PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Quantitative Examination by the Carbon Balance Sheet Method of the Types of Products Formed from Glucose by Miscellaneous Species of Fungi

John Howard Birkinshaw, John Henry Victor Charles, Arthur Clement Hetherington and Harold Raistrick

Phil. Trans. R. Soc. Lond. B 1931 **220**, 99-125
doi: 10.1098/rstb.1931.0017

Studies in the Biochemistry of Micro-organisms.

Part VI.—*Quantitative examination by the carbon balance sheet method of the types of products formed from glucose by miscellaneous species of fungi.*

By John Howard Birkinshaw, John Henry Victor Charles, Arthur Clement Hetherington *and* Harold Raistrick.

In view of the encouraging results obtained from the preparation of carbon balance sheets, particularly for species of *Aspergillus* and *Penicillium*, the work was now extended to include a number of varied species of fungi belonging to many other genera. The carbon balance sheets for these miscellaneous species are given in this paper. The conditions of working adopted were exactly the same as those previously used and described in detail in Parts II and III. The results are arranged under the different genera according to the species of fungi investigated, and include the following :—

Class : ASCOMYCETES.

Genus 1. *Sordaria*, 1 species.
Genus 2. *Chætomium*, 1 species.
Genus 3. *Sclerotinia* (conidial form = *Botrytis*), 1 species.

Class : BASIDIOMYCETES.

Genus 1. *Ustilago*, 2 species.

FUNGI IMPERFECTI.

Order : HYPHOMYCETALES.

Family : Moniliaceæ.

Genus 1. *Eidamia*, 2 species.
Genus 2. *Sporotrichum*, 2 species.
Genus 3. *Trichoderma*, 2 species.
Genus 4. *Cephalothecium*, 1 species.

Family : Dematiaceæ.

Genus 1. *Cladosporium*, 5 species.
Genus 2. *Helminthosporium*, 6 species.
Genus 3. *Heterosporium*, 2 species.
Genus 4. *Alternaria*, 3 species.
Genus 5. *Fumago*, 2 species.
Genus 6. *Clasterosporium*, 2 species.
Genus 7. *Rhacodium*, 1 species.

Family: STILBACEÆ.
Genus 1. *Stysanus*, 1 species.

Family: TUBERCULARIACEÆ.
Genus 1. *Fusarium* (see Part V).
Genus 2. *Epicoccum*, 2 species.

Class: ASCOMYCETES.

The following is the history of the species included in this class:—

Genus 1. *Sordaria*, 1 species.

Sordaria species, Catalogue No. Ae. 11. Isolated at Ardeer from decaying cotton sludge from methane plant.

Genus 2. *Chætomium*, 1 species.

Chætomium species, Catalogue No. Ae. 2. Isolated by Mr. F. T. BROOKS, of Cambridge, from waste paper.

Genus 3. *Sclerotinia* (conidial form).

Botrytis cinerea PERSOON, Catalogue No. Ae. 4. Isolated at Ardeer from decaying rosebud.

The carbon balance sheets of these three species are given in Table I.

None of these species grows particularly well on the CZAPEK-DOX solution used. The three carbon balance sheets show nothing of any particular biochemical interest except in the case of *Sordaria* species. This fungus gives rise to comparatively large amounts of volatile neutral compounds (alcohol) from glucose and has a fairly high respiration coefficient (1·56). In all other respects the main function of these three species seems to be to convert glucose into carbon dioxide.

Class: BASIDIOMYCETES.

Genus. *Ustilago*, 2 species.

(1) *Ustilago Mayidis* (D.C.) CORDA, Catalogue No. Af. 8. Purchased from Centraalbureau voor Schimmelcultures at Baarn.

(2) *Ustilago avenæ* (PERS.) JENSEN, Catalogue No. Af. 7. Purchased from Baarn.

The carbon balance sheets for these two species are given in Table II.

These two species, and in particular *Ustilago avenæ*, were exceptionally difficult to cultivate on CZAPEK-DOX solution. Their carbon balance sheets are uninteresting, as they do not give rise to appreciable amounts of any metabolic products except carbon dioxide.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

TABLE I.—Carbon balance sheets for three species of *Ascomycetes*.

Species of *Ascomycetes* :	*Sordaria* species.	*Chætomium* species.	*Sclerotinia*.
Catalogue number :	Ae. 11	Ae. 2	Ae. 4
Experiment number :	E 1	E 2	E 3
Incubation period in days :	90	70	86
Carbon Balance Sheet.			
Carbon in solution (start) ... ... gm.	4·901	5·043	5·043
Carbon in H_2SO_4 ... ... ,,	0·016	nil	0·002
,, in CO_2 ... ... ,,	1·641	1·294	1·680
,, in mycelium ... ... ,,	0·364	0·671	1·099
,, in solution (end) ... ... ,,	2·747	2·940	2·107
,, accounted for ... ... ,,	4·768	4·905	4·888
,, accounted for ... ... per cent.	97·3	97·3	96·9
Analysis of Solution.			
Carbon in residual glucose ... ... gm.	1·251	2·624	1·574
,, in CO_2 in solution ... ... ,,	0·009	0·039	0·001
,, in volatile acids ... ... ,,	0·005	—	0·009
,, in non-volatile acids ... ... ,,	0·039	0·130	0·102
,, in volatile neutral compounds ... ... ,,	1·156	0·001	0·015
,, in synthetic compounds ... ... ,,	0·050	0·077	0·064
Total carbon accounted for ... ... ,,	2·510	2·871	1·765
,, ,, in solution ... ... ,,	2·747	2·940	2·107
Carbon unaccounted for (by difference) ... ... ,,	0·237	0·069	0·342
Residual Glucose.			
Glucose (by polarimeter) ... ... per cent.	0·734	1·430	0·826
,, (SHAFFER-HARTMANN) ... ... ,,	0·625	1·312	0·787
,, (WOOD-OST)... ... ... ,,	0·603	1·328	0·744
,, (by alkaline iodine) ... ... ,,	0·653	1·380	0·813
Acids.			
Titration (N/1 acid) ... ... c.c.	0·2	Decrease of 0·8	0·6
Volatile acids (N/1 acid) ... ... ,,	—	—	0·32
Barium salts (weight) ... ... gm.	0·038	—	0·021
Calcium salts (weight) ... ... ,,	0·295	0·782	0·457
Volume of oxygen absorbed ... ... c.c.	1974	2049	2739
Respiration coefficient	1·56	1·22	1·15
Mycelium (weight) ... ... gm.	0·730	1·264	1·903
,, (carbon) ... ... per cent.	49·8	53·1	57·8

TABLE II.—Carbon balance sheets for species of *Ustilago*.

Species of *Ustilago*:	*U. Mayidis.*	*U. avenæ.*
Catalogue number:	Af. 8	Af. 7
Experiment number:	D 1	D 2
Incubation period in days:	80	124
Carbon Balance Sheet.		
Carbon in solution (start) ... ... gm.	4·901	5·043
Carbon in H_2SO_4 ... ... ,,	Nil	0·001
,, in CO_2... ... ... ,,	1·440	0·933
,, in mycelium ... ... ,,	0·878	0·526
,, in solution (end) ... ... ,,	2·485	3·416
,, accounted for ... ... ,,	4·803	4·876
,, accounted for ... ... per cent.	98·0	96·7
Analysis of Solution.		
Carbon in residual glucose ... ... gm.	1·994	3·002
,, in CO_2 in solution ... ... ,,	0·005	0·002
,, in volatile acids ... ... ,,	0·022	Nil
,, in non-volatile acids ... ... ,,	0·119	0·170
,, in volatile neutral compounds ... ... ,,	0·006	Nil
,, in synthetic compounds ... ... ,,	0·106	0·081
Total carbon accounted for ... ... ,,	2·252	3·255
,, ,, in solution ... ... ,,	2·485	3·416
Carbon unaccounted for (by difference) ... ... ,,	0·233	0·161
Residual Glucose.		
Glucose (by polarimeter) ... ... per cent.	1·046	1·602
,, (SHAFFER-HARTMANN) ... ... ,,	0·997	1·501
,, (WOOD-OST) ... ... ,,	1·016	1·523
,, (by alkaline iodine) ... ... ,,	1·085	1·558
Acids.		
Titration (N/1 acid) ... ... c.c.	Decrease of 0·2	Decrease of 0·9
Volatile acids (N/1 acid) ... ... ,,	1·26	0·98
Barium salts (weight) ... ... gm.	0·088	0·007
Calcium salts (weight) ... ... ,,	0·580	0·785
Volume of oxygen absorbed ... ... c.c.	2309	1734
Respiration coefficient	1·17	1·01
Mycelium (weight) ... ... gm.	1·561	1·012
,, (carbon) ... ... per cent.	56·2	52·0

FUNGI IMPERFECTI.

Order : HYPHOMYCETALES.

Family : Moniliaceæ.

Genus 1. *Eidamia*, 2 species.

(1) *Eidamia viridescens* Horne et Williamson, Catalogue No. Ac. 75. Received from Dr. A. S. Horne, Imperial College of Science and Technology.

(2) *Eidamia catenulata* Horne et Williamson, Catalogue No. Ac. 76. Received from Dr. Horne.

The carbon balance sheets for these two species are given in Table III.

The general characteristics of the above species of *Eidamia* are given by Horne (A. S.), and Williamson (H. S.) in a paper on "The Morphology and Physiology of the Genus *Eidamia*," 'Annals of Botany,' Vol. 37 (1923), p. 393. To quote from their paper, p. 393, "The genus *Eidamia* was founded by Lindau to include fungi which bear a general resemblance to *Aspergillus*, but differ from it in possessing not only conidia, but also spores of a second type." This is particularly interesting since the carbon balance sheets for both species are of the type associated with certain species of *Aspergillus*. The production of large amounts of volatile neutral compounds, with correspondingly high respiration coefficients, absence of volatile acids, production of moderate amounts of titratable acidity, together with moderate amounts of carbon in the form of non-volatile acids, and a moderate value for "carbon unaccounted for," all suggest the type of carbon balance sheet associated with *A. clavatus*, or some strains of *A. niger*. It is also of interest to note that these two different species of *Eidamia* have similar types of carbon balance sheets.

Genus 2. *Sporotrichum*, 2 species.

(1) *Sporotrichum carneolum*, Catalogue No. Ag. 23. Isolated from meat by Mr. F. T. Brooks, of Cambridge.

(2) *Sporotrichum bombycinum* (Corda) Rab., Catalogue No. Ag. 25. Received from Baarn via Mr. F. T. Brooks, of Cambridge.

The carbon balance sheets for these two species, which are given in Table IV, are both of the same type. Neither species gives rise to an appreciable amount of any metabolic product other than CO_2, and both of them produce an actual decrease in the original acidity of the medium. They both grow quite well on the Czapek-Dox medium used, but require a considerable time to metabolize even a moderate amount of glucose.

TABLE III.—Carbon balance sheets for species of *Eidamia*.

Species of *Eidamia* :	*E. viridescens.*	*E. catenulata.*
Catalogue number :	Ac. 75	Ac. 76
Experiment number :	102	103
Incubation period in days :	45	35
Carbon Balance Sheet.		
Carbon in solution (start) ... ... gm.	4·834	4·834
Carbon in H_2SO_4 ... ... ,,	0·013	0·006
,, in CO_2... ... ... ,,	1·802	1·063
,, in mycelium ... ... ,,	0·583	0·443
,, in solution (end) ... ... ,,	2·376	3·168
,, accounted for ... ... ,,	4·774	4·682
,, accounted for ... ... per cent.	98·8	96·9
Analysis of Solution.		
Carbon in residual glucose ... ... gm.	0·777	1·812
,, in CO_2 in solution ... ... ,,	0·009	0·011
,, in volatile acids ... ... ,,	Nil	Nil
,, in non-volatile acids ... ... ,,	0·254	0·141
,, in volatile neutral compounds ... ... ,,	0·952	0·839
,, in synthetic compounds ... ... ,,	0·125	0·061
Total carbon accounted for ... ... ,,	2·117	2·864
,, ,, in solution ... ... ,,	2·376	3·168
Carbon unaccounted for (by difference) ... ... ,,	0·259	0·304
Residual Glucose.		
Glucose (by polarimeter) ... ... per cent.	0·367	0·911
,, (SHAFFER-HARTMANN) ... ... ,,	0·388	0·906
,, (WOOD-OST) ... ... ,,	0·388	0·978
,, (by alkaline iodine) ... ... ,,	0·425	0·963
Acids.		
Titration (N/1 acid) ... ... c.c.	4·3	2·7
Volatile acids (N/1 acid) ... ... ,,	Nil	0·44
Barium salts (weight) ... ... gm.	Nil	0·008
Calcium salts (weight) ... ... ,,	1·027	0·621
Volume of oxygen absorbed ... ... c.c.	2129	1190
Respiration coefficient	1·59	1·69
Mycelium (weight) ... ... gm.	1·146	0·901
,, (carbon) ... ... per cent.	50·9	49·4

TABLE IV.—Carbon balance sheets for species of *Sporotrichum*.

Species of *Sporotrichum* :	*S. carneolum.*	*S. bombycinum.*
Catalogue number :	Ag. 23	Ag. 25
Experiment number :	C 2	C 3
Incubation period in days :	83	82
Carbon Balance Sheet.		
Carbon in solution (start) ... ... gm.	4·901	4·901
Carbon in H_2SO_4 ... ... ,,	0·001	0·001
,, in CO_2... ... ... ,,	1·715	1·192
,, in mycelium ... ... ,,	0·780	1·041
,, in solution (end) ... ... ,,	2·303	2·439
,, accounted for ... ... ,,	4·799	4·673
,, accounted for ... ... per cent.	97·9	95·4
Analysis of Solution.		
Carbon in residual glucose ... ... gm.	1·780	1·802
,, in CO_2 in solution ... ... ,,	0·016	0·038
,, in volatile acids ... ... ,,	0·024	0·016
,, in non-volatile acids ... ... ,,	0·223	0·182
,, in volatile neutral compounds ... ... ,,	0·001	0·003
,, in synthetic compounds ... ... ,,	0·137	0·152
Total carbon accounted for ... ... ,,	2·181	2·193
,, ,, in solution ... ... ,,	2·303	2·439
Carbon unaccounted for (by difference) ... ... ,,	0·122	0·246
Residual Glucose.		
Glucose (by polarimeter) ... ... per cent.	0·896	0·910
,, (SHAFFER-HARTMANN) ... ... ,,	0·890	0·901
,, (WOOD-OST) ... ... ,,	0·920	0·916
,, (by alkaline iodine) ... ... ,,	0·938	0·963
Acids.	Decrease of	Decrease of
Titration (N/1 acid) ... ... c.c.	0·1	0·7
Volatile acids (N/1 acid) ... ... ,,	2·58	1·19
Barium salts (weight) ... ... gm.	0·110	0·066
Calcium salts (weight) ... ... ,,	0·899	0·994
Volume of oxygen absorbed ... ... c.c.	2788	1797
Respiration coefficient	1·16	1·28
Mycelium (weight) ... ... gm.	1·526	2·001
,, (carbon) ... ... per cent.	51·1	52·0

Genus 3. *Trichoderma*, 2 species.

(1) *Trichoderma* species, Catalogue No. Ag. 47. Isolated at Ardeer from pale green spots on wood.

(2) *Trichoderma lignorum* (Tode.) Harz, Catalogue No. Ag. 22. Isolated at Ardeer from beech bark.

The carbon balance sheets for these two species are given in Table V.

Neither of the species of *Trichoderma* investigated grew well on Czapek-Dox solution, as judged by the weight of mycelium produced. They both give the same type of balance sheet, which indicates, in both cases, the production of considerable amounts of volatile neutral compounds. There are no other items of particular interest in either of the balance sheets.

Genus 4. *Cephalothecium*, 1 species.

(1) *Cephalothecium roseum* Corda, Catalogue No. Ag. 21. Isolated at Ardeer from a decaying twig.

The carbon balance sheet for this species, which is given in Table VI, shows no characteristics of any particular interest. This species grew well on Czapek-Dox solution, but was only able to metabolise very slowly the glucose supplied, since, even after 67 days, only about 65 per cent. of the glucose had been utilised. It apparently gives rise to no metabolic product other than carbon dioxide, in appreciable amounts.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

TABLE V.—Carbon balance sheets for species of *Trichoderma*.

Species of *Trichoderma* :	*T.* species.	*T. lignorum.*
Catalogue number :	Ag. 47	Ag. 22
Experiment number :	C 4	C 6
Incubation period in days :	50	79
Carbon Balance Sheet.		
Carbon in solution (start) ... ... gm.	5·043	5·043
Carbon in H_2SO_4 ... ... ,,	0·009	0·011
,, in CO_2... ... ... ,,	1·474	1·320
,, in mycelium ... ... ,,	0·220	0·375
,, in solution (end) ... ... ,,	3·086	3·141
,, accounted for ... ... ,,	4·789	4·847
,, accounted for ... ... per cent.	95·0	96·1
Analysis of Solution.		
Carbon in residual glucose ... ... gm.	1·978	2·454
,, in CO_2 in solution ... ... ,,	0·008	0·006
,, in volatile acids ... ... ,,	0·028	0·011
,, in non-volatile acids ... ... ,,	0·098	0·118
,, in volatile neutral compounds ... ... ,,	0·620	0·383
,, in synthetic compounds ... ... ,,	0·147	0·104
Total carbon accounted for ... ... ,,	2·879	3·076
,, ,, in solution ... ... ,,	3·086	3·141
Carbon unaccounted for (by difference) ... ... ,,	0·207	0·065
Residual Glucose.		
Glucose (by polarimeter) ... ... per cent.	1·090	1·209
,, (SHAFFER-HARTMANN) ... ... ,,	0·989	1·227
,, (WOOD-OST) ... ... ,,	1·028	1·212
,, (by alkaline iodine) ... ... ,,	1·094	1·247
Acids.		Decrease of
Titration (N/1 acid) ... ... c.c.	2·5	0·5
Volatile acids (N/1 acid) ... ... ,,	1·77	—
Barium salts (weight) ... ... gm.	0·131	0·042
Calcium salts (weight) ... ... ,,	0·498	0·684
Volume of oxygen absorbed ... ... c.c.	1984	2061
Respiration coefficient	1·40	1·20
Mycelium (weight) ... ... gm.	0·407	0·759
,, (carbon) ... ... per cent.	54·1	49·4

TABLE VI.—Carbon balance sheet for a species of *Cephalothecium*.

Species of *Cephalothecium* :	*C. roseum.*
Catalogue number :	Ag. 21
Experiment number :	C 1
Incubation period in days :	67
Carbon Balance Sheet.	
Carbon in solution (start) ... ... gm.	5·018
Carbon in H_2SO_4... ... ... ,,	0·001
,, in CO_2 ... ... ,,	1·780
,, in mycelium ... ... ,,	0·853
,, in solution (end) ... ... ,,	2·287
,, accounted for ... ... ,,	4·921
,, accounted for ... ... per cent.	98·1
Analysis of Solution.	
Carbon in residual glucose ... ... gm.	1·774
,, in CO_2 in solution ... ... ,,	0·049
,, in volatile acids ... ... ,,	0·053
,, in non-volatile acids ... ... ,,	0·175
,, in volatile neutral compounds ... ... ,,	0·077
,, in synthetic compounds ... ... ,,	0·147
Total carbon accounted for ... ... ,,	2·275
,, ,, in solution ... ... ,,	2·287
Carbon unaccounted for (by difference) ... ... ,,	0·012
Residual Glucose.	
Glucose (by polarimeter) ... ... per cent.	0·918
,, (SHAFFER-HARTMANN) ... ... ,,	0·887
,, (WOOD-OST) ... ... ,,	0·868
,, (by alkaline iodine) ... ... ,,	0·875
Acids.	Decrease of
Titration (N/1 acid) ... ... c.c.	0·7
Volatile acids (N/1 acid) ... ... ,,	2·20
Barium salts (weight) ... ... gm.	0·269
Calcium salts (weight) ... ... ,,	0·763
Volume of oxygen absorbed ... ... c.c.	2867
Respiration coefficient	1·19
Mycelium (weight) ... ... gm.	1·624
,, (carbon) ... ... per cent.	52·5

FUNGI IMPERFECTI.

Order : HYPHOMYCETALES.

Family : Dematiaceæ.

Genus 1. *Cladosporium*, 5 species.

(1) *Cladosporium* species S, Catalogue No. Ag. 1. Isolated from cold storage meat by Mr. F. T. Brooks, of Cambridge.

(2) *Cladosporium* species 1020, Catalogue No. Ag. 3. Isolated from cold storage meat by Mr. F. T. Brooks.

(3) *Cladosporium* species 60, Catalogue No. Ag. 5. Isolated from dead leaves by Mr. F. T. Brooks.

(4) *Cladosporium* species 55, Catalogue No. Ag. 9. Isolated from a maize shoot by Mr. F. T. Brooks.

(5) *Cladosporium* species from lichen, Catalogue No. Ag. 109. Isolated at Ardeer from a lichen.

The carbon balance sheets for these five species are given in Table VII.

All the species of *Cladosporium* grew quite reasonably well on Czapek-Dox solution, but with one exception did not metabolize very quickly the glucose provided. The single exception is *Cladosporium* species 55, which completely destroyed all the glucose in 76 days. From a biochemical point of view, the balance sheets for these five species, which are all of the same type, are very uninteresting, since no compounds of any sort other than carbon dioxide are produced in an appreciable amount. None of these species produced appreciable amounts of acid, either of a volatile or non-volatile nature, and in three cases out of five there is an actual decrease in the titratable acidity of the medium. Of minor interest is the uniformly high percentage of carbon in the mycelium.

Genus 2. *Helminthosporium*, 6 species.

(1) *Helminthosporium geniculatum* Tracy et Earle, Catalogue No. Ag. 93.

(2) *Helminthosporium teres* Sacc., Catalogue No. Ag. 94.

(3) *Helminthosporium inaequalis* Shear., Catalogue No. Ag. 95.

(4) *Helminthosporium* species, Catalogue No. Ag. 96.

(5) *Helminthosporium interseminatum* Berk. et Rav., Catalogue No. Ag. 97.

(6) *Helminthosporium gramineum* Rabenh., Catalogue No. Ag. 98.

All these cultures were purchased from the Centraalbureau voor Schimmelcultures at Baarn.

The carbon balance sheets for these six species, which are given in Table VIII, are all of a similar type, and enable one to classify biochemically, species of *Helminthosporium*

TABLE VII.—Carbon balance sheets for species of *Cladosporium*.

Species of *Cladosporium*:	Species S.	Species 1020	Species 60	Species 55	Species fr. lichen.
Catalogue number:	Ag. 1	Ag. 3	Ag. 5	Ag. 9	Ag. 109
Experiment number:	B 4	B 5	B 7	B 9	B 23
Incubation period in days:	81	72	52	76	50
Carbon Balance Sheet.					
Carbon in solution (start) ... ... gm.	4·901	5·043	5·043	5·043	4·952
Carbon in H_2SO_4 ... ... ,,	Nil	Nil	Nil	0·004	Nil
,, in CO_2 ... ... ,,	1·503	1·230	1·451	2·524	0·892
,, in mycelium ... ... ,,	1·282	0·909	1·260	2·025	0·521
,, in solution (end) ... ... ,,	2·033	2·680	2·115	0·181	3·499
,, accounted for ... ... ,,	4·818	4·819	4·826	4·734	4·912
,, accounted for ... ... per cent.	98·3	96·0	96·2	94·4	99·2
Analysis of Solution.					
Carbon in residual glucose ... ... gm.	1·684	2·432	1·620	0·021	3·186
,, in CO_2 in solution ... ... ,,	0·019	0·015	0·016	0·028	0·009
,, in volatile acids ... ... ,,	0·009	0·007	0·060	0·002	0·009
,, in non-volatile acids ... ... ,,	0·080	0·066	0·103	0·103	0·190
,, in volatile neutral compounds ... ,,	Nil	0·001	0·007	Nil	0·006
,, in synthetic compounds ... ,,	0·051	0·040	0·049	0·006	0·101
Total carbon accounted for ... ... ,,	1·843	2·561	1·855	0·160	3·501
,, ,, in solution ... ... ,,	2·033	2·680	2·115	0·181	3·499
Carbon unaccounted for (by difference) ,,	0·190	0·119	0·260	0·021	Surplus of 0·002
Residual Glucose.					
Glucose (by polarimeter) ... per cent.	0·934	1·318	0·874	0·018	1·354
,, (SHAFFER-HARTMANN) ... ,,	0·842	1·216	0·810	0·011	1·593
,, (WOOD-OST) ... ... ,,	0·880	1·222	0·824	—	1·374
,, (by alkaline iodine) ... ,,	0·863	1·277	0·859	0·019	1·598
Acids.		Decrease of	Decrease of	Decrease of	
Titration (N/1 acid) ... ... c.c.	0·1	0·1	0·3	1·4	0·2
Volatile acids (N/1 acid) ... ... ,,	1·05	0·86	1·91	0·18	0·35
Barium salts (weight) ... ... gm.	0·069	0·036	0·294	0·017	0·075
Calcium salts (weight) ... ... ,,	0·517	0·396	0·585	0·804	0·728
Volume of oxygen absorbed ... ... c.c.	2281	1905	2148	3988	1524
Respiration coefficient	1·25	1·22	1·28	1·20	1·10
Mycelium (weight) ... ... gm.	2·341	1·663	2·230	3·600	0·974
,, (carbon) ... ... per cent.	54·7	54·8	56·5	56·3	53·5

TABLE VIII.—Carbon balance sheets for species of *Helminthosporium*.

Species of *Helminthosporium*:	*H. geniculatum.*	*H. teres.*	*H. inaequalis.*	*H.* species.	*H. interseminatum.*	*H. gramineum.*
Catalogue number:	Ag. 93	Ag. 94	Ag. 95	Ag. 96	Ag. 97	Ag. 98
Experiment number:	B 15	B 16	B 17	B 18	B 19	B 20
Incubation period in days:	53	65	61	63	66	37
Carbon Balance Sheet.						
Carbon in solution (start) ... gm.	4·952	4·952	4·952	4·952	4·952	4·952
Carbon in H_2SO_4 ... ... ,,	0·015	0·003	0·005	0·002	0·001	0·003
,, in CO_2 ... ... ,,	2·017	1·547	2·062	—	1·763	1·350
,, in mycelium ... ,,	0·906	0·700	1·460	0·526	0·630	0·659
,, in solution (end) ... ,,	1·827	2·473	1·242	2·706	2·489	2·783
,, accounted for ... ,,	4·765	4·723	4·769	—	4·883	4·795
,, accounted for per cent.	96·2	95·4	96·3	—	98·8	96·8
Analysis of Solution.						
Carbon in residual glucose... gm.	0·242	2·206	0·964	2·350	2·214	2·384
,, in CO_2 in solution ,,	0·007	0·002	0·008	0·005	0·012	0·032
,, in volatile acids ... ,,	0·029	0·013	0·013	0·013	0·055	0·048
,, in non-volatile acids ,,	0·094	0·077	0·109	0·080	0·148	0·078
,, in volatile neutral compounds ... ... ,,	0·818	0·141	0·048	0·107	0·042	0·258
,, in synthetic compounds,,	0·015	0·020	0·015	0·026	0·058	0·043
Total carbon accounted for ,,	1·205	2·459	1·157	2·581	2·529	2·843
,, ,, in solution ... ,,	1·827	2·473	1·242	2·706	2·489	2·783
Carbon unaccounted for (by difference) ,,	0·622	0·014	0·085	0·125	Surplus of 0·040	Surplus of 0·060
Residual Glucose.						
Glucose (by polarimeter) per cent.	0·100	1·072	0·495	1·120	0·822	1·135
,, (SHAFFER-HARTMANN) per cent.	0·121	1·103	0·483	1·175	1·107	1·192
,, (WOOD-OST) ,,	—	0·954	—	1·134	0·968	1·126
,, (by alkaline iodine) ,,	0·162	1·106	0·493	1·189	1·060	1·167
Acids.		Decrease of	Decrease of	Decrease of		Decrease of
Titration (N/1 acid) ... c.c.	0·3	1·1	0·8	1·2	0·3	0·7
Volatile acids (N/1 acid) ... ,,	1·44	—	0·87	0·68	1·74	1·99
Barium salts (weight) ... gm.	0·154	0·063	0·057	0·049	0·237	0·229
Calcium salts (weight) ... ,,	0·449	0·413	0·571	0·510	0·548	0·783
Volume of oxygen absorbed c.c.	2417	2554	3351	2746	3106	1974
Respiration coefficient	1·56	1·13	1·16	—	1·07	1·31
Mycelium (weight) ... ... gm.	1·577	1·362	2·826	1·008	1·148	1·285
,, (carbon) ... per cent.	57·4	51·4	51·7	52·2	53·7	51·3

with those fungi which produce moderate amounts of volatile neutral compounds (alcohol). All the species grow reasonably well on CZAPEK-DOX solution. None of the species gives rise to appreciable amounts of either carbon as non-volatile acids or as titratable acidity, and in fact, four of the species actually produce a decrease in the initial acidity of the medium. Five out of six species give negligible, or even negative amounts of "carbon unaccounted for," but the other species, *Helminthosporium geniculatum*, provides the first instance so far recorded, in this paper, of any of the miscellaneous fungi worthy of further intensive investigation. This species has a figure for "carbon unaccounted for" of 0·622 gm., corresponding to a yield of 13 per cent. of the glucose fermented. This, together with 0·818 gm. of "carbon as volatile neutral compounds," corresponding to a yield of 17 per cent., gives a total yield of metabolic products other than carbon dioxide of 30 per cent. An investigation has been carried out on the nature of the compounds included in the "carbon unaccounted for" produced by this species, and is reported in Part XVII.

Genus 3. *Heterosporium*, 2 species.

(1) *Heterosporium gracile* SACC., Catalogue No. Ag. 99. Purchased from Baarn.

(2) *Heterosporium variabile* COOKE, Catalogue No. Ag. 100. Purchased from Baarn.

The carbon balance sheets for these two species are given in Table IX. Both species grow well on the CZAPEK-DOX medium, and both give balance sheets of a similar type, *i.e.*, the type producing no volatile neutral compounds. Ag. 100 might, if occasion offered, prove a suitable species for further investigation, since it gives a figure for "carbon unaccounted for" of 0·381 gm. (11 per cent.), and a figure for carbon in non-volatile acids of 0·228 gm. (7 per cent.).

Genus 4. *Alternaria*, 3 species.

(1) *Alternaria* species, Catalogue No. Ag. 35. Isolated at Ardeer from tobacco leaf spots.

(2) *Alternaria* species, Catalogue No. Ag. 16. Isolated at Ardeer from black spots on butter.

(3) *Alternaria* species, Catalogue No. Ag. 49. Isolated at Ardeer from a rotting orange.

The carbon balance sheets for these three species are given in Table X, and are all of the same type. The main metabolic product is that included in "volatile neutral compounds," and while only moderate in amount (limits 0·262 gm. to 0·171 gm.) it is perfectly definite. These three species also have respiration coefficients corresponding to this feature (limits 1·31 to 1·26), but do not give rise to any other metabolic products except a small amount of some compound included in "carbon unaccounted for" (limits 0·285 gm. to 0·209 gm.).

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

TABLE IX.—Carbon balance sheets for species of *Heterosporium*.

Species of *Heterosporium*:	*H. gracile.*	*H. variabile.*
Catalogue number:	Ag. 99	Ag. 100
Experiment number:	B 21	B 22
Incubation period in days:	68	44
Carbon Balance Sheet.		
Carbon in solution (start) ... ... gm.	4·952	4·952
Carbon in H_2SO_4 ... ... ,,	0·001	0·001
,, in CO_2... ... ... ,,	2·256	1·545
,, in mycelium ... ... ,,	1·155	1·031
,, in solution (end) ... ... ,,	1·394	2·268
,, accounted for ... ... ,,	4·806	4·845
,, accounted for ... ... per cent.	97·3	97·8
Analysis of Solution.		
Carbon in residual glucose ... ... gm.	0·975	1·585
,, in CO_2 in solution ... ... ,,	0·016	0·004
,, in volatile acids ... ... ,,	0·041	0·021
,, in non-volatile acids ... ... ,,	0·134	0·228
,, in volatile neutral compounds ... ... ,,	Nil	0·002
,, in synthetic compounds ... ... ,,	0·071	0·047
Total carbon accounted for ... ... ,,	1·237	1·887
,, ,, in solution ... ... ,,	1·394	2·268
Carbon unaccounted for (by difference) ... ... ,,	0·157	0·381
Residual Glucose.		
Glucose (by polarimeter) ... ... per cent.	0·340	0·889
,, (SHAFFER-HARTMANN) ... ... ,,	0·488	0·792
,, (WOOD-OST) ... ... ,,	0·438	0·726
,, (by alkaline iodine) ... ... ,,	0·445	0·831
Acids.	Decrease of	
Titration (N/1 acid) ... ... c.c.	0·6	0·9
Volatile acids (N/1 acid) ... ... ,,	3·95	1·26
Barium salts (weight) ... ... gm.	0·135	0·097
Calcium salts (weight) ... ... ,,	0·431	0·882
Volume of oxygen absorbed ... ... c.c.	3893	2465
Respiration coefficient	1·09	1·17
Mycelium (weight) ... ... gm.	2·330	2·036
,, (carbon) ... ... per cent.	49·6	50·6

TABLE X.—Carbon balance sheets for species of *Alternaria*.

Species of *Alternaria* :	*A.* species.	*A.* species.	*A.* species.
Catalogue number :	Ag. 35	Ag. 16	Ag. 49
Experiment number :	B 6	B 11	B 12
Incubation period in days :	67	44	64
Carbon Balance Sheet.			
Carbon in solution (start) ... ... gm.	5·043	5·043	5·043
Carbon in H_2SO_4 ... ... ,,	0·006	0·006	0·005
,, in CO_2 ... ... ,,	1·188	1·816	2·346
,, in mycelium ... ... ,,	0·433	1·064	1·193
,, in solution (end) ... ... ,,	3·210	1·998	1·266
,, accounted for ... ... ,,	4·837	4·884	4·810
,, accounted for ... ... per cent.	95·9	96·9	95·4
Analysis of Solution.			
Carbon in residual glucose ... ... gm.	2·494	1·300	0·527
,, in CO_2 in solution ... ... ,,	0·011	0·015	0·030
,, in volatile acids ... ... ,,	0·024	0·098	0·021
,, in non-volatile acids ... ... ,,	0·091	0·072	0·145
,, in volatile neutral compounds ... ... ,,	0·262	0·261	0·171
,, in synthetic compounds ... ... ,,	0·059	0·043	0·087
Total carbon accounted for ... ... ,,	2·941	1·789	0·981
,, ,, in solution ... ... ,,	3·210	1·998	1·266
Carbon unaccounted for (by difference) ... ... ,,	0·269	0·209	0·285
Residual Glucose.			
Glucose (by polarimeter) ... ... per cent.	1·426	0·684	0·226
,, (SHAFFER-HARTMANN) ... ... ,,	1·247	0·650	0·263
,, (WOOD-OST)... ... ... ,,	1·254	0·648	—
,, (by alkaline iodine) ... ... ,,	1·342	0·692	0·319
Acids.			
Titration (N/1 acid) ... ... c.c.	Nil	1·0	Decrease of 0·8
Volatile acids (N/1 acid) ... ... ,,	1·28	4·37	0·74
Barium salts (weight) ... ... gm.	0·073	0·517	0·077
Calcium salts (weight) ... ... ,,	0·615	0·354	0·797
Volume of oxygen absorbed ... ... c.c.	1704	2668	3534
Respiration coefficient	1·31	1·28	1·26
Mycelium (weight) ... ... gm.	0·849	1·999	2·237
,, (carbon) ... ... per cent.	51·0	53·2	53·3

Genus 5. *Fumago*, 2 species.

(1) *Fumago* species, Catalogue No. Ag. 63. Isolated at Ardeer as a bench contaminant of beer wort.

(2) *Fumago vagans* PERS., Catalogue No. Ag. 92. Purchased from Baarn.

The carbon balance sheets for these two species are given in Table XI. In the case of *Fumago vagans*, Ag. 92, two balance sheets are given. The first one, B 14, was prepared from a culture grown on the usual CZAPEK-DOX solution containing 0·2 per cent. sodium nitrate as the source of nitrogen. The second balance sheet for this species, B 14 (X), was prepared from a culture grown on a similar CZAPEK-DOX solution in which, however, 0·2 per cent. ammonium nitrate was used as the source of nitrogen in place of the usual 0·2 per cent. sodium nitrate.

Both species of *Fumago* give balance sheets which are decidedly interesting from a biochemical point of view, although they are slightly different in type, because of the fact that, while Ag. 63 gives appreciable amounts of volatile neutral compounds (0·320 gm.), Ag. 92 gives only a negligible amount of the same type of compound (0·010 gm.). Of particular interest is the large amount of "carbon unaccounted for" given by both species and amounting to 0·512 gm. (15 per cent. of the glucose fermented) for Ag. 63, 0·965 gm. (19·8 per cent.) for Ag. 92 on sodium nitrate, and 0·468 gm. (19·5 per cent.) for Ag. 92 on ammonium nitrate. Another interesting feature is the relatively high titratable acidity and "carbon in non-volatile acids," which amounts to 0·189 gm. (5·4 per cent.) for Ag. 63, 0·407 gm. (8·4 per cent.) for Ag. 92 on sodium nitrate, and 0·268 gm. (11 per cent.) for Ag. 92 on ammonium nitrate. There is also a very marked difference in the percentage of glucose estimated by the polarimeter and SHAFFER-HARTMANN methods, for, with Ag. 92 on sodium nitrate, the respective figures are 0·344 and 0·043 per cent., while with the same species on ammonium nitrate the figures are 1·709 and 1·300 per cent. It is thus obvious that this species produces some material from glucose which is optically dextro-rotatory, but which has no reducing effect on alkaline copper solutions.

Both species of *Fumago*, and particularly *Fumago vagans*, Ag. 92, are thus marked out as species worthy of further investigation. An account of the metabolic products isolated from *Fumago vagans*, Ag. 92, is given in Part XVII.

Genus 6. *Clasterosporium*, 2 species.

(1) *Clasterosporium* species, Catalogue No. Ag. 64. Isolated at Ardeer from rotting cotton pulp at the methane plant. Identified by Mr. F. T. BROOKS, of Cambridge.

(2) *Clasterosporium* species, Catalogue No. Ag. 15. Isolated by Mr. F. T. BROOKS from sea-weed.

TABLE XI.—Carbon balance sheets for species of *Fumago*.

Species of *Fumago*:	*Fumago* species.	*Fumago vagans*.	*Fumago vagans* on NH_4NO_3.
Catalogue number:	Ag. 63	Ag. 92	Ag. 92
Experiment number:	B 3	B 14	B 14 (X)
Incubation period in days:	77	75	71
Carbon Balance Sheet.			
Carbon in solution (start) ... ... gm.	5·018	4·952	4·975
Carbon in H_2SO_4 ... ... ,,	0·003	0·001	0·001
,, in CO_2 ... ... ,,	1·472	1·860	0·751
,, in mycelium ... ... ,,	0·651	1·440	0·617
,, in solution (end) ... ... ,,	2·780	1·582	3·544
,, accounted for ... ... ,,	4·906	4·883	4·913
,, accounted for ... ... per cent.	97·8	98·6	97·9
Analysis of Solution.			
Carbon in residual glucose ... ... gm.	1·538	0·087	2·600
,, in CO_2 in solution ... ... ,,	0·008	Nil	Nil
,, in volatile acids ... ... ,,	0·049	0·004	0·047
,, in non-volatile acids ... ... ,,	0·189	0·407	0·268
,, in volatile neutral compounds ... ... ,,	0·320	0·010	0·023
,, in synthetic compounds ... ... ,,	0·164	0·109	0·138
Total carbon accounted for ... ... ,,	2·268	0·617	3·076
,, ,, in solution ... ... ,,	2·780	1·582	3·544
Carbon unaccounted for (by difference) ... ... ,,	0·512	0·965	0·468
Residual Glucose.			
Glucose (by polarimeter) ... ... per cent.	0·794	0·344	1·709
,, (SHAFFER-HARTMANN) ... ... ,,	0·769	0·043	1·300
,, (WOOD-OST) ... ... ,,	0·762	—	1·370
,, (by alkaline iodine) ... ... ,,	0·835	0·117	1·395
Acids.			
Titration (N/1 acid) ... ... c.c.	2·3	7·0	7·6
Volatile acids (N/1 acid) ... ... ,,	3·20	—	2·13
Barium salts (weight) ... ... gm.	0·262	0·016	0·260
Calcium salts (weight) ... ... ,,	0·981	1·363	1·029
Volume of oxygen absorbed ... ... c.c.	2177	3144	1220
Respiration coefficient	1·27	1·11	1·15
Mycelium (weight) ... ... gm.	1·224	2·917	1·218
,, (carbon) ... ... per cent.	53·2	49·4	50·7

The carbon balance sheets for these two species are given in Table XII. They are both biochemically interesting, although they differ in type, for while Ag. 64 gives a very considerable amount of volatile neutral compounds, 0·690 gm. (14 per cent. of glucose fermented), Ag. 15 gives only a negligible amount of the same type of product, 0·006 gm. (0·3 per cent.). Both of them, however, give very appreciable amounts of products in the class "carbon unaccounted for." Under this heading Ag. 64 gives 1·070 gm. of carbon (22 per cent.), while Ag. 15 gives 0·356 gm. (9 per cent.). Neither species shows any other item of biochemical interest. It is obvious that both these species, and particularly *Clasterosporium* species, Ag. 64, are worthy of further investigation, and an account of an investigation of the metabolic products of *Clasterosporium*, species Ag. 64, is given in Part XVII.

Genus 7. *Rhacodium*, 1 species.

(1) *Rhacodium cellare* Pers., Catalogue No. Ag. 13. Isolated at Ardeer from wine cellar debris.

The carbon balance sheet for this species is given in Table XIII.

The only point of biochemical interest about this carbon balance sheet is the fact that *Rhacodium cellare* appears to form small amounts, 0·158 gm. (6·3 per cent.), of a non-volatile acid which may possibly be optically dextro-rotatory, since there is a considerable difference between the glucose as estimated by the polarimeter (1·512 per cent.) and by the Shaffer-Hartmann method (1·257 per cent.). With the exception of this there is a complete absence of any other features of biochemical interest.

TABLE XII.—Carbon balance sheets for species of *Clasterosporium*.

	Species of *Clasterosporium*:	*C.* species.	*C.* species.
	Catalogue number:	Ag. 64	Ag. 15
	Experiment number:	B 8	B 10
	Incubation period in days:	39	66
Carbon Balance Sheet.			
Carbon in solution (start)	gm.	5·043	5·043
Carbon in H_2SO_4	,,	0·008	0·001
,, in CO_2...	,,	1·723	1·945
,, in mycelium	,,	0·857	1·302
,, in solution (end)	,,	2·237	1·535
,, accounted for	,,	4·825	4·783
,, accounted for	per cent.	95·7	94·9
Analysis of Solution.			
Carbon in residual glucose	gm.	0·176	0·928
,, in CO_2 in solution	,,	0·019	0·043
,, in volatile acids	,,	0·025	0·019
,, in non-volatile acids	,,	0·117	0·143
,, in volatile neutral compounds	,,	0·690	0·006
,, in synthetic compounds	,,	0·140	0·040
Total carbon accounted for	,,	1·167	1·179
,, ,, in solution	,,	2·237	1·535
Carbon unaccounted for (by difference)	,,	1·070	0·356
Residual glucose.			
Glucose (by polarimeter)	per cent.	0·067	0·468
,, (SHAFFER-HARTMANN)	,,	0·088	0·464
,, (WOOD-OST)	,,	—	0·470
,, (by alkaline iodine)	,,	0·158	0·481
Acids.			Decrease of
Titration (N/1 acid)	c.c.	0·4	0·9
Volatile acids (N/1 acid)	,,	1·05	0·69
Barium salts (weight)	gm.	0·100	0·083
Calcium salts (weight)	,,	0·624	0·808
Volume of oxygen absorbed	c.c.	1869	2846
Respiration coefficient	...	1·74	1·30
Mycelium (weight)	gm.	1·608	2·338
,, (carbon)	per cent.	53·3	55·6

TABLE XIII.—Carbon balance sheet for a species of *Rhacodium*.

Species of *Rhacodium* :	*Rhacodium cellare.*
Catalogue number :	Ag. 13
Experiment number :	B 1
Incubation period in days :	60
Carbon Balance Sheet.	
Carbon in solution (start) ... ... gm.	5·018
Carbon in H_2SO_4... ... ... ,,	0·001
,, in CO_2 ... ... ,,	1·048
,, in mycelium ... ... ,,	0·995
,, in solution (end) ... ... ,,	2·865
,, accounted for ... ... ,,	4·909
,, accounted for ... ... per cent.	97·8
Analysis of Solution.	
Carbon in residual glucose ... ... gm.	2·514
,, in CO_2 in solution ... ... ,,	0·004
,, in volatile acids ... ... ,,	0·002
,, in non-volatile acids ... ... ,,	0·158
,, in volatile neutral compounds ... ... ,,	0·007
,, in synthetic compounds ... ... ,,	0·071
Total carbon accounted for ... ... ,,	2·756
,, ,, in solution ... ... ,,	2·865
Carbon unaccounted for (by difference) ... ... ,,	0·109
Residual Glucose.	
Glucose (by polarimeter) ... ... per cent.	1·512
,, (SHAFFER-HARTMANN) ... ... ,,	1·257
,, (WOOD-OST) ... ... ,,	1·230
,, (by alkaline iodine) ... ... ,,	1·267
Acids.	Decrease of
Titration (N/1 acid) ... ... c.c.	0·4
Volatile acids (N/1 acid) ... ... ,,	0·35
Barium salts (weight) ... ... gm.	0·029
Calcium salts (weight) ... ... ,,	0·571
Volume of oxygen absorbed ... ... c.c.	1914
Respiration coefficient	1·03
Mycelium (weight) ... ... gm.	1·972
,, (carbon) ... ... per cent.	50·4

FUNGI IMPERFECTI.

Order : HYPHOMYCETALES.

Family : STILBACEÆ.

Genus 1. *Stysanus*, 1 species.

(1) *Stysanus* species, Catalogue No. Ag. 51. Isolated at Ardeer from rotting pulped cotton.

The carbon balance sheet for this species, which is given in Table XIV, shows one item of outstanding biochemical interest. This is the figure for "carbon unaccounted for," 0·520 gm. (16·7 per cent. of the glucose fermented). It is obvious that this species should be further investigated with a view to elucidating the nature of the products included under this heading.

There are no other items of biochemical interest in this particular balance sheet.

FUNGI IMPERFECTI.

Order : HYPHOMYCETALES.

Family : TUBERCULARIACEÆ.

Genus 1. *Fusarium* (see Part V).

Genus 2. *Epicoccum*, 2 species.

(1) *Epicoccum* species, Catalogue No. Ag. 57. Isolated at Ardeer as a bench contaminant of CZAPEK-DOX agar.

(2) *Epicoccum* species, Catalogue No. Ag. 32. Isolated at Ardeer from the grain of an infected wheat ear.

The carbon balance sheets for these two species of *Epicoccum* are given in Table XV. They are both very similar in character to the carbon balance sheets given by a certain type of *Fusarium*. Both species give appreciable amounts of volatile neutral compounds, and Ag. 57, at any rate, has a relatively high respiration coefficient, 1·64. They are most closely related to the type of *Fusarium* species given in Table I of Part V in the group including *Fusarium solani* and *Fusarium lini*. The characteristics which these *Epicoccum* species have in common with this group of *Fusaria*—and this applies more particularly to *Epicoccum* species, Ag. 32, than to the species Ag. 57—are (1) a moderate amount of "carbon unaccounted for" and (2) a relatively high value for "carbon in volatile acids." Thus the carbon in volatile acids for *Epicoccum* species, Ag. 32, which is 0·108 gm., is, while small in itself, very much larger than any other figure for the same type of compound given by any other species of fungus described in this paper.

TABLE XIV.—Carbon balance sheet for a species of *Stysanus*.

Species of *Stysanus*:	*Stysanus* species.
Catalogue number:	Ag. 51
Experiment number:	B 13
Incubation period in days:	60
Carbon Balance Sheet.	
Carbon in solution (start) ... ... gm.	4·952
Carbon in H_2SO_4... ... ... ,,	0·002
,, in CO_2 ... ... ,,	1·530
,, in mycelium ... ... ,,	0·685
,, in solution (end) ... ... ,,	2·676
,, accounted for ... ... ,,	4·893
,, accounted for ... ... per cent.	96·6
Analysis of Solution.	
Carbon in residual glucose ... ... gm.	1·842
,, in CO_2 in solution ... ... ,,	0·007
,, in volatile acids ... ... ,,	0·062
,, in non-volatile acids ... ... ,,	0·132
,, in volatile neutral compounds ... ... ,,	0·079
,, in synthetic compounds ... ... ,,	0·034
Total carbon accounted for ... ... ,,	2·156
,, ,, in solution ... ... ,,	2·676
Carbon unaccounted for (by difference) ... ... ,,	0·520
Residual Glucose.	
Glucose (by polarimeter) ... ... per cent.	0·927
,, (SHAFFER-HARTMANN) ... ... ,,	0·921
,, (WOOD-OST) ... ... ,,	0·924
,, (by alkaline iodine) ... ... ,,	1·023
Acids.	Decrease of
Titration (N/1 acid) ... ... c.c.	0·3
Volatile acids (N/1 acid) ... ... ,,	0·23
Barium salts (weight) ... ... gm.	0·032
Calcium salts (weight) ... ... ,,	0·454
Volume of oxygen absorbed ... ... c.c.	2376
Respiration coefficient	1·21
Mycelium (weight) ... ... gm.	1·279
,, (carbon) ... ... per cent.	53·6

TABLE XV.—Carbon balance sheets for species of *Epicoccum*.

Species of *Epicoccum*:	*Epicoccum* species.	*Epicoccum* species from wheat.
Catalogue number:	Ag. 57	Ag. 32
Experiment number:	A 2	A 8
Incubation period in days:	44	57
Carbon Balance Sheet.		
Carbon in solution (start) ... ... gm.	4·834	5·018
Carbon in H_2SO_4 ... ... ,,	0·006	0·011
,, in CO_2... ... ... ,,	1·333	1·587
,, in mycelium ... ... ,,	0·547	0·264
,, in solution (end) ... ... ,,	2·857	3·081
,, accounted for ... ... ,,	4·743	4·943
,, accounted for ... ... per cent.	98·1	98·5
Analysis of Solution.		
Carbon in residual glucose ... ... gm.	1·642	2·206
,, in CO_2 in solution ... ... ,,	0·017	0·002
,, in volatile acids ... ... ,,	0·037	0·108
,, in non-volatile acids ... ... ,,	0·088	0·149
,, in volatile neutral compounds ... ... ,,	0·613	0·297
,, in synthetic compounds ... ... ,,	0·063	0·154
Total carbon accounted for ... ... ,,	2·460	2·916
,, ,, in solution ... ... ,,	2·857	3·081
Carbon unaccounted for (by difference) ... ... ,,	0·397	0·165
Residual Glucose.		
Glucose (by polarimeter) ... ... per cent.	0·825	1·119
,, (SHAFFER-HARTMANN) ... ... ,,	0·821	1·103
,, (WOOD-OST) ... ... ,,	0·832	1·100
,, (by alkaline iodine) ... ... ,,	0·870	1·139
Acids.		
Titration (N/1 acid) ... ... c.c.	1·1	3·7
Volatile acids (N/1 acid) ... ... ,,	1·69	3·74
Barium salts (weight) ... ... gm.	0·176	0·417
Calcium salts (weight) ... ... ,,	0·412	0·606
Volume of oxygen absorbed ... ... c.c.	1537	2558
Respiration coefficient	1·64	1·16
Mycelium (weight) ... ... gm.	0·995	0·519
,, (carbon) ... ... per cent.	55·0	50·9

Discussion of results obtained.

Only a relatively small proportion of the carbon balance sheets presented in this paper, from a large variety of fungi, show no biochemically interesting features at all, though in most cases it is impossible to generalize because the number of species investigated in any particular genus is often small. However, of the species examined it is possible to say that none of the following gives an appreciable amount of any metabolic product from glucose other than CO_2, and they are thus biochemically uninteresting and not promising for further intensive examination.

Class : ASCOMYCETES.

Genus 2. The only species of *Chætomium* investigated.
Genus 3. The only species of *Sclerotinia* investigated.

Class : BASIDIOMYCETES.

Genus 1. Both species of *Ustilago* investigated.

Order : HYPHOMYCETALES.

Family : Moniliaceæ.

Genus 2. Both species of *Sporotrichum* investigated.
Genus 4. The only species of *Cephalothecium* investigated.

Family : Dematiaceæ.

Genus 1. All 5 species of *Cladosporium* investigated.

The only item of interest from a biochemical point of view in the carbon balance sheets of a certain number of other species is the production of varying amounts of " carbon in volatile neutral compounds " (probably ethyl alcohol), and correspondingly high respiration coefficients. These species also are not very attractive for further investigation.

Class : ASCOMYCETES.

Genus 1. The only species of *Sordaria* investigated.

Order : HYPHOMYCETALES.

Family : Moniliaceæ.

Genus 3. Both species of *Trichoderma* investigated.

Family : Dematiaceæ.

Genus 2. Four species of *Helminthosporium* out of six investigated.
Genus 4. All three species of *Alternaria* investigated.

Family : TUBERCULARIACEÆ.

Genus 2. Both species of *Epicoccum* investigated.

These two species have other items of minor interest, *e.g.*, moderately high " carbon in volatile acids " but, like the *Fusaria* (see Part V), they are not generally interesting.

The remainder of the species examined have some points of particular biochemical interest, and most of them give promise of repaying further intensive examination. These species include the following :—

Class : ASCOMYCETES. None.

Class : BASIDIOMYCETES. None.

Order : HYPHOMYCETALES.

Family : MONILIACEÆ.

Genus 1. Both species of *Eidamia* investigated.

These two species show characteristics strongly reminiscent of some of the *Aspergillus niger* group, *i.e.*, high " carbon in volatile neutral compounds," moderate titratable acidity, " carbon in non-volatile acids " and " carbon unaccounted for." They might repay further examination, but are not so promising as some of the other species dealt with in this paper.

Family : DEMATIACEÆ.

Genus 2. *Helminthosporium.* One species of six investigated gives a high figure for " carbon unaccounted for."

Genus 3. *Heterosporium.* One species of two investigated gives a moderate figure for " carbon unaccounted for."

Genus 5. *Fumago.* Both species investigated give—

(*a*) a high figure for " carbon unaccounted for."

(*b*) high titratable acidity and " carbon in non-volatile acids."

Genus 6. *Clasterosporium.* Both species investigated give good figures for " carbon unaccounted for." One species, Ag. 64, gives a very high figure.

Genus 7. *Rhacodium.* The only species investigated produces a quantity of an optically active compound, possibly a non-volatile acid.

This family includes the largest proportion of biochemically interesting genera and species of any investigated in this paper, and if a renewal of the collection of carbon balance sheets is contemplated, it seems advisable to collect a number of species of this family, and of the specified genera, for investigation.

Family : STILBACEÆ.

Genus 1. *Stysanus.* The only species investigated gives a fairly high figure for " carbon unaccounted for."

It is evident from the above facts that the biochemically interesting fungi are by no means confined to the commoner genera and species—such as species of *Aspergillus* and *Penicillium*—but that investigation of some of the rarer species, many of which grow well on purely synthetic media, is bound to lead to results of interest and to the isolation of interesting, and possibly new, types of metabolic products.

Summary.

Carbon balance sheets are given for a wide variety of species of fungi belonging to different orders, families and genera. A number of these species are evidently of biochemical interest and should be further investigated. These are dealt with in some detail in the discussion of results obtained.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES