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[Benjamin Gibson].**

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OBSERVATIONS

ON THE

Effect of Madder Root

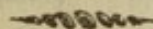
ON THE

BONES OF ANIMALS.

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BEFORE THE LITERARY AND PHILOSOPHICAL SOCIETY
OF MANCHESTER

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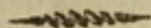


BY

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&c. &c. &c.



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1805.



T. Darnell



*M. Wilson, with the Author's best
refute.*

OBSERVATIONS

ON THE

EFFECT OF MADDER ROOT

ON THE

Bones of Animals.



THERE is, perhaps, no phenomenon, which occurs in an animal body more curious, than the tinge communicated to the bones of living animals, whose food has been mixed with madder root. This, like many other facts, to which no reasoning *à priori* could have directed us, was discovered by chance. Mr. Belcher, dining with a calico printer on a leg of fresh pork, was surprized that the bones, instead of possessing their usual whiteness, were of a deep red colour; and on enquiring the cause of it, was informed, that the pig had been fed upon the refuse of the dyers' vats, and had received so much of the colouring matter of madder into the system, that its bones were dyed by it. So interesting a fact has attracted very much the attention of anatomists, and has been used in many physiological and pathological enquiries; it may not therefore be uninteresting to give a short

history of the phenomena connected with it, and the purposes to which it has been applied, previous to entering upon the more immediate object of this paper.

Many experiments have been made to ascertain how long a time is required to produce the tinge, and whether it be permanent or only temporary. Belcher and Morand, about the same time, mixed madder root with the food of chickens and young pigeons. The result of their observations was, that the tinge was more quickly communicated to the bones of growing animals, than to the bones of animals which had already completed their growth; the bones of young pigeons being tinged of a rose-colour in twenty-four hours, and of a deep scarlet in three days; whilst the bones of adult animals only exhibited a rose-colour in fifteen days. They found the tinge most intense in the solid parts of those bones, which were nearest to the centre of circulation; whilst in bones of equal solidity, at a greater distance from the heart, the tint was more faint. The dye was deep in proportion to the length of time the madder had been continued, and when it was discontinued, the colour gradually became more and more faint, till it entirely disappeared. According to the experiments of these gentlemen, other

other vegetable dyes, such as Logwood, Turmeric and Alkanet Root, did not communicate their respective tints to the bones.*

This effect of madder upon the bones, was soon afterwards made use of by Du Hamel, in his attempt to prove the manner in which the bones of animals are encreased in thickness.—Observing in the vegetable kingdom, that the bark, by a sort of secretion, formed the ligneous part of a tree, in successive layers ; so he conceived that the periosteum, or membrane surrounding bones, being converted into osseous matter, encreased their diameter by adding to them concentric laminae in succession. In order to prove the justness of his opinion, he mixed the food of a cock with madder root for a month, withheld it for a month, and then

From some experiments I made on young pigeons, I found that a considerable quantity of logwood, in the form of extract, communicated an evidently purple tint to the bones. With regard to turmeric, it appears to be altered in its colour by passing through the digestive organs, for the fæces of the animals, who took it in considerable quantity, were constantly green : whilst either logwood or madder root exhibited their respective hues after passing through the intestines. Saffron exhibits properties different from any of these substances ; for though a pigeon took it in considerable quantity and thereby had its fæces tinged, yet no perceptible alteration of colour was produced in its bones.

gave it again. He afterwards killed the animal, and upon inspection thought he observed the appearance, which he expected; viz. two layers of red bone inclosing one of white, corresponding to the periods of the madder's being given or withheld.

This experiment, and some others related by Du Hamel, appear to be conclusive in favour of the theory, which he wished to establish; and as they were conducted by a physiologist of high character, the accuracy of the observations could not have been doubted, had these experiments stood alone. But when they are compared with some of his own previous experiments, and those of other authors, it is difficult to reconcile them. In some of Du Hamel's experiments, for instance, the bones of a cock were tinged of a rose-colour through their whole substance in sixteen days, and those of young pigeons of a deep scarlet in three days. In several experiments I have made on the subject, I have found the bones of young pigeons tinged of a uniform rose-colour, internally as well as externally, in twenty-four hours. This communication of colour to the whole substance of the osseous system in so short a time, makes it highly improbable that the laminated appearance, remarked by Du Hamel, was produced by the

new formation of red and white osseous layers, corresponding to the times (months) the madder had been given or withheld. For, as Mr. John Bell very justly remarks,* “ If a
“ bone should increase by layers thick enough
“ to be visible, and of a distinct tint, and such
“ layers be continually accumulated, upon
“ each other every week, what kind of bone
“ should this grow to?” The only way in which we can reconcile with each other the phenomena observed in the different experiments, and account for their apparent contradiction, is; by supposing, that Du Hamel mistook for an obscurely laminated appearance, the variety in the tint; which is more deeply communicated to the more solid, and more faintly to the less compact parts of a bone.

This property in madder of tinging the bones of animals, has lately been employed by Dr. M'Donald,† in his ingenious researches into the formation and death of bones.— Amongst other objects, he attempted to ascertain, in what manner and how soon, a cylindrical bone is regenerated to supply the place of one artificially killed. As the process is highly curious, I shall briefly relate the principal points.

* Anatomy of the bones, &c. p. 15.

† Disputatio inauguralis de Necrosi ac Callo. 1799.

Dr. M'Donald's experiments were made by amputating the proper leg-bone of young pigeons or chickens immediately above the joint. The marrow was then extracted, and the cavity, which contained it, filled with lint. This process caused the death of the bone, and the formation of a new bone surrounding that destroyed, ensued. Immediately after the experiment, the animal had its food mixed with madder root, and the part was inspected in different animals, at different periods.

On examination three days afterwards, the periosteum or enveloping membrane, was found much thickened; and underneath it a gelatinous humour was effused, surrounding the dead bone, and spotted with red osseous nuclei; proving that the regeneration of the bone had commenced at this early period.

In seven days the new bone was found soft and flexible, not to be distinguished from cartilage or gristle, except by the red tint the madder had communicated to it; yet the bone destroyed was not at all coloured, although the other bones of the animal had acquired a bright red. From this time the new bone continued to encrease in hardness, surrounding the old one like a sheath. The latter in about three weeks was so loose as to be drawn out, and in about fifteen days from this time, the cavity

of the regenerated bone was filled with marrow, and in every respect performed the office of that, for which it was a substitute. This may be considered as a general outline of the progressive changes, which take place during the regeneration of a cylindrical bone, in a young animal, such as a pigeon, or chicken; and the same process is frequently performed in the human body, when, from some internal cause, the life of a bone is destroyed. These changes involve many interesting particulars; but the circumstance most immediately connected with the subject of this paper is, that although the shaft of the bone required three weeks for its renewal, yet in seven days the osseous system generally had acquired a bright red. Now if we explain this change in colour according to the common opinion of absorption of the white, and deposition of the red osseous matter,* we must necessarily draw

* The common opinion of physiologists, with regard to this curious fact, is, that when a bone becomes red, during the exhibition of madder root, the white osseous particles which composed it, have been entirely removed by absorption and replaced by new osseous matter of a red colour: and when a bone assumes its natural colour, these red particles have been removed and replaced by white: If this be the fact, it necessarily follows, that an animal has at least fifty-two new sets of bones in a year:

this conclusion ; that the osseous system of the animal will be renewed three times during the period, which the formation of the substitute bone requires ; a conclusion which we should be inclined to reject merely from its improbability. But besides this, the appearance of the parts strongly militate against it—for, if we may judge at all of the activity of the process in the two parts, by their comparative degrees of vascularity, that employed in forming the substitute bone far exceeds that going on in the osseous system generally ; one striking phenomenon attending the regeneration of a bone being, the very high degree of increased vascularity, which the parts employed in the process rapidly assume.

After this effect of madder upon the bones was known, it long remained a mystery, why some other white parts of the body, such as nerves, cartilages and periosteum, were not equally liable to be coloured by it, as the bones. This fact, I believe, did not receive any explanation, until Dr. Rutherford gave a very ingenious and satisfactory one. When speak-

for the osseous system, according to the experiments of the most respectable physiologists, acquires a deep red tint from madder in one week, and assumes its natural colour in another.

ing of this property of madder, he says,* “ We
“ have, in the fact before us, a beautiful ex-
“ ample of a particular case of chemical at-
“ traction; such as in numberless instances,
“ is observed to take place, between the co-
“ louring particles of both animal and ve-
“ getable substances, and various other bodies,
“ especially earths and earthy salts, and oxydes
“ of metals. So strong is the affinity of the
“ colouring matter to these bodies, that it is
“ frequently observed to quit the menstruum,
“ in which it may chance to be dissolved, to
“ unite with them: they, in consequence of
“ its union, acquiring a particular tinge,
“ whilst the menstruum is proportionably de-
“ prived of colour.—From this principle,
“ this mutual attraction, is deduced the va-
“ rious use of those bodies as mordents, as
“ they are called, intermedia, or means for
“ fixing the colours in dying or staining thread
“ or cloth, whether it be composed of ani-
“ mal or vegetable materials. Upon the
“ same principle depends the preparation of
“ those pigments, known to painters under
“ the name of lakes; these are truly precipi-
“ tates of the colouring matter, in combina-

* See Dr. Blake’s inaugural Dissertation. De dentium
formatione. p. 119.—1798.

“ tion with various mordents, as their basis.—
“ the colouring of the bones of a living animal
“ by means of madder, is, in every circum-
“ stance, analogous to the formation of these
“ lakes. The colouring matter of madder,
“ passing unaltered through the digestive
“ organs of the animal, enters the general mass
“ of fluids, and is dissolved in the serum of
“ the blood, to which, indeed, if it be in
“ large proportion, it communicates a sensibly
“ red tinge. *But there is always present in the*
“ *blood, and in a state of solution in the serum,*
“ *a quantity of the earthy matter of the bones,*
“ *phosphate of lime, ready to be deposited, as*
“ *the exigencies of the animal may require.—*
“ *Now the phosphate of lime is an excellent*
“ *mordent to madder and has a strong affinity*
“ *to it, and is consequently admirably fitted to*
“ *afford a base for the colouring matter of it ;*
“ *in such experiments, therefore, they concrete*
“ *in the state of a bright red lake, whence the*
“ *colour of the bones is derived. That this is*
“ *actually the case, may be shewn by a variety*
“ *of experiments. Thus, if to an infusion of*
“ *madder in distilled water, be added a little*
“ *of the muriate of lime, no change is per-*
“ *ceived : but if to this mixture be added a*
“ *solution of the phosphate of soda, imme-*
“ *diately a double elective attraction takes*

“ place. The muriatic acid combining with
“ the soda, remains suspended, or dissolved
“ in the water; whilst the phosphoric acid,
“ thus deprived of its soda, combines with the
“ lime, which the muriatic acid parted with,
“ and forms phosphate of lime or earth of
“ bones. This substance, however, being in-
“ soluble in water falls to the bottom; but
“ having combined at the instant of its forma-
“ tion, with the colouring matter of the
“ madder, they fall down united into a crim-
“ son lake; precisely of the same tint with
“ that of the bones of young animals, which
“ have been fed with madder. From this
“ simple representation of the matter, we have
“ a ready explication of every circumstance,
“ which has been remarked as extraordinary
“ respecting this subject.”

Whilst Dr. Rutherford thus gives a most satisfactory explanation of the colour of madder being communicated to the bones alone, of all the white parts of an animal; we find that he embraces the same opinion, as other physiologists; that the osseous materials acquire their colour previous to their deposition, whilst in a state of solution or mixture in the blood; from whence they are afterwards deposited, and concrete in the form of a bright lake. In no part of his ingenious remarks does he hint at

the probability, that the bones, already formed in an animal, may, during the use of madder, become red, and after its disuse gradually resume their natural colour, by the agency of a power entirely independent of their deposition and absorption; That this is probable I shall now proceed to prove.

Before it was discovered that madder possessed this property of tinging bones, physiologists had long been of opinion, that the various parts of the body, being worn out by the performance of their actions and functions, were gradually removed, and replaced by new materials. They had seen, as Mr. J. Bell observes, the whole osseous system by the morbid removal of its solid part, rendered so soft and flexible as to bend under the common weight of the body and ordinary action of parts; the regeneration of many bones which had been destroyed by disease; the rapid absorption of fat in some diseases, and its speedy reproduction; and lastly, the gradual change which the fluids of the body undergo, as well as some of its insensible parts, the hair and nails; hence they supposed that the same process of change and renovation went on in every organ, and that the bodies of animals were not composed of the same identical particles, of which they would consist at some

future period. This process, which was before but conjectural, or supported by analogy, physiologists considered as fully proved by the effects of madder upon the bones. They had by this means an opportunity of seeing the bones altered in colour, from the slightest tint to the deepest red; they could observe this gradually removed, until the bones had regained their natural whiteness; and explaining the whole process on the principle of deposition and absorption, they considered it as ocular demonstration of a most rapid change in the constituent elements of a part, of which, from its solidity, they could scarcely have believed it susceptible.

I apprehend, however, that it is by giving an erroneous explanation of the phenomena; by supposing that a change in the osseous particles is denoted by an alteration in their colour, that physiologists have considered this fact as conclusive. However indubitable and well supported may be the opinion, which attributes an imperceptible change to the various parts of the body, we shall, I believe, discover upon a more close examination, that it is by no means supported by the appearances, which the bones display on the exhibition of madder root. The rapid change in their particles, which such ap-

pearances indicate, when explained in the common way ; is completely at variance with all the processes performed by the bones, both in their healthy and diseased states. Thus we find the formation of the ossific matter, called Callus, for the union of fractured bones ; or the exfoliation of a part of a bone, are processes requiring a considerable length of time for their performance. In Dr. M'Donald's experiments, the formation of a regenerated bone required nearly six weeks ; but during the same space of time, the bones of the same animal would be renewed several times, if the common explanation of the communication and disappearance of the tinge of madder were well founded. From these circumstances, I am led to believe, that the appearances produced by the exhibition of madder, require another mode of explanation. That which I have to offer is not liable to the same objections, and is strongly supported by comparative experiments.

It was observed by Du Hamel, in his experiments, that the bones of animals, which had been deeply tinged by madder, by long exposure to air lost their colour and became white. It was this fact which suggested to me a simple explanation of the process. It occurred to me, that if any one of the component parts

of the blood naturally exerted a stronger attraction for the colouring matter of madder, than the phosphate of lime, it might be deprived of the tint by a chemical power. In order to prove this, as far as I could by experiment, I took one dram of the phosphate of lime tinged, as in Dr. Rutherford's experiment, and exposed it for half an hour to the action of two ounces of fresh serum, at the temperature of 98 degrees. By this operation, the serum gradually acquired a red tinge, whilst the phosphate of lime, was proportionably deprived of colour. In a comparative experiment, a similar quantity of tinged phosphate of lime, was exposed to the action of distilled water under similar circumstances; but no change took place. The knowledge of this strong affinity, in the serum for colouring matter, affords an easy and simple explanation of the effects of madder on the bones, upon the principle of chemical attraction.

Thus, when an animal has madder mixed with its food, the blood becomes highly charged with it, and imparts the superabundant colouring matter to the phosphate of lime, contained in the bones already formed; as it circulates through them and moistens them throughout. But as soon as an animal has ceased to receive the madder, and the blood

is freed from the colouring matter by the excretions, the serum then exerts its superior attraction, and by degrees entirely abstracts it from the phosphate of lime, and the bones resume their natural whiteness. In short, the bones are at one time dyed by the colouring matter, at another time bleached by the serum.

Whilst I have attempted to explain the probable manner in which the bones, *already formed* in an animal, at one time receive, and at another are deprived of the colouring matter of madder, I by no means intend to assert ; that the phosphate of lime does not acquire a similar colour during its solution in the serum, or at the time it is precipitated from it to enter into the composition of the bones ; the fact is indisputable. I have, however, found from some experiments lately made upon a hen during oviparation, that only a slight tinge can be communicated to the shell, formed whilst a large quantity of colouring matter is circulating with the blood. So slight indeed is the blush, that it would not be seen by a common observer, unless contrasted with a natural egg : which is probably the reason why it has, I believe, been denied by physiologists, that the shell of the egg is altered by the exhibition of madder. If this may be con-

sidered as a test of the quantity of colouring matter, which the phosphate attracts at the time it is separated from the blood, it forms another strong argument against the theory, which Dr. Rutherford, and all preceding physiologists have adopted; for, consistent with this fact, the bones should never exhibit more than a slight blush. When explained upon the principle of chemical attraction, we see that the phenomena, exhibited by the bones of an animal, by giving or withholding madder root, give no support to the opinion that the various parts of the body continually undergo an imperceptible change; and I consider it a fortunate circumstance for that doctrine, that so simple an explanation of the effect of madder can be given. For whilst so specious a fact has been considered, by the highest authorities, as complete proof of the imperceptible renovation of parts; the rapid change in the constituent elements of the bones, which the communication and disappearance of the colour indicates, must have appeared astonishing to every physiologist. Of this I cannot give you a stronger instance than in the words of Mr. J. Bell.* “Nothing,” says he, “can be more curious than this continual renovation and change

* *Anatomy of the bones, &c.* p. 13.

“ of parts even in the hardest bones. We are
 “ accustomed to say of the whole body, that it
 “ is daily changed; that the older particles
 “ are removed, and new ones supply their
 “ place; that the body is not now the same
 “ individual body, that it was; but it could
 “ not be easily believed that we speak only
 “ by guess concerning the softer parts, which
 “ we know for certain of the bones.—When
 “ madder is given to animals, withheld for
 “ some time and then given again, the colour
 “ appears in their bones, is removed, and ap-
 “ pears again with such a sudden change, as
 “ proves a rapidity of deposition and absorption
 “ exceeding all likelihood or belief; all the
 “ bones are tinged in twenty-four hours; in
 “ two or three days their colour is very deep,
 “ and if the madder be left off but for a few
 “ days, the red colour is entirely removed.”

Although by this chemical explanation of
 the effect of madder upon the bones, the doc-
 trine of the imperceptible change in the com-
 ponent parts of animal bodies, loses the support
 of a fact, which has, since its discovery, been
 universally considered as its strongest proof;
 nevertheless, indisputable arguments, derived
 from different sources, still place that doctrine
 amongst the best supported opinions in phy-
 siology.