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Ambient odor and knowledge acquisition, retention, and retrieval

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AMBIENT ODOR AND
KNOWLEDGE ACQUISITION, RETENTION, AND RETRIEVAL

MASTER'S PROJECT

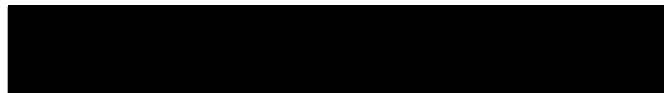
Submitted to the School of Education
University of Dayton, in Partial Fulfillment
of the Requirements for the Degree
Master of Science in Education

by

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School of Education
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Approved by:

A solid black rectangular box used to redact the signature of the official advisor.

Official Advisor

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Purpose of the Study

Olfaction is the most primitive of the five senses and the first sense to develop fully in a young animal. It is olfaction that allows a newborn animal within a very short period of time to recognize its mother. Olfaction is tied through the limbic system, the emotional center of the brain, into the hippocampus, a region of the brain which controls memory. Nearly everyone has experienced smelling a familiar aroma and being inundated with memories. Charles Dickens in A Christmas Carol was familiar with this experience when he wrote of Scrooge, "He was conscious of a thousand odors floating in the air, each one connected with a thousand thoughts, and hopes, and joys, and cares long, long forgotten." (Dickens, 1843) Marcel Proust wrote in Swann's Way of the joyous memories of his aunt's country home which was triggered by the smell of a tea-soaked madelaine (Proust, 1919). It is Proust's description which has led to the name of Proust phenomenon for this experience. Science has long recognized that the smell of a specific odor can trigger a flood of vivid memories which sometimes are from decades earlier. Odors appear to produce clear, unfaded images as the bases for recall of past events (Cann & Ross, 1989). This would imply that there is some type of relationship between olfaction and memory. Whether that relationship is based upon mood (Ehrlichman & Halpern, 1988), number of encoding modalities (Schab, 1990; Lyman & McDaniel, 1990), emotions (Herz & Cupchik, 1995), or an actual connection between the odor and the memory (King, 1994) is yet to be determined.

The investigation into the area of aroma and memory is still in its infancy. There is much yet to be discovered. The research which has been done to date has focused on mood and productivity (Baron, 1994), emotion and memory (Herz & Cupchik, 1995), mood and memory (Bower, 1981), and memory for odor labels (Lyman & McDaniel, 1990; Rabin & Cain, 1984; Davis, 1977; and Eich, 1978). Much of the instrumentation relating to memory has been that of simple recall as opposed to an actual learning task.

The nature of the relationship between olfaction and memory relating to a learning task is of particular relevance to the educator. However, this relevance is dependent upon whether the presence of an ambient odor will show any effect upon a student's ability to acquire, retain, and later retrieve knowledge. Little research has been done to study this interesting and possibly useful memory cue.

Statement of the Problem

Since vivid memories can be evoked by a particular smell, could there be a controllable relationship between an odor and knowledge acquisition, retention, and retrieval? If that controllable relationship does exist, how can it be exploited to enhance students' learning, and, finally, are there certain aromas which are more effective for this purpose than others? The purpose of this study is to determine whether the presence of an ambient odor will have an effect on the acquisition, retention, and retrieval of knowledge.

This study was designed to address the following hypotheses:

1. If an ambient odor is present during periods of knowledge acquisition, there will be no observable relationship between the presence of the ambient odor and the amount of knowledge retained.
2. If an ambient odor does relate to knowledge retention, then any odor is as effective as another.
3. If an ambient odor does relate to knowledge retention, then there will be no difference in the amount of time the memory is retained.

Assumptions

To conduct this study, a Likert-type survey was used to obtain students' preferences to odors (Brody, 1995; Ehrlichman & Halpern, 1988). A second Likert-type survey was employed to assess the students' abilities to respond to the odor. The writer assumes that the students' responses to these surveys were honest. Also to accomplish this study, the writer used three verbal instruments (Schab, 1990) and three visual instruments (Cann & Ross,

1989; Herz & Cupchik, 1995; Lyman & McDaniel, 1990) in a pre- and post-test fashion. The writer assumes these instruments were reliable.

Limitations

A limitation of this study was the small population on which this investigation was performed. Another limitation is that the study was done using cluster grouping as a direct result of the students already being assigned to set classes. In addition, a small number of ambient odors were tested due to time constraints and the exploratory nature of this study.

Definitions of Terms

Ambient - encompassing (Webster, 1966)

Aroma - any smell or odor (Webster, 1966)

Hippocampus - a portion of the limbic system within the brain (Thibodeau & Patton, 1994)

Limbic System - a group of structures surrounding the corpus callosum that produces various emotional feelings (Thibodeau & Patton, 1994)

Memory - the power or process of reproducing or recalling what has been learned and retained, especially through associative mechanisms (Webster, 1966)

Odor - smell, scent (Webster, 1966)

Olfaction - the act or process of smelling (Webster, 1966)

CHAPTER II

REVIEW OF LITERATURE

Of all human senses, olfaction is the one most taken for granted. As a matter of fact, as humans have evolved, they have learned to depend less and less on their sense of smell as other senses have come to the fore culturally (Birchall, 1990). Yet it is olfaction which may be the key to unlocking memory because it is linked directly with the hippocampus which is a part of the brain which has long been implicated in the formation of long-term memory.

This sense has been neglected by science for some time now, but recently, due to the rise in popularity of aromatherapy, scientists have begun looking at olfaction in a new light. Several studies have investigated encoding modalities in association with odors. Cann and Ross (1989) used either an unpleasant or a pleasant odor as a background while male college students rated the attractiveness of photos of females. The anticipated results of finding a correlation with higher attractiveness ratings with the pleasant fragrance did not emerge. However, they did note an improvement in remembrance if the acquisition fragrance matched the testing fragrance. Schab (1990) conducted three separate experiments researching the connection between ambient odors and memory with 72 undergraduate college students. Verbal instruments were utilized in all three experiments. All three experiments demonstrated that if the odor is the same at acquisition as at testing that there is a definite improvement in memory, even if the ambient odor was not particularly pleasant. This study suggests that if no attention is drawn to the odor's name, and/or the odor, itself, recall of odor-related material would also benefit from an odor cue because deliberate elaboration of such material on the basis of name-related semantic associations is reduced and retrieval becomes more dependent on contextual cues.

Lyman and McDaniel (1990) concentrated on the links when 120 young adult subjects were asked to make a connection between an odor, the name of the odor, and picture of the odor source. The theory behind this was that olfactory, verbal, and nonverbal

memories would be associated. When any of the two modalities were combined it was found that memory was enhanced, and when all three were combined, memory was further enhanced. Finally, Monell Chemical Senses Center has been the site of much of the forerunning research in olfaction. The previous study, in part, was done there as was the work of Herz and Cupchik (1995) who studied the ability of undergraduate college student volunteers to remember positive and negative paintings which they had observed in the presence of either a positive or negative odor. The positive and negative natures of the odors as well as the paintings were determined by a separate group of subjects who did not participate in the following study. By using positive and negative context paintings, an assessment was made on the emotional nature of the memory as well. It was found that when the eliciting cue type was an odor the memory contained more inferred emotion. This study showed that verbal cues were equipotent with odor cues to stimulate memory. However, the odor cues led to more emotionally charged memories which might suggest that this would not be an effective means of aiding students' ability to recall subject material.

Many researchers have focused on subjects recalling specific scents or being able to name specific scents. Linking a verbal name to the fragrance itself makes a paired association or two encoding modalities. Rabin and Cain (1984) looked at just this effect using a variety of scents. To check how accurately the undergraduate college subjects were able to recall the target scents, the subjects were tested with three distractor sets of aromas as well. The subjects were to correctly link the verbal name of the aroma with the aroma at intervals of 10 minutes, 1 day, and 7 days.

Lawless and Engen (1977) described the "tip of the nose" effect in which volunteer undergraduate college students when asked to recognize an odor and even label the odor as very familiar could not come up with the actual verbal label for the odor. As with the tip of the tongue effect, cues and hints aided the subject to arrive at the label. Similarly, Eich (1977) chose to use fragrance to assist subjects in encoding a list of target words. The effect of a nominal fragrance cue arises through the mediation of an implicitly generated semantic

cue. Davis (1977) conversely found that there is actually a stimulus encoding deficiency with odors. At his seven day test interval on his introductory college psychology student subjects, he found that the recognition for odors was poorer than the recognition for figures. He concluded that there is an overall limitation on the effectiveness of odors as stimuli during acquisition of verbal associations unless the odor is highly distinctive. In an earlier study Davis (1975) found that only highly familiar odors facilitated association in paired association acquisition with similarly acquired subjects.

Most incidences of Proustian phenomenon tend to recall memories which are more emotionally charged. Many researchers have, therefore, looked at how odors can alter the subject's mood. Several studies have been done to determine what, if any, connection varying aromas have to mood and consequently productivity or relationships. One study (Baron, 1996) investigated whether the fragrance of roasting coffee or baking cookies would actually alter the mood of harried shoppers enough to make them helpful to a stranger. The conclusion was, in fact, that busy shoppers were much more willing to help a stranger when they were approached within a whiffing distance of a coffee store or a cookie or cinnamon roll store. Another study (Baron, 1994) found that productivity increased when humans were working in an atmosphere which contained an odor they enjoyed. A Japanese research group has reported that there may actually be a link between the smelling of a pleasurable aroma and the bolstering of the human immune system (Brody, 1995).

Bower (1981) studied the relationship between the mood - pleasant or sad that a particular odor would elicit. Then he determined which target words, again pleasant or sad, would most often be recalled by a given odor. He found that there was a direct congruence between mood state and the type of target words which were recalled. A subject who was experiencing a pleasant mood would recall a higher frequency of pleasant words, and a subject who was experiencing a sad mood would recall a higher frequency of sad words. Bower also found that like smells, emotions were very difficult to effectively label and quantify.

Some work has been done looking at the contrast of human performance according to the presence of a positive odorant versus a negative odorant (Herz and Cupchik, 1995; Cann and Ross, 1989; and Ehrlichman and Halpern, 1988). It was noted in all three studies that memory is enhanced even in the presence of a foul odor. Interestingly enough, while the subjects in the three previously cited studies were all college students, only Herz and Cupchik (1995) had a mixed gender group. Cann and Ross had all male subjects, and Ehrlichman and Halpern had all female subjects.

A particular study has also investigated whether there is a connection between olfaction and gender (Lehrner, 1993). In Lehrner's study, the females consistently outscored the males with fewer errors. While many of the preceding studies did not specifically deal with the question of gender and olfaction ability, most did separate their subjects based on gender. Not intending to look at the effect of gender, Cann and Ross (1989) by using all male subjects and Ehrlichman and Halpern (1988) by using all female subjects avoided complications of their studies by utilizing single gender subject groups.

Cann and Ross (1989) found that the effects of olfactory cues on memory represent a system distinct from that responsible for mood effects, but whatever the sensory experience the odors produced in the subject, there could arise an association with other encoded information in a useful manner. If these results are viewed as context being the important factor in memory, then an aromatic context is much more easily transported than a physical context. Hence, this would appear to be a useful strategy for use in increasing a student's performance. Smith (1979) using introductory psychology students in his study of list-learning in light of environmental context, determined that context could be brought under cognitive control and that subjects could learn to supply their own contextual retrieval cues if the learning context was not difficult to recall. Smith, Glenberg, & Bjork (1978) using paid undergraduate subjects in five different recall/recognition tests, concluded that environmental context could play a role in memory recall, but they only suggested possibilities for the environmental context to be used as memory cues.

Accordingly, Algom and Cain (1991) looked at quantifying olfaction by using set dilutions of a variety of odors and testing the subjects' abilities to recognize the dilution that they were smelling and their ability to remember the smell of that concentration. Subjects were very effective in recognizing the concentrations, and not only in isolation, but also even when the fragrance was put into a fragrance mixture. This provides a very strong case for the acuity of olfaction as well as an indication to the powerful link with memory.

Finally, King (1994) suggests seaside fragrances for relaxation, while Buchbauer, Jirovetz, Jager, Plank, and Dietrich (1993) studied a variety of fragrances and the motility of mice. The sedative nature of several fragrances was noted. This could prove to be useful information if the elimination of stress in a testing atmosphere would enable the student to better recall memories. However, any fragrance used to create a relaxed state of mind is a very personal preference by the individual. Hurley (1995) provides suggestions on the nature of certain herbs for aromatherapy. Rosemary is an herb which is credited with making a subject feel more alert. Chamomile, basil, lavender, jasmine, and patchouli are credited for having a calming and refreshing effect. To elevate a subject to a happier state of mind, lemon balm, clary sage, or rose geranium would be used. While majoram, lavender, and chamomile produce a relaxed state of mind, peppermint, lavender, or fennel provide clear-headedness. McCutcheon (1989) states that researchers at Yale found apple-spice fragrance to have a calming effect to the point of stopping panic attacks and that researchers in England found "beach perfume" created by using the essence of seaweed to reduce anxiety levels.

Implications for Educators

The studies previously cited certainly suggest that using an aroma while having students learn particularly difficult material might be useful from the standpoint of context. An aroma as a context cue could be very personal and portable when used as a perfume or cologne on test day. From the standpoint of mood, again the use of an aroma would be a simple enough thing to do to help a student feel better about himself/herself or feel more at ease in taking a test. Finally looking at aroma from the standpoint of increasing the

number of encoding modalities also seems a very positive way to help students. Providing students with one more "hook" from which to link new knowledge to existing knowledge has already been identified as a useful strategy. Psychologists and cognitive scientists recognize that the brain can handle many situations simultaneously through layers of self-organization and vast interconnecting networks. Once established, traces of these networks appear to survive almost indefinitely. These memory traces seem to follow neural networks that the individuals - at the time of the original thought - found most to their advantage (Abbott, 1997).

To maximize the usefulness of an aroma, the student would need to recognize that it is a tool for studying and not the box of pixie dust that would magically replace the studying. It would appear, therefore, to be particularly useful for those students who do in fact study, but who experience test anxieties. Perhaps this would be the tool which would allow them to demonstrate their true ability and put them on a more even par with their classmates.

As the focus in education looks for innovative and diverse ways to tap into students' multiple intelligences, aromas could prove quite useful to general populations as well as special education populations. It has already been shown that visual memories decline by fifty percent after only three months while memories associated with smells decline by only twenty percent, even after a full year (McCutcheon, 1989). Another factor to consider is the way in which humans learn. Because the human sense of smell is the sense which is first fully developed and used to help the human infant learn about his/her environment, it seems highly possible that students with developmental disabilities might use this strategy with success.

To date, the research has focused on undergraduate populations. Female populations appear to be more sensitive to this strategy than do males. However, at this point without further testing using different populations, it is difficult to predict whether the use of aroma could effectively be generalized to other, broader or more specific populations.

CHAPTER III

PROCEDURE

Population and Setting

The subjects for this study were 45 biology students enrolled at North Union High School, a rural high school in central Ohio. Cluster grouping was used as a result of students already having been placed in classes. However, assignment to classes was randomly done among the biology classes. (See Appendix 2.)

Materials

The materials used were odorants to produce the selected aromas used during knowledge acquisition sessions as well as knowledge retention and retrieval sessions. Ammonia (Dial Corp.), lavender (Greenleaf, Inc.), and wintergreen (Lorann Oils, Inc.) were the odorants which were selected based on the surveys completed by the students (see Table 1) and the observations of the researcher during the acclimation period. The wintergreen used was in the form of an oil, and the lavender was a sachet which was designed for use in a potpourri pot. An electrical simmering potpourri pot was employed to dissipate the aroma of the odorant. Two types of instruments were employed to measure retention and retrieval. Visual and verbal instruments were utilized based on research by Cann and Ross (1989) and Herz and Cupchik (1995) and Schab (1990).

Data and Instrumentation

Subjects were surveyed (refer to Survey 1) on aroma preference (Brody, 1995 and Baron, 1994). Subjects were exposed to a variety of aromas as ambient fragrances in the air of the classroom during regular class periods and prior to the start of any testing to acclimate them to the idea of having aromas present. Three representative odorants (ammonia, lavender, and wintergreen) were selected for use, and the data generated by the survey was used in analyzing the results of the testing. Pretests were given during regular class time using both the visual instruments (refer to Tests I B, II B, III B, IV B, V B, and VI B) and the verbal instruments (refer to Tests I A, II A, III A, IV A, V A, and VI A). In order to prevent students

from beginning the acquisition process prematurely, half of the pretests given were not used in the testing cycle. The pretests were used to set a baseline for previously existing knowledge. The visual instruments required students to label a diagram. One to two weeks after pretesting and again during regular class time, students were presented with the correct labels. They were then given ten minutes under the aroma condition listed in Experimental Design and instructed to study as if they were preparing for a test. Student papers were then collected to prevent further practice. At this point, the students were then tested as a measure of short-term memory. The verbal instruments required students to select the correct definition for the term presented from a choice of three definitions. Once more, one to two weeks after pretesting and during regular class time, students were presented with the correct definitions. They were allowed ten minutes under the aroma conditions listed in Experimental Design and instructed to study as if they were preparing for a test. Student papers were then collected to prevent further practice. As previously at this point, the students were tested as a measure of short-term memory. The same posttests were administered approximately two weeks following the initial posttests to assess long-term retention. The same arrangement as for the initial posttests in the Experimental Design were used. At the conclusion of each testing period an additional, brief survey was given to determine whether students were having any difficulty breathing, e.g. presence of head cold, allergy flare up, smoking (refer to Survey 2).

A control group was established. This position was rotated among the classes with a different class serving as the control group for each test based on the absence of an aroma during acquisition, retention, and retrieval. These subjects were asked to perform the same tasks, but the tasks were performed in the absence of a fragrance. The potpourri pot was set up with only water in it for the control because the students associated the presence of the potpourri pot with an odor.

Students were directed to attend to the information presented by the experimenter on acquisition day. On retrieval day, students were directed to complete the instrument as

much as they could recall in 10 minutes. To prevent any students from spending more than the allotted time on any of the material, the material was collected at the conclusion of each session and redistributed at the beginning of the next session.

Students occasionally asked for additional information about the test they were taking or the aroma which was present. No additional information was provided to them.

Experimental Design

Due to the use of students already assigned to classes, this investigation was quasi-experimental rather than true experimental in nature. Aside from the comparison of the posttest to pretest scores to determine the actual amount of knowledge learned, students' test scores were assessed based on the experimental conditions. Results of both surveys as well as the posttest questions were also analyzed.

Data Analysis

Each test and odor were assigned unique numbers and subjects were assigned numeric values. The previously described items as well as subjects' scores were entered into IBM Word Perfect 6.0 accordingly, one subject per line. After being converted to an ASCII file, the numerical data was analyzed by Mike Rayle, University of Dayton computing consultant, via SABER::STATS. The data was analyzed to determine interaction among the variables using a correlational analysis and a T-test.

Threats to Validity

There were several possible threats to internal validity. The problem of maturation in the initial posttest was addressed by randomly providing students with tests which had the pages in different orders. Also, no testing period exceeded thirty minutes. The threat of history was dealt with by rejecting the data generated by a student who was not present for the entire testing cycle. The pretest could provide a testing threat, but this threat was minimized by the use of additional pretests that were not used as posttests. The threat of differential selection was possible since the researcher did not select her groups; however, no

ability grouping was used to assign students to any one given class. Class rosters were randomly generated.

There were fewer possible threats to external validity. This particular study would not be generalizable to a larger population due to the small and specific population on which the study was performed. The Hawthorne Effect was minimized by the students experiencing ambient odors and pretests, both of which were not parts of the study. The experimental design allowed for a day with no fragrance between days with fragrances to minimize any multiple treatment interference.

CHAPTER IV

RESULTS

TABLE 1

SURVEY 1 - FEELINGS ABOUT ODORS

<u>Odor</u>	<u>Total Score</u>	<u>Preference Ranking</u>
Ammonia	72	9
Cinnamon	174	5
Citrus	188	2
Evergreen	161 + 1 non-response	6
Gardenia	148	7
Lavendar	177	4
Manure	65	11
Mold	70	10
Peppermint	179	3
Rose	203	1
Vinegar	74 + 1 non-response	8
Wintergreen	179 + 1 non-response	3

The odors chosen for the experiment were ammonia, lavender, and wintergreen. The ammonia was chosen as a negative olfactory sensation as it appeared that most students did not like it as evidenced by its low total score. Also, it was much easier to provide an ammonia stimuli than the other negative odors. Lavender was chosen because of its higher preference ranking and because of its known sedative effects as evidenced in earlier research (Buchbauer, Jirovetz, Jager, Plank, and Dietrich; 1993 and Hurley, 1995). Wintergreen was chosen because of its high preference ranking and also as a result of the researcher's observations. The researcher noted the reaction of the students to the wintergreen during the acclimation period as being that of much relaxation. Students in close proximity to the wintergreen source were struggling to stay awake and focused on class. This was the only odor which produced the effect.

TABLE 2
RESULTS OF TEST IA

Variable	No. of Subjects	Mean Score	Std. Dev.
Background Score	43	47	16
Short Term Memory	43	97	8
Long Term Memory	41	74	26

Clearly short term memory is quite good, while it is evident that long term memory has diminished considerably. All subjects experienced the same odor (wintergreen) throughout the testing cycle from acquisition through long term memory testing. The Pearson correlation coefficient was 0.95 which indicates that there is no significant relationship between the short term memory scores and the long term memory scores. This same coefficient for short term memory correlating them to the original knowledge background scores was 0.97 with no significance.

TABLE 3
RESULTS OF TEST IB

Variable	No. of Subjects	Mean Score	Std. Dev.
Short term memory	42	72	22
Long term memory	41	20	18

15 subjects experienced wintergreen as the ambient odor throughout the testing cycle from acquisition and short term memory testing through long term memory testing. The remaining subjects experienced a different odor during acquisition and short term memory testing from that during long term memory testing. Test IB was a visual instrument which required subjects to remember labels. There were no cues for memory as in the multiple choice verbal instruments. This would account for the larger standard deviation. The Pearson Correlation Coefficient showed a nearly significant effect with a rating of 0.06 relating short term memory scores to long term memory scores.

TABLE 4
DIFFERENCE IN LEVEL OF LONG TERM
MEMORY PERFORMANCE FOR TEST IB
BASED ON THE PRESENCE OF THE SAME
ODOR VERSUS A DIFFERENT ODOR

Odor	T-value	DF	Probability	Significance
Same	-0.31	39	0.75	None
Different	-0.30	39	0.77	None

By the data generated from Test IB there is no significance between the test groups who experienced different ambient odors during the testing cycle from the test group who experienced wintergreen uniformly throughout the cycle.

TABLE 5
RESULTS OF TEST IIA

Variable	No. of Subjects	Mean Score	Std. Dev.
Short term memory	42	98	6
Long term memory	41	70	23

Fifteen subjects on this test experienced no ambient odor throughout the test cycle while the remaining subjects experienced different odors. There is more variation in the scores on the long term memory testing on this verbal instrument than on Test IA.

The Pearson Correlation Coefficient of 0.38 indicates that there is no correlation between the short term memory scores and the long term memory scores.

TABLE 6
 DIFFERENCE IN LEVEL OF LONG TERM
 MEMORY PERFORMANCE FOR TEST IIA
 BASED ON THE PRESENCE OF A DIFFERENT
 ODOR VERSUS NO ODOR

Odor	T-value	DF	Probability	Significance
Different	0.79	35	0.44	None
No Odor	0.77	39	0.45	None

The probability indicates that there is no significance in long term memory scores based on the presence of two different odors or the absence of an ambient odor during the cycle.

TABLE 7
RESULTS OF TEST IIIA

Variable	No. of Subjects	Mean Score	Std. Dev.
Background Score	43	41	12
Short term memory	43	95	11
Long term memory	41	74	19

Sixteen subjects were exposed to the wintergreen fragrance consistently through the cycle from acquisition to long term memory testing. The remaining subjects were exposed to two different ambient odor situations. The Pearson Correlation Coefficient at 0.27 indicates that there is no correlation between the long term memory test scores on Test IIIA and the short term memory scores. However, with a score of -0.11, the Pearson Correlation Coefficient indicates that there is a significant relationship for the short term memory scores related to the original knowledge background scores. This effect could be attributed to the presence of the wintergreen, although there is no direct evidence.

TABLE 8
DIFFERENCE IN LEVEL OF LONG TERM
MEMORY PERFORMANCE FOR TEST IIIA
BASED ON THE PRESENCE OF THE SAME
ODOR VERSUS A DIFFERENT ODOR

Odor	T-value	DF	Probability	Significance
Same	0.49	33	0.62	None
Different	0.49	39	0.63	None

The probability values indicate that there is no significant difference between the long term memory scores of those subjects who were exposed to the wintergreen fragrance consistently and the long term memory scores of those subjects who were exposed to different ambient odor situations.

TABLE 9
RESULTS OF TEST IIIB

Variable	No. of Subjects	Mean Score	Std. Dev.
Background Score	44	13	9
Short term memory	44	87	13
Long term memory	41	46	22

Thirteen subjects experienced no ambient odor for this complete test cycle while the remaining subjects experienced a change in their ambient odor situation. The Pearson Correlation Coefficient at -0.05 indicates that there is a correlation between the long term memory scores and the short term memory scores. With a rating of -0.24, there is a significant relationship between the short term memory scores and the original knowledge background scores.

TABLE 10
 DIFFERENCE IN LEVEL OF LONG TERM
 MEMORY PERFORMANCE FOR TEST IIIB
 BASED ON THE PRESENCE OF A DIFFERENT
 ODOR VERSUS NO ODOR

Odor	T-value	DF	Probability	Significance
Different	0.19	17	0.85	None
No Odor	0.22	39	0.83	None

With the visual instrument IIIB there appears to be no significance between those subject scores who experienced two different odor situations during the cycle as opposed to those subjects who consistently experienced no odor.

TABLE 11
RESULTS OF TEST VIB

Variable	No. of Subjects	Mean Score	Std. Dev.
Background Score	42	5	5
Short term memory	42	67	24
Long term memory	41	14	13

Once more with a visual instrument, subjects demonstrated more difficulty in supplying the correct labels as evidenced by the lower scores and the greater standard deviations. With a Pearson Correlation Coefficient of 0.19, the test shows no correlation between long term memory and short term memory in this case in which all subjects consistently were exposed to no ambient odor. However, a significant relationship between the short term memory scores and the original knowledge background scores is demonstrated with a rating of -0.09.

TABLE 12
RESULTS OF SURVEY II - How Well Can You Breathe

FREQUENCY OF RESPONSES			
CONDITION	Not at all	Some	Mostly
Head cold	12	22	7
Allergy	23	15	3
Smoker	38	1	2
Lives with a smoker	24	5	12

The response to this survey revealed that students were not breathing compromised to the point that it would have had an impact on this study. With the majority of students responding not at all or some to the four conditions listed, the majority of students should have olfactorily been able to detect the ambient aroma present whether they were cognizant of the aroma or not.

TABLE 13
RESPONSE TO POST-TEST QUESTIONS

QUESTION	RESPONSES*		
	Yes	No	No Response
Is an odor present?	21	12	6
Is the odor familiar? ¹	19	2	
<hr style="border-top: 1px dashed;"/>			
	Correct	Related	Wrong
Name the odor. ²	2	7	10

* 6 students were not present for this survey.

¹ Only those who answered yes to the previous question were to respond to this question.

² Only those who answered yes to the previous question were to respond to this statement.

Most students recognized that there was an ambient odor present, and of those students, nearly all recognized the odor as one that was familiar to them. Without any prompts less than 10% of the students could properly identify the odor. However, nearly half the students called it by a related name, e.g. spearmint or mint instead of wintergreen.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

People long ago recognized the importance of aroma and fragrant potpourris, teas, lotions, and baths were part of everyday life. Then humans grew away from these practices. Now aromatherapy is re-emerging as people are rediscovering the uses it has in mood altering and contextual cuing. It has long been recognized that particular aromas can evoke a flood of emotionally-charged memories. Whether the use of aromas can enhance memory as an educational tool is still being investigated.

The purpose of this study was to use aroma while students were acquiring new knowledge and then to analyze whether, in fact, the presence of that aroma during testing would allow students to better access their stored memory of the knowledge. After pre-testing with the actual knowledge material and other similar material, the students were presented with the knowledge material they were to acquire in an appropriate amount of time. They were then immediately post-tested to check short-term retention levels. After approximately a two week interval, they were again post-tested to determine long-term retention levels. During this second post-testing some students experienced the same aroma as they did during the acquisition phase, while some students experienced a different aroma, and one group of students experienced no aroma at either acquisition or post-testing.

Conclusions

In every case, the short term retention scores were drastically higher than the background scores from the tests of the original knowledge. While the scores diminished in the long term retention, they were still considerably higher than the original knowledge background scores. Material had been learned, but had this learning been enhanced by the presence of an ambient odor? No significant correlation was found between the presence of one odor, different odors, or no odors to the retention scores. That is not to say that there is no correlation. One was not demonstrated in this investigation. This study focused

basically on relaxing aromas to provide the contextual cuing and a release from test anxieties. It was not appropriate to look at any type of data as far as a release from test anxieties because subjects were informed from the outset that their participation in this study would in no way effect their biology grade, and so, these subjects should have been experiencing no true test anxiety when they were responding to the study tests. While there is evidence that subjects had, in fact, learned the material, without the extrinsic motivation that the material was for a graded evaluation, the concept of contextual cuing may not have been important either.

Since this study is not definitive, it is apparent to this researcher that further investigation would be useful. A demonstrable link between aroma and learning would most definitely be a useful tool in education. However, if the Proustian phenomenon cannot be controlled to make it productive, then that information is equally important.

Recommendations

This study was very narrow in its focus and only touched the tip of the iceberg in terms of the different odorants that could be used. It is apparent that this is only the beginning and that there is much to do in testing other odorants and various types of learning tasks.

High school age students do not make the most patient of subjects. While they were very keen to be a part of this study initially, their enthusiasm waned drastically as they experienced the repeated testing. Maturity also played a factor. Some high school students want very much to impress their teacher, and so they attempt to psyche out the test. Others, in their quest for attention, enjoy being disruptive and attempt to skew the data by spraying an extraneous odorant. Better data could, perhaps, be obtained using undergraduate college students with additional testing then done on high school students to broaden the base for generalization. Aside from using different age populations, more immediate application might be determined by assessing the results of this type of study on special needs populations, e.g. LD, DH, or MH.

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APPENDIX A

Letter to Parents

January 27, 1997

Dear Biology Parents;

I am in the process of completing my Masters thesis , and I will be conducting my research with my biology classes. I am studying the effect, if any, of an aroma on memory. I need your permission for your student to participate in my study. I can assure you that participation in my study will not affect your student's biology grade, and your student's name will not be used in my research. I plan only to publish the results of the study.

Please complete the attached permission slip and return it to me as soon as possible. I appreciate your cooperation.

Sincerely,

Diane Crosthwaite

I give my permission for _____ to participate in Diane
son or daughter's name
Crosthwaite's Masters thesis research.

Date

Parent's Signature

APPENDIX B

Background Information

Population Information

Class	Time of Day	No. Students	No. Boys	No. Girls	Ave. Grade
3	9:25-10:15 a.m.	16	3	13	84%
4	10:15-11:05 a.m.	17	10	7	80%
6	12:15- 1:05 p.m.	12	3	9	82%

Experimental Design

	Wednesday	Thursday	Friday	Monday	Tuesday	Monday	Tuesday
3rd	IIA	IA VIB	IB	IIIB	IIIA	IA, IIIA, IB	IIA, IIIB, VIB
4th	IIIA	IIA VIB	IA	IB	IIIB	IA, IIIA, IB	IIA, IIIB, VIB
6th	IB	IIIA	IIIB	IIA VIB	IA	IA, IIIA, IB	IIA, IIIB, VIB
	wintergreen	No Arome	Ammonia	No Arome	Levendar	wintergreen	No Arome
	3 verbal skills	IIA, IIA, IIIA					
	3 visual skills	IB, IIIB, VIB					

APPENDIX C

Survey on Odors

Name _____ Class _____ Date _____

SURVEY I

Directions: Circle the number that most closely expresses your feelings about each odor listed.

DI - dislikes intensely **D** - dislikes **N** - no feelings **L** - likes **E** - enjoys

ODOR	DI	D	N	L	E
Ammonia	1	2	3	4	5
Cinnamon	1	2	3	4	5
Citrus	1	2	3	4	5
Evergreen	1	2	3	4	5
Gardenia	1	2	3	4	5
Lavendar	1	2	3	4	5
Manure	1	2	3	4	5
Mold	1	2	3	4	5
Peppermint	1	2	3	4	5
Rose	1	2	3	4	5
Vinegar	1	2	3	4	5
Wintergreen	1	2	3	4	5

APPENDIX D

Instrumentation

TEST I A

Directions: Write the letter which corresponds to your choice for the definition of the word listed.

- _____ 1. frontispiece
A. roof above the front door B. front bumper of a car
C. principal front of a building
- _____ 2. diaposon
A. the full range of a voice B. a diagonal position
C. a direct conversation
- _____ 3. kinesiology
A. the study of kinetic energy B. the study of psychic powers
C. the study of the anatomy and mechanics of human movement
- _____ 4. stenography
A. the art of speaking in a loud voice B. the art of writing in shorthand
C. the art of stenciling
- _____ 5. yardmaster
A. the person in charge of the sails B. the person in charge of recreation
C. the man in charge of operations at a railroad yard
- _____ 6. zymoscope
A. an instrument used to view the colon B. an instrument used to measure enzymes
C. an instrument used to measure the fermenting power of yeast
- _____ 7. grommet
A. a flexible loop fastening B. a Chinese cooking utensil
C. a small Pacific fish
- _____ 8. inglenook
A. a cranny under the eaves of a house B. a corner by the fire
C. a crane used to support a kettle
- _____ 9. escritoire
A. a writing desk B. a French dish containing snails
C. an engraving tool
- _____ 10. palindrome
A. the sound of a swarm of bees B. a word that reads the same backward
C. a large concert hall
- _____ 11. hedonism
A. animal magnetism B. a style of architecture
C. the doctrine that pleasure is the chief good of life

- _____ 12. kamik
A. a boot made of sealskin
C. an Inuit medallion
B. a single passenger boat
- _____ 13. raucous
A. brisk
C. blood red in color
B. disagreeably strident
- _____ 14. comestible
A. edible
C. shiny
B. flammable
- _____ 15. malapropism
A. a lawsuit for wrong doing
C. a poor alteration
B. misapplication of a word

Name _____ Class _____ Date _____

TEST II A

Directions: Write the letter which corresponds to your choice for the definition of the word listed.

- _____ 1. epicure
A. a picture painted in shades of one color B. a healing process for the skin
C. one devoted to sensual pleasure
- _____ 2. apparitor
A. an overseer of banquet preparations B. one who sets fair prices
C. an official who carries out the court's orders
- _____ 3. infuse
A. to instill a principle B. to create a distraction
C. to harmonize with full voice
- _____ 4. vascular
A. well endowed with muscle B. relating to the channel for body fluid
C. pertaining to a vining plant
- _____ 5. kirtle
A. a type of deep-throated laugh B. a Middle Ages tunic or coat
C. a small wading bird
- _____ 6. onus
A. a disagreeable necessity B. a breed of Asian cattle
C. a single item
- _____ 7. diptych
A. a two-part canal gate B. an instrument for measuring depth
C. a two-leaved hinged tablet
- _____ 8. xebec
A. 3-masted sailing ship B. a rare African antelope
C. an outgrowth of xylem tissue
- _____ 9. sputum
A. a vile epitaph B. the water emitted by a geyser
C. expectorated matter from the respiratory passages
- _____ 10. gaffer
A. an individual who runs errands as a job B. an old man
C. an individual who is laughing hysterically
- _____ 11. yew
A. an attitude in a vehicle of flight B. a genus of evergreens
C. an adult female sheep

- _____ 12. breviary
A. a brief summary
C. an abbreviated mass
B. a feminine toiletry item
- _____ 13. ketch
A. a ship similar to a yawl
C. the bottom stop of a zipper
B. a specialized surgical fastener
- _____ 14. stucco
A. a type of cactus
C. a bass aria
B. a cement applied like plaster
- _____ 15. inundate
A. to update a series of files
C. to flood
B. to mismanage others' funds

TEST III A

Directions: Write the letter which corresponds to your choice for the definition of the word listed.

- | | |
|----------------------------------|---|
| _____ 1. inflect | |
| A. to turn from a direct line | B. to encourage |
| C. to rush to completion | |
| _____ 2. quell | |
| A. an antique writing instrument | B. a gentle wave |
| C. to suppress | |
| _____ 3. ado | |
| A. an American folkdance | B. turmoil |
| C. a form of good-bye in Spanish | |
| _____ 4. restive | |
| A. listless | B. uneasy |
| C. lazy | |
| _____ 5. torpid | |
| A. a submarine weapon | B. drippingly humid |
| C. numb | |
| _____ 6. colophon | |
| A. a punctuation mark | B. an inscription placed at the end of a book |
| C. a diacritical mark | |
| _____ 7. nubile | |
| A. of marriageable age | B. double-jointed |
| C. of Nubian descent | |
| _____ 8. efface | |
| A. to scar | B. to obliterate |
| C. to apply cosmetics | |
| _____ 9. sally | |
| A. to drag down | B. to leap out |
| C. to pitch up | |
| _____ 10. whet | |
| A. a small species of owl | B. to make keen |
| C. to tear into small pieces | |
| _____ 11. pinochle | |
| A. a delicate brooch | B. a compartment within a pine cone |
| C. a card game | |

- _____ 12. brogan
A. a heavy shoe
C. an embassy official
B. a strong accent
- _____ 13. infest
A. to financially support
C. to spread or swarm in
B. to induct into membership
- _____ 14. shuck
A. an ancient Egyptian coin
C. an apologetic expression
B. the outer covering of a nut
- _____ 15. faun
A. a marble pattern
C. an ancient Italian deity of fields
B. a young deer

NAME _____ CLASS _____ DATE _____

TEST IV A

Directions: Write the letter which corresponds to your choice for the definition of the word listed.

- | | |
|--|-----------------------------------|
| _____ 1. neural
A. relating to a nerve
C. a line dance | B. remaining aloof from a dispute |
| _____ 2. propagate
A. to spin with great speed
C. to multiply by producing offspring | B. to divide into equal portions |
| _____ 3. hod
A. a type of headgear
C. a coal scuttle | B. cultivation of ground |
| _____ 4. mew
A. a storage place for hay
C. a bench seat in a church | B. a common European gull |
| _____ 5. pallor
A. a close companion
C. a room reserved for special occasions | B. paleness |
| _____ 6. explicable
A. capable of being explained
C. capable of being an example | B. capable of being removed |
| _____ 7. mogul
A. an animal with mixed ancestry
C. a moderate wind | B. a great personage |
| _____ 8. confabulate
A. to join in heated discussion
C. to carry on a whispered conference | B. to chat |
| _____ 9. quaff
A. to drink deeply
C. to dance sprightly | B. to sniff sharply |
| _____ 10. rubric
A. a puzzle
C. a heading of a manuscript done differently from the rest of the text | B. a red building material |
| _____ 11. tincture
A. a beverage noted for its red color
C. a mixture containing alcohol | B. a substance used as a dye |

- _____ 12. fluke
A. the blade of a fan
C. a flatworm
B. the jointed piece of a hinge
- _____ 13. utopia
A. the embryo of a flowering plant
C. a place of ideal perfection
B. the fruit of the utopian tree
- _____ 14. niobium
A. a gray metallic element
C. a large member of the antelope family
B. a tribe in central Africa
- _____ 15. imbroglia
A. an oily meat marinade
C. a confused mass
B. an infectious skin disease

NAME _____ CLASS _____ DATE _____

TEST V A

Directions: Write the letter which corresponds to your choice for the definition of the word listed.

- | | |
|--|---------------------------------|
| _____ 1. denote | |
| A. a high pitched sound | B. to serve as an indication of |
| C. a demerit for misbehavior | |
| _____ 2. hallowed | |
| A. prepared for Halloween | B. emptied of its contents |
| C. consecrated | |
| _____ 3. transcend | |
| A. to transmit a message electronically | B. across a fire |
| C. to rise above or go beyond the limits | |
| _____ 4. affiliate | |
| A. to associate as a member | B. a female colt |
| C. a kosher fish | |
| _____ 5. obtuse | |
| A. dimly lit | B. lacking sharpness |
| C. perfectly square | |
| _____ 6. recipient | |
| A. receiver | B. a returning food-bearer |
| C. the small muscle in the forward jaw | |
| _____ 7. consensus | |
| A. opposed to popular opinion | B. having a common center |
| C. general agreement | |
| _____ 8. concentric | |
| A. opposed to popular opinion | B. having a common center |
| C. general agreement | |
| _____ 9. postulate | |
| A. mailed after the deadline | B. an advanced hypothesis |
| C. insolent or rude | |
| _____ 10. impel | |
| A. to urge or drive forward | B. to force into |
| C. to assail | |
| _____ 11. collateral | |
| A. with adjoining sides | B. team effort |
| C. accompanying as secondary | |

- _____ 12. repugnant
A. a belligerent insect
C. argumentative
B. exciting distaste
- _____ 13. promissory
A. assuming with confidence
C. containing a promise
B. seizing upon to the exclusion of others
- _____ 14. meticulous
A. marked by extreme care
C. flexible
B. chewed thoroughly
- _____ 15. flippant
A. uncontrollable
C. flighty
B. talkative

NAME _____ CLASS _____ DATE _____

TEST VI A

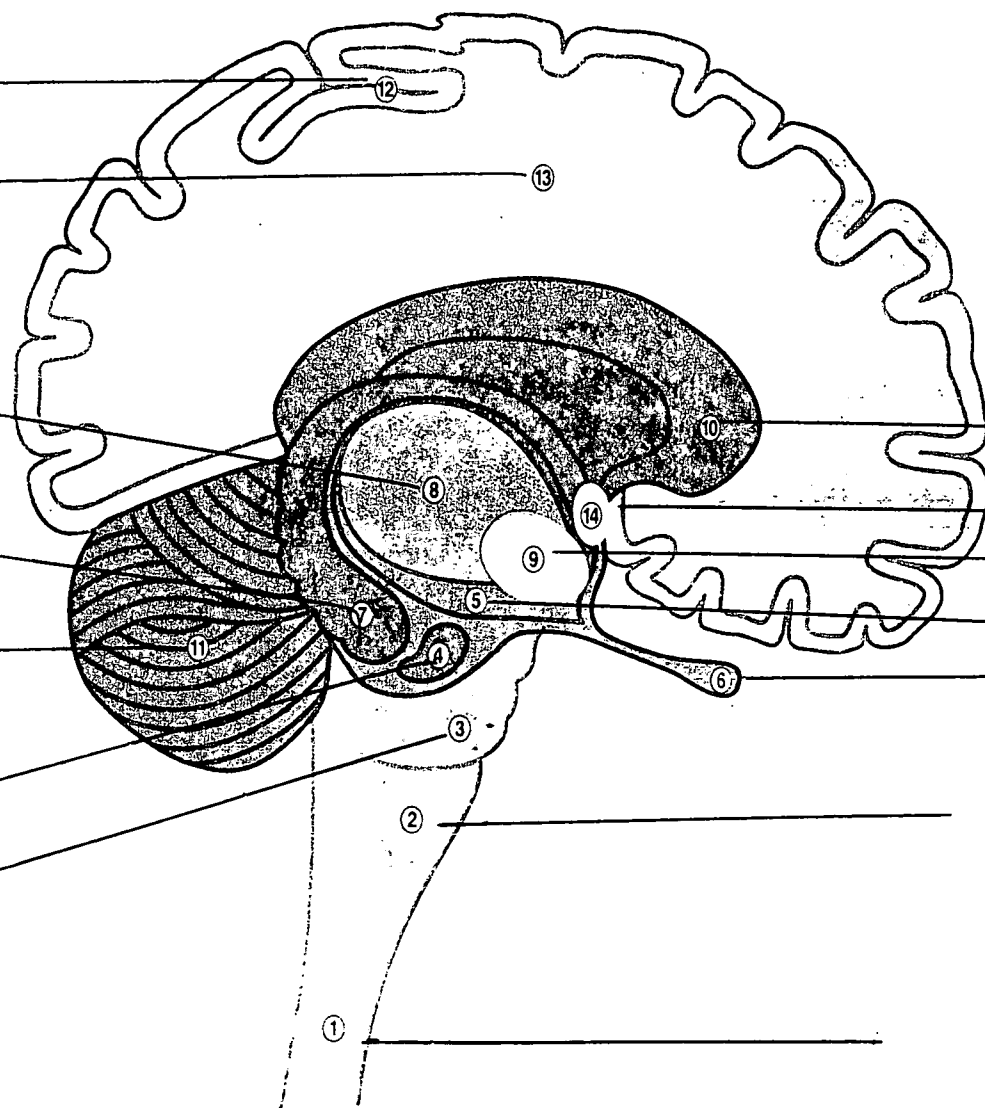
Directions: Write the letter which corresponds to your choice for the definition of the word listed.

- | | |
|------------------------------------|--------------------------------------|
| _____ 1. renaissance | |
| A. surrender | B. a different assignment |
| C. rebirth | |
| _____ 2. dissociate | |
| A. to broadcast seeds | B. to disconnect |
| C. to attach with neat stitches | |
| _____ 3. commemorate | |
| A. to gather a group of believers | B. to call to remembrance |
| C. to piece back together | |
| _____ 4. populous | |
| A. numerous | B. a small, blood-sucking insect |
| C. respected by most | |
| _____ 5. fraudulent | |
| A. deceitful | B. filled with peril |
| C. frightened | |
| _____ 6. inquisition | |
| A. a testing session | B. the act of inquiring |
| C. a curiosity | |
| _____ 7. dexterity | |
| A. right-footedness | B. skill and ease in using the hands |
| C. flexibility | |
| _____ 8. lenient | |
| A. of mild or tolerant disposition | B. lazy attitude |
| C. a loosely constructed dwelling | |
| _____ 9. dilapidated | |
| A. shingle laying | B. specialized double seaming |
| C. fallen into partial ruin | |
| _____ 10. disheveled | |
| A. removed by digging | B. neatly stacked |
| C. marked by loose disorder | |
| _____ 11. tithe | |
| A. to pay or give a tenth part | B. to name a written composition |
| C. to relay gossip | |

- _____ 12. effigy
A. a Native American necklace
C. an islander
B. an image or representation
- _____ 13. adamant
A. angry
C. having first man qualities
B. unshakable
- _____ 14. indemnity
A. a security against loss
C. unerasable ink
B. a loose-woven blue cotton fabric
- _____ 15. sardonic
A. referring to small canned fish
C. bitter
B. a slow type of movement

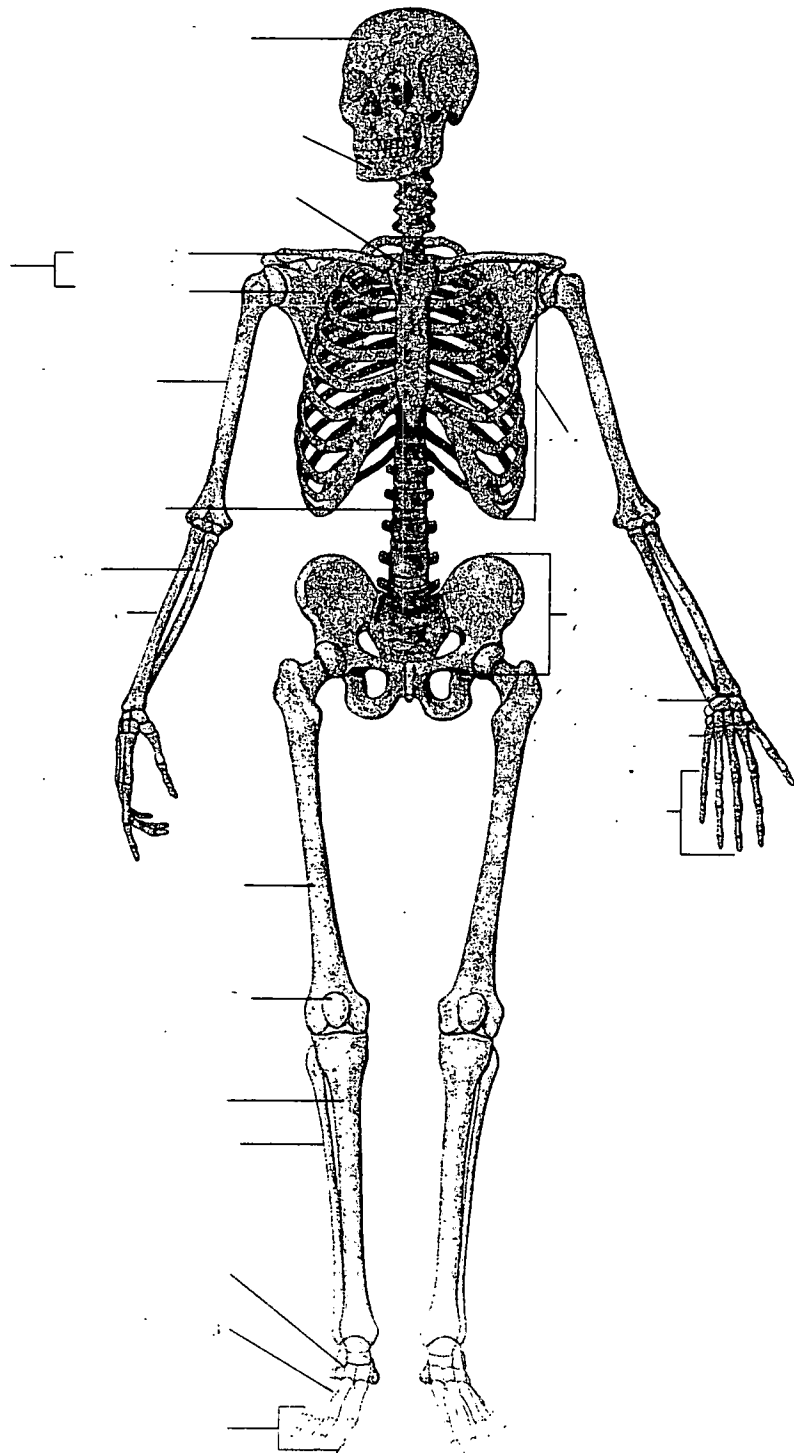
NAME _____ CLASS _____ DATE _____

TEST I B



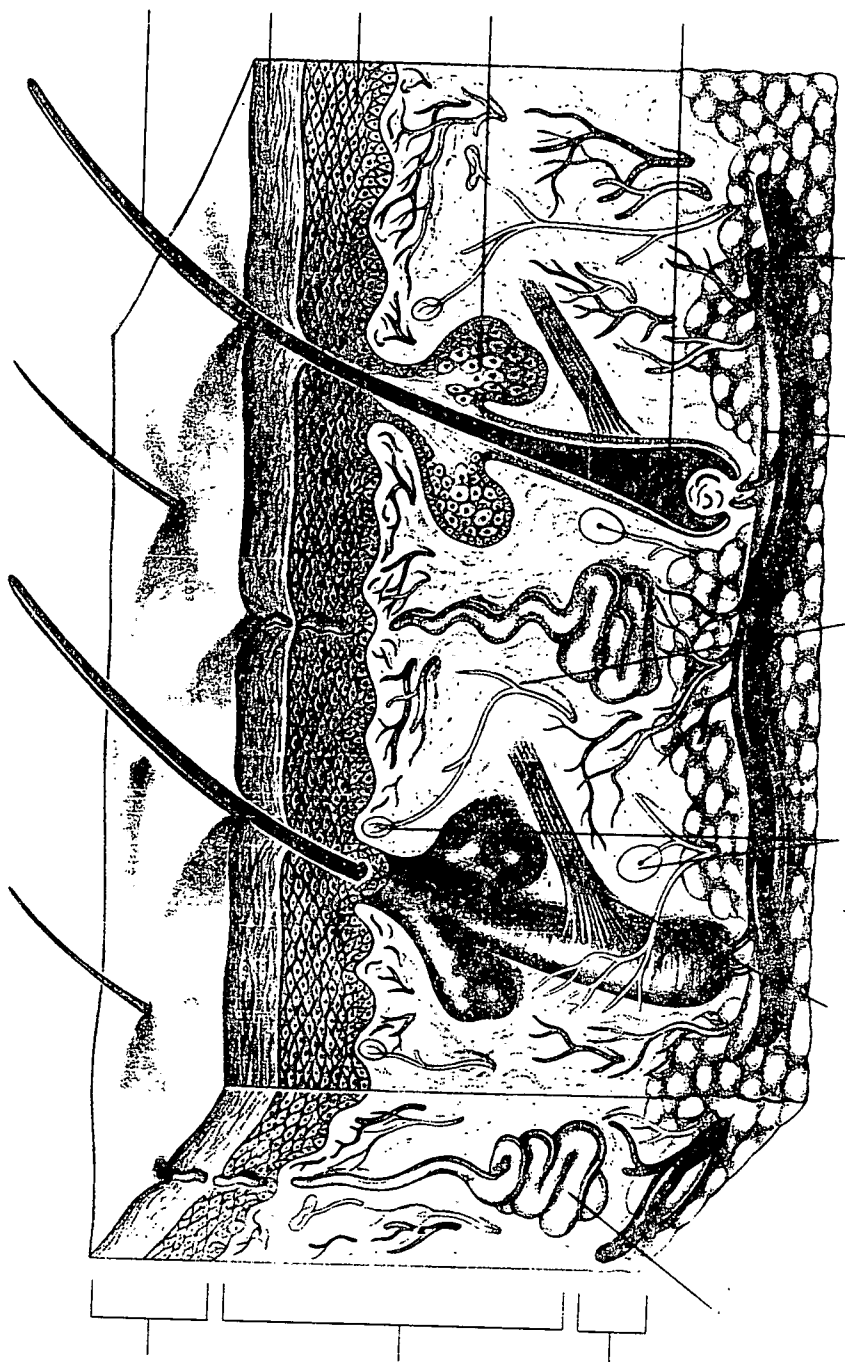
NAME _____ CLASS _____ DATE _____

TEST II B



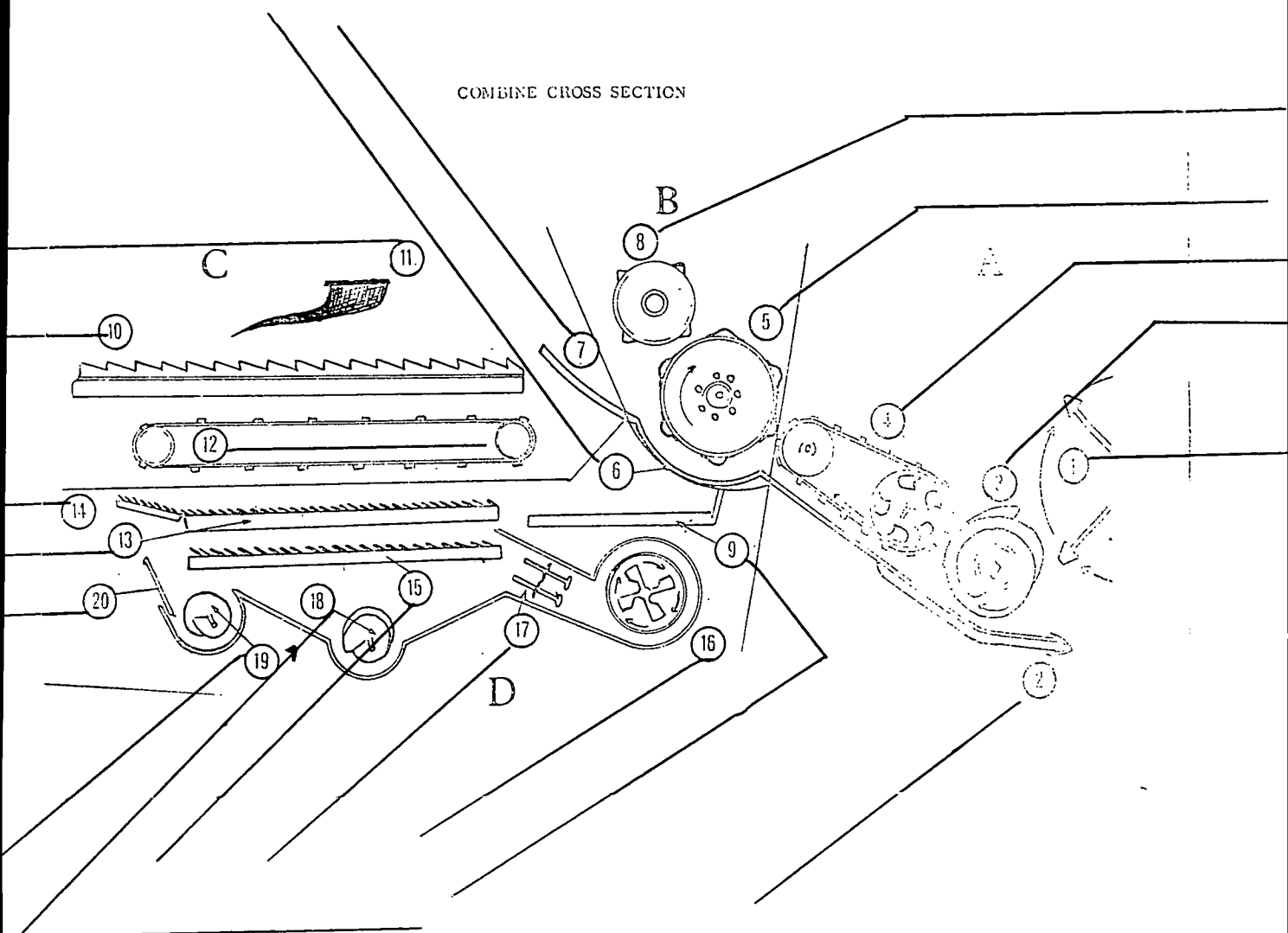
NAME _____ CLASS _____ DATE _____

TEST III B



NAME _____ CLASS _____ DATE _____

TEST IV B



NAME _____ CLASS _____ DATE _____

TEST V B



R002578987

NAME _____ CLASS _____ DATE _____

TEST VI B

