CASE NO. 135 B.

BIOLOGICAL BOARD OF CANADA
FISHERIES EXPERIMENTAL STATION
[ATLANTIC] HALIFAX, CANADA

ATLANTIC FISHERIES EXPERIMENTAL STATION
LIBRARY
HALIFAX, N.S. CANADA

MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 33

The effect of heat on fish muscle II.

By

Dorothy Dow

BIOLOGICAL BOARD OF CANADA
FISHERIES EXPERIMENTAL STATION
[ATLANTIC] HALIFAX, CANADA

22663
Per. "C"

BIOLOGICAL BOARD OF CANADA

MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 33

Title: The Effect of Heat on Fish Muscle II.

Dorothy Dow
Author

BIOLOGICAL BOARD OF CANADA

Manuscript Reports of the Biological Stations

No. 33.

The Effect of Heat on Fish Muscle II.

By Dorothy Dow

These experiments are a continuation of the work begun in the summer of 1928 with the object of obtaining some accurate scientific data concerning the effect of heat on the strength of haddock muscle.

Method

Haddock from the tank were killed, bled, gutted and hung in the tank room at about 10°C. to go into rigor. The length, weight and sex of each fish were recorded. After rigor had passed off the fish was skinned and standard pieces cut from the dorso-lateral muscle in the area extending from three centimeters from the anterior end of the anterior dorsal fin to the middle of the middle dorsal fin in the following manner: Two longitudinal strips approximately paralled to the lateral line were cut with a razor blade one centimeter wide dorsolaterally and extending from the medial to the lateral surface. From these

strips diagonal pieces were cut parallel to the myocomas and each containing one myocoma, the width at right angles to the myocoma being 5 mm. Standard pieces cut as descfibed above were kept in order, alternate pieces heated and the others kept as controls. The heated pieces were placed in wax-paper bags which has been dipped in melted paraffin to insure water-tightness and placed in a large constant temperature bath with an automatic stirrer. The controls were placed in similar wax-paper bags in a water-bath at 0°C. When the time of heating had elapsed the bags were removed from the constant temperature bath and plunged into ice water to obtain a sharp end point. The strength of the pieces was then tested alternating the heated pieces and unheated controls and the percentage gain or loss in strength calculated. The strength was tested as before by the weight in grams required to pull a dull-edged sheet-cutter through the fish at a point one centimeter from the lateral surface, the cut being made dorsoventrally.

I. As a check on last year's work experiments in which alternate pieces of fish were heated in a water bath and kept as controls at 0°C. were run for temperatures of 30°C. and 35°C. but smooth curves were not obtained although decided increases in strength were the rule. Two experiments will serve as an example of the sort of thing obtained.

Temperature 30°C. - Cutting strain in grams.

	Heated 120"	Unheated Controls	Heated 205"	Unheated Controls	Heated 260"	Unheated Controls
	380	225	525	425	700	390
	480	225	460	390	785	575
	585	235	785	185	1000	545
	570	300	240	275	860	455
Average	504	246	487	319	836	491
% change in strength	+105%		+53%		+70%	

Temperature 30°C.- Cutting strain in grams.

	Heated 335"	Unheated Controls	Heated 450"	Unheated Controls	Heated 555"	Unheated Controls
	715	415	1170	425	555	295
	415	195	1735	425	400	345
	420	130	1445	425	280	145
	395	170	1000	465	565	175
	235	285				
Average	436	239	1350	435	450	240
% change in strength	+82%		+210%		+87%	

Temperature 35°C. - Cutting strain in grams.

	Heated 210"	Unheated Controls	Heated 280"	Unheated Controls	Heated 365"	Unheated Controls
	500	320	590	535	1650	735
	345	480	575	425	1230	630
	1410	425	635	670	855	790
	110	490		495	915	765
Average	573	429	600	531	1162	730
% change in strength	+34%			+15%		+59%

Temperature 35°C. - Cutting strain in grams.

	Heated 435"	Unheated Controls	Heated 480"	Unheated Controls	Heated 540"	Unheated Controls
	600	410	350	230	500	455
	590	450	480	390	420	360
	640	535	?	435	510	270
	500	570	640	295	580	325
Average	582	491	490	337	502	352
% change in strength	+18%			+45%		+ 30%

II. To try and get better control of the experiment strips were cut as before and about twelve standard pieces obtained from each. These taken in order were divided into groups of three, the first of which was tested immediately after cutting, the second heated in the water bath, keeping the time and temperature of heating constant for a whole strip, and the third kept at 0°C. for the same length of time as the pieces were heated. In I it will be noticed that the variation in strength of heated pieces treated the same way is as a rule much greater than in the controls and it was thought that two sets of controls would show whether the error was due to poor technique in cutting. Where very good agreement in strength was obtained for both the pieces tested immediately and after keeping at 0°C. for the time of heating the variation in the strength of the heated pieces was much greater.

Temperature 35°C. - Cutting strain in grams.

Tested immediately	0°C. for 180"	35°C. for 180"	Tested immediately	0°C. for 180"	35°C. for 180"
645	550	745	225	250	205
565	550	485	225	235	260
530	520	970	175	210	185
535	610	890	225	215	335
Average 569	558	775	212	230	246
% change in strength	-2%	+ 31%		+ 9%	+16%

Treating whole strips in this way using temperatures of 30°C. and 35°C. for different times again produced irregular curves though with one or two exceptions probably due to experimental error decided increases in strength were again obtained. The strength of the pieces kept at 0°C. was usually less than of those treated immediately though the differences in strength are not great enough to be sure this is significant. When values are plotted the curves obtained for pieces tested immediately, after heating and after keeping at 0°C. tended to be reflexions of each other. This suggests the possibility that some processes which change the strength of the muscle may be going on independent of temperature but accentuated by it.

Temperature 35°C. - Cutting strain in grams.

Tested immediately	35°C. for 30"	0°C. for 30"	Tested immediately	35°C. for 83"	0°C. for 83"
530	885	605	240	215	100
495	685	620	240	130	190
490	440	690	220	225	275
405	850	655	295	60	255
Average 480	765	642	249	157	205
% change in strength	+59%	+33%		-37%	-17%

Tested immediately	35°C. for 120"	0°C. for 120"	Tested immediately	35°C. for 180"	0°C. for 0°180"
675	655	475	645	745	550
705	760	515	565	485	550
490	720	540	530	970	520
535	530	625	535	890	610
Average 601	666	539	569	775	558
% change in strength	+11%	-10%		+31%	-2%

Tested immediately	35°C. for 230"	o°C. for 230"	Tested immediately	35°C. for 280"	0°C. for 280"
620	465	480	480	1145	605
435	580	420	615	1045	680
500	535	430	630	1110	850
575	510	385	750	850	625
Average533	522	429	617	1037	690
% change in strength	-2%	+19%		+66%	+12%

Temperature 35°C. - Cutting strain in grams

Tested immediately	35°C. for 380"	0°C. for 380"
495	805	640
625	910	640
760	785	600
680	1020	700
680	1100	510
Average 648	944	618
% change in strength	+30%	-5%

See graphs III and IV.

III. Unheated standard pieces of fish taken in order were tested at distances of 1, 2, 3 and 4 centimeters from the lateral surface. The pieces near the anterior end of the fish showed an increase in strength followed by a decrease from the lateral to medial surface. Progressing toward the posterior end of the fish the curves gradually flattened out (see graphs V and VI). The point of greatest strength in a standard piece of fish depends on its location. Confirming last year's results the point of greatest uniformity of strength was found to be 1 cm. from the lateral surface.

IV. From this time on the exact location of every standard piece of fish was recorded on a diagram and pieces treated in the same way instead of being taken in order were taken from different parts of the fish so as to distribute the error. Also after consultation of rigor curves worked out by Dr. Huntsman fish were now used 18 to 20 hours after killing. Again consistent results were obtained, the curves for 30°C. and 35°C. being very similar to those worked out last year.

Series I at 30°C. - Cutting strain in grams.

	Unheated controls	30°C.for 30"	Unheated controls	30°C.for 60"	Unheated controls	30°C.for 120"
	510	685	355	610	475	780
	500	610	655	860	695	870
	510	665	545	825	600	800
	520	690	495	840	400	725
Average	510	662	513	784	493	794
% change in strength		+30%		+53%		+61%

	Unheated controls	30°C.for 180"	Unheated controls	30°C.for 260"	Unheated controls	30°C.for 330"
	465	655	525	810	430	835
	485	950	475	765	505	810
	510	770	525	915	545	785
	430	610	590	885	525	935
					475	830
					400	870
Average	473	746	529	844	480	844
% change in strength		+60%		+60%		+76%

Series I at 30°C. - Cutting strain in grams.

	Unheated controls	30°C.for 550"	Unheated controls	30°C.for 740"
	500	615	440	990
	455	985	535	1450
	475	1120	600	850
	485	1185	375	805
Average	479	976	488	1024
% change in strength		+104%		+110%

There is a progressive increase in strength at 35°C. up to 740".

Series I at 35°C. - Cutting strain in grams.

	Unheated controls	35°C.for 30"	Unheated controls	35°C.for 60"	Unheated controls	35°C.for 180"
	735	780	450	565	465	750
	415	585	450	970	300	375
	475	805	445	775	270	575
					520	915
Average	542	723	448	770	389	654
% change in strength		+33%		+72%		+70%

Series I at 35°C. - Cutting strain in grams.

	Unheated controls	35°C.for 300"	Unheated controls	35°C.for 360"	Unheated controls	35°C.for 420"
	440	1055	470	855	460	715
	525	940	530	1275	490	790
	345	980	370	1035	220	1080
	620		505	890	545	785
Average	483	992	469	1014	429	843
% change in strength		+105%		+116%		+ 96%

	Unheated controls	35°C.for 700"	Unheated controls	35°C.for 850"
	440	1045	540	1060
	440	720	535	725
	420	740	615	715
	410	570		
Average	428	769	563	833
% change in strength		+80%		+48%

At 35°C. there is a progressive increase in strength followed by a slower decrease after the maximum is reached though in 850" still showing a decided increase over the original strength.

Series I at 40°C. - Cutting strain in grams.

Unheated controls	40°C.for 20"	Unheated controls	40°C.for 60"	Unheated controls	40°C.for 145"
480	325	320	870	320	450
380	500	600	290	560	575
285	455	325	475	330	560
375	525	295	350	500	320
		380	320		
		453	705		
		455	270		
		300	485		
Average 380	451	391	471	428	476
% change in strength	+16%		+20%		+11%

Unheated controls	40°C.for 300"	Unheated controls	40°C.for 420"	Unheated controls	40°C.for 600"
480	1010	325	625	575	525
390	830	450	450	455	310
270	420	480	460	450	410
615	375	580	560	330	155
Average 439	659	459	524	453	350
% change in strength	+50%		+14%		-23%

Series I at 40°C. - Cutting strain in grams.

Unheated controls	40°C.for 750"
355	90
395	400
435	75
415	230
Average 400	199
% change in strength	-50%

At 40°C. there is a progressive increase followed by a decrease to less than original strength.

Series I at 50°C. - Cutting strain in grams.

Unheated controls	50°C.for 15"	Unheated controls	50°C.for 60"	Unheated controls	50°C.for 150"
500	535	295	170	290	275
520	405	445	760	470	290
500	785	425	75	365	190
590	850	550	495	425	490
		275	180		
		445	300		
Average 528	644	423	330	413	311
% change in strength	+22%		-22%		-25%

Series I. at 50°C. - Cutting strain in grams.

Unheated controls	50°C.for 420"	Unheated controls	50°C.for 480"	Unheated controls	50°C.for 500"
345	535	325	610	420	345
410	170	470	255	365	515
580	470	510	375	540	500
480	560	385	375		
420	365				
520	775				
Average 459	479	423	404	442	453
% change in strength	+4%		+4%		+2%

Unheated controls	50°C.for 600"	Unheated controls	50°C.for 630"
425	270	500	860
350	375	675	780
575	825	680	875
		415	360
Average 450	490	548	719
% change in strength	+9%		+31%

For temperatures of 55°C., 65°C. and 75°C. no gains in strength were obtained and the heated pieces were too weak for their strength to be tested with the apparatus used.

V. To find the variation in percentage change in strength on heating pieces from the same strip depending on their location alternate pieces from a whole strip kept in order were heated 30 minutes at tem eratures of 45°C., 55°C., 65°C. and 75°C., keeping the others as controls. Although these temperatures are too high to obtain accurate results with this apparatus the change in strength tended to be greater at the ends than the middle of the section used. For temperatures of 30°C. and 35°C. longer times were used so as to obtain more extreme changes in strength. Smooth curves were not obtained but again the changes tended to be more extreme at the ends than the middle of the section used.

Conclusion

From these results it is obvious that the strength of haddock muscle as measured by cutting strain is affected by the temperature and time of heating, the degree of change being somewhat dependent on the location of the piece of muscle heated.

Keeping the temperature constant and varying the time curves for 30°C. and 35°C. very similar results to those obtained last year were worked out. At 30°C. there is a progressive strengthening for more than twelve hours. No weakening was obtained during this period of time. At 35°C. there is a progressive strengthening, more rapid than at

30°C., until a maximum is reached, after which there is a slower decrease from the maximum although the strength of the heated pieces is always much greater than that of the controls. At 40°C. a curve similar to that at 30°C. was obtained, but the maximum was reached sooner and the decrease more rapid to much less than original strength. At 50°C. a smooth curve was not obtained. Both strengthening and weakening were recorded though the amounts were hardly extreme enough to be significant. The changes in strength were much more extreme at 30°C. and 35°C. than at 40°C. and 50°C.

In conclusion I would like again to thank Dr. Huntsman for his very kind direction at all times.

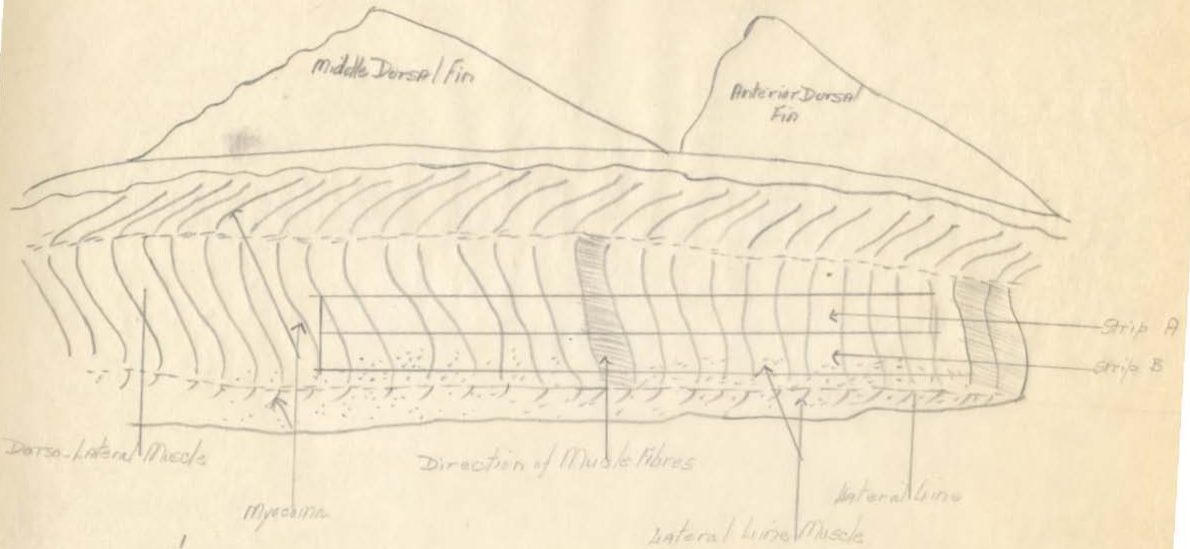
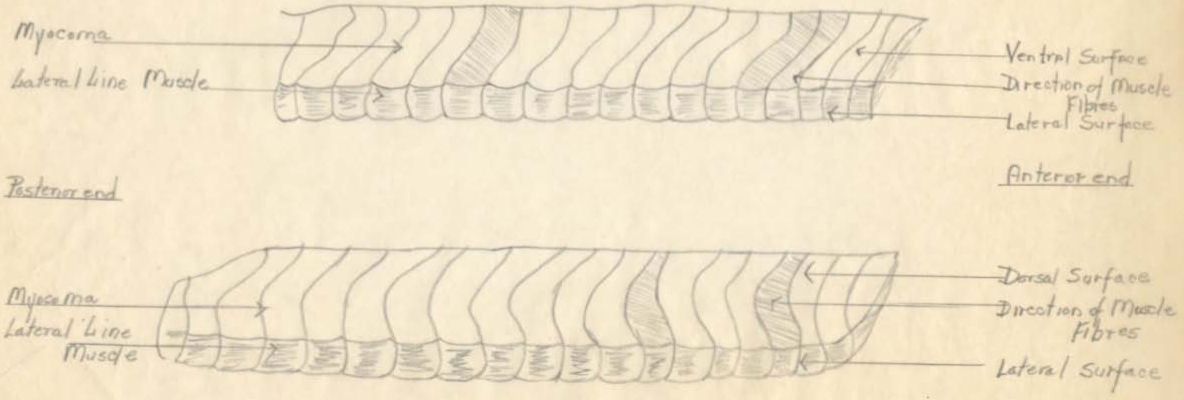


Diagram of Lateral Surface of Dorso-Lateral Muscle of Haddock showing location of longitudinal Strips from which pieces of muscle of Standard Strength were cut.

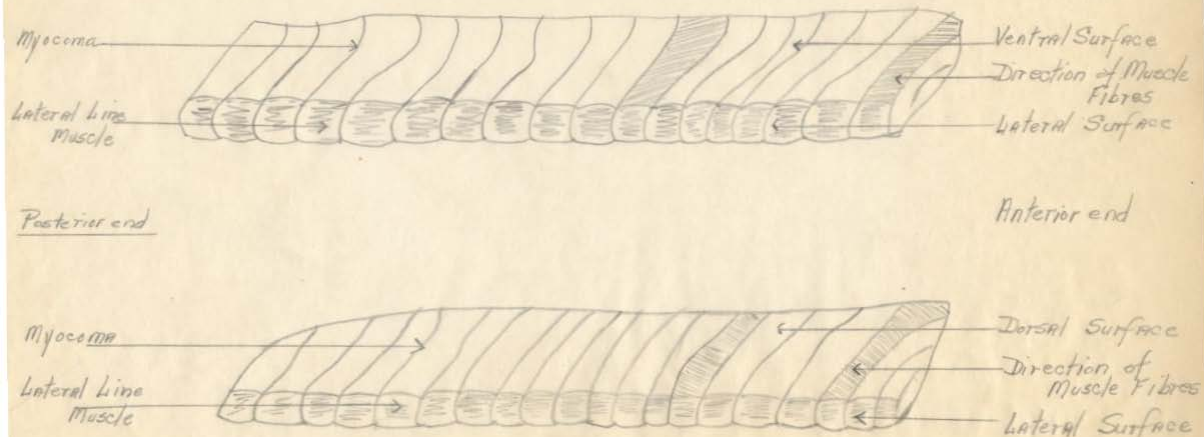
Strip "A"

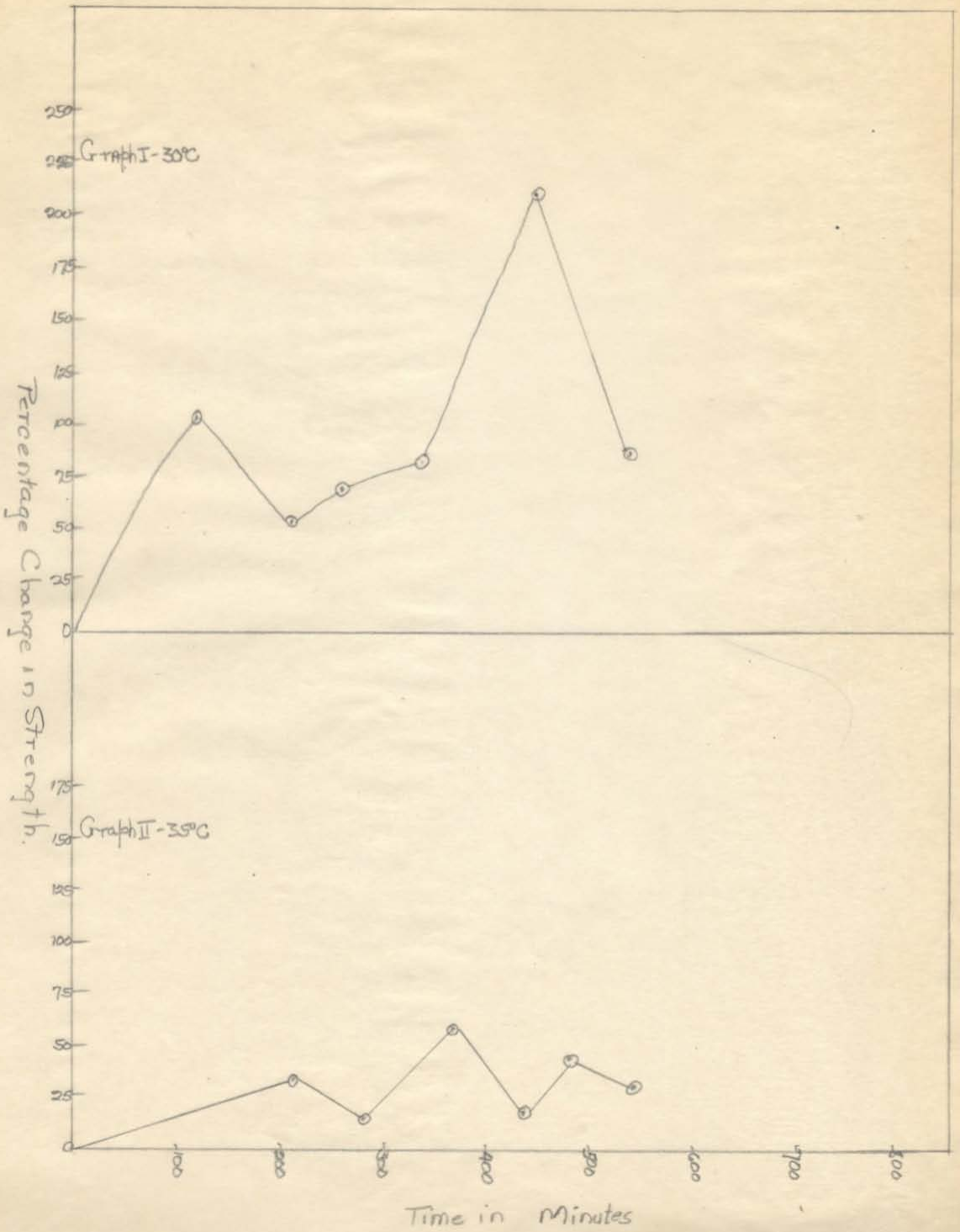
Dorsal and Ventral Surfaces showing arrangement of myocomas and direction of Muscle fibres.

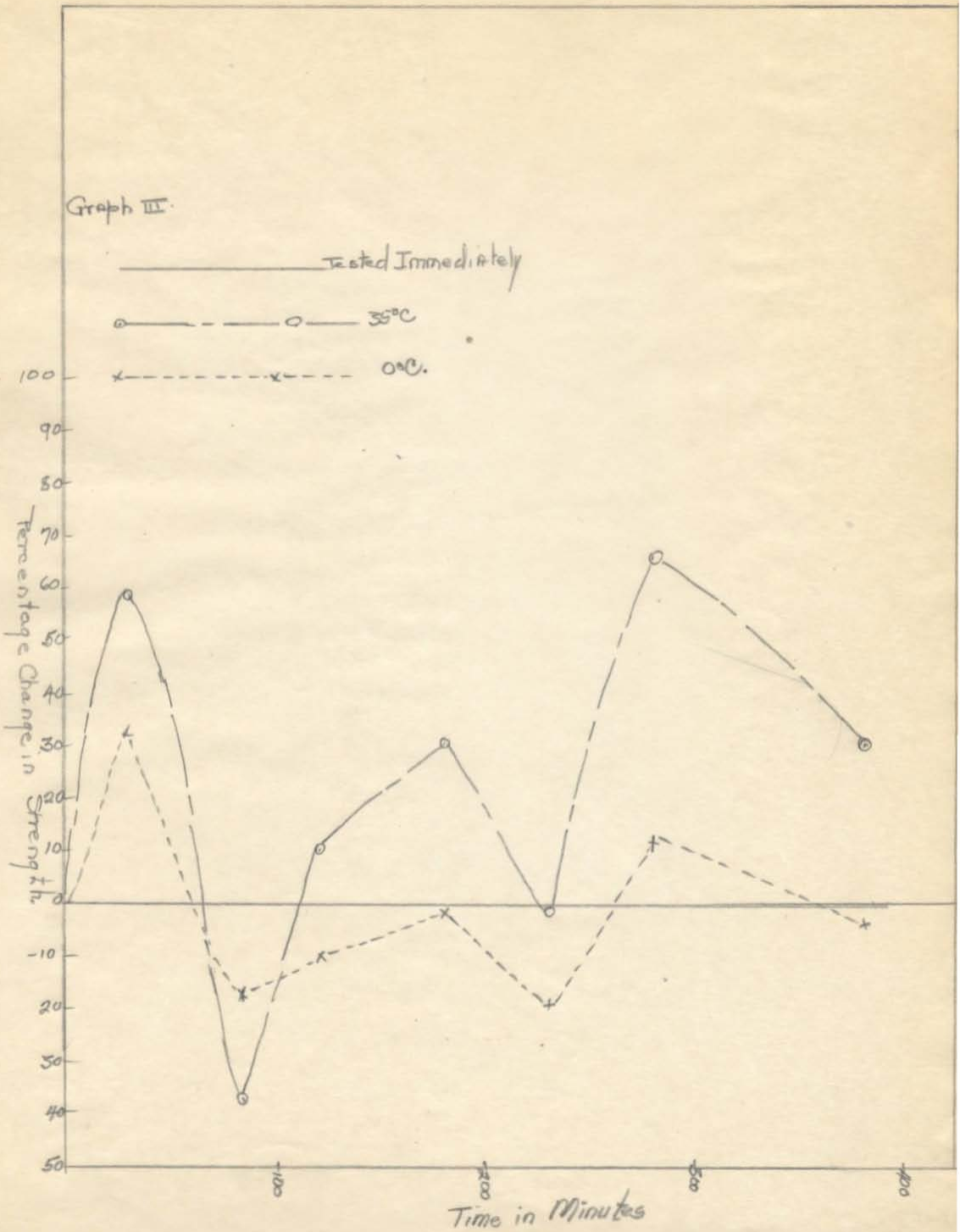


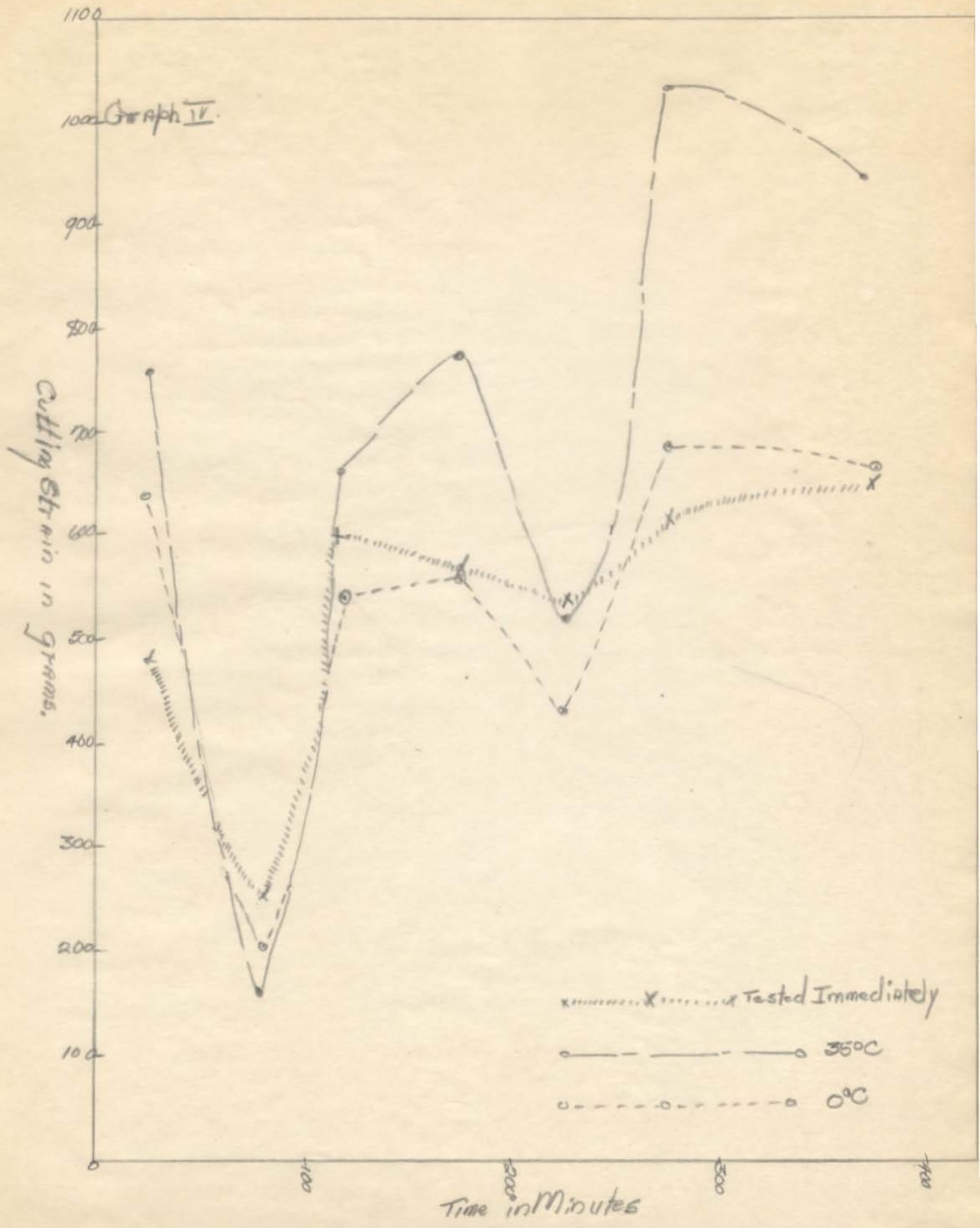
Strip B

Dorsal and Ventral Surfaces shewing arrangement of myocomas and direction of Muscle Fibres

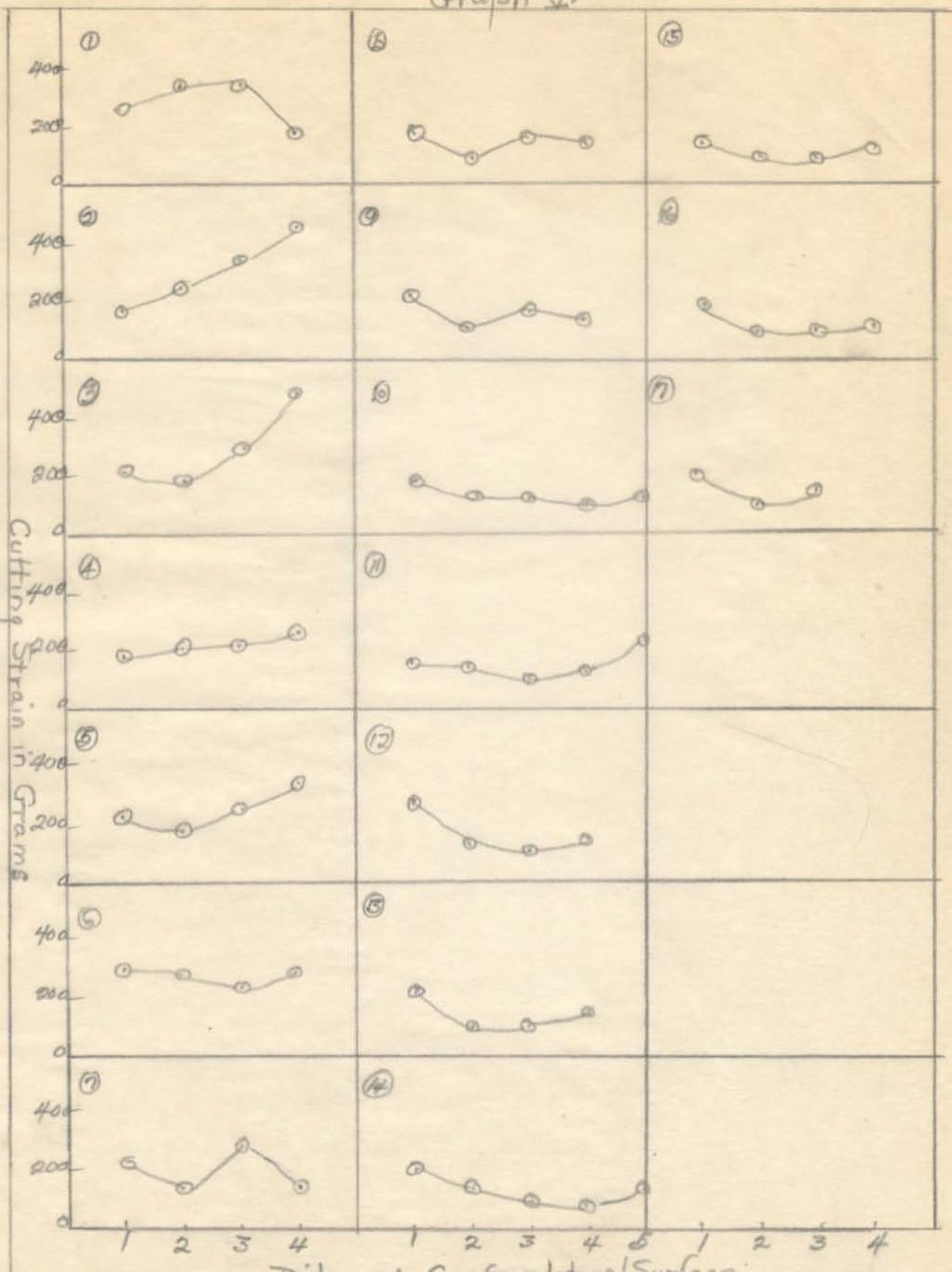



Graph I - 30°C
Graph II - 35°C
Percentage Change in Strength.
Time in Minutes
250
225
200
175
150
125
100
75
50
25
0
100
200
300
400
500
600
700
800


Graph III.
Tested Immediately
35°C
0°C.
100
90
80
70
60
50
40
30
20
10
0
-10
20
30
40
50
Percentage Change in Strength
100
200
300
400
Time in Minutes

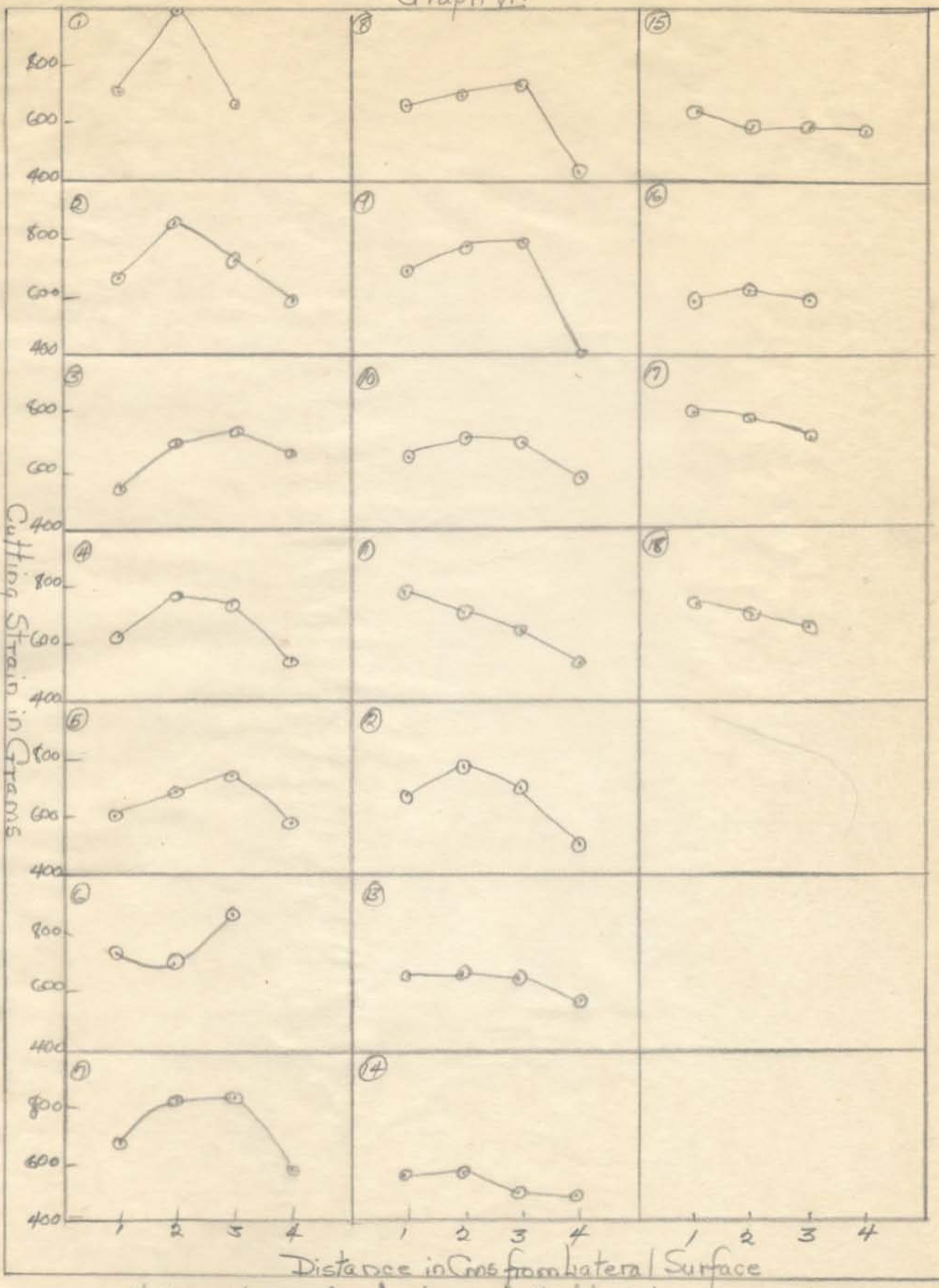

Graph IV.
1100
1000
900
800
700
600
500
400
300
200
100
0
Cutting Strain in Grams.
100
200
300
400
Time in Minutes
Tested Immediately
35°C
0°C

Graph V.

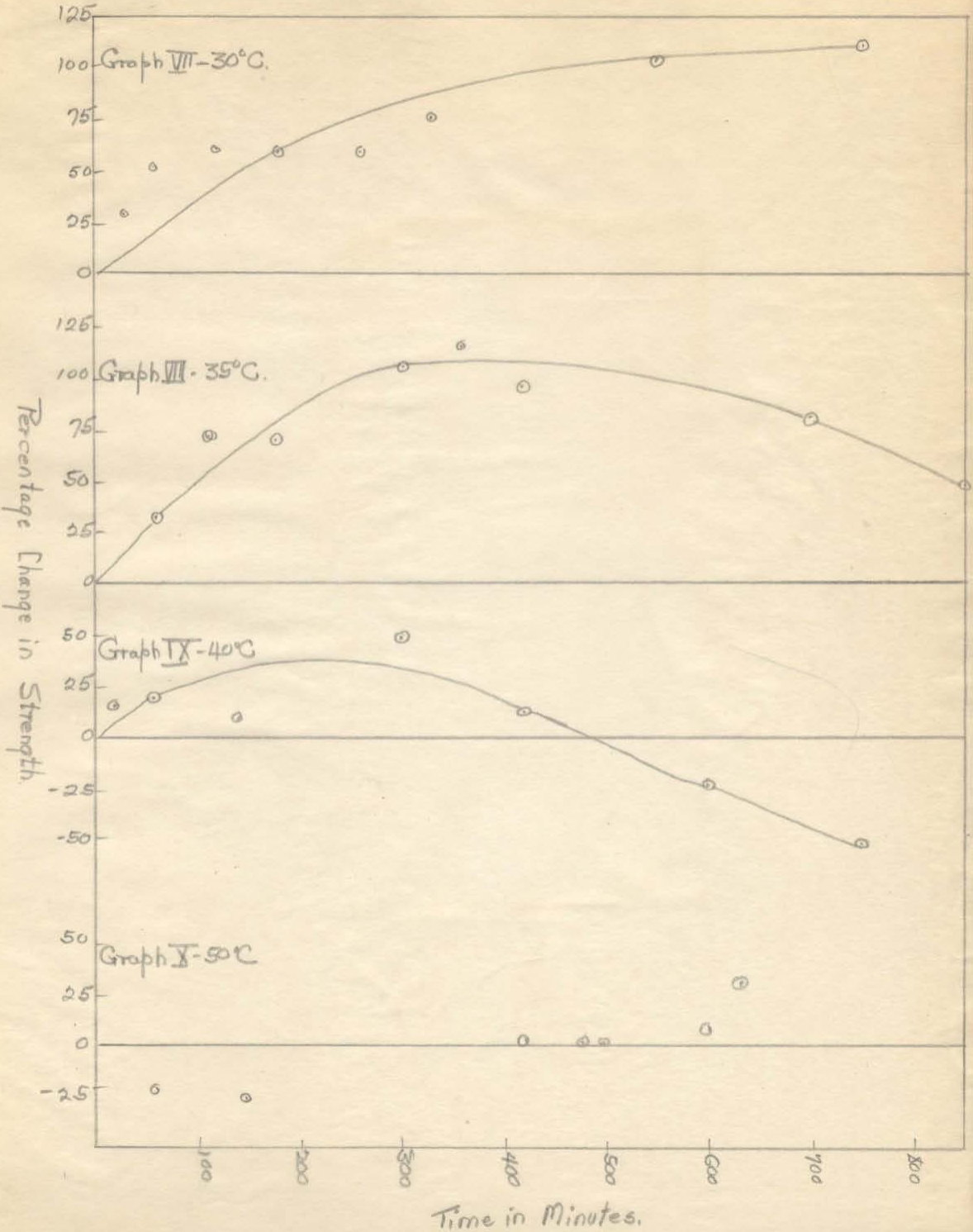


Unheated Standard Pieces of Haddock from Strip "A" as in Diagram taken in order anterior to posterior end Strength tested at Distances of 1, 2, 3 & 4 cms. from Lateral Surface of Fish

Graph VI.



Unheated Standard Pieces of Haddock from Strip "B" as in Diagram taken in order from anterior to posterior end, Strength tested at Distances of 1, 2, 3 + 4 cms from Lateral Surface of Fish.


Graph VIII - 30°C.
Graph VII - 35°C.
Graph IX - 40°C
Graph X - 50°C
125
100
75
50
25
0
-25
-50
Percentage Change in Strength.
100
200
300
400
500
600
700
800
Time in Minutes.