Proceedings of the Royal Society of Edinburgh

<http://journals.cambridge.org/PRE>

Additional services for *Proceedings of the Royal Society of Edinburgh*:

Email alerts: [Click here](#)

Subscriptions: [Click here](#)

Commercial reprints: [Click here](#)

Terms of use : [Click here](#)

On the Blood of the Invertebrata.

Dr A. B. Griffiths

Proceedings of the Royal Society of Edinburgh / Volume 18 / January 1892, pp 288 - 294

DOI: 10.1017/S0370164600007471, Published online: 15 September 2014

Link to this article: http://journals.cambridge.org/abstract_S0370164600007471

How to cite this article:

Dr A. B. Griffiths (1892). On the Blood of the Invertebrata. .
Proceedings of the Royal Society of Edinburgh, 18, pp 288-294
doi:10.1017/S0370164600007471

Request Permissions : [Click here](#)

On the Blood of the Invertebrata. By Dr A. B. Griffiths,
F.R.S.E., F.C.S., &c.

(Read 1st June 1891.)

I. *The Gases of the Blood*.—As very little is known concerning the composition and nature of the gases in the blood of the *Invertebrata*, the following notes may be of some value.

The author has ascertained the approximate composition of the gases in the blood of certain Invertebrate animals. The apparatus used for this purpose was that of Gautier slightly modified (fig. 1); and the method allows the collection of the blood *in vacuo* (from the time of leaving the vein, &c.) without any alteration in its composition. The glass receiver ACD (left-hand figure), in which the vacuum is made, has a canula E fastened to its lower end. The canula is drawn out into a fine capillary point, which is pushed into the artery, vein, or under the hypodermis, as the case may be. After introducing the canula into the blood system, the tap B is opened and the blood rises into the receiver. The gases are evolved almost immediately, and by means of the pump they are collected over mercury in the tube *ab*, where their composition is ascertained.

After the introduction of the blood into the receiver the tap B is turned off; the receiver is then attached to the pump. Before opening the tap A, the receiver is placed in a bath of water heated to about 40° C. The heat assists in the liberation of the gases from the blood. Coagulation is prevented by previously introducing a small quantity of sodium chloride into the receiver (*i.e.*, before the introduction of the blood).*

The pump and pneumatic trough do not require description, as they are of the usual kind. The volume of the mixed gases collected in *ab* having been ascertained, the percentage of each gas is estimated by the ordinary methods of gas analysis. The carbonic

* The liberation of carbonic anhydride is accelerated by previously introducing into the receiver a small quantity of a hot solution of tartaric acid.

FIG. 1.

Apparatus for Extracting, &c., the Gases of the Blood.

anhydride is absorbed by potash, the oxygen by pyrogallie acid, whilst the amount of nitrogen is represented by what remains.

(a) *Blood of Sepia officinalis.*

100 volumes of the blood of the cuttle-fish contained the following volumes of the three gases—the volumes being reduced to 0° C. and 760 mm. :—

	I.	II.	III.	IV.	V.	VI.
Oxygen, . . .	13·26	12·91	13·14	14·62	14·21	14·34
Carbonicanhydride,	30·12	31·21	32·10	30·14	29·12	29·89
Nitrogen, . . .	1·60	2·00	1·51	1·41	1·73	1·23

The nitrogen is simply dissolved in the blood, but the oxygen and carbonic anhydride are partly dissolved, and partly in a state of loose chemical combination with certain constituents of the blood. The oxygen with the hæmocyannin ; and possibly the greater part of the carbonic anhydride is united to certain salts contained in the blood.

(b) *Blood of Cancer pagurus.*

The blood was obtained from very large individuals, by opening the carapace and passing the capillary point of the canula directly into the heart.

100 volumes of the blood yielded the following volumes of oxygen, carbonic anhydride, and nitrogen, after being reduced to 0° C. and 760 mm. :—

	I.	II.	III.	IV.
Oxygen,	14·79	14·88	14·96	14·85
Carbonic anhydride, . . .	28·62	27·21	27·14	28·39
Nitrogen,	1·01	1·20	1·22	1·30

(c) Blood of Palinurus vulgaris.

100 volumes of the blood of this animal gave the following results :—

	I.	II.	III.	IV.
Oxygen,	14·62	14·71	14·29	14·76
Carbonic anhydride,	30·00	29·62	28·92	29·79
Nitrogen,	1·82	1·60	1·20	1·34

(d) Blood of Homarus vulgaris.

100 volumes of the blood obtained from several large lobsters yielded the following results :—

	I.	II.	III.
Oxygen,	14·99	14·81	14·85
Carbonic anhydride,	31·11	28·84	29·26
Nitrogen,	1·76	1·82	1·85

(e) Blood of Octopus vulgaris.

100 volumes of the blood yielded the following results :—

	I.	II.	III.
Oxygen,	13·33	13·28	13·65
Carbonic anhydride,	30·23	31·29	31·22
Nitrogen,	1·45	1·30	1·29

(f) Blood of Acherontia atropos.

100 volumes of the blood of the larvæ of this moth yielded the following results :—

	I.	II.
Oxygen,	16·21	16·79
Carbonic anhydride,	32·92	34·24
Nitrogen,	1·09	1·98

It may be stated that the oxygen and carbonic anhydride in the blood of the *Invertebrata* do not behave according to the law of Dalton (the law of partial pressures) in regard to the absorption of a mixture of gases by a simple fluid. A portion of each gas combines chemically with some constituent or constituents of the blood. It was Magnus (*Poggendorff's Annalen*, vol. xl. p. 583) who first demonstrated that the carbonic anhydride and oxygen of the Vertebrate blood did not obey the law of Dalton; and the same is true concerning the gases of the blood of the *Invertebrata*.

II. *The Mineral Matter in the Blood.*—The percentages of saline matter contained in the blood of various Invertebrates is given in the following table:—

	I.	II.	III.	Average.	
Pulmo- gastero- poda.	<i>Helix pomatia</i> ,	1·065	1·072	1·069	1·068
	<i>Helix aspersa</i> ,	1·079	1·080	1·062	1·077
	<i>Limnæus stagnalis</i> ,	1·200	1·203	1·210	1·204
	<i>Limax flavus</i> ,	1·122	1·100	1·115	1·112
	<i>Limax maximus</i> ,	1·119	1·127	1·114	1·120
Branchio- gastero- poda.	<i>Buccinum undatum</i> ,	1·699	1·710	1·698	1·702
	<i>Patella vulgata</i> ,	1·706	1·721	1·719	1·715
	<i>Anodonta cygnea</i> ,	1·002	0·998	1·006	1·002
	<i>Mytilus edulis</i> ,	1·796	1·799	1·810	1·801
Cepha- lopoda.	<i>Sepia officinalis</i> ,	2·840	2·862	2·851	2·851
	<i>Octopus vulgaris</i> ,	3·004	3·032	3·020	3·018

The author has also submitted to analysis the ashes of the blood of several Invertebrate animals. The ashes were obtained by incinerating the blood, partially covered, in a platinum dish at a very low temperature. By so doing the alkaline metals are not volatilised as they are when a high temperature is used. The following results represent the averages of three analyses in each case:—

	<i>Cancer pagurus.</i>	<i>Carcinus menas.</i>	<i>Astacus fluviatilis.</i>	<i>Palinurus vulgaris.</i>	<i>Homarus vulgaris.</i>
Copper oxide (CuO), .	0·22	0·19	0·20	0·18	0·18
Iron oxide (Fe ₂ O ₃), .	trace.	trace.	...	...	trace.
Lime (CaO), .	3·55	3·57	3·58	3·79	3·54
Magnesia (MgO), .	1·91	1·89	1·88	1·90	1·89
Potash (K ₂ O), .	4·97	4·78	4·82	4·92	4·77
Soda (Na ₂ O), .	43·90	44·91	44·98	43·98	44·99
Phosphoric acid (P ₂ O ₅), .	4·90	4·86	4·81	4·87	4·84
Sulphuric acid (SO ₃), .	2·90	2·81	2·75	2·86	2·81
Chlorine, .	37·65	36·98	37·00	37·50	36·96
	100·00	99·99	100·00	100·00	99·98

	<i>Anodonta cygnea.</i>	<i>Mytilus edulis.</i>	<i>Pinna squamosa.</i>	<i>Sepia officinalis.</i>	<i>Octopus vulgaris.</i>
Copper oxide (CuO), .	0·23	0·22	trace.	0·24	0·21
Manganese oxide (MnO ₂), .	...	trace.	0·19	...	...
Iron oxide (Fe ₂ O ₃), .	...	...	trace.	...	...
Lime (CaO), .	3·61	3·72	3·70	2·31	2·40
Magnesia (MgO), .	1·82	1·86	1·83	1·51	1·55
Potash (K ₂ O), .	4·90	4·80	4·86	4·92	4·90
Soda (Na ₂ O), .	44·18	43·90	44·02	45·40	45·31
Phosphoric acid (P ₂ O ₅), .	4·89	4·82	4·79	4·90	4·88
Sulphuric acid (SO ₃), .	2·80	2·76	2·73	2·81	2·83
Lithium,* .	trace.	...	...	...	...
Chlorine, .	37·55	37·92	37·88	37·90	37·92
	99·98	100·00	100·00	99·99	100·00

There is no doubt, from the above analyses, that copper † plays an important part in the blood of the *Invertebrata*; in fact it plays a similar rôle to iron in the blood of the higher *Vertebrata*. ‡

In the majority of the *Invertebrata* the carrier of oxygen to the tissues is hæmocyanin§ contained in the blood; but in many of the *Annelida*, as well as in nearly all *Vertebrates*, the transport of oxygen from the surrounding medium (air or water) to the living tissues is made by means of the hæmoglobin of the blood.

* Detected by the spectroscope.

† See Dr Griffiths' paper in *Chemical News*, vol. 48, p. 37; also *Journal Chemical Society*, 1884, p. 94.

‡ In *Pinna squamosa*, the copper is replaced by manganese.

§ Fredericq in *Archives de Zoologie Expérimentale*, 1878; see also his book *La Lutte pour l'Existence*, p. 84.

This substance (as is well known) forms an oxygenised combination which is very unstable, and which is carried by the blood across the tissues of the animal, and is there dissociated, yielding its oxygen to the elements of those tissues which require it.

Professor Ray Lankester discovered that in some of the *Annelida* the hæmoglobin is replaced by a green-colouring matter—chlorocruorin; but in the majority of these animals hæmoglobin is present, which the author has proved to be similar in composition to that present in the higher animals. Concerning this point, the author obtained the blood of 500 earthworms (*Lumbricus terrestris*) which was treated with benzene. The mixture (in solution) was allowed to stand for twenty-four hours at 0° C., when it separated into two distinct layers. The one containing the colouring matter was now separated from the other; and about one-sixth its volume of pure absolute alcohol was added. After filtration the alcoholic extract was exposed to -12° C., when red crystals were obtained. These crystals yielded the following results on analysis:—

	Blood of <i>Lumbricus</i> .			Blood of Dog.
	I.	II.	III.	
Carbon, . . .	53·91	53·86	...	52·85
Hydrogen, . . .	7·02	7·10	...	7·32
Nitrogen, . . .	...	...	...	16·17
Sulphur, . . .	0·41	0·37	...	0·39
Iron, . . .	...	...	0·39	0·43
Oxygen, . . .	...	...	...	21·84

The above analyses prove that the colouring matter of the blood of *Lumbricus* is comparable chemically to that of a Vertebrate animal—like the dog. The spectrum of this colouring matter is identical with that of Vertebrate hæmoglobin.

Although hæmoglobin is present in the blood of certain Invertebrates, the chief constituent in the blood of the majority of these animals is hæmocyanin—a compound analogous to hæmoglobin, but containing copper instead of iron.*

* Concerning the *coagulation* of the blood of certain Invertebrates, the reader is referred to the important paper by Drs J. B. Haycraft and E. W. Carlier in the *Proc. Roy. Soc. Edin.*, vol. xv., p. 423.