colour arise from the peculiar and independent function of each cell; the purple pigment is formed in one, and the yellow in another, so that there is no intermingling of tints; each coloured cell is perfect and distinct in itself. The nucleus of the cell may generally be seen adhering to the transparent membraneous wall (figs. 28 and 30); and, from the form and situation of this body, it appears to be the nutrimental organ of the cell wall: it is usually composed of a central matter, surrounded by minute molecules.

The various species of *Conferva* are composed of exquisitely formed granulated cells (plate 4, figs.

32 and 33), possessing a power of reproduction;* and the fleshy leaves of *Sedum acre* afford beautiful examples of perfectly independent vesicles or cells, with thin walls, and apparently no nucleus or special nutrimental organ, but which contain a great number of large green granules, each granule having smaller objects in its interior. (Plate 4, fig. 31.) This plant will flourish on the bare rocks exposed to the hot sun, yet its fleshy leaves are very juicy, (evincing great activity of function), and have very strong sensible qualities.† The cells of the pith at the extremity of the young and tender shoots of the elder, (*Sambucus niger,*) are nearly filled with molecules and granules, which gradually diminish in number towards the older portions of the branch, and ultimately disappear when the wood is completely formed. In the former situation, the cells of the pith have strong sensible qualities, whereas in the latter they are altogether insipid. In these examples it is much more probable to suppose, that the reproductive function of the *Conferva,* and the hot and biting qualities of the *Sedum,* reside in the

* Carpenter's *General and Comparative Physiology,* p. 447, &c.

† La cellule pendant sa période de développement, est remplie d'un liquide incolore plus ou moins chargé de substances organiques ou inorganiques dissoutes, et quelquefois même d'un liquide colorè...... Si la cellule est exposée à l'influence de la lumière, elle sera, dans certains cas, mais non toujours, tapissèe a l' interieur par des expansions vertes ou par une couche de *petits granules* verts plus ou moins rapprochès, mais non superposés, ni entassés, qui sont la matière verte des végétaux, nommèe *l' endrochrôme,* ou *la chromule* ou *la chlorophylle,* et douée d'une vitalité propre, et d' une organisation non appréciable a la vue, mais bien réelle.—*Dujardin, loc. cit.,* chap. 3, pp. 172, &c.

very conspicuous and highly-organized granules of the cell, rather than in the thin, transparent, and almost invisible membrane forming the cell wall.* Again, in the cultivated fruits, the cells are inordinately increased in magnitude, and distended with a much blander or more watery fluid than in their natural uncultivated state. The nucleus of the cells is very much enlarged, but the granules of the cell are small and ill defined, as in a thin section of the fruit of the strawberry. (Plate 4, fig. 34.) In the fruit of the sloe, *(Prunus spinosa)*, the cells are comparatively small, possessing numerous green granules; whereas in the fruit of the cultivated varieties of the plum the cells are larger, and have much fewer and paler granules.

The cells of vegetable structures, therefore, appear to perform perfectly independent functions; and the sensible qualities of the contents, and the nature of the function of a cell would seem to depend, not upon the thickness or development of the membrane of the cell, nor on the size of the nucleus or nutrimental organ, but upon the number and structure of the molecules and granules in its interior.

The very close analogies which have been shown to exist between the structure and functions of vegetable and animal tissues, by the admirable researches of Schleiden and Schwann, render it unnecessary for me to adduce any additional arguments to show that the foregoing conclusion is

* See Dr. Barry's remark; *Philosophical Transactions*, 1842, part i., par. 90.

applicable to the various cells of animal structures.* That all the secretions of the animal tissues are formed in the interior of vesicles or cells, is a result which has been already advanced, and ably illustrated and supported, by the researches of Mr. Goodsir ;† and it further appears that these secretions are elaborated, and their sensible qualities determined, by the molecules and granules in the interior of the cells.

16. Granulated vesicles or cells, having a diameter of $\frac{1}{1000}$in. are very conspicuous in the liver (plate 4, fig. 35) ; they compose a considerable portion of the bulk of this organ, and from ten to thirty molecules and granules may be counted in the interior of each cell.‡

When water is added to these granulated vesicles, they become larger and their outline less distinct. The dilute acetic acid renders an *inner* vesicle or central matter, containing molecules and granules, exceedingly conspicuous, and similar objects are also seen distributed in the outer portion of the vesicle; liquor potassæ also renders a central

* As these sheets were passing through the press I saw the October No. of the *Microscopic Journal,* containing "Researches on the Structure of Hairs," &c., by G. Busk, Esq., from which I extract the following—"Hairs are furnished in the interior with distinct, regular, colour cells, in which only is the colouring matter of the hair deposited. In the white hair of the rabbit the cells will be observed to be 'quite empty;' in a hair partly black and partly white, some of the cells are empty ; while others are more or less filled with black matter."

† *Transactions of the Royal Society of Edinburgh,* 1842.

‡ It appears to me that Dr. Barry has figured these vesicles with their contained objects, (*Philosophical Transactions,* part ii., 1841, plate 17, fig. 35.) He notices their full yellow colour, (par 84), which I have more than once seen in the vesicles of a diseased human liver.

portion, with numerous molecules and granules, very evident, but in a few minutes they fade away and disappear.

It is impossible to adduce any direct proof that the granulated vesicles of the liver are formed from colourless blood corpuscles, but the details of their structure render the supposition by no means improbable; and the following cases and observations, showing the gradual transition of these corpuscles into the most complex forms of epithelium, afford strong ground for believing that such may be the fact. In the following case, pus corpuscles, or half-formed epithelial cells, were seen furnished with active vibratile cilia, the normal appendage to the perfect cell.

Catarrh, (Hay Fever,) accompanied by great irritation and coryza, with a copious discharge of a clear limpid fluid from the nostrils. Having received a drop of this fluid on a slip of glass, a great number of corpuscles were found in it, exactly resembling in all particulars the colourless corpuscles of the blood; they burst open, and discharged molecules and granules on the application of liquor potassæ. These corpuscles were of different sizes, forming a regular series, passing gradually through several varieties of pus corpuscles or granulated vesicles, into the ciliated epithelium of the respiratory passages. A great majority of these corpuscles were provided with vibratile cilia, in a very active state; not only were the vibratile cilia, fringing the circumference, moving, but the whole interior of many of the corpuscles was in a state of agitation; molecules and granules were continually shifting their position, and in some of the corpuscles an undulatory kind of motion was very perceptible.

Plate 5, fig. 38, exhibits the form and appearances of the corpuscles, which were drawn while the objects were still under examination by the microscope.

(*a.*) Colourless corpuscles, resembling in every respect the colourless blood corpuscle.

(*b.*) Various granulated corpuscles, larger than the blood corpuscles.

(*c.*) A large corpuscle with a notch in the circumference, which frequently changed to the excentric granule shown in the figure below, and this again changed to the notch, and so on several times.

(*c.*[1]) The vibratile cilia, extremely active.

(*d.*) Various granulated corpuscles, with vibratile cilia, in active motion, and in

(*d.*[1]) The interior of the three corpuscles seen joined together, was actively moving, as well as their vibratile cilia.

(*e.*) Corpuscles, with active cilia gradually passing into epithelium.

(*f.*) Epithelium, with active cilia.

I had several opportunities of verifying these results; and on many occasions, by careful inspection by the microscope, I have seen corpuscles with vibratile cilia, among the granulated vesicles and epithelial cells, brought by an effort from the throat; and sometimes the cilia and the interior of these corpuscles have been observed moving.* The gradual transition from corpuscles, resembling in all particulars the colourless corpuscles of the blood, through various forms of granulated vesicles or pus corpuscles, into epithelial cells, may be witnessed in all the secretions of mucous membranes; and a microscopic examination of the particles, continually exfoliating from the skin, will convince any one that the scales of the epidermis differ in no respect from the epithelium of mucous membranes, except in the alterations produced by exposure to the air.

The cases, however, which afford the most instructive and interesting examples of the gradual transition of the colourless blood corpuscles, through the form of the pus corpuscle, into the normal epithelial cell of the tissue, are familiar in every surgery. Frequently, after considerable pain and inflammation in the skin, usually of the hand or of one of the fingers, and arising from various causes, the cuticle becomes raised into a large bulla, or bag, containing what has hitherto been considered unhealthy pus, *i. e.*, a quantity of watery or serous fluid full of white flakes; if these white flakes be examined by the microscope, they will be found to consist of half-formed epithelium,; every variety of granulated vesicle, from those agreeing in all particulars with the colourless corpuscles of the blood, discharging molecules and granules on the application of liquor potassæ, to others resembling different kinds of pus corpuscles, and from these

* *Philosophical Transactions*, 1841, part ii., p. 226, pars. 124, &c.

again to others so large as to measure $\frac{1}{800}$in. in diameter; and several varieties of epithelium may be readily detected.

The incipient epithelial cells, in many instances, were already joined side by side and elongated, forming a regular pavement; in addition to the numerous molecules and granules in their interior, a central matter may be detected in all stages of growth, forming an incipient nucleus or nutrimental organ for the strengthening and further development of the wall of the cell; on adding liquor potassæ to these objects, it caused all the smaller granulated cells or colourless blood and pus corpuscles to enlarge and explode in the manner already pointed out; but it appeared to have more difficulty in acting on the larger ones, in which the incipient nucleus is already formed; and in the perfect epithelial cells, where the nucleus was well developed, and where the wall or tunic of the cell may be supposed to be strengthened, it was a long time before any effect was produced.

These experiments and observations, together with the facts mentioned in a former part of this memoir, viz., the increased amount of the colourless blood corpuscles in vessels actively administering to nutrition, or engaged in any inflammatory process; their abundance in all the spots or patches of cutaneous diseases, and their accumulation in the vessels of the skin, in cases of scarlet fever, where they may be found in great numbers prior to the exfoliation of the cuticle (par. 2), almost necessarily lead to the conclusion, that *all the varieties of epithelial cells are formed of colourless blood corpuscles.*

This conclusion appears to be substantiated by the following considerations: first, *liquor potassæ* causes all the white or colourless corpuscles, which are known under the denomination of "exudation corpuscles," and all the varieties of pus corpuscles, to discharge precisely similar objects to those discharged by colourless blood corpuscles; there is no difference whatever, in this respect, between the colourless corpuscles or globules from the surface of inflammatory blood, and those from the transparent vesicles of *herpes labialis,* or from the serum of a blister. Secondly, the fibrine, when coagulating, forms fibres or filaments, which entangle in their meshes all the previously existing molecules, granules, and corpuscles, and by their extraordinary contractile power draw them together. The fibrine has never been observed to form a granule, globule, or corpuscle, of any kind, although it has many times been carefully watched during coagulation by the microscope; and the minute particles, resulting from the coagulation of the albumen of the serum, are entirely distinct from the molecules and granules, either of the chyle, of the blood, of tubercle, or pus. If additional proof be required to show that the colourless blood corpuscles form the various tissue or epithelial cells, it appears to me to be contained, thirdly, in the facts so elaborately adduced by Dr. Barry himself, in his memoirs on "The Corpuscles of the Blood;" and fourthly, in the important researches of Dr. Gruby, which have recently been presented to the English reader, in the pages of the *Microscopic Journal,* by Dr. Goodfellow.*

17. I am not aware that any attempt has been made to show that the molecules and granules in the interior of the tissue, or epithelial cells of the higher orders of animals, are reproductive objects or young cells; and the question to be determined would seem to be, whether the reproduction of blood cells takes place in the chyle or in the blood. What is the nature and destination of the molecules and granules of the chyle or of the blood? Dr. Barry speaks of the latter, and calls them "*young blood discs,*" which have been discharged from their "*parent cells,*" the colourless blood corpuscles.† If this interpretation be true, then it is evident, from the preceding researches, that the colourless blood corpuscles perform two distinct functions: the one as "parent cells," and the other as "tissue cells." It has been shown that the function of reproduction is very closely allied to that of nutrition, and that in many of the lower orders of vital structures the two functions are united in the same cell.‡ It is therefore extremely probable that a certain number of the colourless corpuscles, while circulating in the blood, discharge their contained granules into this fluid, which become young cells, while those corpuscles which are drawn

* "Microscopical Observations on the Pathological Morphology of some of the Animal Fluids," by David Gruby, M.D.; translated from the Latin by S. J. Goodfellow, Esq., M.D., &c.

† *Philosophical Transactions,* 1842, part i, "On Fibre," par. 109.

‡ "Principles of General and Comparative Physiology," by Dr. Carpenter, par. 585.

out of the circulation by the tissue, lose their reproductive power by ministering to the nutrition of the organism; assuming different forms, and performing different functions, in subjection to the primitive law of the development of the tissues.

The minute objects or organised molecules, visible in the interior of all epithelial cells, are very similar to those seen in the interior of reproductive cells; but this similitude, there is every reason to believe, may arise from the insufficiency of our means of observation, and ought not therefore to be considered as indicating a similarity of function. The illustrations which have already been adduced (par. 15), appear to show that the molecules and granules, in the interior of the tissue cells, are essential to the functions of the cell, giving sensible qualities to its contents; and there is every reason to believe that they are not "germs," or "young cells."

I had often remarked the very great similitude of size and appearance between several of the smaller forms of the polygastric animalcules and some of the varieties of pus corpuscles; so great is this similarity, that in many instances it would have been difficult to distinguish the one from the other, had it not been for the voluntary and very active movements of the animalcules. Now liquor potassæ produces upon these animalcules the same effect as it does upon the colourless blood and pus corpuscles: it penetrates the transparent integument of the animalcule by imbibition, and causes it to burst open and discharge its contents, which have the same appearance as the molecules and granules from the colourless blood and pus corpuscles. In the larger forms of the polygastric animalcules there are a great number of large vesicles or cells (*which have been called stomachs*), very visible in their interior; and these are all discharged from the bodies of the creatures in the same way when they are submitted to the action of liquor potassæ. These so-called stomachs may be seen enlarging in the interior of the animalcule prior to the rupture of the external integument; and when they are discharged from the body of the animalcule, numerous minute molecules may be seen within them.*

The pollen-grains of phænogamous plants, and the spores of the epiphyllous fungi, imbibe water, enlarging more or less in size, altering their figure, and becoming nearly transparent. Their contents appear very similar to those of the colourless blood corpuscles and of the polygastric animalcules; under the influence of liquor potassæ, they give a sudden jerk, increase in size, and in a short time burst open or explode, discharging an immense quantity of molecules and granules. The pollen-grain of the common lilac (*Syringa vulgaris*), (plate 4, fig. 36, *a*,) after having been moistened first with water and then with liquor potassæ, measured from $\frac{1}{860}$in. to $\frac{1}{900}$in.; and I have counted in some of them from 12 to 15 granules stretching across it, (fig. 36, *b*); hence the diameter of these granules are from $\frac{1}{10,000}$in. to $\frac{1}{15,000}$in.

The bursting of the pollen-grain under the in-

* The *paramœcium chrysalis* and the *vorticella convallaria* are well adapted for the verification of this very singular and highly instructive result: the former animalcule always revolves rapidly on its long axis before it bursts, and the latter assumes a globular form.

fluence of liquor potassæ, and the attendant phenomena, vary in different species of plants, and also in different grains from the same plant. Many of them discharge their contents through a large rent, and the molecules and granules are widely dispersed (plate 4, fig. 36, *c*); others eject them from a smaller orifice, and the molecules and granules sometimes come out in a long tube-like, or, as Raspail describes it, "gut-like" form. (Fig. 36, *d.*) Frequently after the application of the alkali, very light coloured transparent projections are visible, extending some distance from the dark outline of the grain, as if a thin membrane were distended* (fig. 36, *e*); and sometimes the grain bursts, so as to exhibit the appearance of two or three tunics.

These experiments certainly indicate a very remarkable similarity in the contents of the colourless blood corpuscles of man, the lymph globules of the batrachia, the pollen of phænogamous plants, the reproductive cells and spores of the cryptogamia, and *the stomachs* of the polygastric animalcules; they show that all these objects are cells containing particles so minute that the microscope fails to indicate in them any distinction of parts. These particles, which I have called molecules and granules, although varying in size, are therefore similar in appearance to one another, and to those seen in the interior of the various tissue cells; yet we are perfectly assured of their very different nature and functions. Among the many wonderful and beautiful objects displayed by the micros-

* I have frequently seen similar projections from the body of the *paramœcium*, under the influence of liquor potassæ.

cope, there are none exceeding in variety and interest the ova and the bundles of seminal animalcules of the common earth-worm (*Lumbricus terrestris*); and from their size they are admirably adapted to display the singular effects of liquor potassæ. Mingled with these objects are numerous cells, containing in their interior dark and well defined molecules, in the greatest state of activity; they are continually shifting their position within the cell, presenting exactly the same appearance as those which I observed in the colourless corpuscles or cells from the case of *catarrh*, previously related (par. 16.) (Plate 5, fig. 38, *d.*[1]) On the application of liquor potassæ, all these molecules were quickly ejected, and their restlessness and motions, after they were discharged from the cell, were very singular; but not more remarkable than the motions of the molecules discharged from the lymph globules of the frog, or from the colourless blood corpuscles and pus corpuscles of man. Now it matters little what terms may be employed to designate these minute objects, which the microscope exhibits under a similar aspect from such various sources, but it is very important to bear in mind that this similarity of aspect does not imply a similarity of function; and that although, in many instances, molecules and granules are reproductive objects, they may not be so in all cases.

18. The following is a recapitulation of the points which appear to have been established, partly by the observations of others, and partly by the foregoing experiments.

The blood contains red corpuscles, colourless corpuscles, and minute granules, all of which possess a certain degree of independent vitality, and represent different stages of the same object, viz., the blood-cell, which may be considered as undergoing a regular series of changes, until at length it becomes colourless and filled with granules.* These granules, as long as the cells containing them remain isolated from the tissue, (swimming in the plasma or liquor sanguinis,) possess the usual endowments of those granules seen in the interior of other simple cells, *i. e.*, they are reproductive objects or "germs;" but when the cell becomes fixed to, or *planted* in, the tissue of a compound structure, it alters its form, and the granules in its interior lose their reproductive or simple cellular function, which merges into a secretive or nutritive function for higher purposes, under the controul of the general law regulating the development of the tissues of

* At one period of their development, blood-cells have a peculiar and much stronger attraction for each other than for the tissue bounding the channels in which they circulate, and this attraction disposes them to cohere and keep together; at a subsequent period they lose this property, and the mature or colourless cells evince no tendency of the kind; on the contrary, they have a much stronger disposition to adhere to the tissue than to their fellow cells (par. 2 and 11), and they are thus disposed, as it were, to be drawn out of the current of the circulation. The disposition of the red corpuscles to congregate and cohere, and the indisposition of the colourless corpuscles to do so, may be frequently well seen by examining a minute drop of inflammatory blood before the formation of the colourless layer at the top is completed. After a certain interval, red and colourless corpuscles are mingled in equal proportions, and the behaviour of the two kinds is well shown. During this examination the molecules and granules will be seen congregating in various places, before the appearance of the fibres of fibrine.

the more complex organism, to the stability of which they are now become essential elements.

We thus recognise two very distinct epochs in the career of cells, during the former of which, they circulate independently in the blood; and during the latter, are fixed to and form part of the tissue, and there can be no doubt, that the series of changes and developments of *blood-cells* may be normal or abnormal, as well of those of the *tissue-cells.* With respect to the healthy or unhealthy characters of the former, we yet know nothing, and our knowledge of the peculiar characteristics of disease in the latter, is very small; the following general remarks appear to be all that can at present be affirmed respecting them.

If cells pass through *all* the stages of their growth with a certain degree of activity and in due subjection to the law of the structure, nutrition and healthy functions are the natural results; any local accumulation of them, these conditions being fulfilled, constitutes a "*vital turgescence,*" and an increased activity of function, with an increased desire for food, ensues; but if from any cause they do not experience their normal changes within a certain period, or with a certain degree of rapidity, nutrition is arrested, and impaired functions, with loss of appetite, are the attendant phenomena. If cells congregate in particular tissues, from their excess in the circulating fluid, or from any accidental circumstance, then this accumulation constitutes an "*inflammatory turgescence,*" and the function of an organ may be destroyed by an abnormal nutrition; the cells being in excess, and having their usual development and growth partially or wholly arrested, form pus corpuscles; or, exercising their own inherent vitality, uncontrolled by the assimilative law of the tissue, give origin to specific forms of disease.

Note.—The reader will find at the bottom of plate 4, fig. 37, the following objects drawn correctly from the microscope to a scale, so that their average magnitudes and appearances may in some degree be appreciated:—

(*a.*) Molecules and fibres of fibrine, $\frac{1}{100,000}$ in.
(*b.*) Granules, and a few fibres of fibrine, $\frac{1}{10,000}$ in. to $\frac{1}{20,000}$ in.
(*c.*) The red corpuscles of the blood, $\frac{1}{3800}$ in.
(*d.*) The colourless corpuscles of the blood, $\frac{1}{2600}$ in.
(*e.*) Pus or granulated corpuscles, $\frac{1}{1500}$ in.
(*f.*) Granulated cells or vesicles, from the liver, $\frac{1}{1000}$ in.

VI. ON THE AËRIFEROUS STRUCTURE OF THE LUNGS.

19. The nature and primary seat of tubercles cannot be comprehended unless the anatomy of the aëriferous structure of the lungs be understood. The opinions of anatomists have been much divided as to the manner in which the bronchial tubes terminate, whether in a series of communicating cells, or in a single "*cul de sac*;" the latter opinion, founded on the results of Reisseissen's investigations, prevails. Malpighi was the first to describe the air vesicles of the lungs and the air tubes ending in them. Helvetius attempted to prove that these

Malpighian vesicles were nothing more than common cellular tissue diffused without order through the lungs, and that the inspired air, proceeding thither through the minute air tubes, not only passes easily from cell to cell, but likewise from the lobules into their interstices, and finally diffuses itself through the whole lung. Haller adopted these opinions of Helvetius;* but Reisseissen, in his work, *De Fabrica Pulmonum*, controverts them, and proves that the cells of each lobular subdivision of the lungs have no communication with those of the adjoining ones in the manner of cellular tissue; and he concludes, from his experiments, that the air cells are *culs de sac* terminations of the air tubes, and perfectly independent of one another.† Cruveilhier, however, describes the air cells as freely communicating with each other in the interior of the lobules.‡ At an early period of my investigations I remarked that no bronchial tubes could be found ending in a *cul de sac*; on the contrary, communicating air cells were readily seen with a lens in every section of the lungs. Several of Reisseissen's experiments were therefore repeated, and others instituted; from which ample evidence was derived that the bronchial tubes, after subdividing into a multitude of minute ramifications which take their course in the cellular interstices of the lobules, terminate in their interior in symmetrically branched air passages and freely communicating cells.

* Haller (*Von Albert*); *Elementa Physiologiæ*, "*Cap. de Respiratione.*"

† Reisseissen; *Op. cit.*, p. 6, &c.

‡ *Cruveilhier's Anatomy*, vol. i., by A. Tweedie, M.D., F.R.S., p. 552.

In the fœtus the lungs lie at the back part of the chest, not occupying more than one-half or a third of its cavity, and neither air vesicles nor air cells can be detected in them. The ultimate bronchial sub-divisions are tubular; they have a regular branched arrangement, ramifying symmetrically in all directions, and terminating in closed extremities, which are generally situated at the boundary of the lobules. (Plate 5, fig. 39, *a*.) But when an animal has respired, the entrance of the air into the lungs distends the lobules to twice or three times their fœtal dimensions; they now occupy the whole interior of the chest, and the ultimate bronchial sub-divisions experience a great and important change: the delicate membrane composing them offers only a feeble resistance to the pressure of the air, and it is consequeutly pushed forward and distended laterally into rounded inflations (plate 5, fig. 39, *b*), forming a series of communicating cells, which, meeting on all sides those of the adjoining sub-divisions, are moulded by pressure against each other into various pentagonal and hexagonal forms. (Plate 5, fig. 39, *c*.) The cells thus formed are immediately occupied by minute air bubbles, in the multitude of which all trace of the symmetry of a branched arrangement is entirely lost. The symmetrically-branched air passages thus formed by respiration are no longer tubes. I have, therefore, distinguished them by the term "lobular passages;" and a section of these passages shows the *oval foramina*, leading from cell to cell, so conspicuous in a thin layer of inflated and dried lung.*

* *Phil. Trans.*, part ii., 1842; "On the Ultimate Distribution of the Air Passages, and the Formation of the Air-Cells of the Lungs."

The air cells of the lungs, then, are formed at birth by the pressure of the atmosphere acting upon the extremities and against the sides of the *intra-lobular* bronchial sub-divisions. They have not a general and indiscriminate intercommunication, for there are no anastomoses between the *intralobular* sub-divisions of the bronchi; therefore the cells forming one lobular passage have no communication with those of the adjoining ones, except by their common opening into a larger ramification. (Plate 5, fig. 39, *b* and *c*.)

Anatomical writers use the terms air vesicles and air cells without discrimination, so that they are convertible terms; but it is evident that an air vesicle is an air bubble, and has nothing to do with the structure of a pulmonary air cell. It is not necessary to the existence of an air bubble that it should be contained in a membraneous cell; thousands of them may not only exist, but in any slightly viscous liquid may even press against each other and lose their globular figure without destruction to their individual isolation. The air vesicles of the lungs are just such bubbles; they are of all dimensions; some large, some small, and others so minute as not to measure more than $\frac{1}{800}$ or $\frac{1}{1200}$in. in diameter; and as the pulmonary cells are fequently much larger, three or four air vesicles or air bubbles may be located in a single cell. (Plate 5, fig. 39, *c*.) The adhesion between these air-bubbles and the tissue of the lung is so strong, that it is impossible to expel them by pressure; and to any one who has witnessed the extreme difficulty of removing them even from the thinnest section, it must appear very improbable that they can pass to and fro in the *lobular passages* by any respiratory effort.

The membrane of the *air cells* is exceedingly tough, thin, and elastic; it is a continuation of the membrane lining the interior of the bronchial tubes, and numerous granulated vesicles or cells are distributed upon it, which appear to constitute the normal form of epithelium.

20. The dimensions of the air cells, as might have been expected from their structure and mode of formation, vary greatly in the same lung; they are generally larger in men than in women at the same periods of life, and they increase in magnitude with age. The size of the air cells and lobular passages appears to be very much under the control of the individual; exercise of the lungs, or habitual expansions of the chest, by slow and full inspirations, in the early periods of life, certainly have a considerable influence on their volume; the area of the membrane of the cells is increased, and the blood thereby more freely exposed to the influence of the air, giving greater freedom to the circulation. Even the deep inspirations which attend an habitual cough have appeared to me, from an examination of cases of chronic bronchitis, to have considerable influence in increasing the dimensions of the air cells; for I have found them increased in diameter, the minute structure of the lungs being at the same time perfectly healthy. The following cases will be sufficient to show the variable size of the air cells, and to indicate the circumstances which tend to promote an increase of their dimensions :—

Case 1.—A woman, aged 82, long affected with chronic cough, died after two days' illness. The minute or vesicular structure of the lungs was quite healthy, the membrane of the cells being transparent, tough, and elastic; but the lobular passages and the air cells were remarkably large, without having lost in any degree their normal form and characteristics.

Case 2.—A young woman, of sedentary habits, teacher in a school, and not accustomed to much exercise, aged 23, became low spirited, and destroyed herself by dividing both carotids. The minute structure of the lungs was perfectly healthy; the membrane of the cells was transparent, tough, and elastic; but the lobular passages and the air cells were not more than one-third the size of the former case.

Case 3.—Intermediate between these two examples, a healthy man died a few hours after an accident. The minute structure of the lung was quite healthy; the membrane of the air cells was transparent, tough, and elastic; the lobular passages and cells were less than in the first case, but larger than in the second. Taking the air cells in this individual as indicating their average dimensions, I found them varying from $\frac{1}{200}$ to $\frac{1}{500}$ of an inch in diameter, and the *oval foramina* from $\frac{1}{60}$ to $\frac{1}{80}$ of an inch; some of these *foramina* were not more than $\frac{1}{100}$in. or $\frac{1}{150}$in., and there were others still less.

In these examples very thin sections of the recent lung were macerated in water for two or three days, changing the fluid frequently, by which means the whole of the air bubbles and the blood were removed or dissolved, rendering the minute structure exceedingly distinct; and by very gently extending it on a dark surface, the variable dimensions of the cells were readily distinguished by a lens.*

21. The blood vessels lie exterior to, or between the lobular passages; and as the membrane forming one of these passages is pressed by the inspired air into close contact with that of the adjoining ones, it follows, that the capillary blood channels ramify or run between two membraneous layers, and any increase of the diameter of these channels must separate these layers, so that two contiguous channels soon run into each other. The double character of the membrane of the air cells and the separation of the two layers by the enlarged blood channels, may be demonstrated in the lung of a toad, by an examination of the capillary network by the microscope, previous to and after inflammation: in the former case, only one, or at most two, rows of blood corpuscles are seen passing at the

* M. Bourgery has lately investigated the structure of the lungs, and the results have been communicated to the *Academie des Sciences.* He describes the *oval foramina* and the lobular passages, terming the latter *canaux labyrinthiques aërifères.* The views of Bourgery resemble those of Helvetius and Haller in this: he considers that the air cells have a general intercommunication throughout a lobule; but he differs from them and from all previous observers in his account of the *canaux labyrinthiques,* which he describes as anastomosing in every direction with each other, and as turning back at the boundary of a lobule to re-enter its interior, and terminate in some of the deeper canals. An examination of the ultimate bronchial sub-divisions in a fœtal lung injected with mercury, in the way pointed out in my Memoir, (*Philosophical Transactions, l. c*) will be sufficient to show the probable inaccuracy of Bourgery's theory.—*Journal Universel des Sciences,* No. 447, *Juillet* 21, 1842.

same time along the channels, and the intervening islets of tissue are comparatively large (plate 5, fig. 40); but in the latter case, five or six corpuscles may be seen side by side, or lying partially over one another, passing through the same channels which are now much enlarged, while the islets of tissue in some places are very nearly, and in others entirely obliterated. (Plate 5, fig. 41.) It is evident in this examination, that the increase in the size or area of the channels has taken place from a separation of the two layers composing the membrane of the cells.

It appears from my observations, and from preparations in my possession, that the blood-corpuscles, arrested in their progress through the capillary channels of the lungs, by an abnormal or inflammatory turgescence, undergo various changes, notwithstanding their circulation is stopped; and that red corpuscles may become pus corpuscles while stationary in inflamed vessels. The distinctness with which the inner vesicles of the red corpuscles of a frog may be seen when dry, or when subjected to the action of very dilute acetic acid, has been particularly mentioned (par. 10); in the irritated and inflamed vessels from which fig. 41 was taken, the outer vesicles of the red corpuscles had almost disappeared, but the inner vesicles were particularly large and distinct; so that it was quite impossible to distinguish the greater number of them from the "lymph globules." This result is in some degree elucidated by the remark of Dr. Barry, who states that red corpuscles, in parts, undergoing a rapid growth and development, (as in the tail of the larva of the newt, where they are exposed to the influence of the air,) may be traced into epithelium.*

VII. ON TUBERCLES.

(22.) Tubercles of the lungs are generally described as devoid of organization; but this description of them must be understood in a qualified sense; for, in the first place, a tubercle involves or includes in its substance the vesicular structure of the lungs: minute blood vessels, lobular passages, and air cells, are all capable of demonstration on the dissection of a tubercle under a Coddington lens; the blood vessels are no longer permeable, but their presence may be demonstrated. Secondly, I shall endeavour to show that tubercles are composed of *abnormal epithelial cells.*

If a tubercle, or even the tissue of the lung near it, be slightly compressed between two slips of glass with a drop of water, it will crumble down and break to pieces, the fluid at the same time being rendered quite white or milky. This white appearance is attributable to a great number of minute objects, the assemblage of which constitutes the substance of the tubercle. They consist, for the most part, of molecules, granules, and granulated corpuscles, of various sizes, of aggregated granules without any tunic, and of collapsed tunics without any granules. These objects are mingled with a great many shapeless flakes and filaments, which are no doubt fragments of the membrane of the

* *Philosophical Transactions, l. c.,* par. 113.

air cells, and of the minute blood vessels which, when involved in a tubercle, become so extremely brittle that they must necessarily form a considerable proportion of the objects occupying the field of the microscope. The granulated corpuscles of a tubercle are sometimes very large ($\frac{1}{800}$in. or $\frac{1}{1000}$in.); and the molecules and granules, which are very conspicuous, may frequently be seen on the point of escaping from them.

The increased amount of the colourless blood corpuscles in all vessels engaged in active nutrition or inflammation, the growth of molecules and granules in their interior, the rupture or dissolution of the tunics of the corpuscles, and the discharge of their contents, have been frequently adverted to in the preceding parts of this memoir. These facts, when considered in connexion with the origin of pus corpuscles and epithelial cells, can leave no doubt that the objects composing tubercles of the lungs originate from blood corpuscles, and not from any peculiar formation foreign to the normal structure of the tissue.

The semi-transparent forms of tubercle and tubercular infiltrations owe their peculiarity to a great relative amount of granulated vesicles, whereas the opaque white forms of tubercle are attributable to great numbers of isolated granules.

Tubercles of the lungs are exceedingly common. They are at first visible as minute white rounded bodies, dispersed at more or less distant intervals in the vesicular tissue of these organs; and very frequently they entirely elude observation, not being discernible unless specially searched for with a lens in thin macerated sections of the lung, slightly extended on a dark surface, in the manner already described.

The following cases are illustrations in point, and I might have added others of a similar kind:—

Case 1.—A girl, six years old, making no complaint whatever of the chest, was taken with vomiting and fever, succeeded by pain in the head, drowsiness, dilated pupils, and insensibility; in which state she died. On examining the lungs, they appeared to be quite healthy, their tissue was crepitant in all parts, and of the normal light pink hue; no tubercles could be detected by the touch, and all the sections that were made swam in water. After two days' maceration, the sections were slightly extended, and examined by a lens, when a great many minute tubercles were discovered. The tissue of the lung immediately surrounding the tubercles appeared to be healthy, even when examined by a Coddington lens; but when it was submitted to the higher power of the compound microscope, the membrane of the cells was found much less transparent than in its normal condition; it was thickly encrusted or frosted over with molecules, granules, and corpuscles, and the area of the cells appeared to be encroached upon by these objects.

Case 2.—A boy, aged 15, died of fever, ulceration of the ileum, and erysipelas, in the Fever Hospital; no mention of any pectoral symptoms. The lungs were in some places of a dark bluish black, in others of a bright scarlet. Several thin sections were made, in which tubercles could neither be seen nor be detected by the touch ; the sections swam in water and were very crepitant. After two days' maceration all the air bubbles and blood contained in them were removed, and then minute tubercles were found distributed in the tissue; several of the tubercles were surrounded by small patches of grey infiltration, characteristic of commencing hepatization from a slight degree of pneumonia.

Case 3.—A gentleman, aged 60, had enjoyed good health till within six years of his death, when he complained of headache, his mind became deranged, and he died from disease in the brain. He had a slight cough for a few weeks towards the termination of his illness, but it had never excited the attention of himself or his medical attendant. On inspection after death, both lungs were found thickly studded with tubercles, some of which were as large as a hazel nut ; and in several places small vomicæ were formed.

These cases show that the formation and growth of tubercles may take place in a very gradual manner, unobserved either by the patient or his friends.

Case 4. (Tubercular Phthisis.)—A young woman, whose age could not be ascertained, died in one of the metropolitan hospitals, and the lungs were sent to me, unaccompanied with any of the particulars of the case.

These lungs afforded some very beautiful preparations of uncomplicated tubercular disease. There were no marks of adhesion on the pleura ; the structure was not dark red, nor even of a blood colour, but of a pale pinkish white, and full of tubercles of various sizes, which occupied at least two-thirds of the area of every section that was made. These sections, after having been macerated in water for two or three days, became perfectly white; the minute structure was very distinct between the tubercles, and in the middle of each tubercle there were two or three openings or dark depressions, showing the situation of the *oval foramina* and the *lobular passages.* On submitting the white matter of one of the tubercles to high microscopic power, the following forms were recognised:—Round and irregular-shaped corpuscles; much larger corpuscles filled with granules, from fifteen to twenty of which were counted in some of them; corpuscles, in which the central portion had assumed various irregular shapes; corpuscular tunics, from which the granules had either entirely escaped or were lying partially without the ruptured tunics; and a great multitude of molecules and granules, some of which adhered together in little rounded masses without any tunic.* These objects were mingled with irregular-shaped shreds and filaments, and with ciliated epithelial cells in all stages of growth, which, under the influence of liquor potassæ, were found to swell and elongate themselves suddenly with a jerk, and frequently to exhibit many singular movements, after which they gradually dissolved away and disappeared.†

* See Gerber's *General Anatomy* and Mr· Gulliver's *Appendix.*

† On applying the alkali to these objects, they should first be largely diluted and well mixed with water, otherwise the mucus with which they are mingled interferes with its operation.

Case 5. (*Phthisis.*)—A fine young man, aged 20, reported that he had cough and pain in the side two months ago, for which he was bled, blistered, &c., and relieved. Afterwards, from sleeping in a damp room, he renewed his cold; he had a little hecking cough which plagued him at times, and pain in the left side when he coughed; in all other respects he felt well. He had a hearty robust look, a fine muscular frame, and evidently had not lost flesh; he said that he slept well, and that his appetite was very good; he walked three miles to the Dispensary. On examining the chest, the respiratory murmur was found very indistinct on the left side, and there was a marked difference between that and the right; on taking a full inspiration, there was an obscure deep-seated bubbling mucous *râle*, and on coughing the very characteristic *plash;** yet on closely questioning him, he said that he had no expectoration, *only a crumb or two now and then.* He died in four months, with all the attendant symptoms of a deep and rapid decline.

Now there can be no doubt that in this case tubercles, in considerable numbers, existed in the lungs for a long period anterior to the first attack; and the cold damp room, the supposed cause of the second, was merely an accidental concomitant with the inflammatory irritation which the tubercles were beginning to excite, and the rapid softening they were undergoing in consequence.

23. If the matter deposited in the air cells in cases of pneumonia, and termed "hepatization," be

* Latham's *Clinical Lectures.*

examined by the microscope, objects in all respects similar to those which compose a tubercle are seen, mingled with pus corpuscles.

Case 6. (*Pneumonia.*)—A man, aged 32, died in the Worcester Infirmary. The lungs were very much congested and of a bluish black colour; sections were made, all of which sank in water. After having been macerated for a day or two, the tissue was found filled with a dark yellowish infiltration. The infiltrated matter appeared, through a lens, in minute, distinct, rounded masses, projecting into the air cells. The pulmonary tissue was extremely brittle; it broke to pieces by the slightest attempt to extend it, and when seen by the compound microscope had exactly the appearance of the tissue in the immediate vicinity of a tubercle, *i. e.*, it was encrusted with numerous granulated corpuscles and a great multitude of molecules. The only difference discernible between the little rounded masses of corpuscles and granules in the air cells in this case, and the small tubercles of *Case* 4, was in the yellowish brown colour, and the extensively diffused character of the one and the white appearance and isolated disposition of the other.

Case 7. (*Pneumonia.*)—A sailor, aged 26, died in the Fever Hospital. The lungs were altogether red and solid, having all the appearance of liver. On making thin sections for maceration, white purulent matter oozed out from the air cells and minute bronchial tubes in innumerable places. This matter was found by the microscope to consist of altered red corpuscles, pus corpuscles, and ciliated epithelial cells, mingled with molecules and granules; and large granulated corpuscles, some of which contained three or four granules, others twelve or fifteen; in some of these corpuscles the granules were crowded together at one side of the corpuscle, in others they had partially escaped.

On examining the macerated sections with a lens, minute granulations were visible, filling up the air cells; these granulations or granular masses were found by the microscope to be composed of the usual objects, various shaped pus and granulated corpuscles, molecules and granules.*

So far then as the microscope enables us to determine, it would appear that similar objects constitute both the matter of hepatization and tubercle. In pneumonia the deposit is diffused over a wide space, it is general and extensive, and takes place with rapidity; whereas in phthisis it occurs in patches, at more or less distant intervals, accumulating very slowly.

From the peculiar and highly exalted nature of the morbid action between the blood and the tissue in pneumonia, the red corpuscles, contrary to their normal disposition, form vital combinations with the structure; this abnormal attraction of the tissue for the red corpuscles is one of the characteristics of inflammation, and has given rise to the

* I take this opportunity of cordially acknowledging the great obligations I am under to S. J. Goodfellow, Esq., M.D., the talented resident physician at the Fever Hospital, for the promptitude with which, on all occasions, he has assisted me in my researches with valuable specimens of diseased lung. My acknowledgments are also due to the medical officers and pupils of the Worcester Infirmary, for similar valuable assistance.

remark of Chomel, that an inflammatory reddening of the tissue may be distinguished from mere congestion, by maceration ; in the former cases, the red colour is only partially removed from thin sections by water, in the latter it is so entirely ; and this agrees with my observations.

24. That tubercles in the lungs arise from an error in nutrition is therefore quite true; but this explanation has hitherto afforded no idea of the nature of the objects composing them, nor does it give any physiological or pathological explanation why they are found in detached or isolated spots. An "error of nutrition" appears to me to be no more applicable to tubercle and hepatization, than to cancer or to warts on the skin.

The circumstances which determine the formation of tubercles, must be studied in conjunction with the origin and progress of cutaneous diseases to many of the chronic forms of which tubercles of the lungs have the most marked analogy; an analogy arising not only from the anatomical structure of the tissue, but from a perfect identity in the character of the pathological results of the two classes of disease. (Par. 16.)

For example, if croton oil be rubbed upon the skin, and the thick matter filling the white heads or points to which it gives rise be examined by the microscope, objects in all respects similar to those which compose a tubercle will be seen, viz., various kinds of pus corpuscles, large granulated corpuscles, ruptured corpuscular tunics, with granules adhering to them, and an abundance of isolated molecules and granules.

There appears from my researches to be no distinction whatever between spots of lepra on the skin and tubercles in the lungs, if we except those arising from the different situation and function of the two tissues. The essential character of both diseases consists in an accumulation of abnormal or unhealthy epithelial cells, derived from vessels in a state of abnormal turgescence; and if the isolated spots of squamous diseases are termed "eruptions," the isolated spots of tubercle are equally entitled to rank under the same designation.

Tubercles of the lungs are more formidable in their symptoms, and more fatal in their tendencies, than eruptions on the skin; not from any peculiarity in their nature, but from the physiological uses of the part they occupy. The tissue of the lungs is so delicate and vascular, that it cannot be in any degree injured, or its functions impaired, without injury to the system at large: on the other hand, the structure of the skin is less complicated and delicate, and its function less intimately essential to the continuance of life. Abnormal epithelial cells, originating a tubercle of the lungs, cannot be readily discharged; whereas the abnormal epidermis cells of the skin dry and fall off, or may be easily removed: hence tubercles in the lungs constitute a most formidable, and very frequently fatal, disease; while chronic cutaneous eruptions are troublesome, but comparatively harmless.

We are not yet able to assign any reason why cutaneous eruptions should appear in spots, any more than we can explain the cause of the peculiar isolation of tubercles; nor are we likely to answer satisfactorily the latter topic of the inquiry, until a sufficient cause has been assigned for the former. The anatomical structure of the lungs will better explain the isolated character of tubercles than will that of the skin the isolated forms of lepra and psoriasis.

In all cases of obstinate squamous eruptions in which I have seen blood taken from the arm, it has exhibited a thick buffy coat; and all the decided characters of what is called an inflammatory state of the blood have been furnished by these cases. I need hardly remark, that in tubercular disease of the lungs the blood presents a similar appearance.

The various forms and complications of tubercular disease of the lungs are neither greater nor more numerous than those of lepra and psoriasis. An increased turgescence, or inflammation of the vessels of the skin, arising from various causes, will frequently quite alter the appearance of a chronic cutaneous disease, changing scurfy spots into purulent sores, and giving rise to irritation and distress. The varied symptoms of tubercular disease during life, and the different appearances presented by the affected organs after death, arising from acute inflammatory complications, are too well known to require particular mention.

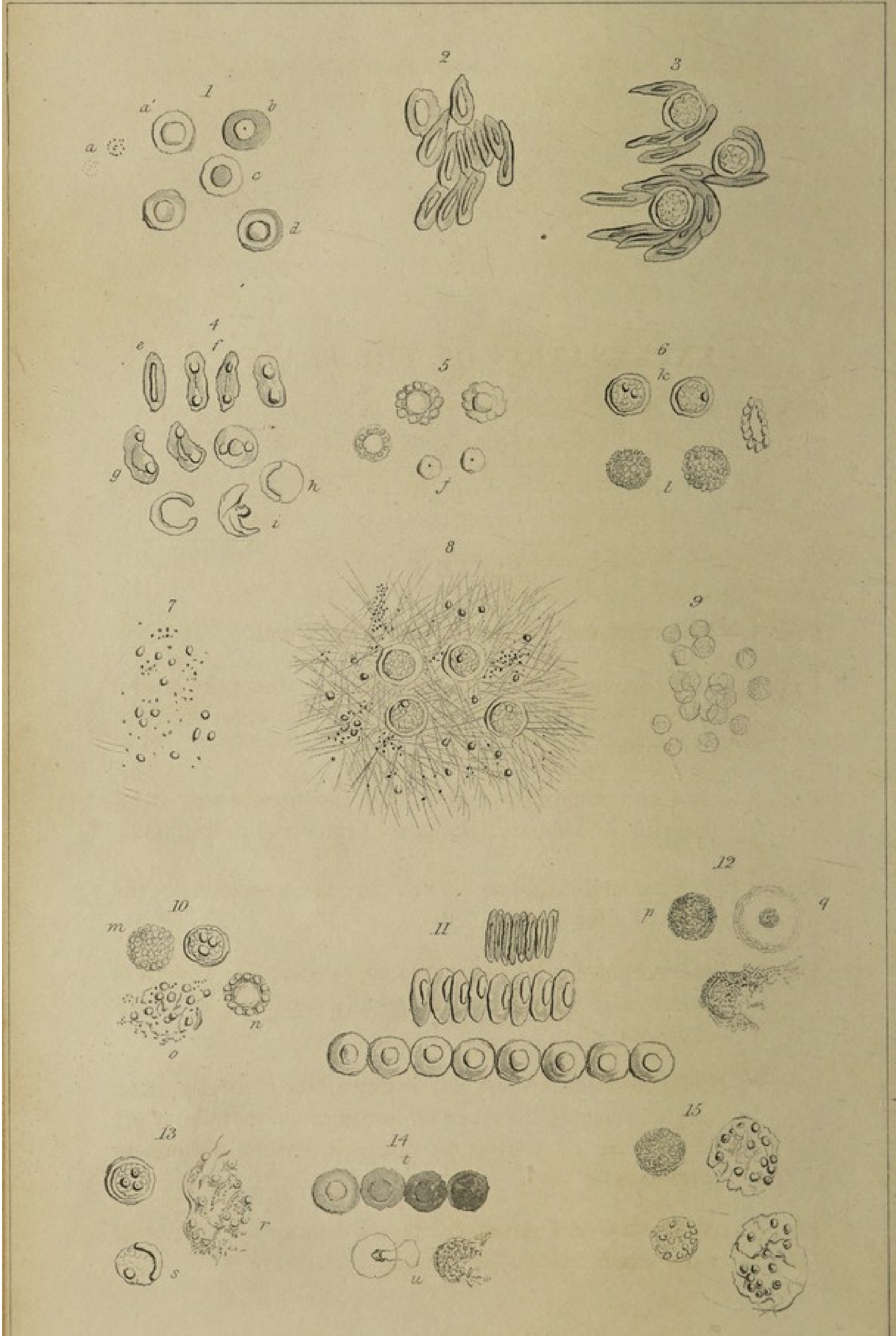
Tubercles of the lungs are composed of objects originating from blood corpuscles, which have been arrested in their circulation through the minute vessels of the structure of the air cells. So long as this retardation is confined to the colourless corpuscles, the morbid actions which ensue are strictly those of an abnormal nutrition, and various forms of imperfect and degenerated epithelium are the results; but if it extend so as to interfere with the free circulation of the red corpuscles, we then have all the phenomena of inflammation. No new elementary particles are formed to constitute a tubercle; and although from the insidious nature of the primary actions, from the delicacy of the structure, and the important character of the function of the lungs, the treatment of tubercular diseases must always be attended with more than common difficulties; still there is every reason to believe, that they are susceptible of prevention and cure, especially if our efforts for the attainment of these ends be enforced previous to the appearance of a cough, which is not a concomitant of the first stages of tubercular depositions in the lungs.

It is not my intention on the present occasion to enter into the details of the treatment of pulmonary consumption. The primary object in all cases is to regulate the amount of the colourless corpuscles in the blood, and to promote the freedom of their circulation through the minute capillary reticulations in the membrane of the air-cells. By accomplishing this, we necessarily controul the nutritive functions of the tissue, and retard or prevent the accumulation of an abnormal epithelium, of which the substance of a tubercle is composed.

In concluding this enquiry, I must observe, that whatever may be the opinions of physiologists respecting the origin of epithelium and pus, there can be no doubt that the colourless corpuscles of the blood are the elements which administer to nutrition, and from which the results of inflammation are derived. These corpuscles enter very largely into the composition of all membranes, and they are particularly conspicuous in those which are experiencing a rapid increase of development by active nutrition, as may be shown in the pleura or peritoneum, and in the various layers of the chorion, or of the amnion of a very young fœtus. However thin and perfectly transparent the layers may be, they will, on examination, be found composed of fibres of fibrine and colourless corpuscles, with well-defined molecules and granules in their interior. If similar forms of membraneous tissue, (termed by Mr. Bowman "basement membrane,") be everywhere interposed as a septum between the colourless blood corpuscles on the one hand, and the nascent epithelial cells on the other, they must partake in the rapid and constant changes which are essential to the function of secretion.

There appears to me to be no more difficulty in understanding how the corpuscles, in the progress of these active changes, may coalesce and form the epithelial or secretory surface of such a membrane, and be subsequently evolved from it, as pus globules or epithelial cells, than there is in understanding how they are primarily drawn out of the circulating current and incorporated in such structures for the purpose of nutrition. Still, whether pus globules and epithelial cells arise from a conversion or transformation of the entire corpuscles into these objects, or whether the tunics of the corpuscles are incorporated with any of these forms of tissue, from which the granules or "germs" in their interior subsequently grow to form them, may be considered as still *sub judice*.

My own opinions upon this point have already been expressed, and I have now only to remark, that the question has reference not to the objects themselves, but to the mode in which they administer to the ulterior functions of secretion and nutrition; and its determination, therefore, either way, does not in the least degree invalidate the fact, that the first step of an increased nutrition, or of inflammation, is an accumulation of the colourless blood corpuscles in the minute vessels of the part; nor does it weaken the argument as to the origin of pus globules or epithelial cells; and what is still more important as regards the present inquiry, it cannot affect the results which relate to the origin and nature of tubercles of the lungs.



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EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1.—Molecules and red corpuscles of the blood.

Fig. 2.—Red corpuscles pressing against each other; the central portion loses its figure equally with the outer tunic of the corpuscle.

Fig. 3.—Red and colourless corpuscles: the former very compressible and elastic; the latter firmer and granulated.

Fig. 4.—Various altered forms of red corpuscles, seen after the lapse of a few hours.

Fig 5.—Red corpuscles with granulated border; (*j*) alteration in size and appearance frequently produced in a few moments.

Fig. 6.—Colourless corpuscles; (*k*) outline of the central portion very distinct, molecules and granules in their interior; (*l*) outline of central portion not visible, corpuscles granulated.

Fig. 7.—Molecules and granules in the liquor sanguinis of buffy blood.

Fig. 8.—Liquor sanguinis from the surface of buffy blood, as it appears coagulating under the microscope; showing colourless corpuscles, molecules, granules, and filaments of fibrine.

Fig. 9.—Red corpuscles after the addition of a small quantity of water; showing the central portion of the corpuscles rendered faint and enlarged; the outer portion has been dissolved.

Fig. 10.—Colourless corpuscles after the addition of water; (*m*) granulated at the surface; (*n*) large granules at the circumference; (*o*) corpuscle burst, and granules dispersed.

Fig. 11.—Alterations in the appearance of red corpuscles by imbibition.

Fig. 12.—Red corpuscles after the addition of acetic acid; (*p*) darker and of a minutely molecular aspect; (*q*) *central portion,* dark and distinct; *outer portion,* enlarged and very pale.

Fig. 13.—Colourless corpuscles after the addition of acetic acid, granulated; (*r*) corpuscle ruptured, granules dispersed; (*s*) central portion drawn to the circumference, but not divided into granules.

Fig. 14.—Red corpuscles after the addition of liquor potassæ; (*t*) corpuscles rendered darker; (*u*) central portion protruded.

Fig. 15.—Colourless corpuscles altered in appearance, and much enlarged by liquor potassæ. The corpuscles enlarge suddenly by a kind of explosion, which takes place in their interior without rupturing their outer tunic; this gives way afterwards, and the molecules and granules are dispersed.

PLATE II.

Fig. 16.—Pus or exudation corpuscles; (*v*) irregular and shrivelled; the rest enlarged and ruptured by liquor potassæ.

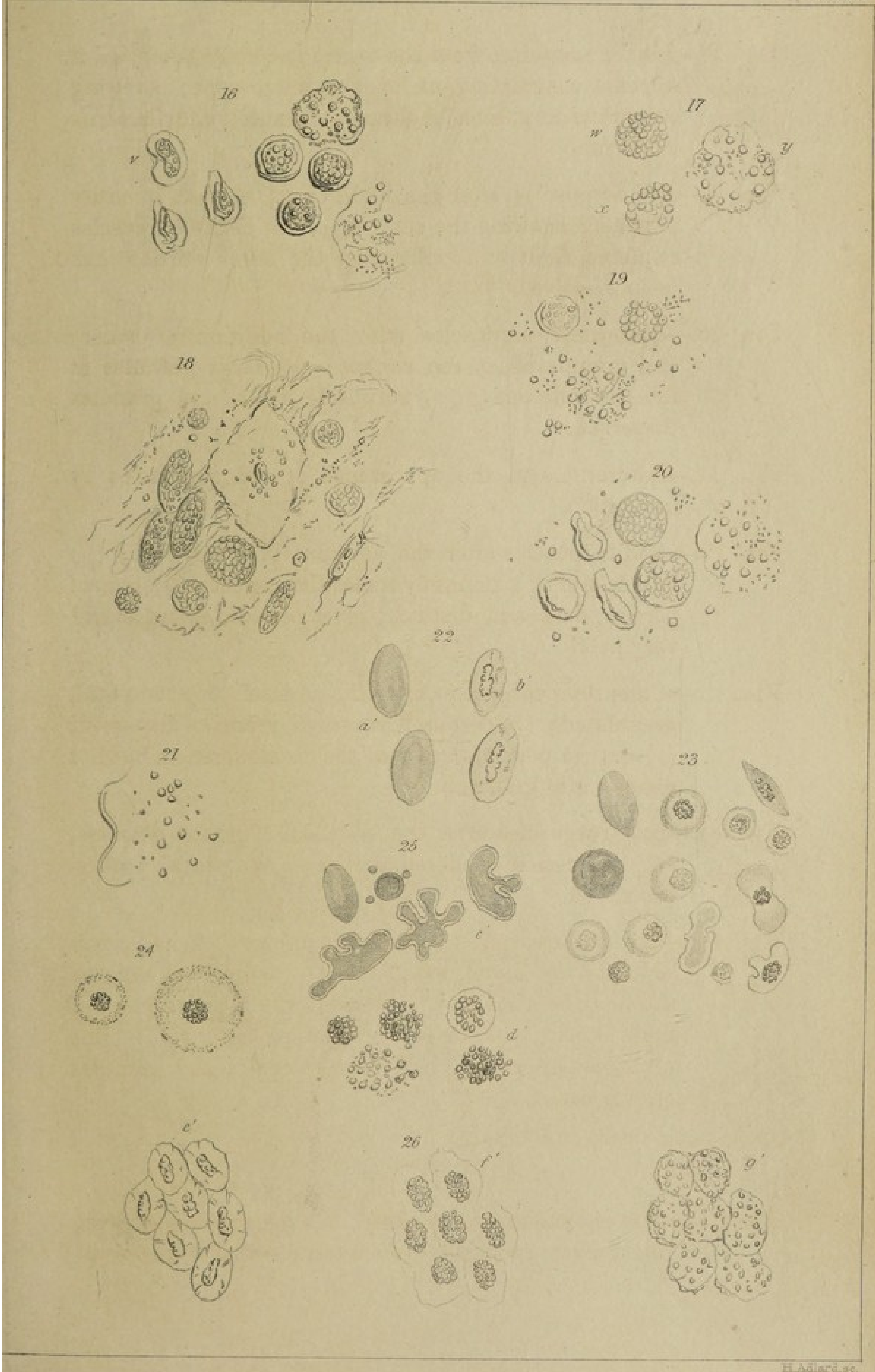

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FIG. 17.—Pus corpuscles; (*w*) granulated; (*x*) granules escaping; (*y*) corpuscle enlarged and ruptured by liquor potassæ; granules dispersed.

FIG. 18.—Molecules and granules; granulated corpuscles and epithelial cells in mucous from the throat.

FIG. 19.—Molecules and granules; pus corpuscles filled with similar objects, from a chronic abscess.

FIG. 20.—Shrivelled corpuscles, from a tear collected at the corner of the eye: the figure shows the effect of water and liquor potassæ.

FIG. 21.—Shows the bursting of one of the preceding corpuscles, with the escape of the molecules and granules.

FIG. 22.—Blood corpuscles of a frog; (a^1) recent; (b^1) dried, showing the inner vesicle or central portion.

FIG. 23.—Blood corpuscles of a frog after the addition of a drop of water; the corpuscles are rendered globular, and the inner vesicle, or the central portion of the corpuscles, likewise appears circular, and resembles the lymph globule.

FIG. 24—Shows the appearance of some of the corpuscles mentioned above, after the addition of a little dilute acetic acid; the inner vesicle exactly resembling the lymph globule.

FIG. 25.—Various appearances presented by the red corpuscles of a frog after the addition of a little liquor potassæ; (d^1) the lymph globule, showing the effect of liquor potassæ.

FIG. 26.—(e^1) Red corpuscles of the frog, dried, showing the inner vesicle; (f^1) the appearance of the inner vesicles after the addition of a drop of water; they are composed of a number of minute granules; (g^1) the appearance presented by these inner vesicles on the subsequent addition of a very minute quantity of liquor potassæ.

PLATE III.

FIG. 27.—Inflamed vessels in the web of a frog's foot; showing the accumulation of the lymph globules, and the peculiarity of their situation; apparently lying among the fibres forming the wall of the vessels, and exterior to their boundary.

FIG. 28.—Cells of the parenchyma of the petal of the *Garden Pansy*. Some of these cells contained a yellow pigment, others a blue or purple; the granules of the cells are attached to the angles of the cell wall. The nucleus is shown in the centre of each cell; diameter of the cells, $\frac{1}{1080}$in.

FIG. 29.—Cells of the parenchyma of the petal of *Borago*. Granules variously distributed in the interior of the cells; diameter of the cells, $\frac{1}{300}$in.

FIG. 30.—Cells of the parenchyma of a petal of *Campanula trachelium*. Granules variously distributed in the interior of the cells. The nucleus, containing a central matter and numerous molecules, is very conspicuous; diameter of the cells, $\frac{1}{450}$in.

PLATE IV.

FIG. 31.—Cells or vesicles from the leaf of *Sedum acre*, containing a multitude of well-formed and highly-organized granules; the wall of the cells is very thin and transparent; there is no especial nutrimental organ or nucleus visible; diameter of the cells from $\frac{1}{150}$in. to $\frac{1}{500}$in.

FIG. 32.—Granulated cells of *Conferva;* diameter of the larger granules, $\frac{1}{3240}$in.; of the smaller ones, $\frac{1}{10,000}$in.

FIG. 33.—Granulated cells of another *Conferva;* diameter of the granules, $\frac{1}{6480}$in.

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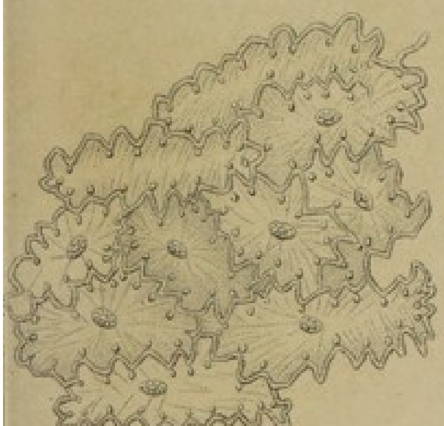

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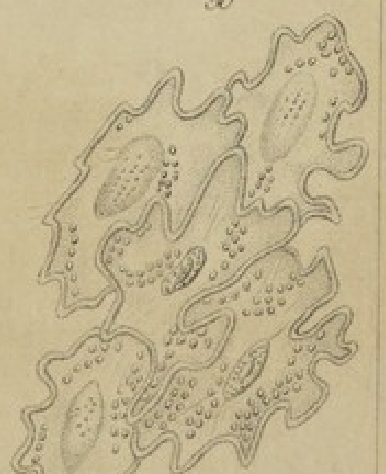

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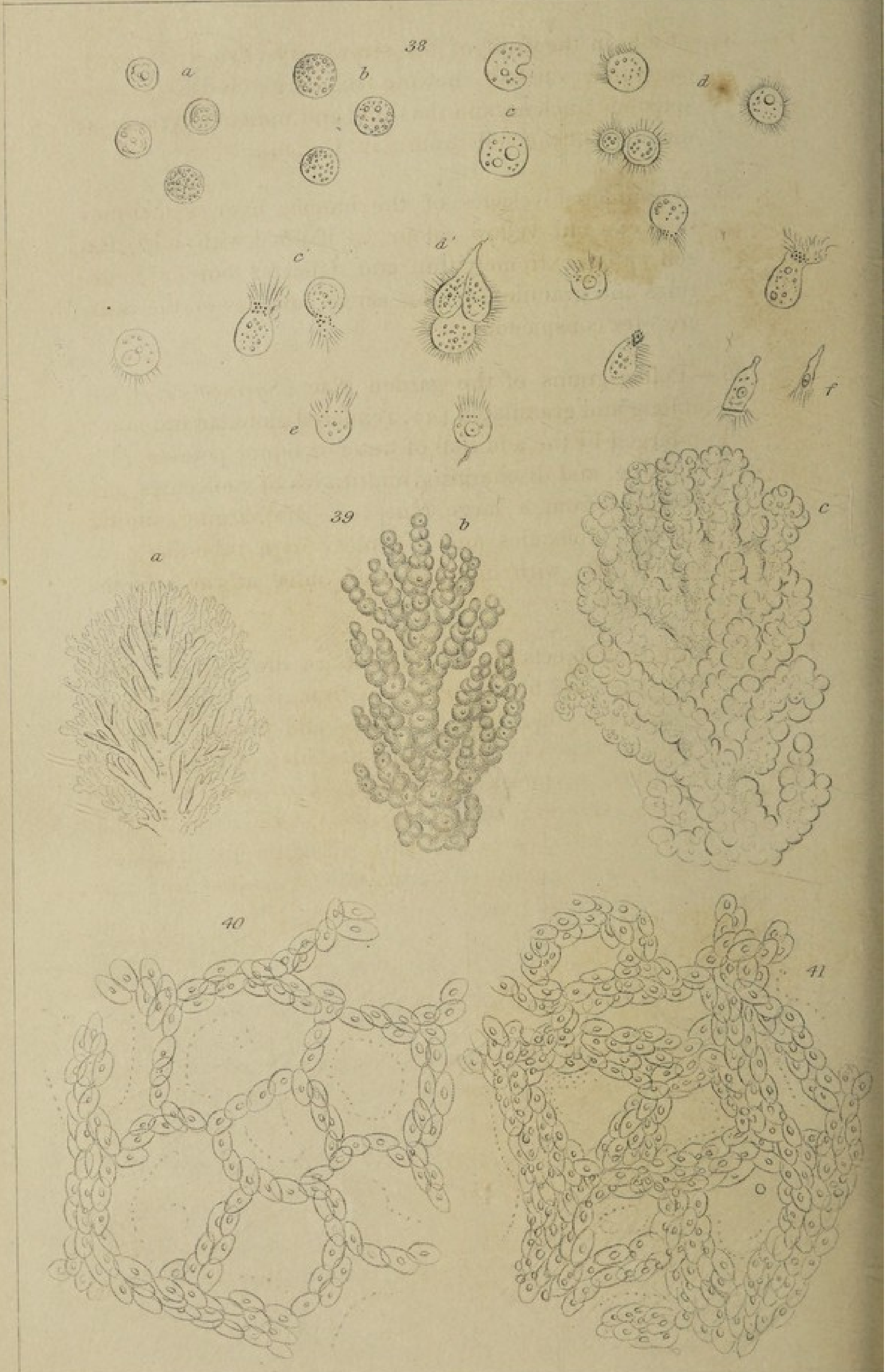

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Fig. 34.—Cells in the fruit of the strawberry (*Fragaria vesca*), cultivated variety, showing the large and very conspicuous nucleus, and the small and indistinct granules; diameter of the cells from $\frac{1}{100}$in. to $\frac{1}{500}$in.

Fig. 35.—Granulated vesicles of the human liver, sometimes seen of a full yellow colour, as if filled with bile; the cell wall is extremely thin and delicate; but the molecules and granules, or the active particles of the cells, are very conspicuous.

Fig. 36.—Pollen-grains of the garden lilac (*Syringa vulgaris*), oblong and granulated (*a*); rendered globular and much enlarged by the addition of water or liquor potassæ (*b*); bursting, and discharging multitudes of molecules and granules from a large rent (*c*); discharging similar objects (molecules and granules) in a tube-like projection (*d*); with light-coloured bullæ at the circumference (*e*.)

Fig. 37.—All the objects in this figure are drawn to a scale. Molecules and fibres of fibrine from the buffy coat of inflammatory blood (*a*); granules and fibres of fibrine from the same (*b*); red corpuscles, diameter, $\frac{1}{3800}$in. (*c*); colourless corpuscles, diameter, $\frac{1}{2600}$in. (*d*); pus corpuscles, showing their transition state between the colourless blood corpuscles and epithelial cells; diameter, from $\frac{1}{2000}$in. to $\frac{1}{1500}$in. (*e*); granulated vesicles from the liver, diameter, $\frac{1}{1000}$in. (*f*.)

PLATE V.

Fig. 38.—Colourless blood corpuscles (*a*); granulated corpuscles resembling pus corpuscles (*b*); corpuscles with large granules (*c*); corpuscles with active vibratile cilia (*d*); corpuscles gradually assuming the form of ciliated epithelial cells (*e*); ciliated epithelial cells (*f*.)

Fig. 39.—(*a*) The intralobular bronchial divisions in the fœtal lung; (*b*) the same injected with mercury, showing

the manner in which the air-cells are formed: each branch or sub-division forms a lobular passage, which consists of a series of air-cells, opening into or communicating with one another; (*c*) the extremities of the intralobular bronchial sub-divisions fully inflated and pressing against each other, forming polygonal air-cells filled with air bubbles, and communicating, to a certain extent, with each other by means of the lobular passages.

Fig. 40.—A portion of the membrane of an air-cell from the lung of a toad; the blood corpuscles pass in single files along the vessels or channels of the tissue.

Fig. 41.—A portion of the same membrane in a state of "abnormal turgescence;" the vessels are greatly enlarged, and the islets of tissue much less.

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