ON THE

ART OF INJECTING BLOOD-VESSELS.

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[The old Dutch anatomists were long famous for their skill in preparing injected anatomical specimens; and in this country it is generally believed that they either altogether concealed the nature of the processes which they followed, or, by the affectation of mystery, deterred imitators from repeating them. It is not so in modern times. Ruysch has worthy followers in Schrœder van der Kolk and Harting; and thanks to their enlightened spirit, the art of injecting, as practised at Utrecht, is no secret. We have great satisfaction in transferring to our pages the following translation of the chapters on "Injection of Vessels," from Harting's great work "Het Mikroskoop."]

The injecting of the finest vessels with coloured materials affords an assistance absolutely indispensable for the microscopical study of the anatomy of animal organs. Indeed it is impossible in any other way to convince one's self of the mode of distribution, course, nay, very existence, of the most minute capillaries, as these are in fact very seldom found full of blood, and even when this is the case, the transparency of the blood-corpuscles is so great, that they can only be distinctly seen at points where they, or the containing vessel, are well isolated. Any one who has taken much trouble thoroughly to investigate the structure of an organ, but without injecting its bloodvessels, will learn, on continuing his observations with the assistance of well injected preparations, that his first ideas of the structure were most incomplete and inaccurate. Injection not only shows the course of the vessels, but, as this is always intimately connected with other tissues, serves to unfold *their* nature and relations; the whole picture becomes more comprehensible—more plastic, which is in great measure due to the strong contrast between the tissues and the colouring materials used for the injection. Indeed a successful injection never fails to make a vivid impression upon the eye which

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observes it for the first time,—an impression due not only to the beauty of all capillary arrangements (and how various are these in form and distribution?), but to the facility with which the microscopical picture is appreciated, and which speedily puts the least practised observer in a condition to form a distinct idea of what he has seen. This can hardly be said of any other class of microscopical objects.

Directions for making such preparations will not be out of place here. Yet, lest I should encroach too much on the province of general practical anatomy, I shall be brief, and limit myself to the description of what I have, by personal experience, found to be useful.[1]

The instrument most generally used in making injections is the syringe. That it must be good and clean, so that the piston shall have free play up and down, and yet accurately fill the tube, is self-evident. Its size should be regulated according to the dimensions of the preparation whose bloodvessels it is proposed to inject; for although a small quantity of fluid may be injected with a large syringe, and the want of a large instrument supplied by repeatedly filling a small one, it is certainly expedient to have two or more of different sizes. When the syringe is wide, and the dimensions of the piston large, it is difficult, on the one hand, so to regulate the pressure as to avoid rupturing the vessels of very small animals or organs; and, on the other hand, the injection of larger objects is often unsuccessful, when frequently interrupted by the necessity for recharging the syringe. For ordinary use a syringe capable of holding thirty cubic inches of water, and for smaller objects an instrument of six cubic inches' capacity is perfectly sufficient.

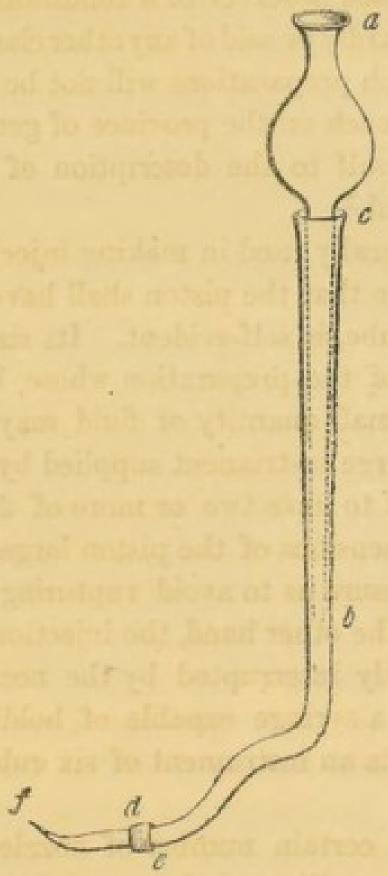
To each syringe belong a certain number of nozzles, or canulæ, of different widths, corresponding to the calibre of the vessels into which they are to be inserted. These can be procured so fine as hardly to admit a human hair; but these narrow nozzles are apt to be easily obstructed, and are hardly ever required. The most generally useful are of a calibre varying between one-third of a millimetre and three millimetres ($\frac{1}{70}$th and $\frac{1}{8}$th English inches nearly). Sometimes one meets with syringes connected with the nozzles, by means of a screw. This is unnecessary and inconvenient,—a simple sliding connection is perfectly sufficient, if the extremity of the syringe accurately fits the opening of the nozzle.

Besides the common syringe, there are other pieces of apparatus described as serviceable for injecting, but on their several merits I can offer no opinion founded on personal experience. I believe, however, that the syringe not only surpasses them all in simplicity of use, but also in security; for the pressure made by the hand upon the piston can be perfectly regulated according to the degree of resistance felt, and the greater or lesser delicacy of the structure which is being injected.

In a few cases, however, as in injecting small and tender animals, mollusca, &c., where it is impossible to apply ligatures to the vessels, a glass pipette, drawn out at one end into a fine bent nozzle, will be found useful. The point should

[1] For a more detailed description of apparatus used in making injected preparations, I may, once for all, refer the reader to the treatise of Strauss-Durkheim, and to the English work of Alfred Tulk and Arthur Henfrey, on "Practical Comparative Anatomy and Physiology," translated into Dutch, and enlarged by C. J. Snijders, 1847, p. 13.

be conical, so that it may prevent regurgitation from any vessel into which it is fitted. The following apparatus, which any one may prepare for himself, is, how



ever, more convenient.[1] It consists of a common glass pipette, *a*, *b*, of moderate width, such as may be had of any vender of chemical apparatus, and of a caoutchouc tube, *c*, *d*,[2] one extremity of which is attached by means of a thread to the thicker end of a fine glass nozzle, *e*, *f*, drawn out and bent into an obtuse angular form by the blowpipe flame. In using the apparatus, the pipette is first filled with the coloured fluid, and then introduced into the open end of the caoutchouc tube, which by its conical form it accurately closes.

The same object is perhaps even better attained by the procedure recommended by Rusconi.[3] This consists in forming a species of trocar, with a needle and the quill of a crow, partridge, or smaller bird. In using it, the small vessel through which the injection is to be thrown is held with a forceps against the extremity of the trocar, and punctured with the needle. The quill is then directed into the puncture, and the needle withdrawn. Into the upper extremity of the quill the small nozzle of an injecting syringe, previously filled with coloured fluid, is finally inserted.

[1] Strauss-Durkheim, Tulk, and Henfrey, describe a similar, but more complicated, apparatus. The woodcut is reduced one-half.

[2] Caoutchouc tubes, for purposes of this sort, may be easily made from a fragment of caoutchouc sheeting, by rolling it round a glass rod, and fixing the edges together by a solution of gutta percha in oil of turpentine.

[3] *Annales des Sciences Naturelles*, 2de serie, Zool. xvii. p. 111. Rusconi also uses for the injecting of the lymphatics of reptiles, a silver syringe with a golden nozzle. A copper one is quite as good.

The success of an injection depends, in great measure, on the choice of the substance which is injected. For coarser injections, when it is only required to display the larger vessels, or such as are visible to the naked eye, this is easily made; but for finer preparations destined for microscopical examination, it is very difficult to provide an injecting fluid suitable in every respect, and the choice becomes here more restricted. A fluid for these finer injections should fulfill all the following conditions:—

1. It should penetrate without difficulty into the minutest capillaries, and yet neither over-distend nor tear them.

2. It should not have such a degree of fluidity as to permit it to percolate through the walls of the capillaries.

3. It should have a proper colour, permitting the distinct definition of every vessel either by transmitted or reflected light.

4. The colour should be everywhere uniform,—that is, it should form a consistent mass, without traces of grittiness, even in the most minute vessels.

Every injection consists of a fluid vehicle containing some coloured substance.[1] The vehicles recommended are very numerous. Melted wax, fat, spermaceti, cocoa-butter, and other substances which become fluid on increase of temperature, can only be used for coarser injections. For fine injection some have greatly extolled turpentine varnish; but, although both I and my colleague, Schrœder van der Kolk, have made frequent attempts with this substance, our injections have never been successful. The turpentine varnish has the disadvantageous property of hardening and drying very slowly, permitting the escape of injection from the extremities of the divided vessels, and the consequent soiling of the surface of the preparation.

The best vehicle is a watery solution of glue, both because the size encounters far less resistance than oil or fatty matters in penetrating the capillaries which are always in contact with blood,—*i.e.*, with a fluid consisting chiefly of water; and because the fluid congeals on cooling, so that sections or other preparations may be made and preserved with little or no risk of the injection issuing from the divided vessels.

White or light yellow coloured glue is sufficient for the preparation of the size. Its relative proportion to the water should be such, that the mixture should, on cooling, form a jelly of moderate consistence, which may be tested by letting a drop of the warm fluid fall on a cold object. On this test the temperature of winter and summer exercise some influence; and the congelation is also in some measure affected by the kind of glue employed. In general, it may be assumed that 1 part of glue to 8 or 10 parts of water is a proper strength for the solution. It is by no means necessary at once to prepare a solution of this particular strength; but a stronger size may be made, in the first instance, containing about 4 parts of water to 1 of glue.

[1] I say nothing of quicksilver, which is by no means well adapted for microscopical injection; its weight causing it to overstrain and rupture the small vessels, and then find for itself channels among the tissues of organs. Even for injecting lymphatics it may be dispensed with, and fluids of less specific gravity substituted, as Rusconi, Breschet, and others, have recommended.—*Annales des Sciences Nat.*, 2de ser., Zool. xvii. p. 115.

In making the solution, care must be taken to regulate the heat, and above all, to avoid a boiling temperature, which lessens the congealing property of the mixture. When the glue is dissolved, which may be ascertained by stirring, the size is filtered through a cloth, to remove any trace of impurities which it may hold in suspension.

The number of colouring materials recommended for injections is very great; but however large the choice, there are in reality very few which unite in themselves all the requisites of a good colouring material.

Colours entirely soluble in water, such as litmus, turmeric, &c., penetrate, it is true, into the smallest capillaries, but easily transude through their walls, and discolour all the tissues. Besides, all such organic colours readily undergo changes from heat or light; while preparations into whose composition they enter, cannot be kept in any watery fluid. Those substances are consequently preferable whose particles remain suspended in the vehicle, and which are not soluble in the fluids used for preservation of specimens—such as water, spirit, and turpentine. It is for these reasons that different metallic preparations are to be regarded as the best materials for coloured injections.

I have made some careful trials in this department with a considerable number of different mixtures of substances. The following is a summary of the results of my experience:—

Yellow Injection.

Of all substances with which I am acquainted, there is none better adapted for microscopical injections than the chromate of lead,[1] precipitated by the double decomposition of solutions of 100 parts of acetate of lead mixed with 52·4 parts of chromate of potass. For the convenience of the reader, I subjoin the proportions in which I have employed these substances reduced to ordinary weights and measures.

a. ℥iv. ʒj. ℈j. (2000 grs.) of acetate of lead are dissolved in so much water as will make up a measure of ℥xvi.

b. ℥ij. ʒj. gr. xxviii. (1048 grs.) of chromate of potass are dissolved in water, and the measure filled up to ℥xxxii.

For the preparation of the injection—take

1 measure of *a.*
2 measures of *b.*
2 measures of the concentrated size solution—*i. e.*, 1 part glue, and 4 of water.

First mix the solutions of the salts in a separate vessel, stir them well together for a short time, and then add them to the size. These successive steps in the process are not mere matters of indifference; for if the saline solutions be at once

[1] The yellow chromate of commerce, which is often used for injections, is ill adapted for the purpose, its great specific gravity causing it to subside rapidly in the suspending fluid. Doyère (*Comptes Rendus*, 1851, Juillet 12) first recommended the successive injection of solutions of acetate of lead and of chromate of potass, and the consequent formation of the chromate of lead within the vessels themselves; but although by this procedure the finest vessels are injected, they never remain properly or uniformly filled, for the precipitate does not take place regularly, but forms in knots.

added to the size (without previous admixture), the precipitation will be found to be very imperfect. Care must also be taken not to allow the fluid in which the precipitate has been formed to stand too long before adding it to the size, otherwise the fine division of the colouring matter will become impaired by the aggregation of its particles.

Blue Injection.

For the last two years my colleague Schrœder van der Kolk, has been in the habit of preparing in the above manner a blue injection, by mixing solutions of persulphate of iron and yellow prussiate of potass. The size coloured in this way possesses indeed a good penetrating property; and the prussian blue which is formed is suspended in the fluid in a state of extremely fine division. For the formation of this precipitate, the solutions may be prepared as follows :—

a. ℥iij. ʒj. (1500 grs.) of protosulphate of iron dissolved in 20 to 25 ounces of water are converted into the persulphate, by the addition of ʒiv. grs. xlv. (285 grs.) of sulphuric acid, of density 1850, and the requisite amount of nitric acid, aided by a moderate temperature; water is then added till the mixture amounts to ℥xl.

b. ℥iij. ʒvi. grs. xlv. (1845 grs.) of yellow prussiate of potass are next dissolved in water, till the solution amounts to ℥lxxx.

For making the injection there are employed—

1 measure of the solution *a*.
2 measures of the solution *b*.
2 measures of the concentrated size solution.

A curious circumstance connected with the employment of this injection is, that the chemical action of the soda contained in the blood causes more or less decomposition, and consequent decoloration of the Prussian blue in the minute vessels. But if the injected preparation be placed in an acid solution,—and for this purpose, according to circumstances, diluted sulphuric, acetic, or tartaric acid may be employed,—the original blue colour is restored. A small quantity of tartaric acid, sufficient to neutralise the carbonate of soda in the blood, may also be added to the above mixture.

No less penetrating and more easily prepared than the former mixture is the *apparent*[1] solution of Prussian blue in oxalic acid. This, moreover, has not the disadvantage of becoming decolorised by contact with the soda constituents of the blood. The best proportions I find to be—

1 part of Prussian (Berlin) blue.
1 part of oxalic acid.
12 parts of water.
12 parts of concentrated size solution.

The oxalic acid is first finely triturated in a mortar, and the Prussian blue afterwards added to it. Water is then added in successive small portions, tritu-

[1] That the solution is only apparent—although the microscope does not exhibit distinct molecules in the fluid—is shown, both by a good filter, which enables us to separate the colouring matter from the fluid, and by the circumstance, that after some time the blue colour falls to the bottom of the solution.

ration being continued diligently till the solid particles totally disappear; the coloured fluid is then added to the warm size solution.

This blue injection-material, after the lapse of some time, does occasionally lose its colour in the vessels. In my opinion, this is caused by the impurity of the Prussian blue of commerce. It is consequently advisable to prepare the Prussian blue for one's self, either by the precipitation of a *per*salt of iron with yellow prussiate of potass, or by purifying the commercial Prussian blue, by rubbing it in a mortar with an equal quantity of sulphuric acid, and then washing it with water till every trace of free acid is removed.

Red Injection.

Of precipitates used for making red injection, there may be mentioned,—freshly prepared golden sulphuret of antimony; basic chromate of lead, obtained by treating the yellow chromate (see p. 249) with caustic potass; and deutoioduret of mercury.

As for the first of these substances, its fine state of division, when first precipitated in the fluid, renders it an excellent material; but the sulphuretted hydrogen gas which it always contains destroys the copper syringe.

Basic chromate of lead has a very lively colour, but is too coarse-grained and heavy for fine injections.

Deutoioduret of mercury is rather better adapted for this purpose. To colour an injection with this substance, proceed as follows:—

a. ℥j. ʒv. ℈j. (800 grs.) of corrosive sublimate are dissolved in water, and the measure should amount to ℥xxii.

b. ℥ij. (960 grs.) of iodide of potassium are dissolved in water, so as to make a solution of ℥iiij.

In making the injection fluid, mix—

4 measures of solution *a*.
1 measure of solution *b*.
4 measures of concentrated size solution.

Although this mixture is of a very pure colour, and penetrates tolerably well, it has the disadvantageous property of losing its colour in the minuter vessels, and becoming yellow. This tendency to discoloration is so strong, that if the smallest quantity of glue be present in the glass vessel in which the (saline ?) solutions are mixed, the precipitate formed is not red, but yellow.

None of these mixtures, therefore, deserve unqualified approval; and in most cases preference should be given to other powdered colours, such as *carmine, vermilion*, or *golden sulphuret of antimony*, well washed and dried.

The first of these three substances would probably be most generally useful, were its high price not a bar to its employment. Of the other two, the vermilion has the more lively colour; but, on the other hand, the golden sulphuret is lighter, and consequently better adapted for injecting the minutest vessels.

In using such coloured powders, it is above all necessary to divide them as finely as possible. For this purpose, they should first be levigated in a mortar, and the finest particles decanted off. To do this, part of the water to be used in the injection may be employed. For example, take one part of Chinese vermilion, and mix it with eight parts of water; let the mixture stand for a few econds in a glass jar, till about one third of the vermilion has subsided, then decant off the supernatant stratum, and mix it with eight parts of concentrated size solution.

With *golden sulphuret* the same procedure may be followed; but as this powder is lighter than the vermilion, a smaller quantity,—say 1 part to 12 of water and 12 of size solution,—is required.

These injections should be well stirred immediately before being used; and in charging the syringe with them, care should be taken to hold its nozzle but a short way below the surface of the fluid, in order that only the finer coloured particles may be sucked up.

White Injection.

Of the great variety of white precipitates formed by double decomposition, I have not yet succeeded in finding one which unites in itself all the requisites of a good colouring material for very fine injections. Of the many which I have carefully tried, and of which, for brevity's sake, I shall say nothing, *precipitated carbonate of lead* has alone given moderately satisfactory results. The proportions recommended are as follows:—

a. ℥iv. ʒj. grs. xx. (2000 grs.) of acetate of lead dissolved in water, making a ℥xvi. mixture.

b. ℥iij. ʒj. gr. xx. (1520 grs.) of carbonate of soda dissolved in water, and forming a ℥xvi. mixture.

The injection material should consist of—

1 measure of solution *a*.
1 measure of solution *b*.
2 measures of strong size solution.

This material is more penetrating than that formed by simply mixing size with white lead. In some injections a mixture containing oxide of zinc has been more successful. The proportions used are the same as those recommended for golden sulphuret of antimony.

Of all the injections above-mentioned, the first—the size solution, coloured with precipitated neutral chromate of lead — deserves a decided preference. In fact, it unites in itself, and in a high degree, all the properties of a good injecting material, easy penetrating quality, uniform cohesion of the coloured particles, and a lively well-marked colour, contrasting well, when viewed by reflected light, with the darker parts of the field of view. When one's choice is free, and a single colour only is required, this is the one most to be recommended.

In the second rank, I am inclined to place the solution of Prussian blue in oxalic acid (see p. 249). True, it is not less penetrating than the yellow, but vessels filled with blue injection are well exhibited only when viewed by transmitted light, or by light reflected from a white ground; and when many such vessels are grouped together, it is the more difficult to separate them the clearer the colour with which they are injected; for single twigs of a blue colour do not form the necessary contrast with the larger and darker arteries. There are, however, cases in which the transparency of the above-mentioned blue injection constitutes its special advantage, especially in the course of investigations for which high magnifying powers are required. Thus, for example, it deserves to be preferred in injecting the capillary system of the lungs,—a structure which can be far more distinctly made out after injecting the blue material and then inflating and drying the lungs, than by using any other injection.

When two colours are required for filling both the arterial and venous ramifications, it is, for reasons already given, in general not expedient to choose *blue* for one of them. Yellow and red are the best colours, as both may be seen by reflected light, and they generally contrast sufficiently. White and red would naturally succeed as well, if the white had the same penetrating property as the yellow. Finally, for some purposes—as, for example, when the two venous systems of the liver, together with the branches of the hepatic artery and bile-ducts, are to be injected—three or four different colours are requisite. In such cases, the rule should be observed to select the least penetrating injection for filling the system whose capillaries are known to be the widest,—as, for instance, the branches of the vena hepatica in the liver.

There are, besides, a few other directions which should be kept in view, when making injected preparations, and which, in concluding this section, may be briefly given :—

1. Before commencing the injection of an animal or of an organ, a proper plan must be formed, for which a knowledge of the course and relations of the blood-vessels is, of course, absolutely indispensable. Guided by this, and knowing that when the injection is thrown in a suitable direction, it may find its way sidewards through an anastomosing vessel to an organ, which for the moment it is wished not to inject, care must be taken, as a preliminary, to place ligatures on such vessels. When a highly penetrating injection is used, more extreme precautions must be adopted, suggested by the reflection that the fluid, after passing through the capillaries, may be returned from the great vessels to which these lead.[1]

2. The injection of young and lean subjects always succeeds better than that of old and fat ones; and the most suitable period for the process is by no means that which immediately succeeds death, but some time later, when the general stiffening of parts has given place to some degree of flaccidity. This period always arrives sooner or later, and is especially influenced by the temperature of the surrounding air; in summer, injections may be undertaken with advantage a few hours, or the next day, after the death of the subject; while in winter they may be postponed for four days, or even for a longer time.

3. Injection by the arteries is, in consequence of the comparative strength of their tunics, always the most convenient and sure. Consequently, when the sole object is to fill the capillary system with injection, this is always better done through the arteries than through the more tender veins. Besides, these are in most organs provided with valves, rendering the injection of the capillaries through them impossible. But where these valves are wanting, as in the

[1] The following illustration may show that such precaution is by no means superfluous :—In injecting the hind foot of a rabbit, through the crural artery, with the yellow fluid whose composition has been above given, the capillaries of a considerable portion of the intestines, and even of the liver, were filled with injection which flowed back from the capillaries and veins of the foot.

veins of the intestines, injection may be thrown into both classes of vessels successively, which is indispensable in order to exhibit the secondary (and yet microscopic) plexus of arteries and veins, in which the common capillary network takes its origin. In making these venous injections, care must be taken, before fixing the nozzle in the vessel, to remove the coagulated blood, which is often present, by pressing it gently outwards with the handle of a scalpel. When the organ is obviously very full of blood, it is sometimes even advisable to throw warm water into the arteries, till it returns by the veins and brings the blood along with it. But recourse should only be had to these injections of water, when their necessity is quite apparent; for the smaller vessels always suffer from them, so that extravasation is afterwards apt to take place.

4. When the nozzles are properly placed in the vessels, and secured by means of threads, which may be passed round each vessel with a curved needle, the preparation to be injected should be placed in water between the temperature of 97° and 104° Fahrenheit, and the injection deferred till the heat has sufficiently penetrated to the inmost parts of the preparation.

5. The injecting material should be brought to a temperature at which it is sufficiently fluid. This degree of heat may always exceed that of the water-bath in which the preparation is placed, but must not amount to 140° Fahrenheit, at which temperature albumen coagulates.

6. In filling the syringe, by sucking up the injection, care must be taken to exclude all air, which may be best done by forcing the piston home against the bottom of the syringe before putting its extremity under the surface of the fluid.

7. After connecting the charged syringe with the nozzle, slow and gentle pressure must be made upon the piston. If strong resistance is encountered, this may be accounted for by obstruction of the nozzle, and the syringe being withdrawn, the nozzle may be cleared of the impediment by moving a wire or hog's bristle backwards and forwards within it. Further, let the syringe be held in the direction in which the fluid may be most easily ejected,—that is, in the direction in which the current of blood has flowed during life.

8. It is difficult to lay down defined rules as to the time during which the process of injection may be kept up. In fact, it requires some experience to hit exactly the moment for discontinuing the injection; and as the most practised hand may fail, it is necessary to ascertain, sooner or later, whether the vessels are insufficiently filled in consequence of the too early discontinuance of the injection, or whether, from too long perseverance, the operator has not ruptured the walls of the finer vessels, permitting the escape of injection and extravasation into the tissues.

When such fluid and penetrating injections as we have above described are employed, it is in general not advisable to persist in injecting when strong resistance is felt, for in such circumstances extravasation has in all probability occurred. It is, consequently, better to attend only to the outward progress of the injection; for example, in injecting by the carotid artery, to the colouration of the lips, of the conjunctiva, &c. If an injection thrown into an artery is observed to return through the veins, it is of course to be understood that the process of injecting should be discontinued.

9. After every injection, the vessel in which the nozzle is fixed should be tied, or the nozzle itself closed with a cork, to prevent regurgitation of the fluid. When the whole process is completed, the injected specimen should be well washed with cold water, and then placed in weak spirit, in which it should be permitted to lie for some hours, or till next day, before being further examined.

As for the examinatiou of injected organs, it may be said in general that the distribution of the capillary system, its arrangements and relations to other parts and tissues, are exhibited only while the preparation is wet. Drying crumples up all the parts, so that vessels, which originally lay in layers of two or three deep, all appear, when dry, on the same level. On the other hand, drying has the advantage that the preparation may be afterwards put up in turpentine or Canada balsam, which, by rendering the surrounding tissues clear and transparent, permits certain peculiarities of vascular arrangement to be seen far better than is possible in wet specimens. It is consequently for the most part best to examine preparations both in the moist and dry state. The choice of methods is, moreover, somewhat circumscribed by the nature of the organ to be examined. In the case of the liver, kidney, &c., the vascular distribution both on the surface and in the deeper parts may be studied by means of dried sections, without danger of the observer being misled in consequence of the circumstance above-noticed; in other organs, again, a most inaccurate idea of structure is obtained from dried preparations; thus the mucous membrane of the stomach and intestines, with its villi, rugæ, and glands, becomes, on drying, so altered, that one acquainted with it only from examining such specimens, would of course possess a most inadequate knowledge of its true structure.[1]—*Harting, in "Het Mikroskoop,"* vol. ii., pp. 171-191.

[1] A great part of the plates in the well-known work of Berres, "Anatomie der Mikroskopischen Gebilde des Menschlichen Körpers," though admirable as works of art, have been copied from dry preparations, and are consequently quite useless. But one who has examined fresh preparations of the same parts, is in some degree enabled to find the clue to these labyrinths of vessels.

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