Country: _____	Student Code: _____

19th INTERNATIONAL BIOLOGY OLYMPIAD

13th – 20th July, 2008

Mumbai, INDIA

PRACTICAL TEST 2

ANIMAL ANATOMY AND PHYSIOLOGY

Total Points: 66

Duration: 60 minutes

Dear Participants,

- In this test, you have been given the following two tasks:

  Task 1: Study of animal skeletal systems (54 points)

  Task 2: Semi-quantitative estimation of nitrogenous waste products (12 points)

- **You have to write down your results and answers in the ANSWER SHEET. Answers written in the Question Paper will not be evaluated.**
- Please make sure that you have received all the materials and equipment listed for each task. In case any of these items is missing, please raise the yellow card.
- At the end of the test, put the Answer Sheet and Question Paper in the envelope. The supervisor will collect this envelope.

Good Luck!!

Country: _____

Country Code: _____

First Name: _____

Middle Name: _____

Family Name: _____

Student Code: _____

Task 1 (54 points)

Study of animal skeletal systems

You should try and complete this task in 45 minutes.

Materials and equipment	**Quantity**
1. Set of skeletal specimens labeled 1 to 9 in sealed boxes **(Please do not open the boxes!)**	9
2. A set of photographs of three skulls labelled 1A, 2A and 3A	1
3. Magnifying hand-lens	1

Introduction

The skeletal system provides physical support and a scaffold for the body and defines its architecture in animals. The three types of skeletal systems include an external (exoskeleton), internal (endoskeleton) and a fluid-based (hydrostatic skeleton) system.

The internal skeleton in vertebrates determines its body shape, provides support for its weight and offers sites for muscle attachment. Although structural modifications in the skeleton may occur in different groups of animals, the basic plan by and large remains the same.

In this task, you will observe and compare the internal skeletal systems of three present-day vertebrates. The models of the skeletal parts provided to

you include the skull, the vertebral column and the limb bones. At the end of the task, you will match these parts to form the complete skeletal system of each of the three vertebrates.

Part A: Comparative study of skulls

(i) Types of skull:

The skull of vertebrates is a bony structure that serves as the general framework for the head. Structurally, the skull comprises four regions – frontal, parietal, occipital and temporal (Figure 1). There are various openings in different regions of the skull, including the nostrils, eye sockets and the temporal openings. The placement of the eyes with respect to each other determines the field of vision of the animal.

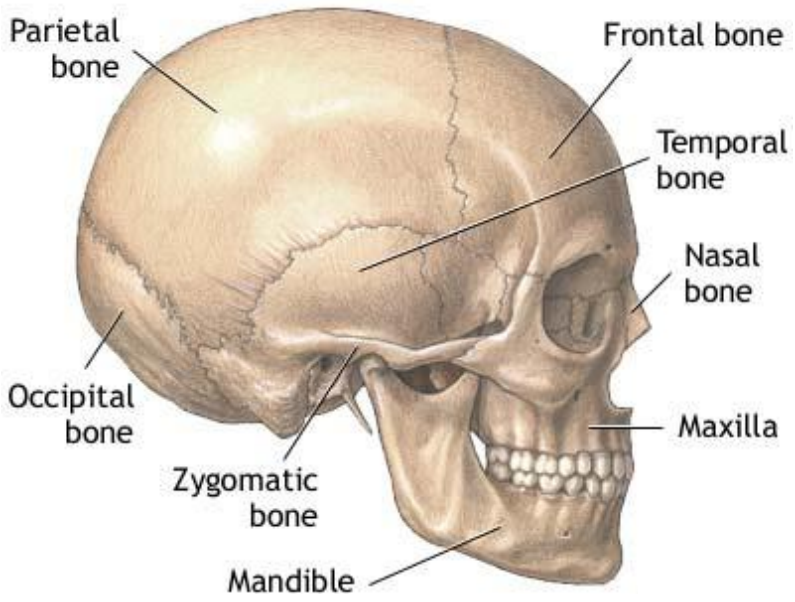


Figure 1

The number of temporal fenestrae (openings) and the position of these openings are used to broadly classify vertebrate skulls into the following four major categories:

(A) Anapsid skull: Anapsids get their name from the fact that they have no additional openings in their skulls apart from their eye sockets and nostrils. The temporal region is covered completely by bone. This type of skull is characteristic of fishes, amphibians, and early reptiles (Figure 2).

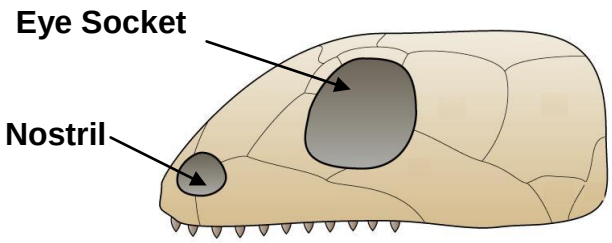


Figure 2

(B) Synapsid skull: It has a single pair of temporal openings. It was found in mammalian ancestors and represented an early divergence from the anapsids. The skull of present day mammals represents a modified synapsid pattern (Figure 3).

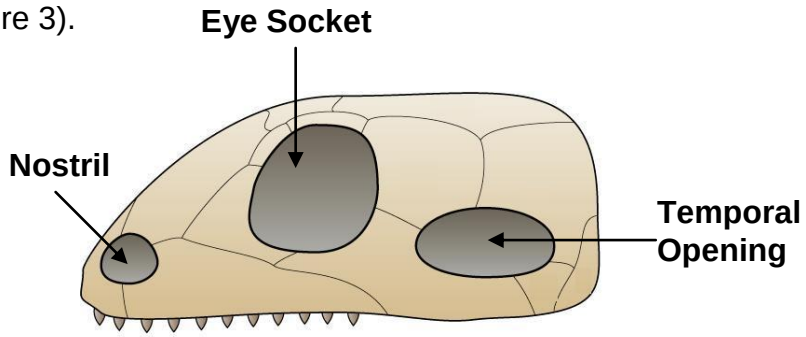


Figure 3

(C) Diapsid skull: It is characterized by two pairs of temporal openings. This type diverged from the anapsids and has undergone extensive modification. It is found in pterosaur and dinosaur fossils, as well as in birds and all living reptiles. One of the highly modified forms of the diapsid skull is found in lizards, where the lower temporal opening is not as distinct as the upper one (Figure 4).

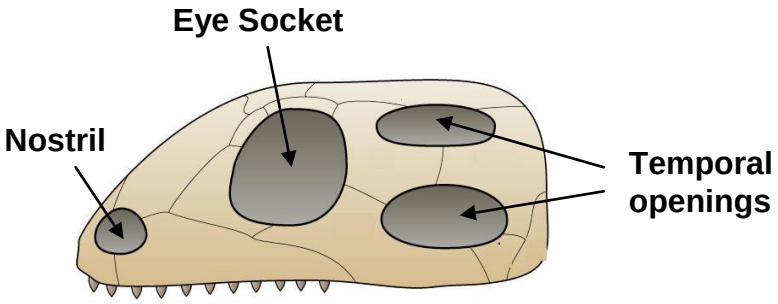


Figure 4

(D) Euryapsid skull: It has a single pair of temporal openings. The euryapsid skull seems to be derived from diapsid ancestors by loss of the lower temporal openings. Two groups of Mesozoic marine reptiles (plesiosaurs and ichthyosaurs) possessed this type of skull (Figure 5).

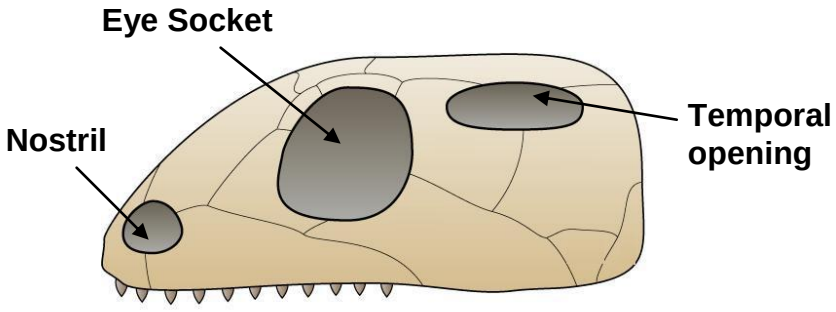
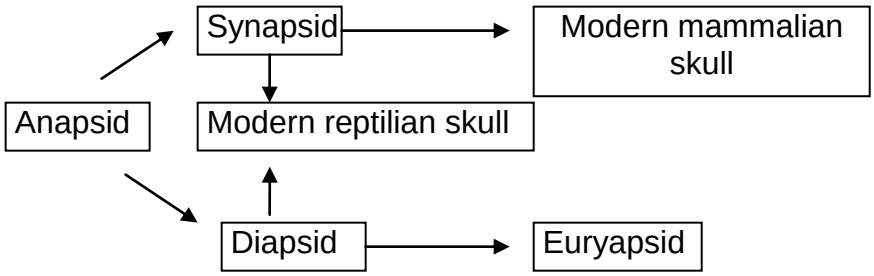


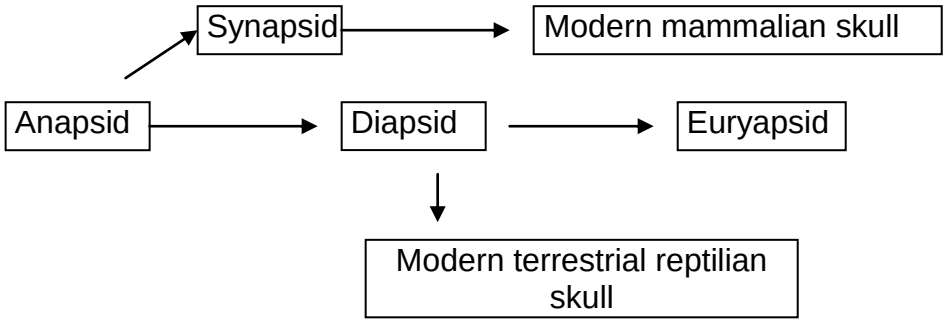
Figure 5

Q. 1.A.1. (2 points): Based on the information provided earlier, choose the cladogram that most likely depicts the evolution of skulls by putting a tick mark (√) in **Q. 1.A.1. in the Answer Sheet**.

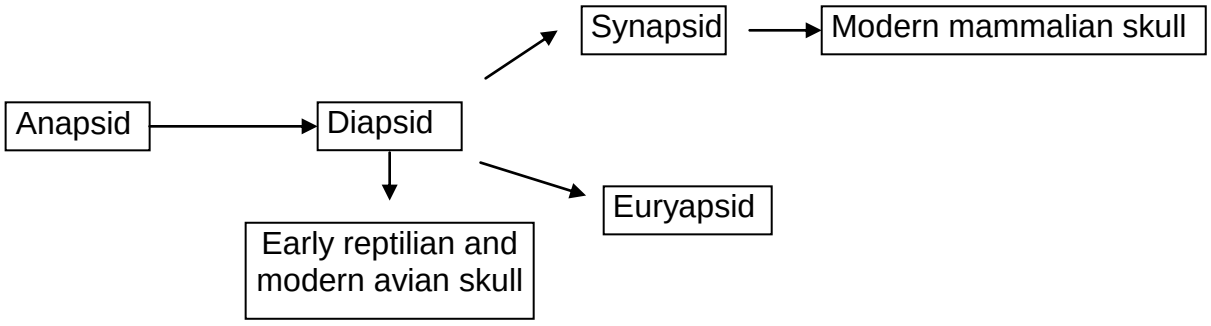
a.



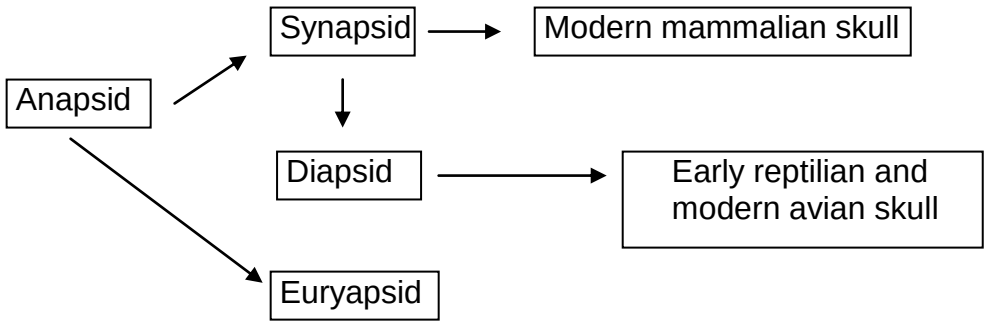
b.



c.



d.



a.	
b.	
c.	
d.	

(ii) Dentition: Dention refers to the type and arrangement of teeth in an animal and is an adaptation to its feeding habit. Based on the dentition, vertebrates can be broadly classified as homodont or heterodont. Depending on the number of times the teeth are replaced during the life span of an animal, they can be further classified as diphyodont or polyphyodont.

Q. 1.A.2. (6 points) Observe the Specimens 1, 2 and 3 for the type of skull and the respective photographs 1A, 2A, and 3A for their dentition. Put tick marks (√) in the appropriate boxes in **Table 1.A.2. in the Answer Sheet**.

Table 1.A.2.

Character		1	2	3
Type of skull	Anapsid			
	Diapsid			
	Synapsid			
	Euryapsid			
Type of dentition	Homodont			
	Heterodont			

Q. 1.A.3. (6 points) Observe the specimens for position of orbit (the eye sockets), and for types of teeth. Fill in the **Table 1.A.3. in the Answer Sheet** by putting tick marks (√) in the appropriate boxes.

Table 1.A.3.

Features		1	2	3
Vision	Predominantly stereoscopic vision			
	Predominantly non-stereoscopic vision			
Feeding habit	Predominantly carnivorous			
	Predominantly herbivorous			

Part B: Comparative study of vertebral columns and ribs

The vertebral column and ribs are components of the axial skeletal system. The vertebral column defines the major body axis and comprises a series of separate bones (vertebrae) joined to form a backbone (Figure 6).

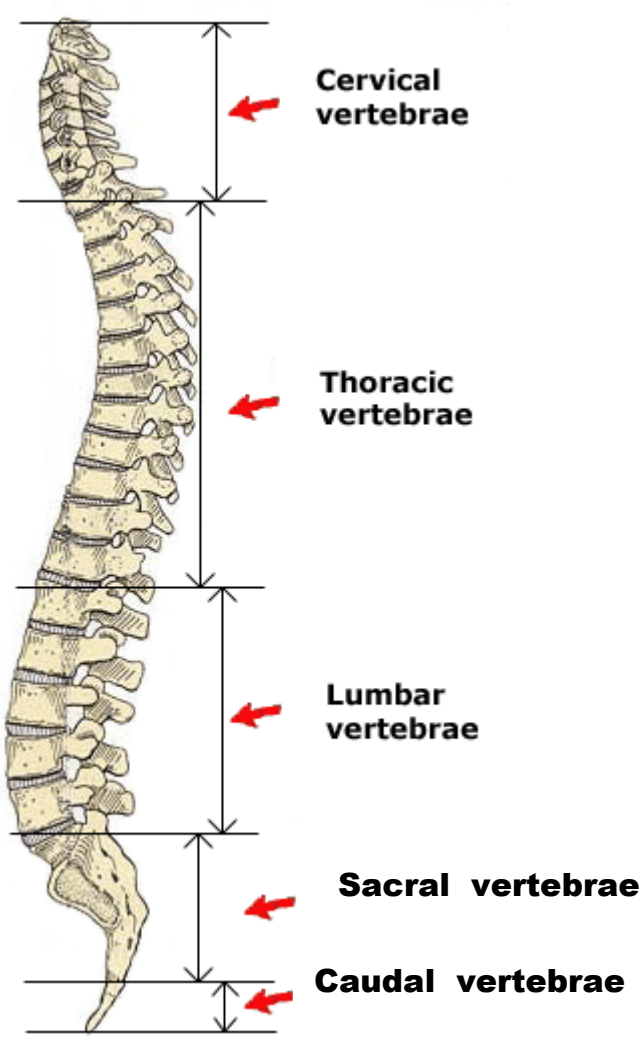


Figure 6

Cervical vertebrae, the first set of vertebrae, are characterized by highly reduced transverse processes in contrast to the following set of vertebrae, the

thoracic vertebrae. The number of cervical vertebrae is usually correlated with the degree of neck movement.

In higher animals, the thoracic vertebrae are important because they articulate with the ventral sternum and ribs to form a rib cage.

Ribs also provide sites for secure muscle attachment, help suspend the body, form a protective case around the viscera and sometimes serve as accessory breathing devices (Figure 7).

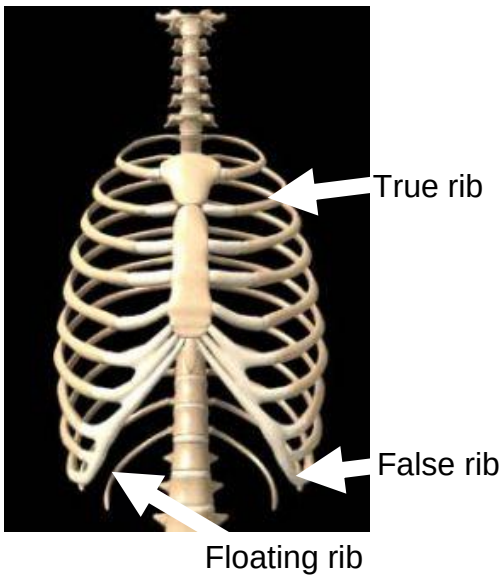


Figure 7

The sternum is a mid-ventral skeletal structure that offers a site of origin for chest muscles and secures the ventral tips of true ribs to complete the protective rib cage. A well-developed rib cage is characteristic of mammals.

The classification of ribs in tetrapods is based on the type of association they establish with the sternum. The three kinds of ribs are:

True ribs – these ribs meet ventrally with the sternum.

False ribs – these ribs articulate with each other but not with the sternum.

Floating ribs – these ribs do not articulate with the sternum or any other structure. These ribs, when present in large numbers offer flexibility to the body during locomotion.

Q. 1.B.1. and Q.1.B.2. (8 + 3 = 11 points) Observe the Specimens 4, 5 and 6 and put tick marks (√) in the appropriate boxes in **Tables 1.B.1. and 1.B.2. in the Answer Sheet**.

Table 1.B.1.

Characters		4	5	6
Ribs	Present			
	Absent			
Major type of ribs	True			
	False			
	Floating			
Tail	Present			
	Reduced /Absent			

Table 1.B.2.

Feature		4	5	6
Neck movement	Restricted			
	Free			

Part C: Comparative study of limb bones

The transition of vertebrates from aquatic to terrestrial and from terrestrial to aerial has had an impact upon the design and redesign of the appendicular system. The appendicular skeleton includes the paired fins or limbs and the girdles. Schematic figures of representative limb arrangements are given below (Figures 8 and 9).

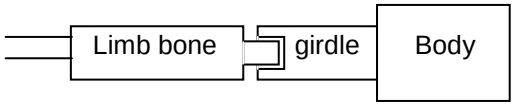


Figure 8: Schematic representation of the articulation of a sprawled limb

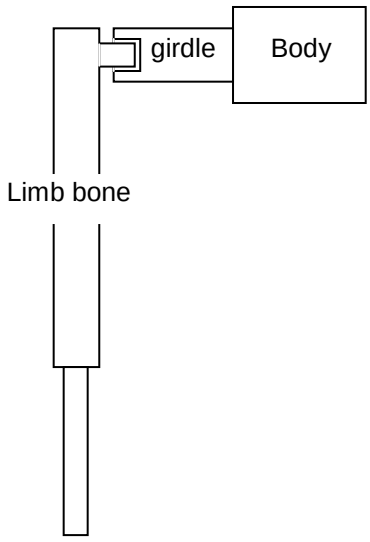


Figure 9: Schematic representation of the articulation of an underneath limb

Q. 1.C.1. (12 points) Carefully study the Specimens 7, 8 and 9, and fill in **Table 1.C.1. in the Answer Sheet** by putting tick marks (√) in the appropriate boxes.

Characters		7	8	9
Position of limb with respect to body	Sprawled			
	Underneath			
Length of fore- and hindlimbs	Similar			
	Fore limbs longer			
	Hind limbs longer			
Claws	Present			
	Absent			
Modifications	Tibia and fibula completely fused			
	Tibia and fibula partially separate			

Q. 1.C.2. (8 points) Based on your observations, fill in **Table 1.C.2. in the Answer Sheet** by putting tick marks (√) in the appropriate boxes.

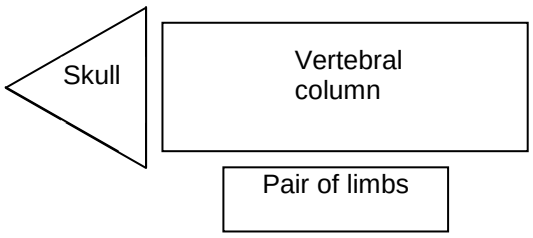
Table 1.C.2.

Features		7	8	9
Limb movement during locomotion	Swinging (rotational movement)			
	Pendulum-like			
Habit of the animal	Saltatorial (jumping)			
	Cursorial (walking)			
	Fossorial (digging)			

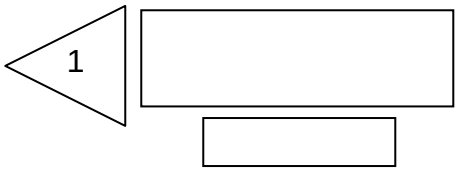
Part D: Assembly of the skeletal systems

Q. 1.D.1 (6 points) The nine specimens (three skulls, three vertebral columns and three sets of limb bones) belong to three different animals (I, II, and III). In the schemes given below, write the respective specimen numbers (4 to 9) in the appropriate boxes to construct the three animals in **Q. 1.D.1. in the Answer Sheet**.

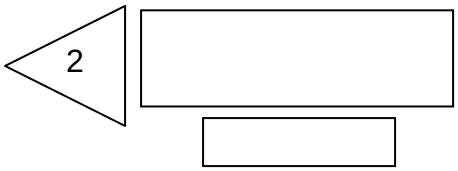
.



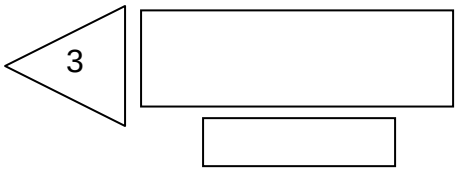
Animal I



Animal II



Animal III



Q. 1.D.2 (3 points): Assign each of the three animals to the most probable class. Choose from the options given below and write appropriate letter in **Q. 1.D.2. in the Answer Sheet.**

Animal I: Class: _____

Animal II: Class: _____

Animal III: Class: _____

Options:

A. Mammalia

B. Reptilia

C. Aves

D. Amphibia

E. Pisces

Task 2 (12 points)

Semi-quantitative estimation of nitrogenous waste products

You should try and complete this task in 15 minutes.

Materials		**Quantity**
1.	Porcelain spot plates, each with 6 cavities	3
2.	Toothpicks	20
3.	Permanent marker pen	1
4.	Tissue paper roll	1
5.	Container for wash and discard	1
6.	Reagents (given in a plastic box)	1 bottle each

Label	**Reagent**
A	Phosphotungstic acid
B	Sodium carbonate (20% w/v)
C	Uric acid (standard solution)
D	Ehrlich’s reagent (mildly corrosive)
E	Urea (standard solution)
F	Sodium nitroprusside
G	Oxidizing solution
H	Phenol solution (mildly corrosive)
I	Ammonia (standard solution)
S1	Simulated Sample 1
S2	Simulated Sample 2
S3	Simulated Sample 3
H_2O	Distilled water

Introduction

Vertebrates have evolved different modes of excretion of nitrogenous wastes, which are mostly derived from degradation of proteins and nucleic acids. They use different ways of excretion of these wastes during their transition from an aquatic to terrestrial mode of life. The three major forms of these wastes are ammonia, urea and uric acid. While ammonia is highly soluble in water, uric acid is the least soluble. Ammonia, being most toxic, needs to be excreted in a highly diluted form. Uric acid is mostly excreted as semisolid crystals.

Three simulated samples (S1, S2 and S3), representing nitrogenous wastes from three groups of animals, are provided. Follow the protocols given below to find out the relative levels of uric acid, urea and ammonia in these samples.

General Instructions

1. ***For each test, run a positive control and a negative control using the standard solutions and distilled water, respectively.***
2. ***Grade the colour of positive control as '+++' and that of negative control as ' – '.***
3. ***Please note that the recording of the results for the positive and negative controls carries NO points.***

Protocols for estimation

1. Estimation of uric acid by phosphotungstic acid reduction method

Principle

Under alkaline conditions, uric acid reduces phosphotungstic acid to give a blue- coloured product.

Method

(i) Put three drops each of Samples S1, S2 and S3 in separate cavities of a given spot plate.

(ii) Add one drop each of solutions A followed by B to each cavity. Mix with separate toothpicks and observe the developed colour.

(iii) Grade the colour of the positive control as '+++' and that of the negative control as ' – '.

Q. 2.1.1. (3 points) Record the results in **Table 2.1. in the Answer Sheet** by putting '+++', '++' or '+' for positive results depending on the intensity of the colour developed and '–' for negative results.

2. Estimation of urea using Ehrlich's reagent

Principle

Under strong acidic conditions, urea reacts with Ehrlich's reagent (*p*-dimethylaminobenzaldehyde) to form a yellow-coloured dye (protonated Schiff's base).

Method

(i) Put three drops each of Samples S1, S2 and S3 in separate cavities of a given spot plate.

(ii) Add one drop of solution D to each cavity. Mix with separate toothpicks.

Q. 2.1.2. (3 points) Record your results **immediately** in **Table 2.1. in the Answer Sheet** by putting '+++', '++' or '+' for positive results depending on the intensity of the colour developed and '-' for negative results. For comparison, grade the colour of the positive control as '+++' and that of the negative control as ' – '.

3. Estimation of ammonia by indophenol blue method

Principle

In an alkaline solution, ammonium ions react with oxidizing solution to form monochloramine. In the presence of phenol and an excess of oxidizing solution, the monochloramine forms a blue-coloured product, indophenol, when nitroprusside is used as a catalyst.

Method

(i) Put three drops each of Samples S1, S2 and S3 in separate cavities of a given spot plate.

(ii) Add one drop each of solutions F, followed by G and finally H to each cavity. Mix with separate toothpicks.

Q. 2.1.3. (3 points) Record your results **after two minutes** in **Table 2.1. in the Answer Sheet** by putting '++++', '+++', '++' or '+' for positive results depending on the intensity of colour developed and '-' for negative results. For comparison, grade the colour of positive control as '+++' and that of negative control as ' – '.

Table 2.1.

Samples	Uric acid test	Urea test	Ammonia test
S1			
S2			
S3			
Positive control			
Negative control			

Q. 2. 2. (3 points): Based on the results obtained, match each of the samples with the appropriate class of vertebrates listed below. Fill in your answer by putting the appropriate letter in **Q. 2.2. in the Answer Sheet**.

Answer: _____

a.	S1: Pisces	S2: Mammalia	S3: Reptilia
b.	S1: Amphibia	S2: Aves	S3: Pisces
c.	S1: Mammalia	S2: Reptilia	S3: Aves
d.	S1: Mammalia	S2: Pisces	S3: Aves
e.	S1: Aves	S2: Pisces	S3: Mammalia
f.	S1:Reptilia	S2: Amphibia	S3: Mammalia
g.	S1: Aves	S2: Reptilia	S3: Amphibia

********** END OF PRACTICAL TEST 2 **********

STUDENT CODE:

Student Code: _____

19th INTERNATIONAL BIOLOGY OLYMPIAD

13th – 20th July, 2008

Mumbai, INDIA

PRACTICAL TEST 2

ANIMAL ANATOMY AND PHYSIOLOGY

Total Points: 66

Duration: 60 minutes

ANSWER SHEET

STUDENT CODE:

Task 1 (54 points)

Study of animal skeletal systems

Q. 1.A.1. (2 points)

a.	
b.	
c.	
d.	

Q. 1.A.2. (6 points)

Table 1.A.2.

Character		1	2	3
Type of skull	Anapsid			
	Diapsid			
	Synapsid			
	Euryapsid			
Type of dentition	Homodont			
	Heterodont			

STUDENT CODE:

Q. 1.A.3. (6 points)

Table 1.A.3.

Features		1	2	3
Vision	Predominantly stereoscopic vision			
	Predominantly non-stereoscopic vision			
Feeding habit	Predominantly carnivorous			
	Predominantly herbivorous			

Q. 1.B.1. (8 points)

Table 1.B.1.

Characters		4	5	6
Ribs	Present			
	Absent			
Major type of ribs	True			
	False			
	Floating			
Tail	Present			
	Reduced /Absent			

STUDENT CODE:

Q. 1.B.2. (3 points)

Table 1.B.2.

Feature		4	5	6
Neck movement	Restricted			
	Free			

Q. 1.C.1. (12 points)

Table 1.C.1.

Characters		7	8	9
Position of limb with respect to body	Sprawled			
	Underneath			
Length of fore- and hindlimbs	Similar			
	Fore limbs longer			
	Hind limbs longer			
Claws	Present			
	Absent			
Modifications	Tibia and fibula completely fused			
	Tibia and fibula partially separate			

STUDENT CODE:

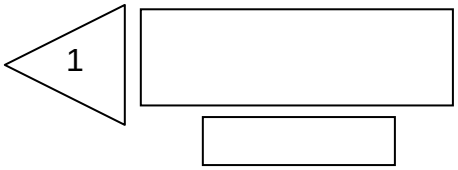
Q. 1.C.2. (8 points)

Table 1.C.2.

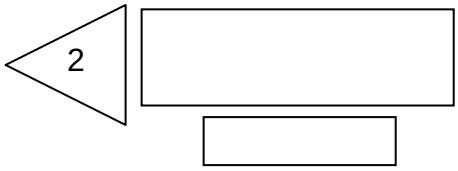
Features		7	8	9
Limb movement during locomotion	Swinging (rotational movement)			
	Pendulum-like			
Habit of the animal	Saltatorial (jumping)			
	Cursorial (walking)			
	Fossorial (digging)			

Q. 1.D.1 (6 points)

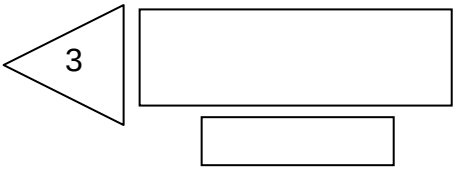
Animal I



Animal II



Animal III



STUDENT CODE:

Q. 1.D.2 (3 points):

Animal I: Class: _____

Animal II: Class: _____

Animal III: Class: _____

Task 2 (12 points)

Semi-quantitative estimation of nitrogenous waste products

Q. 2.1.1. to 2.1.3. (9 points)

Table 2.1.

Samples	Uric acid test	Urea test	Ammonia test
S1			
S2			
S3			
Positive control			
Negative control			

Q. 2. 2. (3 points):

Answer: _____

********** END OF PRACTICAL TEST 2 **********