CERTIFICATION OF APPROVAL

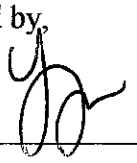
Veterinary Medical Expert System Focusing on Diagnosis of Hematological Disease in Feline Health

By

Azliza Bt Mohamad Ariff

A project dissertation submitted to the
Information System Programme
Universiti Teknologi PETRONAS
In partial fulfillment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(INFORMATION SYSTEM)

Approved by,

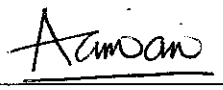


(Vivian Yong Suet Peng)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
JUNE 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



AZLIZA MOHAMAD ARIFF

ABSTRACT

This project is to develop veterinary expert systems that can help veterinarian diagnose type of cat's disease focusing on blood testing. This project is targeted for veterinarians. The main purpose of developing this project is to centralize and computerize the process of blood diagnosis.

Base on the research at two of veterinary institute in Ipoh which are Jabatan Perkhidmatan Haiwan (JPH) and Veterinary Research Institute (VRI), there are some problems encountered in diagnosing blood diseases. First, both institutes have no proper database to keep the information. In other words, they use filing system in recording the information regarding diagnosing cat's diseases. Second, the process of diagnosis cat's diseases is not centralized. JPH only diagnose normal cat's diseases like flue, fever etc. If there is a serious case, they will take the blood sample and send to VRI, so that VRI can do further investigation. After VRI do the blood test, they send the result to JPH and JPH will diagnose cat's diseases base on the result given by VRI. In simple words, VRI is more on lab testing focusing on blood.

Therefore, this project proposal is to help both institutes in diagnosing blood diseases especially for VRI. Instead of doing lab testing focusing on blood, VRI may know what type of diseases that cat suffered. This project is applicable for VRI because they may know the cat's diseases directly after they do the lab test without send the result to JPH.

ACKNOWLEDGEMENTS

IN THE NAME OF Allah most gracious, most merciful.

First and foremost, I would like to thanks Allah SWT for the guidance and wisdom to come this far in this report presentation.

As a most gracious mentor and guide, I would like to thank to Ms Vivian Yong Suet Peng as a supervisor for the tremendous support and up-most collaboration in making a success of this Final Year Project: "Veterinary Expert System; Feline Hematology Expert System". I hope the experiences that have shared during development of this project will be beneficial, and bring warm and sweet memories during the years to come.

Special thanks also goes to the Dr. Gurmeet Khaur, Lecturer from Universiti Pertanian Malaysia (UPM) for approving and allowing to do research, also gathered some useful information and giving good cooperation during the development of the project.

Besides that, deepest appreciation goes to Veterinary Research Institute (VRI), Ipoh. I really appreciate the Veterinarian of VRI, Dr. Azizah, Dr, Chandra Wathani, Dr Rohaiza and all the VRI staffs, thank you all for the support and guidance that have been allocated which contributed the successful of this project. I really appreciate the feedback and advice that have been given.

Thank you to Jabatan Perkhidmatan Haiwan (JPH), Ipoh especially to Dr. Wan Mohd Kamil B. Dato' Wan Nik, for helping and showing some methods and guideline in the overall flow involve in diagnosing cat's diseases process.

Thank you and love goes to my parents. Thank you for the countless and meaningful advice and *doa*. Sincere thanks to the wonderful friends for their cooperation.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

ABBREVIATION AND NOMENCLATURES

JPH	: Jabatan Perkhidmatan Haiwan
VRI	: Veterinary Research Institute
FHES	: Feline Hematology Expert System
CBC	: Complete Blood Count
BUN	: Blood Urea Nitrogen
WBC	: White Blood Count
RBC	: Red Blood Count
Hb	: Hemoglobin
HCT	: Hematocrit
MCV	: Mean Corpuscular Volume
MCHC	: Mean Corpuscular Hemoglobin Concentration

CHAPTER 1
INTRODUCTION

1.1 Background of study

Owners want pets to live the best quality life possible. One year in the life of a pet is the same as 5-7 in a human. One year represents 10-20% of a pet's life span. Detecting disease early prolongs quality life. Preventing disease is much cheaper than treating disease. [1]

Nowadays, most cats' diseases are difficult to detect especially internal diseases. Blood testing for cat is one of the medical tools we have today. Through blood testing, vets can identify the functionality of internal organs. Instead of detecting the organs' function, blood testing allows vets identify the number of blood components.

Blood tests are an important way of taking charge of pets' life. Blood tests are one of the most valuable health tools. Modern science has given us precise, focused ways to determine the state of cat's health concerns. Health awareness is necessary to move forward in the direction of better, more confident health. Blood tests make this all possible, and they are now convenient and affordable.

Blood testing is a vital part of the care of our pets. Know the signs of diseases can get help for our pet before it is too late for treatment to be effective. Our care and attention to the pets will help keep them in good health. Regular examinations can help avoid problems by detecting them before they become serious.

Obviously, a blood test tells us what is going on in the blood. Which, in turn, tells us what is going on with internal organs; how well they are (or are not) performing. By determining values of specific components (proteins, enzymes, minerals, acids etc) we can identify acute and chronic conditions, and in most cases we can "adjust" those diseases. [2]

Blood test reports serve a critical purpose. They are the primary means of determining what is going on inside pet's body.

Blood test is performed to get an initial overview of the health, and sometimes the function, of body organs. Some blood tests are very specific for a single organ, whereas other tests are affected by several organs.

Realizing the important of blood testing on cat that had been mention above, the author had proposed a system called Feline hematology Expert System (FHES).

1.2 Problem Statement

- Paper-based documentation.

  Generally, most of us tend to keep important information on paper. We prefer not to record all the important information in computer. Base on the research in both veterinary institutes in Ipoh, they kept all the information regarding lab testing on paper. They don't have proper database to keep the information. In other words, both places still use filing system to keep the data. This may lead to loss of information or miss place the file. If let say, one file about components of cat blood lost, it may affect the vet's tasks. May be the components of cat's blood is important for vets in order to do other lab testing. Most of works could not be done successfully and effectively.

- Blood diagnosing process not centralized.

  Besides that, base on the interview done in both veterinary institutes in Ipoh, the obvious problem that has been encountered is blood-diagnosing process is not centralized. There are two veterinary institutes in Ipoh, which are Jabatan Perkhidmatan Haiwan (JPH) and Veterinary Research Institute (VRI). Both are different places and different scope of works. JPH is place where pet's owners send their pet only when the pets are sick. They do not do further check-up for the pet. They just check the pet's disease and give treatment to the pets. However, Veterinary Research Institute is more on lab testing. VRI focus on equine, feline, canine and other small animals. Base on the research, VRI only do the lab test and the result will be sent to JPH to diagnose the cat's diseases. Basically, pet owners will send their pet to JPH. JPH will check the pet's disease. JPH only do the diagnosing process for normal diseases such as flue, fever etc. They will give appropriate medicine to the pet. In other words, JPH only act as veterinary clinic. However, all tasks that related to the lab test like blood test, JPH need to send the blood sample to VRI. VRI will do the lab test and send back the result to JPH, so that JPH can diagnose the pet's diseases.

1.3 Objectives

The objectives of the project are as follows:

- To understand the concept and development of rule-based expert systems.
- To develop veterinary expert systems that can help veterinarian diagnose type of cat's disease focusing on blood testing.
- To have better understanding on the software that will be used in order to develop veterinary expert system.

1.4 Scope of Studies

[16] Blood testing is recommended strategy to prolong pet's life. The foundation of successful disease prevention is early detection. [1] Blood Testing is the tools that can give us the first hint of a problem so the potential problem can be explored much earlier.

The scopes of this project are focusing on this area:

- **COMPLETE BLOOD COUNT (CBC):** Blood analysis allows evaluation for anaemia, nutritional status, and presence of inflammation, stress, and inability to fight disease, specific diseases, and clotting defects. [1]
- **BLOOD UREA NITROGEN (BUN):** is produced by the liver and excreted by the kidney. Testing for it helps to detect liver and kidney abnormalities. [1]

CHAPTER 2
LITERATURE REVIEW AND THEORY

2.1 Introduction to Expert System

Peter Jackson illustrated [3] an expert system is a computer program that represents and reasons with knowledge of some specialist subject with a view to solving or giving advice. An expert system may play the role of an assistant to a human decision maker. The client may interact with the program directly or interact with a human expert who interacts with the program. It can be simply stated, an expert system is to make a program intelligent, provide it with high quality of technology and specific knowledge about some problem area.

In other words, an expert system is a computer program. A computer program is a piece of software, written by a "programmer" as a solution to some particular problem. The primary goal of expert systems is [14] to make expertise available to decision makers and person who need answers quickly. There is never enough expertise to go around; certainly, it is not always available at the right place and the right time. Instead of relying on expertise, an expert system is to be an alternative source of decision-making ability for organizations to use. Expert systems are often interpreted to be "replacements" for decision makers, however, in many organizations; these systems are used to help the decision-maker to address more complex and important issues facing the organization.

[15] Expert system can also be stated as a computer application that performs a task that would be performed by a human expert. For example, expert systems are used in applications such as medical diagnosis, investment analysis, financial, insurance planning etc. Most expert systems are developed through specialized software. Expert systems use human knowledge to solve problems that normally would require human intelligence.

2.2 Medical Expert System

Medical Expert System helps consumers and health care providers in medical decision support. Using an Expert System called ILIAD, [4], which uses artificial intelligence; it provides clinicians with a list of diagnostic possibilities in patients with difficult or complex problem.

[6] Internist system (1970) has been designed for the diagnosing of the internal diseases. The clinical look of the disease, the results of lab analysis and the history of the disease etc. are inserted into the system. The system can define the probable diagnosis, depending on these data, and later it can pick out the most probable one for the disease.

Besides that, 5GL-Doctor is one of the Medical Expert System. [5] From a list of 8000 symptoms items are selected and become part of the inquiry. Using advanced searching techniques, the inquiry is matched against known medical conditions. A short list is produced. The short list is in order of the most likely based on how common a condition is and how well the inquiry maps onto the symptoms of a medical condition. There are different analysis approaches including a sequential analysis (i.e. step by step).

The enhancements of office computerization and expert system integration have made the office task efficient. Today, many clinicians employ computers as one of the part of their office practices. Some clinicians work interactively with a computer during their office activities to review their patients' medical records. It is expected that this trend will continue.

2.3 Hematology Expert System

Hematology is the study of the bodies' blood cell.

Besides that, [7] DXplain is a decision support system which acts on a set of clinical findings (signs, symptoms, laboratory data) to produce a ranked list of diagnoses. The system uses a modified form of Bayesian logic. It was developed at the Massachusetts General Hospital over ten years ago and has been used by thousands of users since then, both as a stand-alone version and over the Internet. DXplain can provide a comprehensive description of over 2,000 different diseases, emphasizing the signs and symptoms that occur in each disease. DXplain also provides up to 10 recent references that have been selected as being appropriate reference material for each specific disease.

Other technology associated with hematology expert system is QBC (TM) Reference System. [8] Becton Dickinson, an international health care technology company, has developed this system at the corporate R&D centre and is in routine use by customers. This system is integrated into the QBC hematology analyzer product line and provides possible medical interpretations of a patient's hematological test results. It is used primarily in physicians' office laboratories.

The most well known medical expert system is MYCIN. [10] This expert system was developed at Stanford University in 1976 to aid physicians in diagnosing and treating patients with infectious blood diseases caused by bacteria in the blood and meningitis. These diseases can be fatal if not recognized and treated quickly.

IntelligentMD is one of the hematology expert system. IntelligentMD is for human. It is [9] developing a patent-pending system that will analyze patient specimens (blood or sputum, for example) and deliver results that indicate why a patient is sick and, often, the most effective treatment. A patient's specimen is collected and tested in a clinical laboratory. Within hours, the test system will identify the specific disease etiologic agent and recommend a primary therapeutic treatment.

As a conclusion, Hematology Expert System is implemented as an interface between the clinician and the laboratory. The significant benefit of expert systems technology is the ability to represent more sophisticated knowledge. Besides that, expert system is the ability to make that information available to clinicians at the time of ordering.

Hematology Expert System also was developed to be used in assisting the clinicians in making decision without consulting the specialists directly. The software was not meant to replace the specialist, yet it was developed to assist general clinician and specialist in diagnosing and predicting patient's condition from certain rules or "experience".

CHAPTER 3
METHODOLOGY / PROJECT WORK

3.1 Project Approach.

In order to develop expert system, there are five key activities to be performed within the [13] development life cycle of an expert system. There are:

- Problem Selection
- Knowledge Acquisition
- Knowledge Representation
- Development
- Testing, Verification, Validation, Evaluation

3.1.1 Problem Selection

In software development and scientific research, the most critical step is choosing the problem. The problems statements encourage the development of this project are as follows:

- Shortage of veterinarians.
- Unavailability of veterinarians.
- Lack of skill or experience in veterinary field.
- Hematological diseases are too broad. The amount of knowledge that is required is large enough to make the knowledge based developed interesting.

3.1.2 Knowledge Acquisition

To get knowledge into a computer program we must acquire it from some source. Two major sources exist for the knowledge used in expert systems: experts (which could include the veterinarians) and documents or text. Experts tend to be more current and have a broader range of knowledge than documents. They also can respond to questions and provide different sets of examples. However, their time is expensive. In some cases, expertise may have been lost, and need to rely on documents. Documents are generally cheaper to acquire and use. However, they typically have limited amounts of information and what they have is not always completely relevant.

There are several means that have been done in researching more information regarding the veterinary expert system specifically in hematology aspects. The article in the internet, reference books, e-journals are some of the ways to explore additional information on the overall veterinary fields, as well as the needs and requirement of the veterinary institute of using the computerized way of diagnosing cat's diseases. From this information gathering, veterinary expert system can definitely save major time and money by offering efficient data manipulation between clinician and the laboratory. This will help the vets to perform their work faster and efficient whereby they would have more time to spend on their professional duties.

Besides that, there are some interview sessions that have been conducted, in order to get the detail information of the problem faced by vets in diagnosing cat's diseases. The interviews have been done with the vets.

There are two major methodological components of knowledge acquisition from experts which are acquisition and analytical. Acquisition methods describe the process of interacting with the expert to obtain information, while analytical methods describe how we use the information to derive rules. Each of these two methodological components has two subclasses.

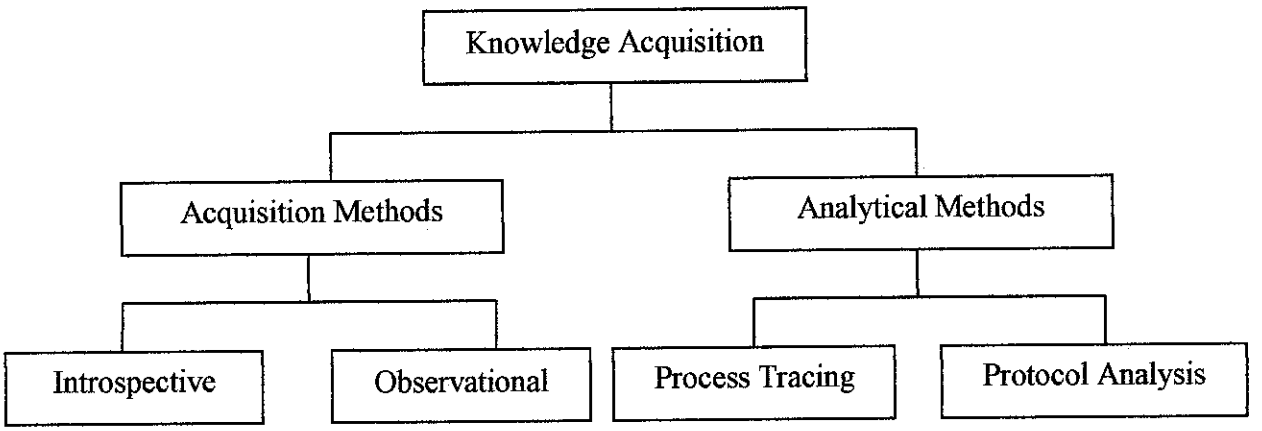


Figure 3.1: Knowledge Acquisition Method [11]

As shown in Figure 3.1, acquisition methods consist of either observational or introspective approaches. In the observational approach, experts give their opinions and explanation regarding certain issues. Besides that, experts describe their solution approach as they go through it. The introspective approach, experts respond to examples that have been provided.

Information acquired from the expert must be converted into rules. Process tracing takes the transcript of the session with the expert and looks for paths from data to decisions. Protocol analysis is a more detailed look at the transcript and also other relevant information about the problem-solving situation. To develop protocols, the most important thing is to look for inputs to decision making.

Converting protocols into rules is the final phase of knowledge acquisition. In some cases the protocol analysis provides easily interpreted If-Then statements.

In acquisition method, some of the vets in Ipoh area have been interviewed. There are two veterinary institutes that are Veterinary Research Institute (VRI) and Jabatan Perkhidmatan Haiwan (JPH). About two to three vets from each institute have been interviewed. Besides that, one of the lecturers from Universiti Pertanian Malaysia (UPM) has been interviewed to get the relevant information regarding this project. Instead of verbal information, they have provided some articles as supplementary information.

In analytical method, all the gathered information has been transferred into rules. First of all, the acquired knowledge has been arranged and decision tree has been constructed to see the decision flow. See appendices.

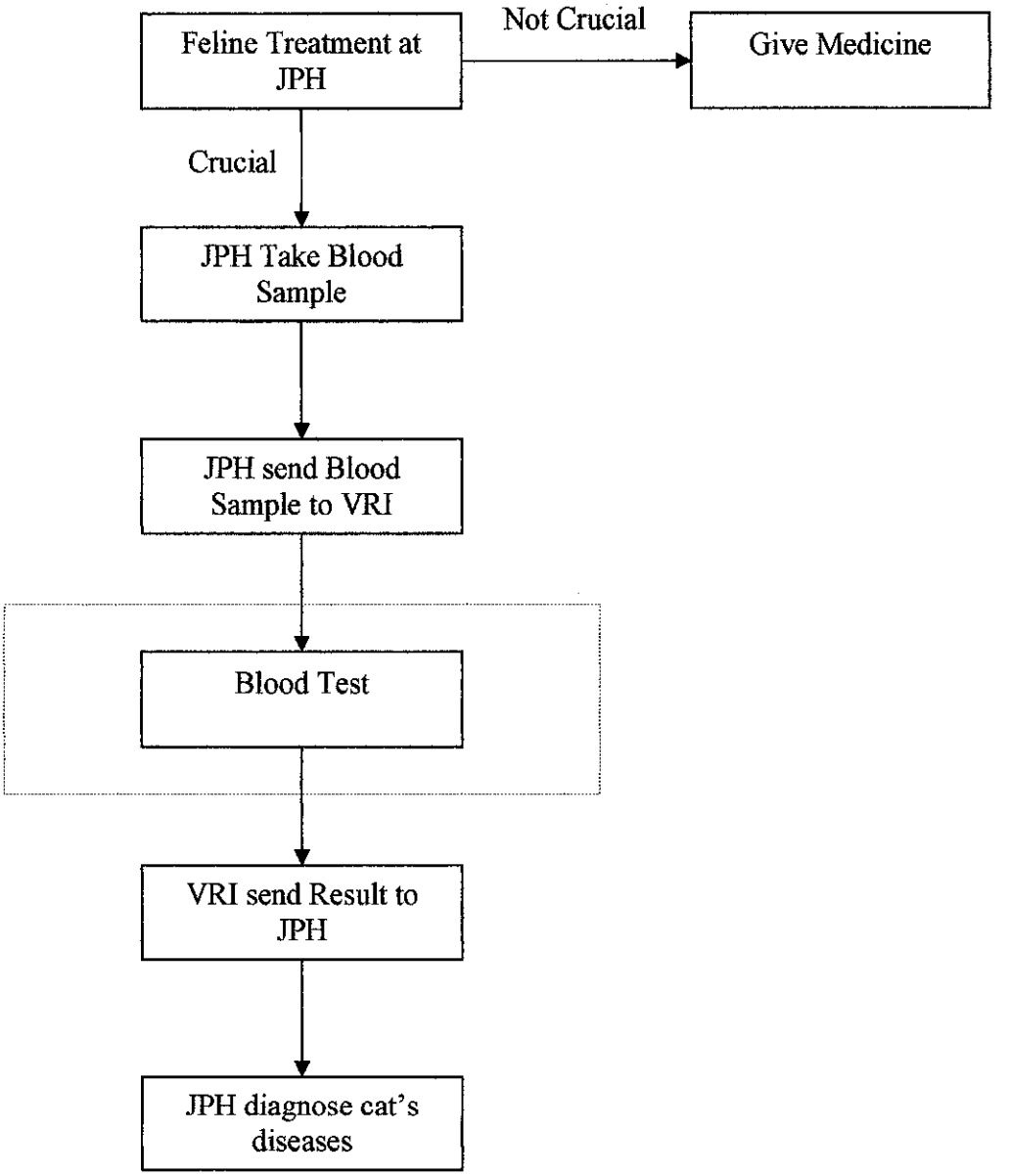


Figure 3.2: Flowchart of Knowledge Acquisition Process for FHES

Base on the interview done in both veterinary institutes in Ipoh, the flow of diagnosis cat's diseases is shown above. JPH and VRI are different places. JPH is place where pet's owners send their pet only when the pets are sick. JPH do not do further check-up for the pet. They just check the pet's disease and give treatment to the pets. However, Veterinary Research Institute is more on lab testing. VRI focus on equine, feline, canine and other small animals. Base on the research, VRI only do the lab test and the result will be sent to JPH to diagnose the cat's diseases. Basically, pet owners will send their pet to JPH. JPH will check the pet's disease. JPH only do the diagnosing process for normal diseases such as flue, fever etc. They will give appropriate medicine to the pet. In other words, JPH only act as veterinary clinic. However, all tasks that related to the lab test like blood test, JPH need to send the blood sample to VRI. VRI will do the lab test and send back the result to JPH, so that JPH can diagnose the pet's diseases.

The dot box represented the application of FHES. From the figure 3.2, we can see that FHES is applicable for VRI. As mentioned above, the scope of VRI is more on lab testing focusing blood diagnosis. Specifically, FHES is an expert system that help vets diagnosis cat's diseases through blood testing. Therefore, FHES is useful for vets at VRI.

3.1.3 Knowledge Representation

The third phase in expert system development is knowledge representation. The major objective in this phase is to take the acquired knowledge and translate it into machine-readable form. There are many different methods of knowledge representation in expert system development and the most popular ways to represent knowledge is *rules*. Currently, the most popular method of knowledge representation is in the form of rules (also known as production rules or rule-based systems). The knowledge of the decision-making process is given in the form of simple IF-THEN statement.

Generally, the information that has been gathered is represented in table below:

		High			Low		
		Stress & Infection	Hormones & Drug	Others	Stress & Infection	Hormones & Drug	Others
White Blood Count (WBC)	Eosinophil	- Acute Stress - Severe Bacterial Infection	- No Diseases	No	- Acute & Severe Stress - Leptospirosis - Severe Stress with Tissue Damage - Feline Infectious Peritonitis	- Cushing's Syndrome - Steroid Admin - Hypoadrenocorticism - Megestrol Acetate in cat	No
	Lymphocyte	- Accute Stress - Post - Vaccine - Chronic Infection - Feline Leukaemia Virus Infection	Hypoadrenoticism	No	- Lymphoid Atrophy - Septicaemia - Leptospirosis - Feline Leukaemia Virus Infection - Severe Stress with Tissue Damage - Overwhelming Bacterial Infection with Toxaemia - Feline Infectious Peritonitis - Chronic Granulomatous Bacterial & Mycotic Infections - Severe Stress	- Cushing's Syndrome - Steroid Admin - Cancer Therapy Drugs - Magestrol Acetate in Cat	No

Table 3.1: White Blood Count (WBC) for Eosinophil and Lymphocyte [17]

		High			Low		
		Stress & Infection	Hormones & Drug	Others	Stress & Infection	Hormones & Drug	Others
White Blood Count (WBC)	Monocyte	- Leptospirosis - Acute Bacterial Infection & Inflammation - Severe Stress with Tissue Damage - Severe Bacterial Infection - Feline Infectious Enteritis - Chronic Active Bacterial Infection - Chronic Granulomatous Bacterial & Mycotic Infections - Septicaemia	- Cushing's Syndrome - Steroid Admin	No	No Diseases	No Diseases	No

Table 3.2: White Blood Count (WBC) for Monocyte [17]

		Stress & Infection	Hormones & Drug	Others	Stress & Infection	Hormones & Drug	Others
White Blood Count (WBC)	Neutrophil	- Acute Stress - Severe Bacterial Infection - Acute & Severe Stress - Severe stress with tissue damage - Leptospirosis - Feline Infectious Perotinitis	- Cushing's Syndrome - Steroid Admin	No	- Feline Leukaemia virus Infection - Feline Infectious Enteritis - Early Viral Infection - Septicaemia - Overwhelming Bacterial Infection with Toxaemia	- Cancer Therapy Drugs	No
		High / Kitten			Low / Kitten		
		Stress & Infection	Hormones & Drug	Others	Stress & Infection	Hormones & Drug	Others
		- Feline Infectious Peritonitis - Leptospirosis - Chronic Active Bacterial Infection - Poor Prognostic Sign - Overwhelming Bacterial Infection with Toxaemia - Septicaemia - Severe Bacterial Infection - Acute Bacterial Infection & Inflammation - Severe Stress with Accute Damage	- Cushing's Syndrome - Steroid Admin	No	No diseases	No diseases	No

Table 3.3: White Blood Count (WBC) for Neutrophil [17]

		High	Low
Red Blood Count (RBC)	Hemoglobin (Hb)	- Dehydration - Absolute Polycythaemia - Shock, Fear & Excitement - Anaemia - Hemolysis - Late Pregnancy	- Anaemia - Haemolysis - Late Pregnancy
	Hematocrit (HCT)	- Altitude - Fear/Excitement - Streneous Activity - Shock - Absolute Polycythaemia - Hyperthyroidism - Dehydration	- Anaemia - Anaesthasia - Late Pregnancy
	Mean Corpuscular Volume (MCV)	- Large Mature RBC - Hyperthyroidism - Reticulocythosis - Inherited Macrocythosis	- Iron Deficiency - Pyridoxine Deficiency - Haemobartonellosis
	Mean Corpuscular Hemoglobin Concentration (MCHC)	Haemolysis	- Inherited Hypocromia - Pyridoxine Deficiency - Iron Deficiency - Nucleated RBCs - Reticulocytosis

Table 3.4: Red Blood Count (RBC) [17]

	High	Low
Blood Urea Nitrogen (BUN)	- Kidney Injury - Diabetes - High Blood Pressure	- SIADH - Rhabdomyolysis - Cirrhosis - Pregnancy

Table 3.5: Blood Urea Nitrogen (BUN) [17]

In this phase, all the information has been transferred from paper – based into computerized system. The information that has been constructed in decision tree, need to represent in the machine-readable form. Generally, the format of transformation of knowledge is as follows:

IF

Type of test = Complete Blood Count (CBC)

Type of CBC = Red Blood Count (RBC)

Type of RBC = Hemoglobin (Hb)

Value of Hb < 9

THEN

The Hb value is (user input). The feline is suffered from;

i) Anaemia.

ii) Haemolysis.

iii) Late Pregnancy.

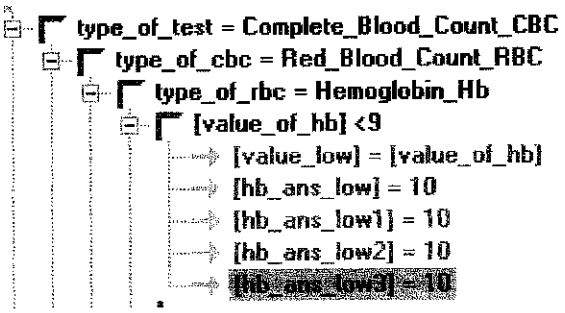


Figure 3.3: Logic Block in EXSYS CORVID

3.1.4 Development

The development of an expert system is the process of taking the knowledge that has been acquired and represented—in rules, and put it into machine-readable format. That is, actually taking the knowledge and putting into some computer code. This can be accomplished by using an expert system programming environment known as a *shell.* Many of the shells, like EXSYS CORVID are primarily rule - based shells that allow for easy development of rule –based expert system.

In this phase, after all the variables have been defined and the acquired knowledge has been transformed into logical block, the next step is to make some coding in order to allow user input the data. In transferring all rules into computer code, it needs to do carefully especially in logical block. Variables and logical block need to be integrated. The variables must be uniquely identified.

In this phase, the interface of the system has been designed. The major element in this phase is to identify how the system will looks like. An appropriate graphic or picture has been imported in order to make the system attractive. Besides that, the font of the system has been modified so that it will look professional.

The result page has been modified so that only confidence variables will appear on that page. During this phase, there are a lot of works need to be done. During this phase, several feline websites has been referred to get an idea on how to build the system. Besides that, some websites' books have been referred in order to create html. There are a lot of difficult medical terms. So, the html is used as an explanation for those terms.

System Architecture

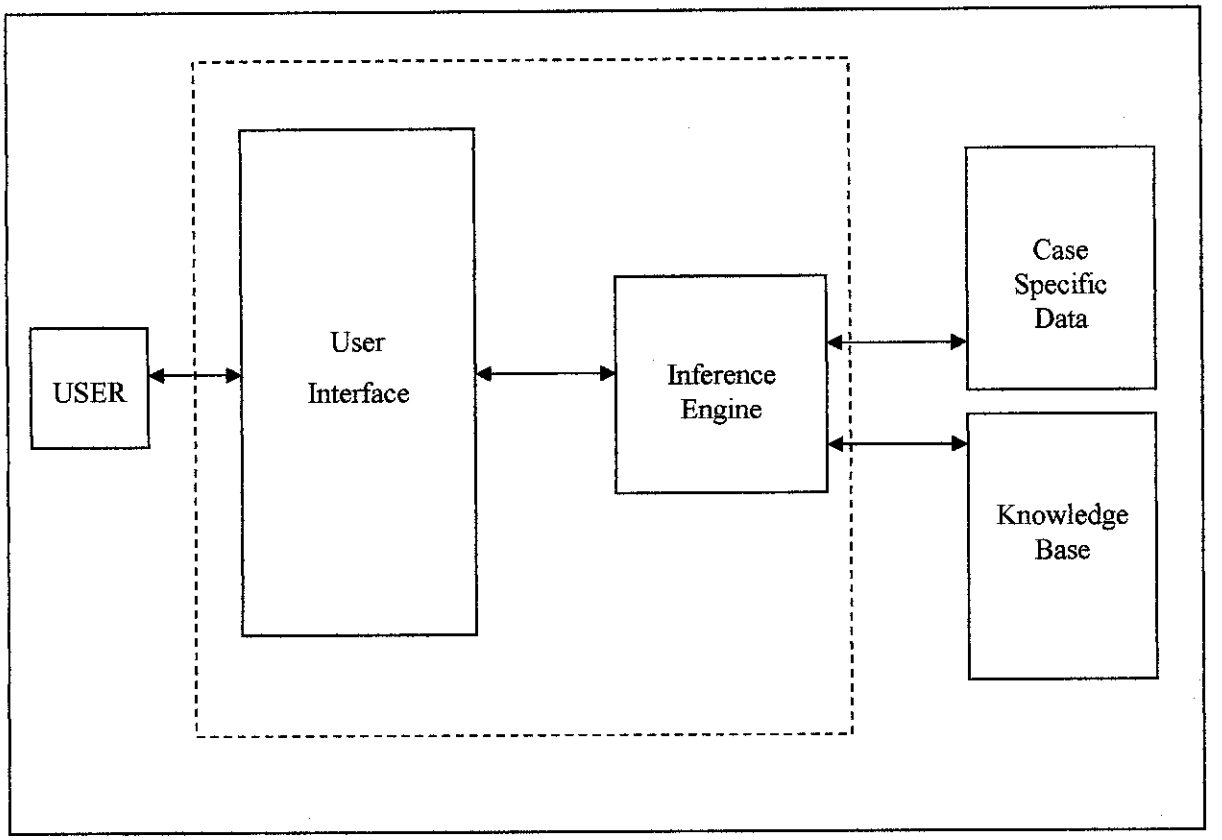


Figure 3.4: Expert System Architecture [12]

Figure 3.4 shows the most important modules that make up a rule-based expert system for FHES. The user interacts with the system through a user interface which may use menus, natural language or any other style of interaction. Then an inference engine is used to reason with both the case specific data and knowledge base to the particular problem being solved. The knowledge base will typically be in the form of a set of IF-THEN rules. The case specific data includes data provided by the user.

3.1.5 Testing, Verification, Validation, Evaluation

An important component of any software development effort is the testing and evaluation of the software system to ensure correctness of the outputs and user satisfaction with the product in solving the given problem.

Two important aspects in the testing of expert system software have been mentioned which are *completeness* and *consistency*. Completeness is defined either the expert system solve most of the problems or not. In other words, is it expert system gives correct solutions for many of the inputs? Within completeness, the items that are checked for include dead-end rules, missing rules, and unreachable rules. Consistency, on the other hand, checks for redundant rules, conflicting rules, and unnecessary conditions.

In the testing phase, questionnaires have been developed. The questionnaire is designed to find out on the factor that influenced the development of Feline Hematology Expert System. In addition, the questionnaire is helpful in order to get feedback and comment from vets, so that the system can be improved in the future.

In preparation of selecting the best instrumentation method for testing, the survey questionnaire was designed over 2 weeks and the target areas have been explored. The instrument consisted of closed-ended questions that collected information on the respondent perceptions. At the same time this instrumentation is to determine the effectiveness of the Feline Hematology Expert System.

Besides that, in order to check the accurateness of the data collected, data analysis is performed. During the data analysis, knowledge that has been gathered in FHES is compared with the expert's knowledge. Below is the table that listed the level of knowledge accuracy of proposed FHES. The level of accuracy is ranked from 1 to 5. 1 is strongly inaccurate, 2 is inaccurate, 3 is neither accurate nor inaccurate, 4 is accurate and 5 is most accurate.

Blood Sample	Type of Blood Test	Level of Accuracy
1	Hb	5
2	HCT/PCV	4
3	MCV	4
4	MCHC	4
5	Eosinophil	4
6	Monocyte	4
7	Lymphocyte	4
8	Neutrophil	4

Table 3.6: Level of Knowledge Accuracy of Proposed FHES

3.2 Tools Required

3.2.1 Hardware

The minimum configuration and requirement that required for supporting Veterinary Expert System application and tools is first the standard or basic hardware infrastructure used is a stand alone PC, keyboard, mouse, and monitor.

Basic or Minimum Requirement for personal computer:

CPU	: 800 MHz Pentium III
Memory	: 256 MB RAM (Recommended)
Monitor	: 14" monitor with 32MB VRAM
Hard Drives	: Hard Drive 10 GB
Operating System	: Windows 95, 98, ME, NT 4.0, 2000, XP
Network Card	: 10mbps – 100 mbps

3.2.2 Software

The software that required for this research project is EXSYS CORVID. EXSYS CORVID is primarily rule -based shells that allow for easy development of rule –based expert system.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Results

1. Based on the surveys conducted in Veterinary Research Institute and some of the Veterinary Clinics in Ipoh, most of the respondents have reacted to a positive feedback towards the Feline Hematology Expert System especially respondent from VRI. 50% of the respondents strongly agree with FHES. The second highest percentage denotes by the respondents who agree with FHES that is 33% follows by 17% of the respondents perceived the system neither agree nor disagree. 0% of the respondents disagree while the remaining also 0 % strongly disagree with FHES. Please refer to table 4.1 for the results on the perception of respondents towards the FHES. The result of this survey can be evaluated and influence the respondents acceptance towards this research project.

	PERCEPTION TOWARDS FELINE HEMATOLOGY EXPERT SYSTEM					
	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
Respondents	0	0	1	2	3	6

Table 4.1: Perception towards FHES

2. With the statistic of 50% from the total respondents, the respondent feels that the feline hematology expert system would definitely help in diagnosing cat's diseases through blood testing. Therefore, this research project is proposed together with the enhancement of the system itself.

3. Based on the surveys concerning the level of acceptance of the proposed FHES, 17% of the total respondents strongly agree that the FHES is a good application to be implemented in diagnosing blood diseases. 50% of the respondents agree with the FHES. This is followed by 17% of respondents neither agree nor disagree and 17% of respondents disagree on the system. The remaining 0% of the participants strongly disagrees. Please refer to Table 4.2 for the results on the level of acceptance of the proposed FHES.

	LEVEL OF ACCEPTANCE OF PROPOSED FELINE HEMATOLOGY EXPERT SYSTEM					
	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
Respondents	0	1	1	3	1	6

Table 4.2: Level of Acceptance of Proposed FHES

4. With the statistic of 50% from the total participants, the respondents agree with the implements FHES in diagnosing cat's diseases through blood testing.

5. Based on the surveys concerning the level of knowledge accuracy of the proposed FHES, 12.5% of the total blood sample is most accurate. 87.5% of the total blood sample is accurate. Please refer to Table 4.3 for the results on the level of knowledge accuracy of the proposed FHES.

	LEVEL OF KNOWLEDGE ACCURACY OF PROPOSED FELINE HEMATOLOGY EXPERT SYSTEM					
	Strongly Inaccurate	Inaccurate	Neither Accurate Nor Inaccurate	Accurate	Most Accurate	Total
Blood Sample	0	0	0	7	1	8

Table 4.3: Level of Knowledge Accuracy of Proposed FHES

6. With the statistic of 87.5% from the total blood sample, the level of accuracy of proposed feline hematology expert system is accurate.

4.2 Findings

From the survey, majority of the respondents are satisfied and pleased with FHES. This can be proved using figure 4.1 below. Based on figure 4.1, half of the respondents strongly agree with FHES. This is directly shows that the system is acceptable among the vets.

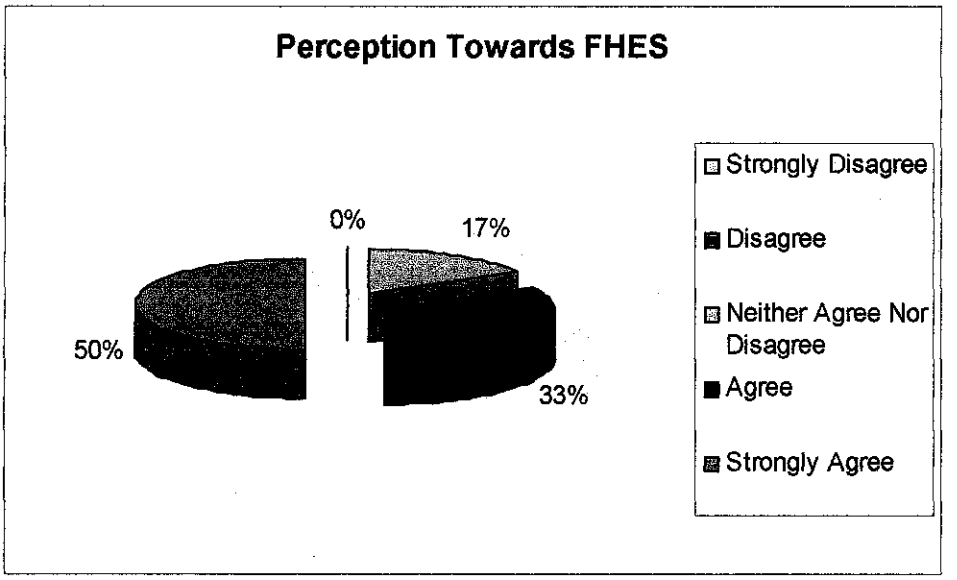


Figure 4.1: Perception towards FHES

Based on figure 4.2 below, majority of the respondents agree that the proposed FHES would give a good impact in diagnosing cat's diseases through blood testing. This means that vets are expecting to have a better service in blood diagnosing industry and at the same time benefits them. From the result itself, it shows that the vets are able to accept the new technology that led high quality and performance to pet care services.

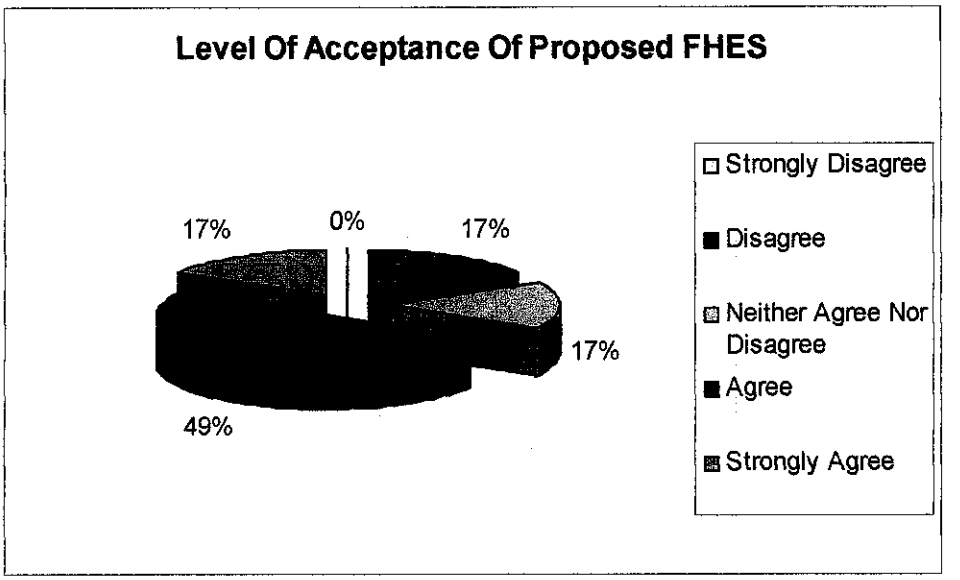


Figure 4.2: Level of Acceptance of Proposed FHES

Based on figure 4.3 below, the level of knowledge accuracy of FHES is accurate compare with the expert's knowledge. This is show that the knowledge gathered in FHES is almost same with the expert's knowledge. Most of the value and result provided by FHES is accurate with the expert's requirement.

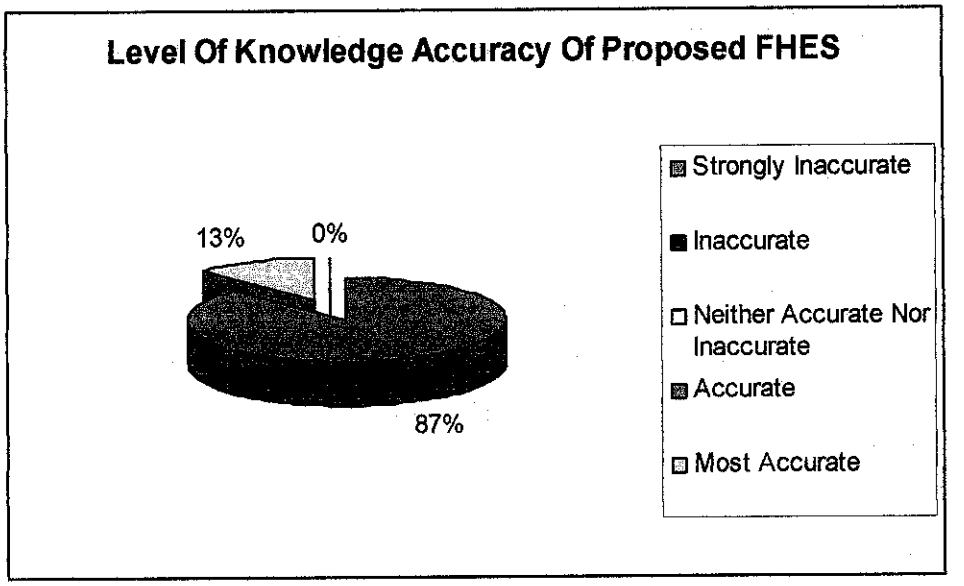


Figure 4.3: Level of Knowledge Accuracy of Proposed FHES

4.3 System Flow Chart

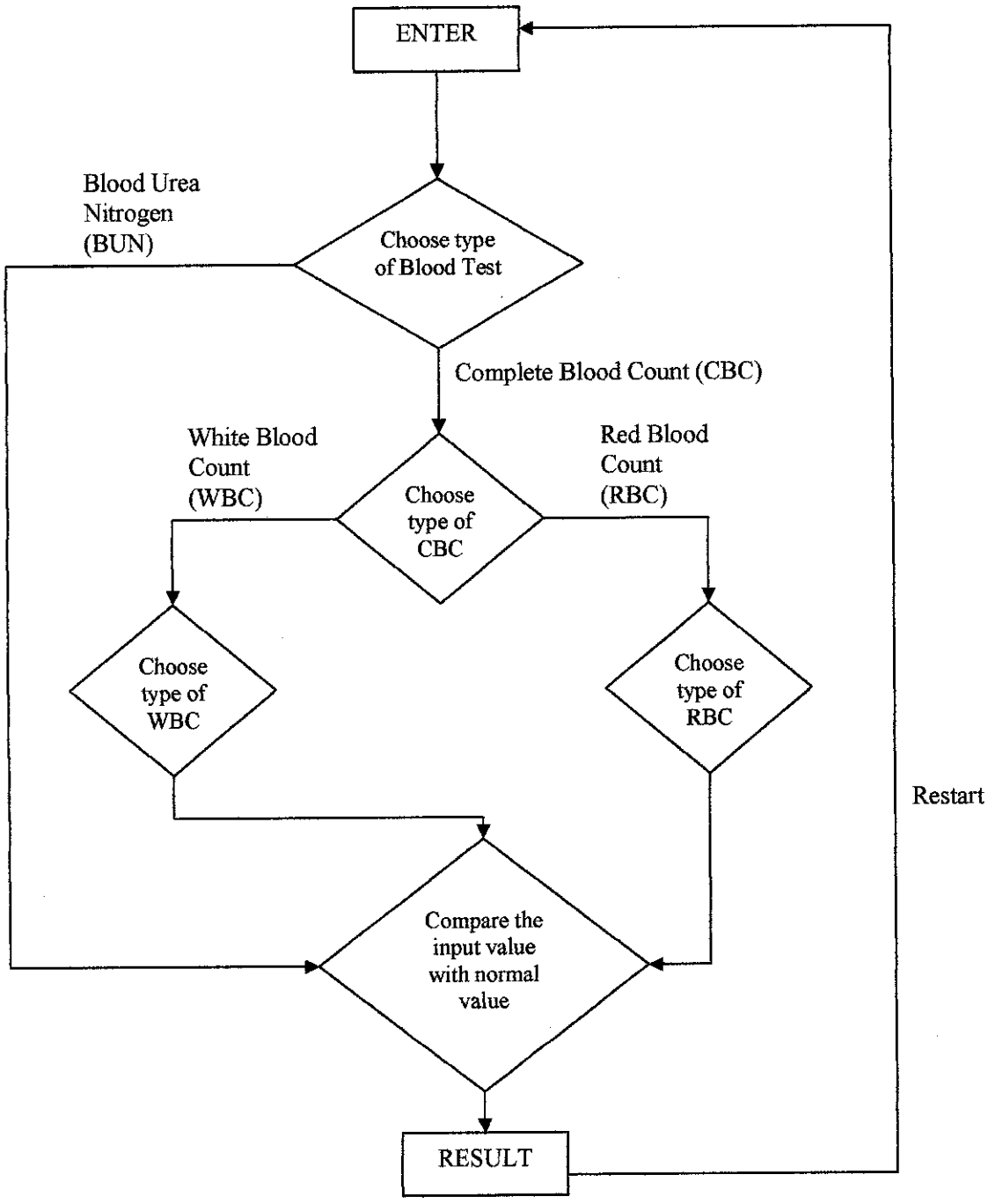


Figure 4.4: FHES Flow Chart

4.4 User Manual

In this section, users will be shown and explained on how to use this system. In other words, users will be explained about the function of each element in the system.

This is the main page for Feline Hematology Expert System (FHES). There is an ENTER buttons that navigate users to a second page.

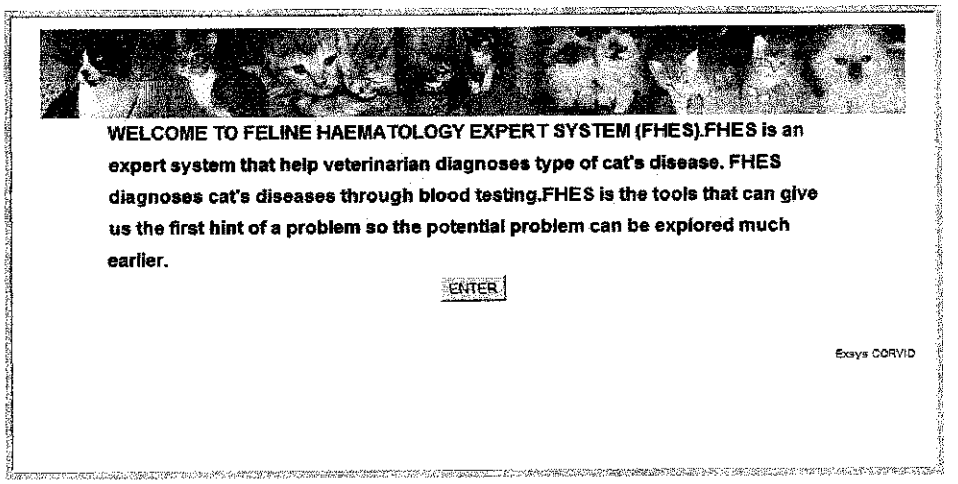


Figure 4.5: Front Page of FHES

This is the second page of the system. Users need to choose the blood test that they are using, either Complete Blood Count (CBC) or Blood Urea Nitrogen (BUN). There are three buttons, which are NEXT, RESTART and BACK. NEXT button will navigate users to the next page. BACK button will navigate users to the previous page. While the RESTART buttons, navigate users to the main page or welcome screen. After users choose the type of blood test, users need to click the NEXT button to go to the next page.

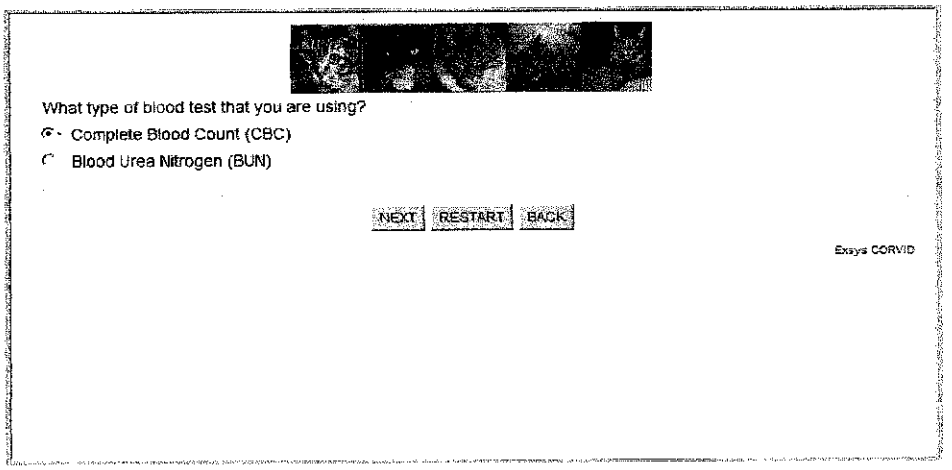


Figure 4.6: Type of Blood Test Page

This is the page where users need to identify what type of CBC that they want to know, either Red Blood Count (RBC) or White Blood Count (WBC). Then, users need to click the NEXT button.

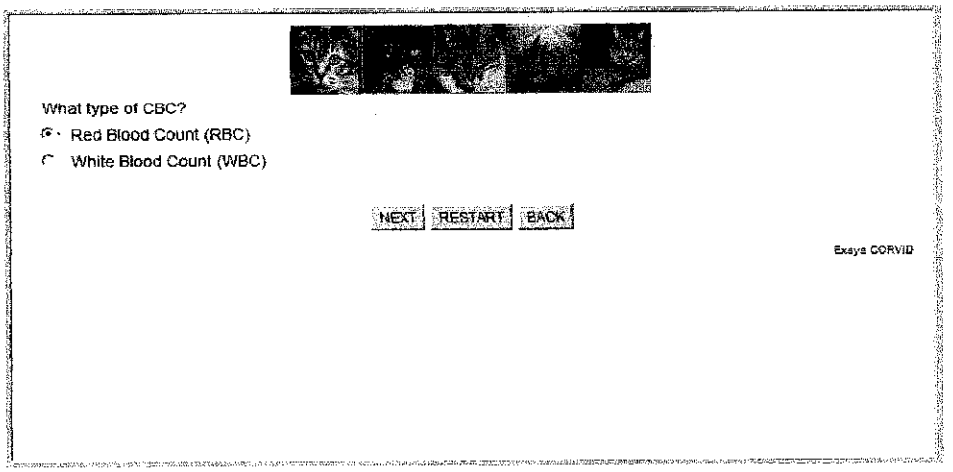


Figure 4.7: Type of CBC Page (RBC)

If users choose RBC this type of page will appear. In this page, users need to choose type of RBC. There are several types of RBC as shown below. Then, click the NEXT button.

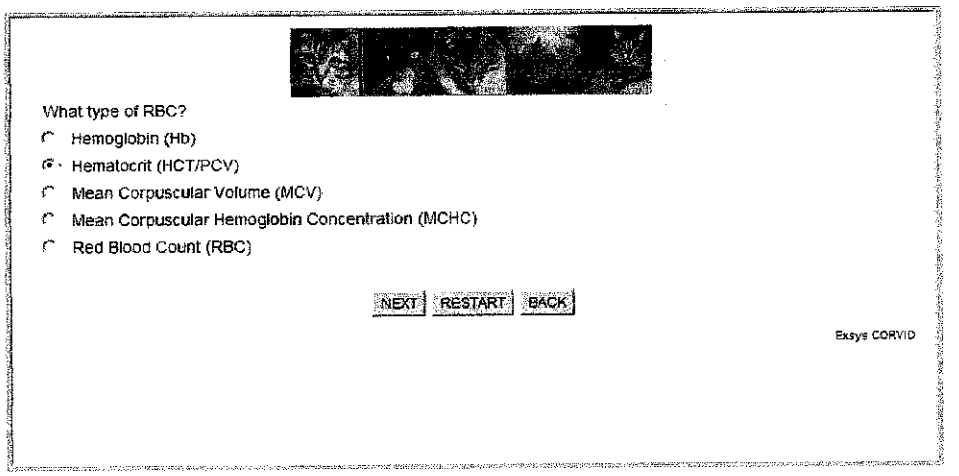


Figure 4.8: Type of RBC Page

When users choose any type of RBC, this page will appear. This page allows users to key in the value of RBCs' type that has been chosen. However, users only allow to key in the value that is lower or higher than the normal value that is stated in parentheses. In this case, users can specify the value either less than 38 or more than 52. Users are not allowed to put the value within the range of normal value. To see the result, click the NEXT button.

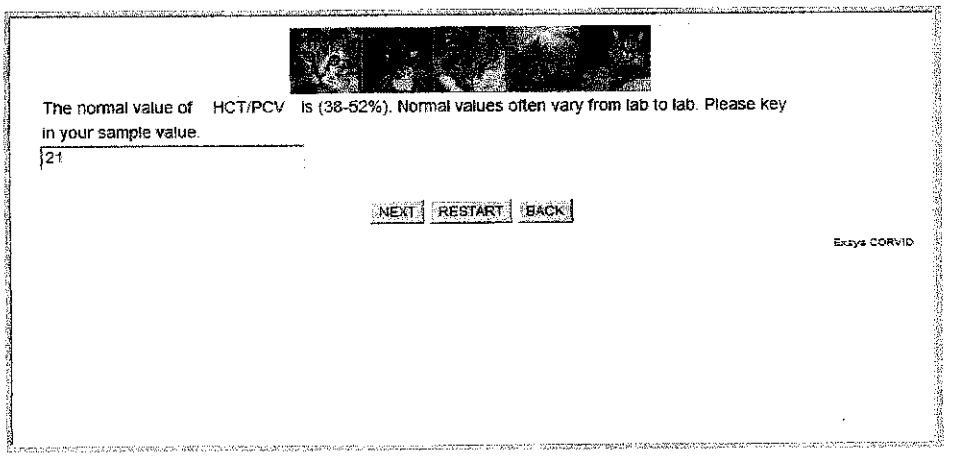


Figure 4.9: Input Value Page (RBC)

This is the result page. This is the final output for RBC after users choose all the options.

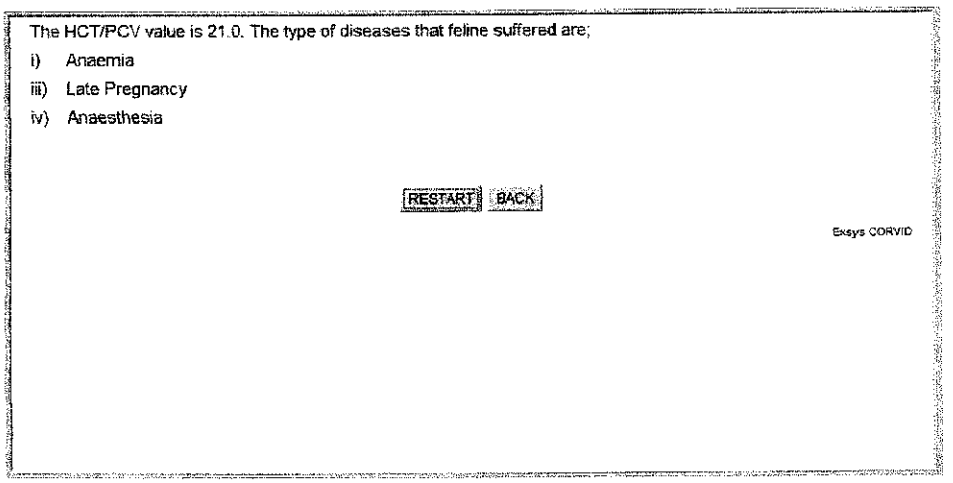


Figure 4.10: Result Page (RBC)

Users can choose White Blood Count (WBC) rather than Red Blood Count (RBC) as shown below. Then, click NEXT button.

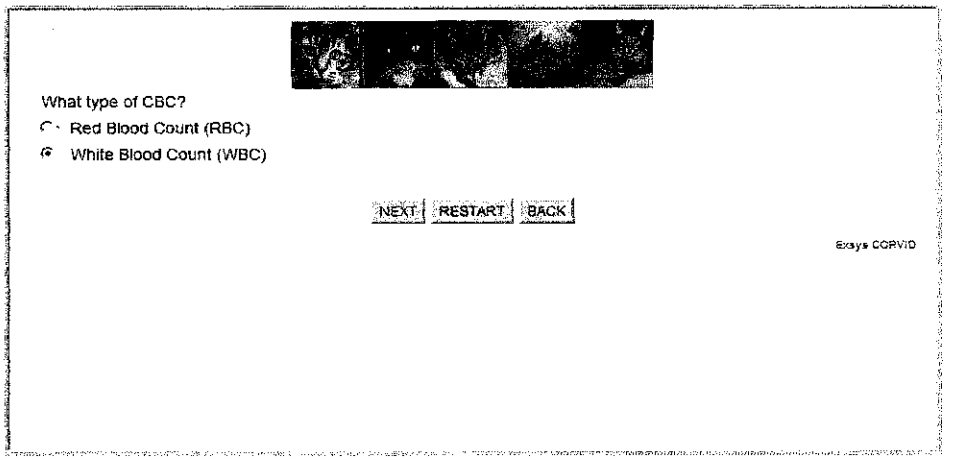


Figure 4.13: Type of CBC Page (WBC)

This is the page where users need to choose the type of WBC.

Figure 4.14: Type of WBC Page

After users choose the WBCs' type, the system will navigate users to the page as shown below. However, in this page, users only compare the number of WBC that they have got with the normal value that is stated in parentheses, the value either higher or lower from the normal value. Then, click NEXT.

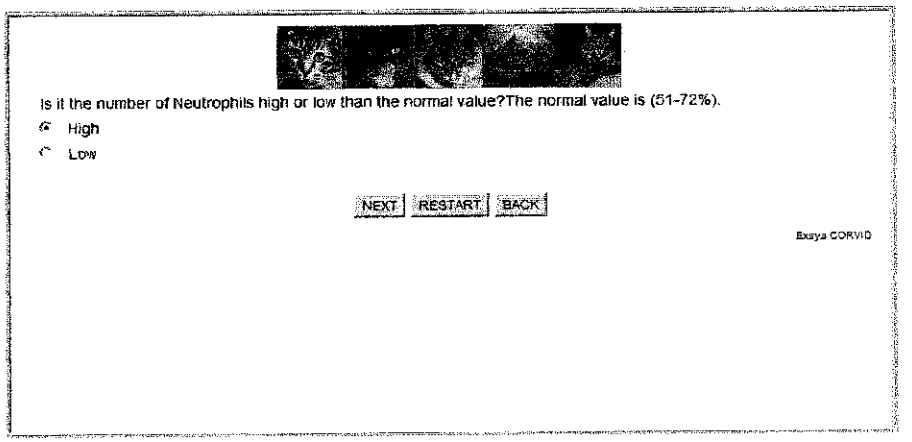


Figure 4.15: Value Page

This page will divide the causes into tree parts that are stress and infections, hormones and drugs and other diseases. In order to know what is the causes that might increase or decrease the value of WBC, users can choose which part they want to know.

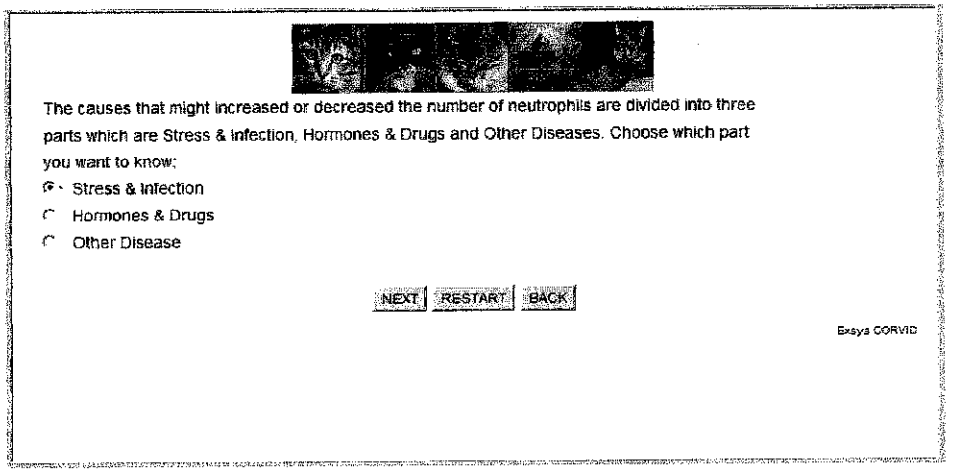


Figure 4.16: Categories of Diseases Page

This is the result page. This is the final output for WBC after users choose all the options.

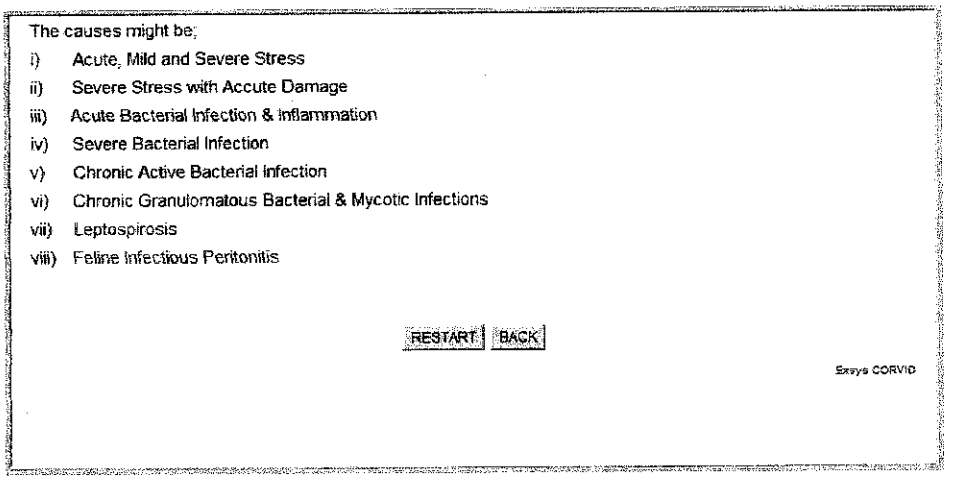


Figure 4.17: Result Page (WBC)

Instead of CBC, users can choose Blood Urea Nitrogen (BUN) as the parameter to diagnose cat's diseases.

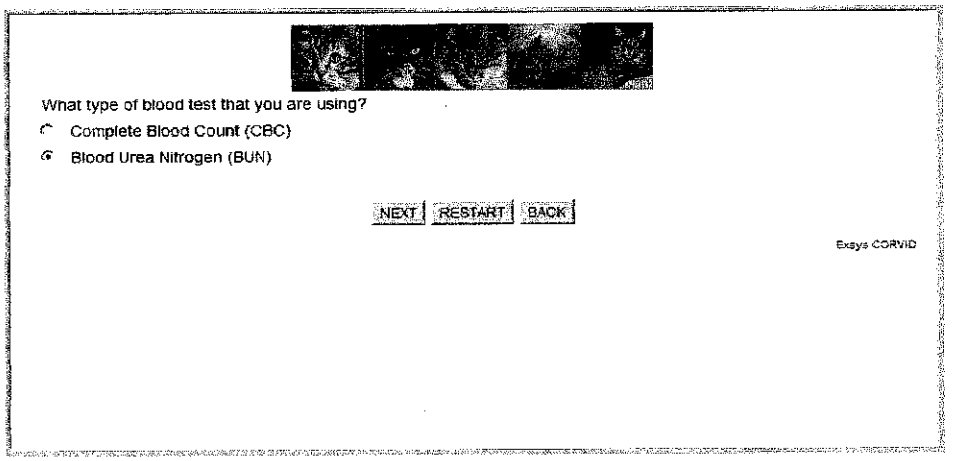


Figure 4.18: Type of Blood Test Page (BUN)

This type of page will allow users to key in the value. Users only need to put the value that lower or higher than the normal value which is stated in parentheses. Users are not allowed to put the value within the normal range. For example, in this case, users are not allowed to put the value start from 5 up to 11. Then, click NEXT to see the result.

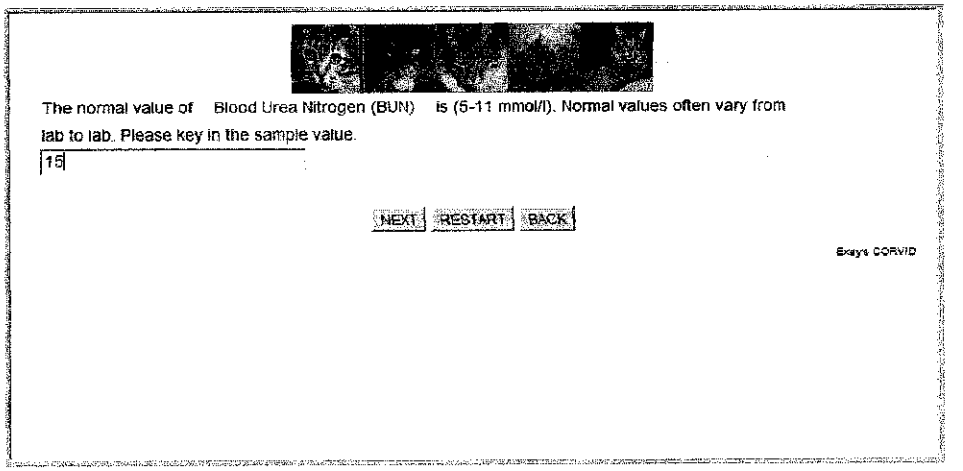


Figure 4.19: Input Value Page (BUN)

This is the result page. This is the final output for BUN after users choose all the options.

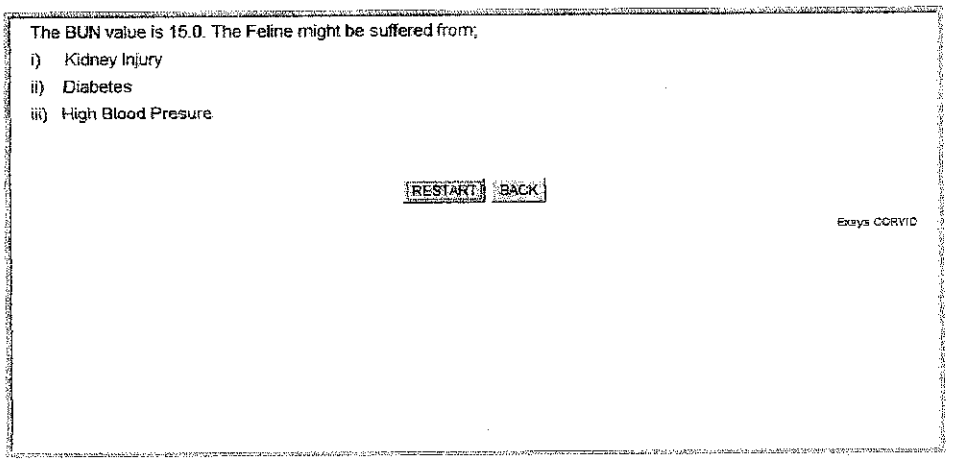


Figure 4.20: Result Page (BUN)

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Nowadays, Malaysian government recognizes the urgent need for a more computerized system for benefits and services. The current delivery mechanisms are often paper-based and tend to be manually intensive. For lab testing specifically, most of the information is kept in filing system. The need of the new advance technology is needed to upgrade the quality of the blood diagnosing focusing on cats.

The description of lab testing in diagnosing cat's diseases together with the enhancement of veterinary expert system may focus on eliminating the errors that occurs in manual way. Instead of writing in the paper-based, the vets only need to type in and choose all the related items via the interface of computerized system. This may speed up the process of diagnosing cat's diseases.

There are several methods and processes have been applied in realizing this research project. The development life cycle of an expert system have been applied in conducting and investigates the details of this research project. There are several steps involve in this method such as problem identification, knowledge acquisition, knowledge representation, testing, verification, validation, evaluation and maintenance. All these headed to the correct way of conducting a scientific research.

As a conclusion, hope that this project would really satisfy the regarding requirement and bringing the new environment and methods in diagnosing cat's diseases focusing blood test in Malaysia. The best foot forward has been putting and hopes that the effort will be paid.

5.2 Recommendations

There are several recommendations and suggestion that can be done in the future:

1. The scope of research project can be expanded to a broader range.
   Currently, this research project only focuses on the Complete Blood Count (CBC) and Blood Urea Nitrogen (BUN). Due to the time constraint and lack of knowledge about veterinary field, the research project scope only focus and concentrate in CBC and BUN in order to make feasible to be delivered on time. In the future, the project could include the veterinary expert system that diagnosing cat's diseases through Blood Glucose (GLU) or any other Bio Chemical Test.

2. The value of each blood test can be specific to particular diseases.
   Currently, the sample values of the veterinary expert system only focus on the high and low value only. There is no specific value to a particular disease. Hence, in the future the project could specify each value to a specific disease.

REFERENCES

[1] Parkway Animal Hospital's, **PET OWNER'S GUIDE ON Health Screening**, <www.parkwayanimal.com>, (Accessed in February 2005).

[2] <www.assistfeed.com/understandingBloodwork.htm>, (Accessed in February 2005),

[3] Peter Jackson, third edition, 1999, **Introduction to Expert System**, Addison-Wesley.

[4] **How to Get the Best Medical Care, A Guide for the Intelligent Patient**, < www.thebestmedicalcare.com/doctors/expert.htm>, (Accessed in March 2005).

[5] 5GL-Doctor, **Expert System Techniques; Medical Diagnosis Decision Support**, <home.pacific.net.au>, (Accessed in March 2005).

[6] Novruz Allahverdi and Süleyman Yaldýz, **Expert System Applications In Medicine And Example Of Design Of A Pre-Diagnosis Expert System,** <http://alaeddin.cc.selcuk.edu.tr/~noval/ESMD.htm>,(Accessed in May 2005).

[7] **AI System in Clinical Practise, DXplain Diagnostic decision support system for general medicine**, <www.openclinical.org/aisp_bd.htm>, (Accessed in March 2005).

[8] Becton Dickinson Systems, **Laboratory System**, <www.openclinical.org/aisp_bd.html>, (Accessed in March 2005).

[9] **Symptom-Based Disease Diagnosis (more accurate diagnosis & treatment)**, <www.intelligentmd.com/products/symptoms.htm>, (Accessed in March 2005).

[10] Keith Darlington, **Basic expert systems,** <http://www.bcsnsg.org.uk/itin08/darling.htm>, (Accessed in April 2005).

[11] Dianne Berry & Anna Hart, first edition, 1990, **Expert System "Human Issues"**, Chapman and Hall.

[12] Donald A.Waterman, 1986, **A Guide to Expert System**, Addison Wesley.

[13] G Benchimol, P Levine & J C Pomerol, 1987, **Developing Expert System**, Instrument Society of America.

[14] Durkin, J., 1994, **Expert System: Design and Development**, Macmillan Publishing Co.

[15] Awad, E. M., 1995, **Building Expert Systems; Principles, Procedures, and Applications**, Minneapolis, USA: West Publishing Company.

[16] Szolovits P., R.S. Patil, W.B. Schwartz, 1988, **Artificial Intelligence in Medical Diagnosis**, Annals of Internal Medicine.

[17] B.M. Bush, 1991, **Interpretation of Laboratory Results for Small Animal Clinicians**, Blackwell Scientific Publications.

APPENDIXES

Appendix 1: About FHES

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1	2	3	4	5

With reference to the Likert Scale above, circle the extent to which you agree with the following statement

The system is easy to use	1	2	3	4	5
The system flow is easy to follow	1	2	3	4	5
Clinical signs and symptoms asked in the system are understandable	1	2	3	4	5
The content of the results/diagnosis is understandable	1	2	3	4	5
The diagnose made by FHES is useful	1	2	3	4	5
The system is helpful in assisting vets to better understand the nature of their cat's illness and the appropriate health care needed	1	2	3	4	5
I will use this system for feline hematological diagnosis	1	2	3	4	5

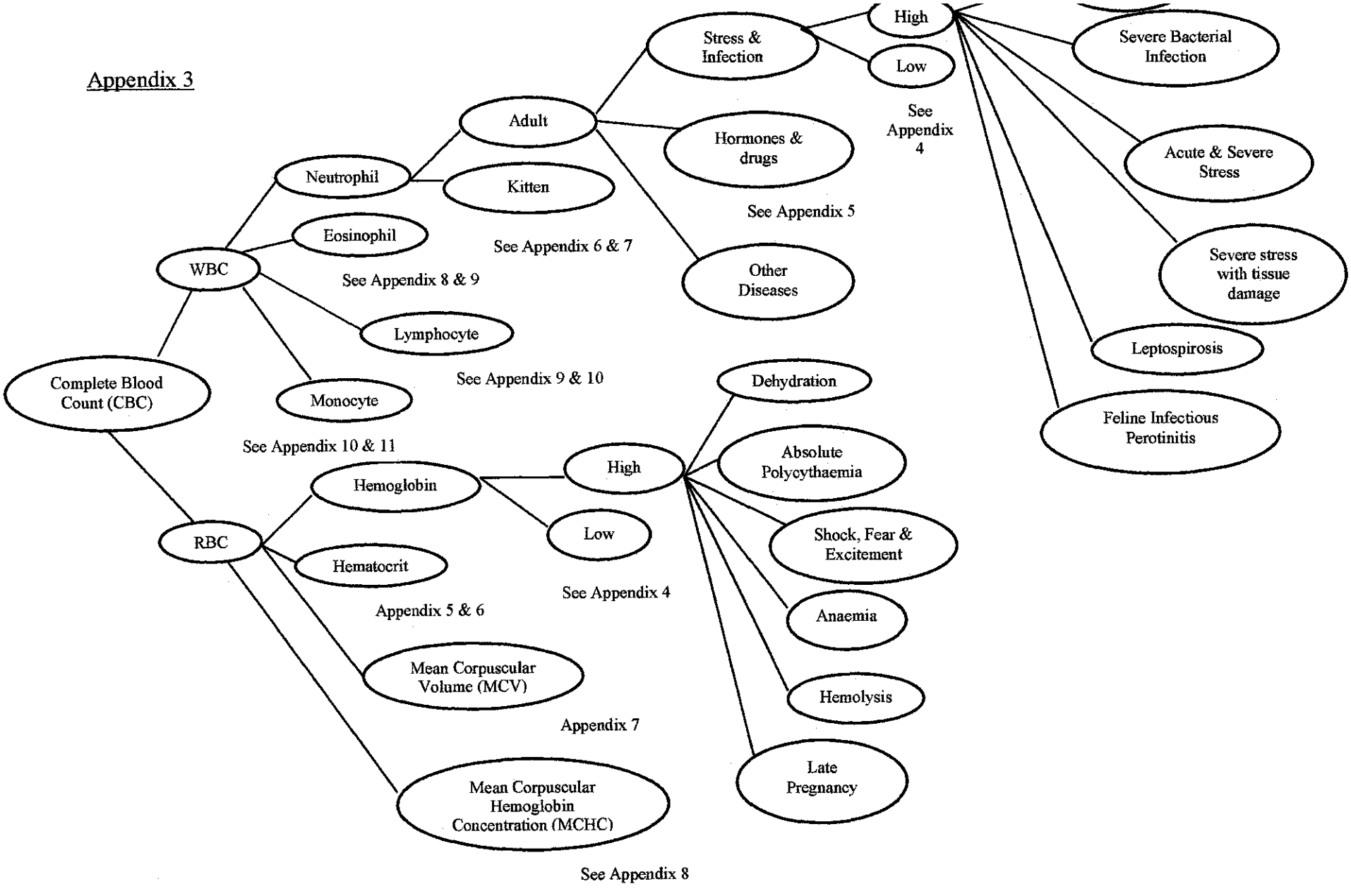
Appendix 2: Questionnaire for veterinarians

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1	2	3	4	5

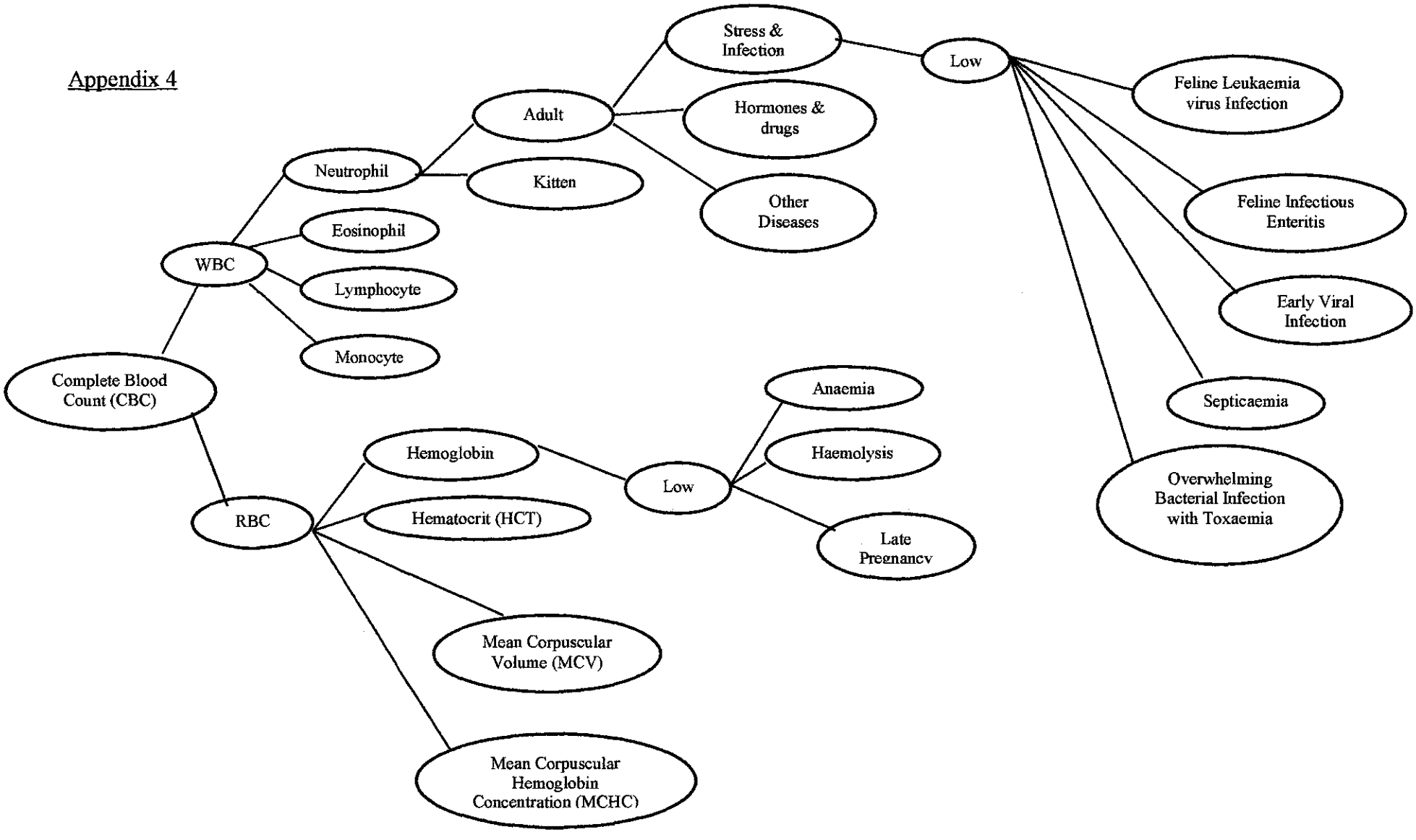
With reference to the Likert Scale above, circle the extent to which you agree with the following statement

The system is easy to use	1	2	3	4	5
Clinical signs and symptoms asked in the system are understandable	1	2	3	4	5
The content of the results/diagnosis is understandable	1	2	3	4	5
The diagnose made by FHES is useful	1	2	3	4	5
The system is helpful in assisting vets to better understand the nature of their cat's illness and the appropriate health care needed	1	2	3	4	5
I will use this system for feline hematological diagnosis	1	2	3	4	5

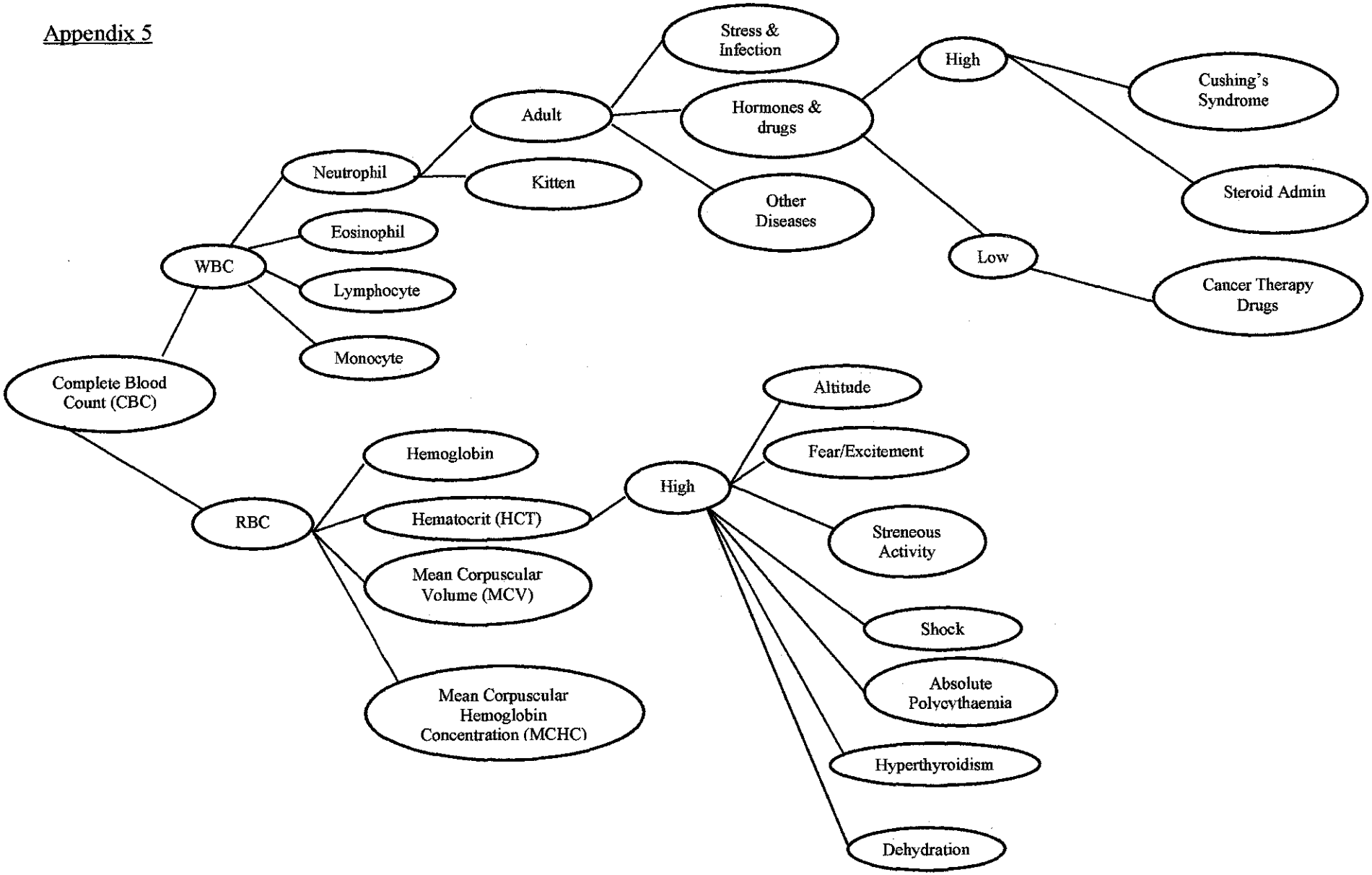
Appendix 3


Complete Blood Count (CBC)
WBC
RBC
Neutrophil
Eosinophil
Lymphocyte
Monocyte
Hemoglobin
Hematocrit
Mean Corpuscular Volume (MCV)
Mean Corpuscular Hemoglobin Concentration (MCHC)
Adult
Kitten
Stress & Infection
Hormones & drugs
Other Diseases
High
Low
Severe Bacterial Infection
Acute & Severe Stress
Severe stress with tissue damage
Leptospirosis
Feline Infectious Perotinitis
Dehydration
Absolute Polycythaemia
Shock, Fear & Excitement
Anaemia
Hemolysis
Late Pregnancy
See Appendix 4
See Appendix 5
See Appendix 6 & 7
See Appendix 8 & 9
See Appendix 9 & 10
See Appendix 10 & 11
See Appendix 4
Appendix 5 & 6
Appendix 7
See Appendix 8

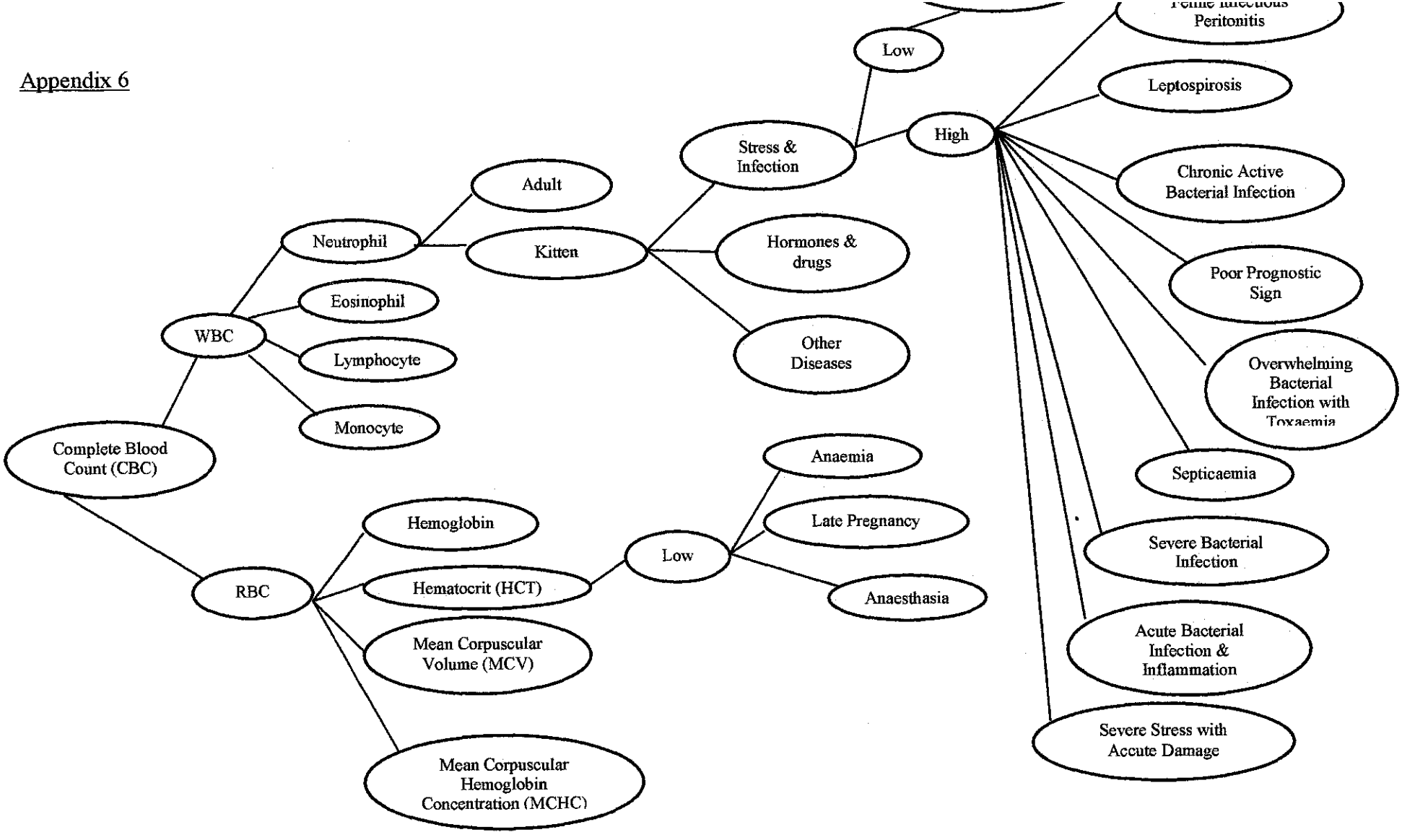
Appendix 4


Complete Blood Count (CBC)
WBC
Neutrophil
Eosinophil
Lymphocyte
Monocyte
Adult
Kitten
Stress & Infection
Hormones & drugs
Other Diseases
RBC
Hemoglobin
Hematocrit (HCT)
Mean Corpuscular Volume (MCV)
Mean Corpuscular Hemoglobin Concentration (MCHC)
Low
Anaemia
Haemolysis
Late Pregnancy
Low
Feline Leukaemia virus Infection
Feline Infectious Enteritis
Early Viral Infection
Septicaemia
Overwhelming Bacterial Infection with Toxaemia

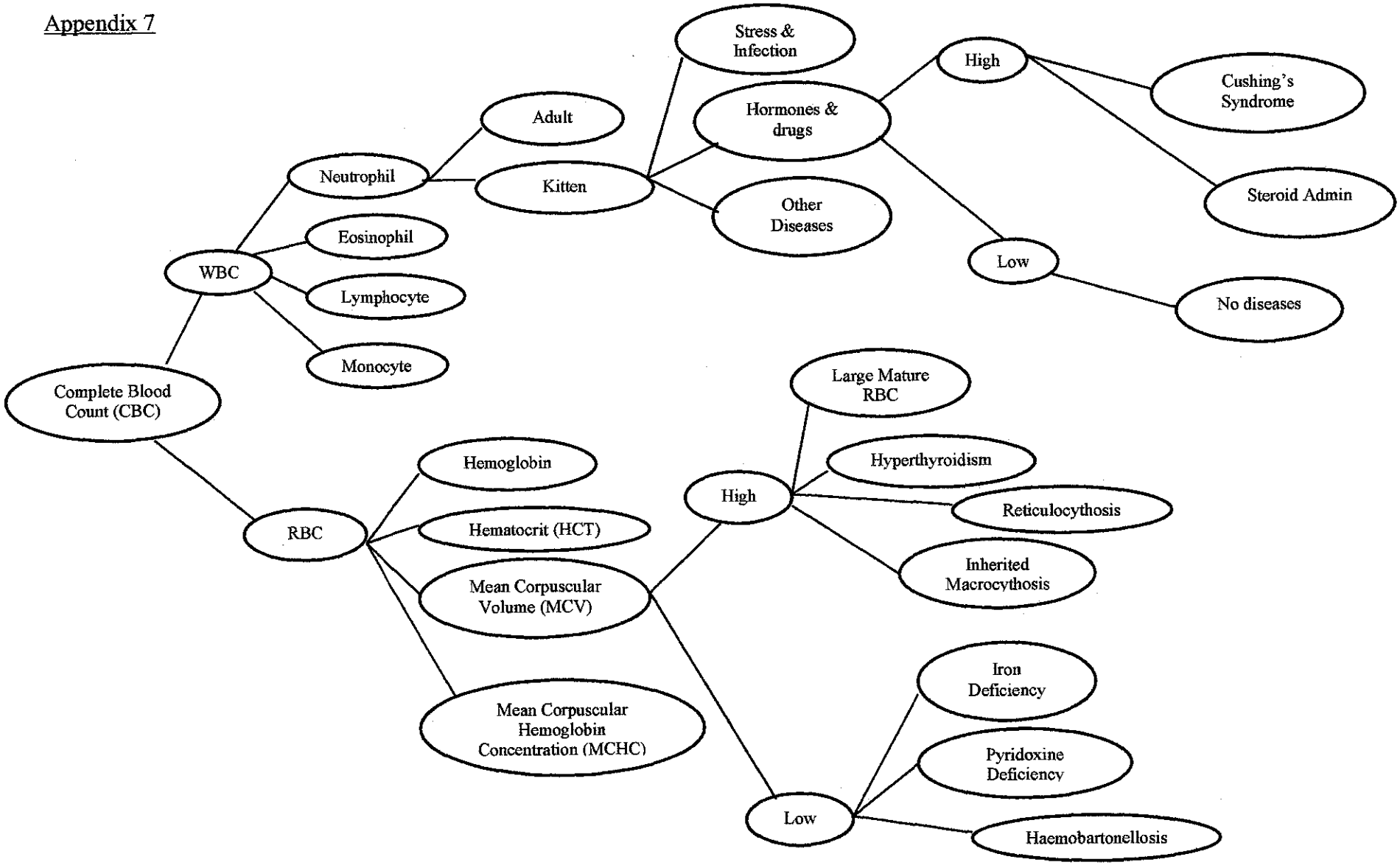
Appendix 5


Complete Blood Count (CBC)
WBC
Neutrophil
Eosinophil
Lymphocyte
Monocyte
Adult
Kitten
Stress & Infection
Hormones & drugs
Other Diseases
High
Low
Cushing's Syndrome
Steroid Admin
Cancer Therapy Drugs
RBC
Hemoglobin
Hematocrit (HCT)
Mean Corpuscular Volume (MCV)
Mean Corpuscular Hemoglobin Concentration (MCHC)
High
Altitude
Fear/Excitement
Streneous Activity
Shock
Absolute Polycythaemia
Hyperthyroidism
Dehydration

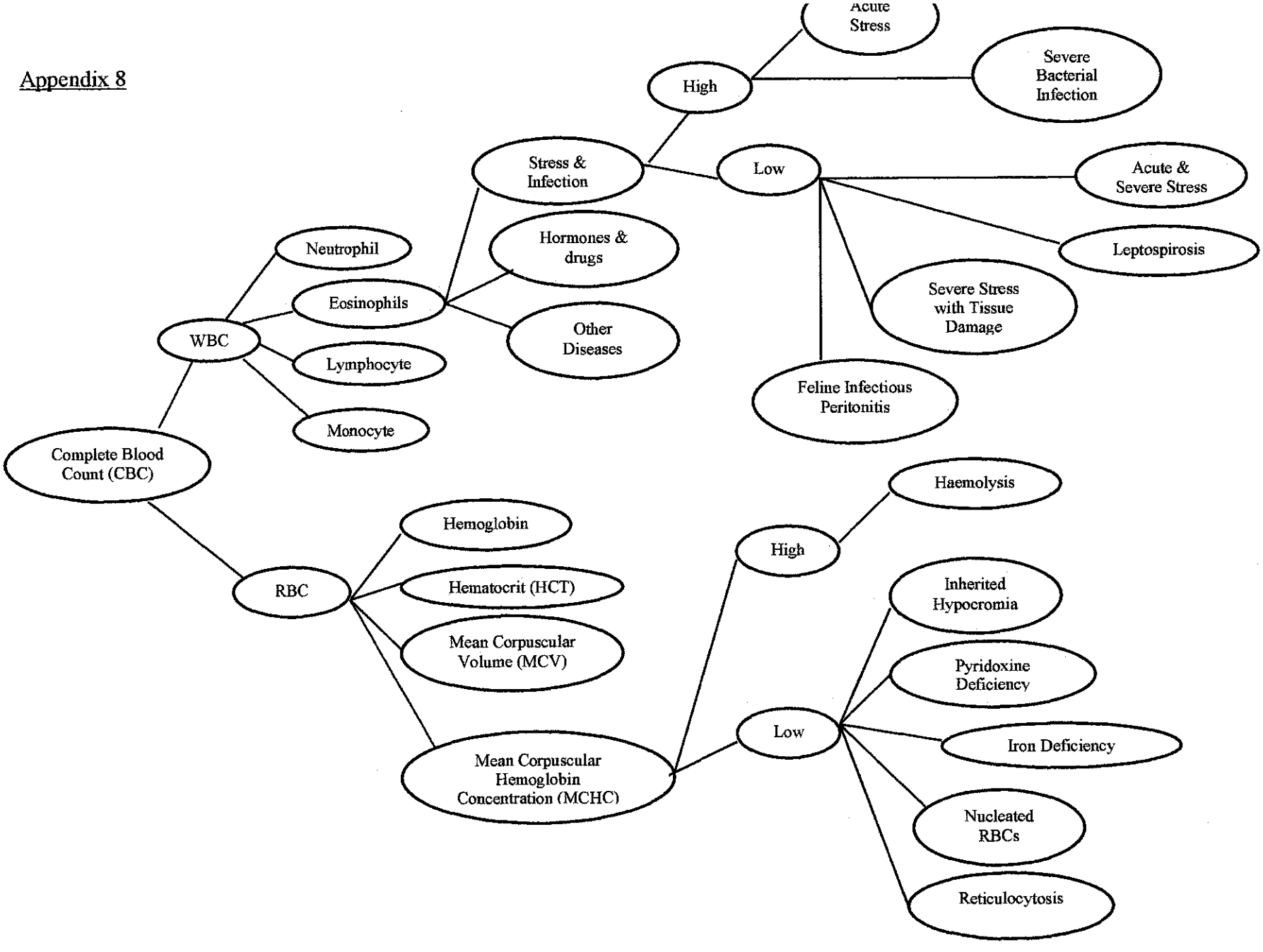
Appendix 6


Complete Blood Count (CBC)
WBC
Neutrophil
Adult
Kitten
Eosinophil
Lymphocyte
Monocyte
RBC
Hemoglobin
Hematocrit (HCT)
Mean Corpuscular Volume (MCV)
Mean Corpuscular Hemoglobin Concentration (MCHC)
Low
Anaemia
Late Pregnancy
Anaesthasia
Stress & Infection
Hormones & drugs
Other Diseases
Low
High
Peritonitis
Leptospirosis
Chronic Active Bacterial Infection
Poor Prognostic Sign
Overwhelming Bacterial Infection with
Septicaemia
Severe Bacterial Infection
Acute Bacterial Infection & Inflammation
Severe Stress with Accute Damage

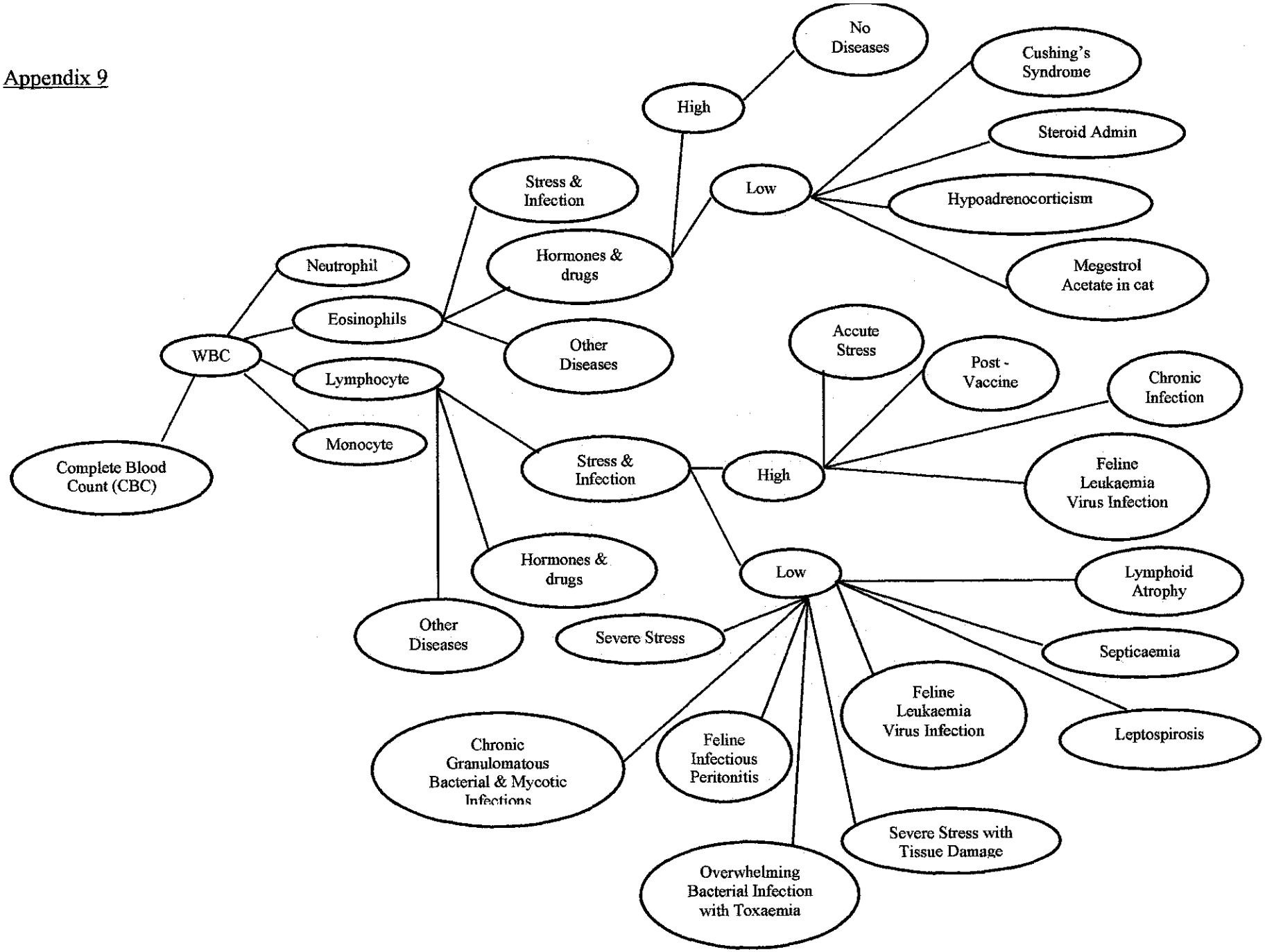
Appendix 7


Complete Blood Count (CBC)
WBC
Neutrophil
Adult
Kitten
Eosinophil
Lymphocyte
Monocyte
Stress & Infection
Hormones & drugs
Other Diseases
High
Low
Cushing's Syndrome
Steroid Admin
No diseases
RBC
Hemoglobin
Hematocrit (HCT)
Mean Corpuscular Volume (MCV)
Mean Corpuscular Hemoglobin Concentration (MCHC)
High
Low
Large Mature RBC
Hyperthyroidism
Reticulocythosis
Inherited Macrocythosis
Iron Deficiency
Pyridoxine Deficiency
Haemobartonellosis

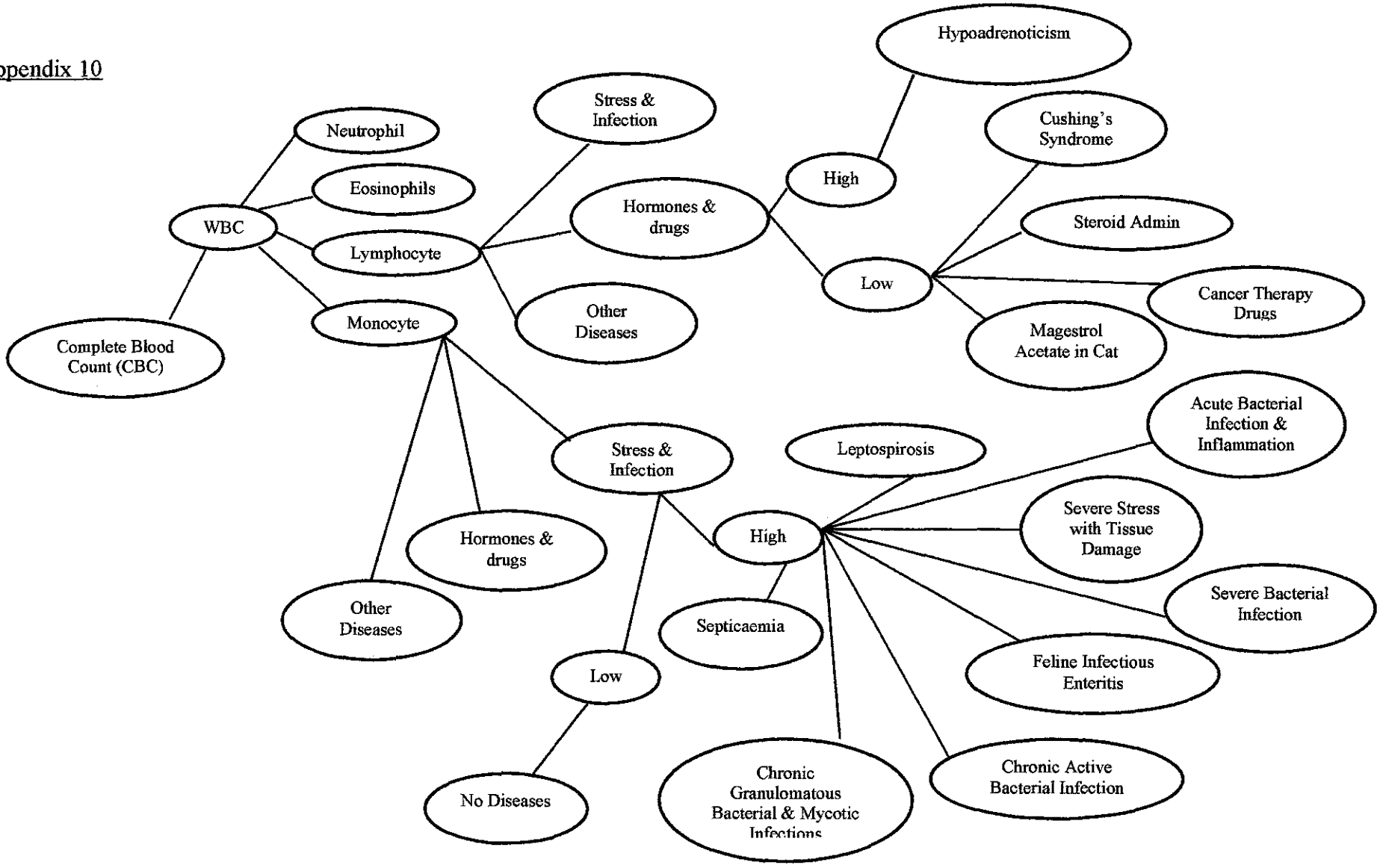
Appendix 8


Complete Blood Count (CBC)
WBC
Neutrophil
Eosinophils
Lymphocyte
Monocyte
Stress & Infection
Hormones & drugs
Other Diseases
High
Acute Stress
Severe Bacterial Infection
Low
Acute & Severe Stress
Leptospirosis
Severe Stress with Tissue Damage
Feline Infectious Peritonitis
RBC
Hemoglobin
Hematocrit (HCT)
Mean Corpuscular Volume (MCV)
Mean Corpuscular Hemoglobin Concentration (MCHC)
High
Haemolysis
Low
Inherited Hypocromia
Pyridoxine Deficiency
Iron Deficiency
Nucleated RBCs
Reticulocytosis

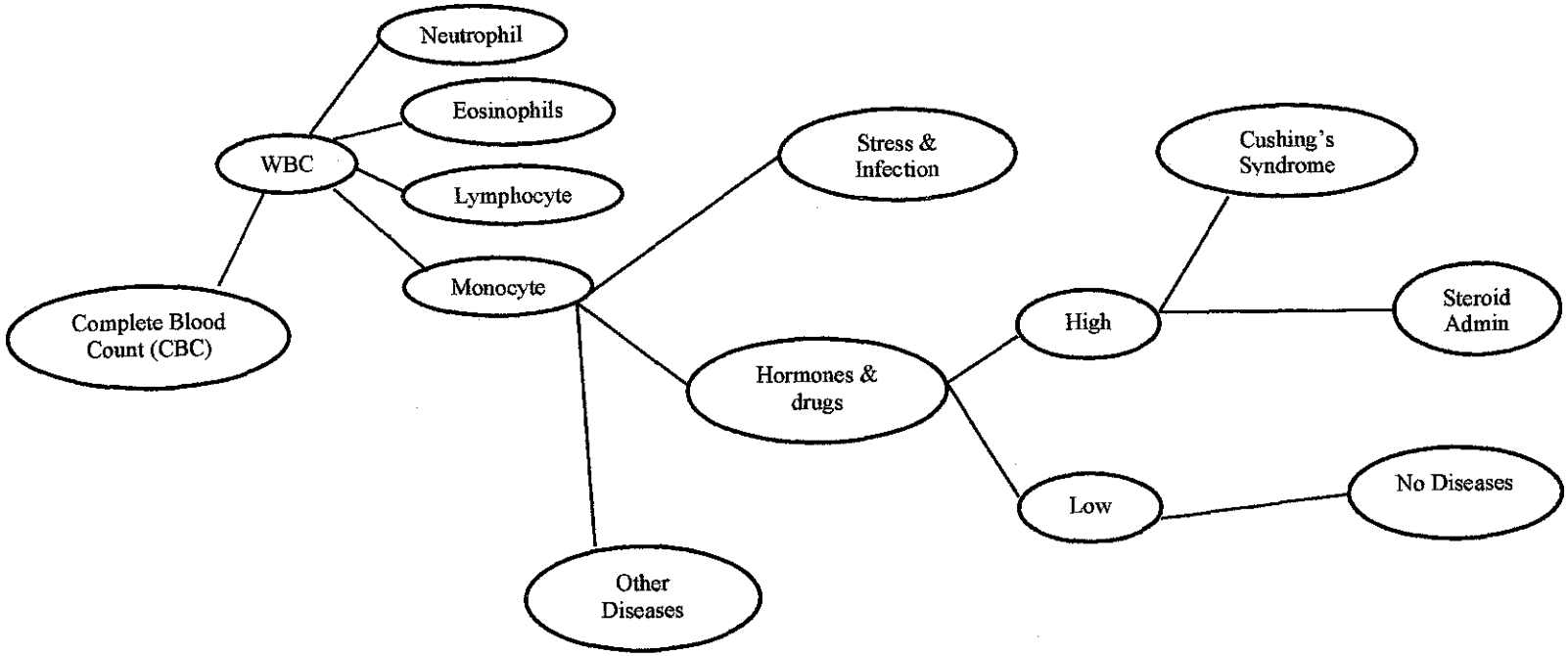
Appendix 9


Complete Blood Count (CBC)
WBC
Neutrophil
Eosinophils
Lymphocyte
Monocyte
Stress & Infection
Hormones & drugs
Other Diseases
High
No Diseases
Low
Cushing's Syndrome
Steroid Admin
Hypoadrenocorticism
Megestrol Acetate in cat
Stress & Infection
Accute Stress
Post - Vaccine
Chronic Infection
Feline Leukaemia Virus Infection
High
Hormones & drugs
Other Diseases
Low
Severe Stress
Lymphoid Atrophy
Septicaemia
Leptospirosis
Feline Leukaemia Virus Infection
Feline Infectious Peritonitis
Chronic Granulomatous Bacterial & Mycotic Infections
Severe Stress with Tissue Damage
Overwhelming Bacterial Infection with Toxaemia

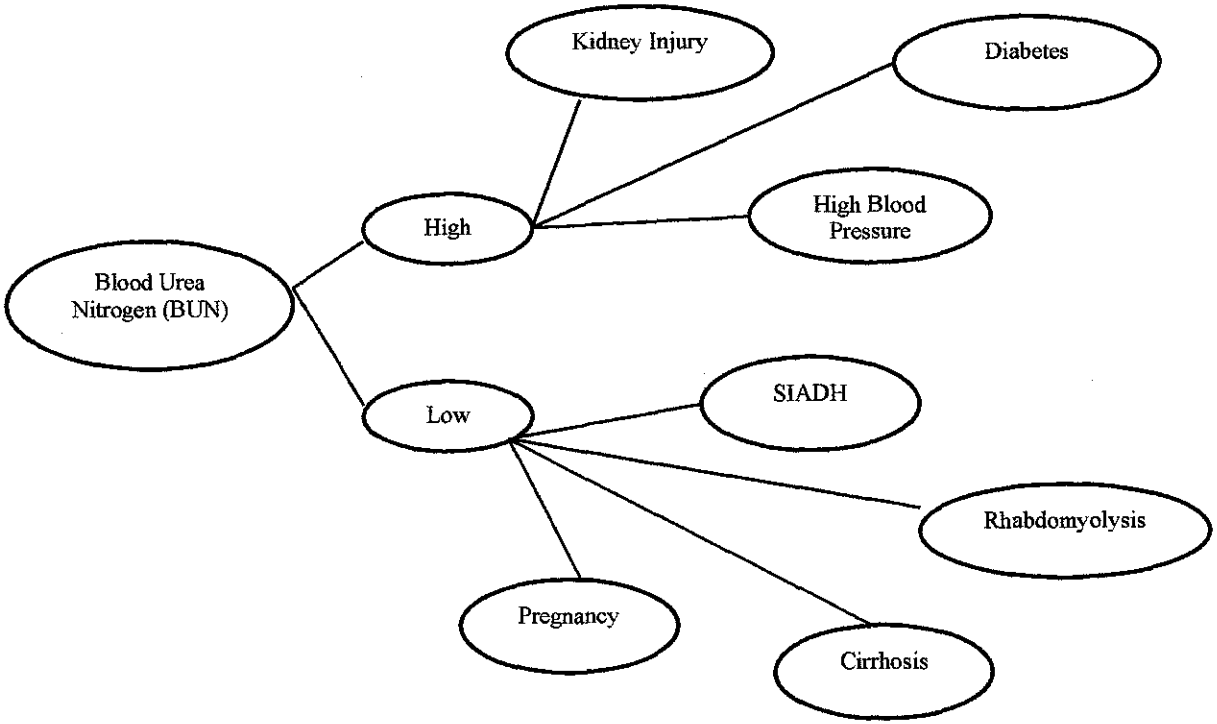
Appendix 10


Complete Blood Count (CBC)
WBC
Neutrophil
Eosinophils
Lymphocyte
Monocyte
Stress & Infection
Hormones & drugs
Other Diseases
High
Low
Hypoadrenoticism
Cushing's Syndrome
Steroid Admin
Cancer Therapy Drugs
Magestrol Acetate in Cat
Stress & Infection
Hormones & drugs
Other Diseases
Low
No Diseases
High
Leptospirosis
Acute Bacterial Infection & Inflammation
Severe Stress with Tissue Damage
Severe Bacterial Infection
Feline Infectious Enteritis
Chronic Active Bacterial Infection
Septicaemia
Chronic Granulomatous Bacterial & Mycotic Infections

Appendix 11


Neutrophil
Eosinophils
WBC
Lymphocyte
Complete Blood Count (CBC)
Monocyte
Stress & Infection
Cushing's Syndrome
Steroid Admin
High
Hormones & drugs
Low
No Diseases
Other Diseases

Appendix 12


Kidney Injury
Diabetes
High Blood Pressure
High
Blood Urea Nitrogen (BUN)
SIADH
Low
Rhabdomyolysis
Pregnancy
Cirrhosis