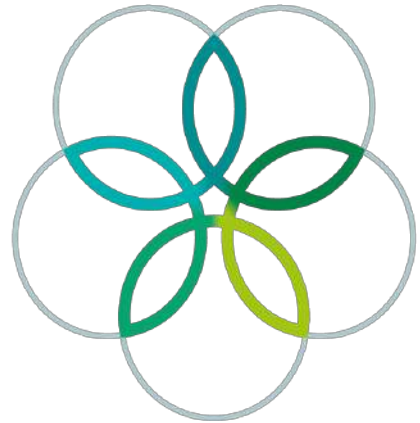
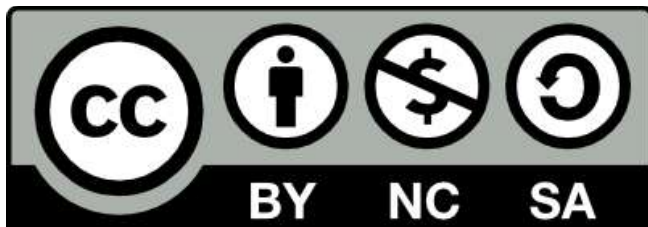


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**IBO**



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# Animal Systematics and Anatomy Practical



English (Official)

## 33rd International Biology Olympiad

July 10 - 18, 2022

Yerevan, Armenia

<b>Student Code</b>	<input type="text"/>
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### Practical Exam 1

#### ANIMAL SYSTEMATICS AND ANATOMY

Total points: 100

Duration: 90 minutes

# Animal Systematics and Anatomy Practical



English (Official)

## GENERAL INSTRUCTION

Dear PARTICIPANT, This practical assignment is comprised of the following 2 parts:

### Part 1. Taxonomic identification of fish (51 points)

- **Task 1.** Determine the taxonomic order for each of your 3 fish specimens.
- **Task 2.** Demonstrate the process of arriving at your decision in Task 1.
- **Task 3.** Determine the species for each fish specimen.
- **Task 4.** Demonstrate the process of arriving at your decision in Task 3.

### Part 2. Identifying a supposed "new" species of fish (41 points)

- **Task 5.** Determine diagnostic features of a supposed "new" fish species.
- **Task 6.** Choose the right dichotomous key (keys) for identifying the supposed "new" species.

### Part 3. General questions about anatomical and physiological peculiarities of fishes (8 points)

In those two practical tasks you will be asked to use multiple taxonomic keys. Each key has a series of statements that can be either true or false. Use the keys to identify the species, i.e. question 1.1.

Labeling in dichotomous key demonstrated in example below:

1(2) The snout is elongated and pointy. The mouth is located under the snout. The upper lobe of the caudal fin is significantly longer than the lower. The body has five rows of small bony rhomboid scutes.

In '1(2)', 1 is the number of the characteristic described in the sentence that follows. (2) If the characteristic is NOT seen in your specimen the number in the brackets tells you which characteristic to consider next. i.e. if false go to 2.

'Sturgeons - Acipenseriformes (1)', here (1) indicates the number to enter in your answer key after identifying this species.

1. **Always wear gloves. In case of any injuries during the tasks immediately call the lab assistant by raising the red card.**
2. **Check that you have received all the instruments and materials. If any are missing, let the lab assistant know by raising the red card during the first 10 minutes of the exam.**
3. **Use all the materials and instruments appropriately, handle equipment properly.**
4. **No spilled solution or broken instrument will be replaced.**
5. **Write your Student Code in the given box on every page of your answer sheet.**
6. **Record your answers in your answer sheet. Only the answers recorded in the Answer Sheet will be evaluated.**
7. **Stop writing and put down your pen immediately when you hear the bell ring at the end of the exam.**
8. **Put all the papers in an empty envelope, and then close it.**
9. **Wait in your seat until the assistant comes to you to pick up your envelope.**
10. **No piece of paper, material, stationery, or instrument should be taken out of the lab.**

# Animal Systematics and Anatomy Practical



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## Materials and Instruments

<b>Name</b>	<b>Quantity</b>
Fish specimens for Part 1 only	3
Fish specimen of a supposed "new" species for Part 2 only	1
Photographs of fish for Part 2 only	3
Mask	1
Dissection tray	1
Magnifier with a double 3x and 10x lens	1
Tweezers	1
Scissors	1
Scalpel	1
Plastic gloves	1
A water bottle to keep fish moist	1
Paper tissue	1
Plastic bag for biological waste	1
Stationery (pen, pencil, pencil sharpener)	1
Red card	1

# Animal Systematics and Anatomy Practical



English (Official)

## Part 1. Taxonomic identification of fish

You are given three fish specimens numbered #1-3, each of which belongs to a separate species. You will start taxonomic identification of these individuals by first determining their order and then the species. You should use the suggested procedure below. Repeat the same for each of the individuals.

### Procedure:

1. Place each of the specimens sequentially on the tray.
2. Explore the external structure of the fish.
3. Perform a dissection (when needed for the task), using scissors, tweezers and a scalpel, and observe the internal structures of the fish.
4. Use the magnifying glass if you would like to get a more detailed look
5. After finishing, place all biological waste into the plastic bag.

Detailed instructions will be provided for the specific tasks.

### During your observations of external and internal structures, consider the following features:

- **The shape of the body.**
- **Body coloring and patterns.**
- **Fins.**
  - The dorsal fin of fish might be longer or shorter or conjoined with the caudal fin. Some fish have an adipose fin located posterior to the dorsal fin. The adipose fin has a very distinct structure and lacks rays. The structure of the caudal fin differs from species to species.
  - The number of rays in a fin (Appendix 2, Image 1) and their shape (Appendix 2, Image 2) can be different. The rays can be unbranched (firm, spiky) or branched near their endings (soft). The last ray of dorsal and anal fins is frequently bifurcated near its base.
  - To count the number of rays you need to pull from the anterior of the fin and observe whether the last rays originate from a single base or two separate bases. If they leave from a single base, they should be counted as one ray.
- **Position of the mouth.**
  - In fish, the terminal position of the mouth and relative positioning of the jaws can be different. Thus, we can distinguish the following positions of the mouth: superior, inferior, terminal, subterminal, supraterrminal. (Appendix 2, Image 3).
- **The presence and number of barbels, or their absence.**
- **Teeth.**
  - In addition to teeth located on the jaws, fish of some taxonomic orders have pharyngeal teeth located on the pair of pharyngeal bones. Pharyngeal teeth can be in one, two or three rows (Appendix 2, Image 4).
  - In such fish, pharyngeal bones are located on the two sides of the oesophagus under the operculum. To isolate the pharyngeal bone, you will need to pull open the operculum and then, by using your tweezers, find the bone by touching the region after the last branchial arch around the oesophagus. Finally, hold it with the tweezers and gently pull away by slight tilts to the left and right. Pharyngeal bones of small fish are fragile and can break if handled without proper care.
- **Shape and arrangement of scales.**

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- Fish of most species are covered with scales of different shapes and structures. They look like tiny “shields”, and are called **scutes** (scutes are a modified ganoid scale) and are arranged in rows along the body. They can also be in the form of thin bony plates, belonging to either the **cycloid** type (smooth contours) or the **ctenoid** type (rough contours). In some species, the body is not covered with scales.
- Scales of the lateral line are very important for determining the species identity of fish. Those scales are typically located on the sides of the body and are distinguished from other scales by the small fissures. The lateral line usually runs from the posterior of the operculum to the base of the caudal fin. In some species, the scales of the lateral line are few and located closer to the body anterior.
- **Pyloric caeca.**
  - Some fish have 3 to 400 dead-end projections on the gut at the junction of the intestine and the stomach, the so-called pyloric caeca, which are important for determining taxonomic identity.
- **The body length of the fish.**
  - To determine the total body length, we take the distance from the tip of the snout to the tip of the caudal fin (Appendix 2, Image 5). For identification of the taxonomic group of certain fish species, Smith’s distance is commonly used. **Smith’s distance (fork length)** is measured from the edge of the mouth to the end of the middle rays of the caudal fin. For industrial applications, only the length of the body excluding the head is measured (i.e., the distance from the back of the head to the base of the caudal fin).

**Q.1.1. Determine the taxonomic order for each of 3 fish specimens (6 points, 2 points each)**

Using a dichotomous key (Appendix 1, Dichotomous Key 1), determine the correct taxonomic order for each of the three specimens. In your Answer Sheet, record the identifying **number of the taxon for each individual**. Taxon identification numbers are written in parentheses next to their names in the dichotomous key. You have to follow the following sequence: assess the first statement of dichotomous key and go to the number in parentheses if false, or proceed to the next statement if true.

**Table 1**

Specimen N	1	2	3
Order N			

Specimen N (number written next to the specimen)	
Order N	

**Q.1.2. Show how you reached your decision in Q1.1 (14 points)**

Record in Table 2 of your Answer Sheet the steps you took for the taxonomic identification. You will be

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given points for each correctly filled cell. The correct answer for each row is built sequentially (from left to right), and each next answer is based on the previous one. So, if you make a mistake at any step, the next answer will be wrong. Some cells at the end can be blank. Example of correctly filled in cell : 1(2).

**Table 2**

	Sequential numbers of steps for determining fish orders									
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Sequential numbers of steps for determining fish order	<input type="text"/>
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**Q.1.3. Determine the biological species of each fish specimen (12 points, 2 point each)**

Taking into account results from the previous task and using dichotomous keys for species belonging to various orders (Appendix 1, Dichotomous Keys 2-9), identify the species of each individual. Record it in Table 3 of your Answer Sheet, denoting it by the species identification number. You can find identification numbers in the parentheses next to species names in each dichotomous key.

**Table 3**

Specimen N	Dichotomous key N	Species N
1	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>

# Animal Systematics and Anatomy Practical



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Specimen N	
Dichotomous key N	
Species N	

**Q.1.4. Demonstrate the process of arriving at your decision in Q.1.3 (19 points)**

Record in Table 4 of your Answer Sheet the steps you took for the taxonomic identification.

**Table 4**

Specimen N	Sequential numbers of steps for determining fish species									
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Specimen N	
Sequential numbers of steps for determining fish species	



# Animal Systematics and Anatomy Practical



English (Official)

## Part 2. Identifying the supposed “new” species of fish

Biodiversity of fish is one of the great unexplored areas of vertebrate zoology, and every year, scientists discover and describe new species. This process is regulated by the **International Code of Zoological Nomenclature** (2012), which ensures consistent and harmonious actions when describing new species. These actions include the isolation of a representative individual (called holotype), the description of its diagnostic features and the comparison of these features with diagnostic features from other (already well established) species

**Q.2.1. Determine diagnostic features of a supposed “new” fish species.** Diagnostic feature is a characteristic that differentiate the species most clearly. (27 points, NB: incorrect entries will be penalized. Minimum number of points is 0).

Observe the individual from a supposed “new” species, as well as pictures of individuals from well-known fish species (Appendix 3, Pictures 1-3) and image of external diagnostic features of fish (Image 6 in Appendix 2). Mark with **X** in the appropriate cells of Table 5 in your Answer Sheet to point out main external features, which you consider diagnostic (i.e., fundamental and definitive) for identifying the supposed “new” species.

**Table 5**

Comparable species	Selected distinctive/diagnostic external features												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comparable Species 1: *Salvelinus fontinalis* is different from the new species:

Comparable Species 2: *Salmo salar* is different from the new species:

Comparable Species 3: *Salmo trutta* is different from the new species:

Comparable Species 4: All of the above are different from the new species:

Comparable species	
Selected distinctive/diagnostic external features	

# Animal Systematics and Anatomy Practical



English (Official)

**Q.2.2. Choose the correct dichotomous key (keys) for identifying the supposed "new" species**  
(14 points, incomplete or partially correct answer(s) will be given 0 points)

To identify the supposed "new" species of fish, you have 5 new dichotomous keys below. Explore them all and mark with **X** in Table 6 of your Answer Sheet the number corresponding to the correct key or keys.

**Table 6**

Dichotomous determinant table number	1	2	3	4	5
Answer/answers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Dichotomous determinant table number	
Answer/answers	

# Animal Systematics and Anatomy Practical



English (Official)

## Identifying the supposed "new" species - dichotomous key N 1

1(2) The mouth is supraterminal, and the lower jaw is considerably longer than the upper jaw.

**Brook salmon (*Salvelinus fontinalis*)**

2(5) The mouth is subterminal, and the upper jaw is considerably longer than the lower jaw.

3(4) Along the sides of the body there is a reddish colored layer.

**Brown trout (*Salmo trutta*)**

4(3) There are red and black dots on the sides of the body.

**Unknown salmon (*Salmo* sp.)**

5(2) The mouth is terminal, and jaws are of equal size.

**Atlantic salmon (*Salmo salar*)**

## Identifying the supposed "new" species - dichotomous key N 2

1(4) The adipose fin is present and is located between dorsal and caudal fins.

2(3) The mouth is large, and the upper jaw reaches the base of the pectoral fin.

**Brook salmon (*Salvelinus fontinalis*)**

3(2) The mouth is small, and the upper jaw does not reach the base of the pectoral fin.

**Atlantic salmon (*Salmo salar*)**

4(1) Adipose fin is absent. 5(6) The lobes of the caudal fin are equal in size, and the fin is not forked.

**Brown trout (*Salmo trutta*)**

6(5) The lobes of the caudal fin are not equal in size, and the fin is forked.

**Unknown salmon (*Salmo* sp.)**

## Identifying the supposed "new" species - dichotomous key N 3

1(2) The mouth is large, and the upper jaw reaches the preoperculum.

**Brook salmon (*Salvelinus fontinalis*)**

2(1) The mouth is small, and the upper jaw does not reach the preoperculum

3(4) Both sides of the body are covered only with dark orange and red spots. Each of those spots is surrounded by a brightly colored ring.

**Brown trout (*Salmo trutta*)**

4(3) The body does not have orange or red spots. Even if those are present, they are rare and not surrounded by a brightly colored ring.

5(6) The body is covered with occasional small blurry dark spots. The colorful layer along the side of the body is absent.

**Atlantic salmon (*Salmo salar*)**

6(5) The body is covered with numerous dark and well-defined spots. The colorful layer along the side of the body is present.

**Unknown salmon (*Salmo* sp.)**

# Animal Systematics and Anatomy Practical



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## Identifying the supposed "new" species - dichotomous key N 4

**1(4)** The lateral line is incomplete and is present only on the scales near the anterior.

**2(3)** The length of the pectoral fin is more than half the distance between the bases of the pectoral and pelvic fins.

**Brook salmon (*Salvelinus fontinalis*)**

**3(2)** The length of the pectoral fin is less than half the distance between the bases of the pectoral and pelvic fins.

**Brown trout (*Salmo trutta*)**

**4(1)** The lateral line is complete and traverses the full length of the body.

**5(6)** The base of the dorsal fin starts after the perpendicular line drawn from the base of pelvic fins.

**6(7)** The external contour of the dorsal fin is curved.

**Atlantic salmon (*Salmo salar*)**

**7(6)** The external contour of the dorsal fin is straight.

**Unknown salmon (*Salmo* sp.)**

## Identifying the supposed "new" species - dichotomous key N 5

**1(4)** The contour of the body from the base of the head to the base of the dorsal fin is straight (i.e. uncurved).

**2(3)** Pectoral fins are long and reach the base of pelvic fins.

**Brook salmon (*Salvelinus fontinalis*)**

**3(2)** Pectoral fins are short and do not reach the base of pelvic fins.

**Atlantic salmon (*Salmo salar*)**

**4(1)** The contour of the body is curved from the base of the head to the base of the dorsal fin.

**5(6)** The upper and lower lobes of the caudal fin are equal in size; the fin is not forked. The colorful layer along the side of the body is present.

**Brown trout (*Salmo trutta*)**

**6(5)** The upper and lower lobes of the caudal fin are not equal in size, and the fin is forked. The colorful layer along the side of the body is absent.

**Unknown salmon (*Salmo* sp.)**

# Animal Systematics and Anatomy Practical



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## Part 3. General questions about anatomical and physiological peculiarities of fishes (8 points)

Answer the questions by putting an **X** in the appropriate box of the **Answer sheet** in questions **3.1, 3.2, 3.3, 3.4, 3.6, 3.7.**

	True	False
1	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>
3	<input type="checkbox"/>	<input type="checkbox"/>
4	<input type="checkbox"/>	<input type="checkbox"/>

**3.1. What type of fish scales do the fish scales provided to you belong to? (1 point) Please fill the correct answers in the *Answer sheet*.**

1	The fish scales belong to the ctenoid type.
2	The fish scales belong to the cycloid type.
3	The fish scales belong to the ganoid type.
4	The fish scales belong to the placoid type.

**3.2. Which statement regarding the origin of fish scales of bony fishes is correct? (1 point). Please fill the correct answers in the *Answer sheet*.**

1	They are derived from the outer skin layer – the epidermis.
2	They are derived from the main skin layer – the dermis.
3	They are derived from the cells of the hypodermis.
4	They are derived both from the epidermis and the dermis.

**3.3. Which statement regarding the skin of fish is correct? (1 point). Please fill the correct answers in the *Answer sheet*.**

# Animal Systematics and Anatomy Practical



English (Official)

1	The glands responsible for the mucus secretion are multicellular.
2	The silver metallic sheen typical for the majority of fish occurs due to guanine crystals. These are formed by cells in both the skin and the fish scales.
3	The mucus accelerates the coagulation of blood and supports wound healing.
4	The epidermis consists of simple epithelium.

**3.4. Which statement regarding the lateral line organ is correct? (1 point). Please fill the correct answers in the *Answer sheet*.**

1	They are typical for the majority of fish, amphibian larvae, some adult amphibians, crustaceans and some species of cephalopods.
2	Can be modified into electroreceptors.
3	Can be modified into light emitting organs.
4	The lateral line organ consists of ciliated epithelial cells – hair cells

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**3.5. Match the fish fin types with their according functions. (2 points, 0.4 for each fin type. All the functions of the given fish must be chosen correctly). Please fill the correct answers in the Answer sheet.**

For each Fish fin (Letters) mark the correct Performed function (Numbers) with X mark in Answer sheet.

	Correct statement									
	1	2	3	4	5	6	7	8	9	10
A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Fish fin	Performed function
A. Pectoral fin	1. Functions as a steering wheel when performing a sharp turn.
B. Ventral fin	2. Helps the fish turn left or right.
C. Dorsal fin	3. Aids in stability and balance.
D. Anal fin	4. Helps the fish move upwards and downwards through the water.
E. Tail fin	5. Enables the dorsal part of the body to constantly face upward.
	6. Is used when moving along the sea floor.
	7. Prevents the rolling of the fish when moving.
	8. Functions as a steering when moving forward.
	9. Regulate the direction of swimming.
	10. Has a defensive function.

**3.6. What is/are correct characteristic(s) for the fish circulatory system? (1 point). Please fill the correct answers in the Answer sheet.**

# Animal Systematics and Anatomy Practical



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1	The ventral aorta divides into 4 pairs of gill arteries.
2	The ventral aorta divides into 2 gill arteries.
3	The blood in the capillaries of the gills and the water surrounding the gills flow in opposing directions.
4	The blood in the capillaries of the gills and the water surrounding the gills flow in the same direction.

**3.7. Which statement regarding the swim bladder of fish is correct? (1 point). Please fill the correct answers in the *Answer sheet*.**

1	It regulates the gas composition of the blood.
2	Its volume changes due to gas entering from the intestines.
3	It is typical for all bony fish.
4	It communicates with the balancing organs of the inner ear.



# Animal Systematics and Anatomy Practical



English (Official)

## Appendix 1. Dichotomous Keys

### Dichotomous Key N1

#### Orders of fish occurring in Armenia

**1(2)** The snout is elongated and pointy. The mouth is located under the snout. The upper lobe of the caudal fin is significantly longer than the lower. The body has five rows of small bony rhomboid scutes.

#### Sturgeons - Acipenseriformes (1)

**2(1)** The skin is covered with scales or does not have scales. Bony scutes are absent. The snout is short. The mouth is located at the tip of the snout. The caudal fin has two equal lobes, either forked or with a curved contour.

**3(4)** An adipose fin is present. Multiple pyloric caeca are present along the gut right past the stomach.

#### Salmonids - Salmoniformes (2)

**4(3)** The adipose fin is absent.

**5(6)** The body has no scales. The anal fin is elongated and joined with the caudal fin. There are three pairs of barbels. Two of those pairs are under the snout, while one pair is on the upper jaw. The barbels on the upper jaw are elongated and reach the pectoral fins. The first ray of the pectoral fin is thicker. The dorsal fin has 3-5 rays.

#### Catfish - Siluriformes (3)

**6(5)** The body is covered with scales. Those are small and can be indiscernible at first. If the scales are indiscernible, then the body is snake-like or the barbels are short and do not reach past the posterior of the head.

**7(8)** The body is snake-like. Barbels and pelvic fins are absent.

#### Eels - Anguilliformes (4)

**8(7)** The body is not snake-like. Pelvic fins are present.

**9(12)** Two dorsal fins are present. Bases of pelvic fins are located under the bases of pectoral fins or the throat.

**10(11)** Pelvic fins are conjoined and form a single structure.

#### Gobies - Gobiiformes (5)

**11 (10)** Pelvic fins are not conjoined and form two separate structures.

#### Perches - Perciformes (6)

**12(9)** Only one dorsal fin is present. Bases of pelvic fins are located past the bases of pectoral fins, near the midpoint of the abdomen.

**13(14)** The dorsal fin is located in the midpoint of the back. Jaws do not have teeth on them. Pharyngeal teeth are present, located on pharyngeal bones.

#### Carps - Cypriniformes (7)

**14(13)** Only one dorsal fin is present, located near the posterior of the back, near the vertical line drawn from the base of the anal fin. Pharyngeal teeth are absent.

#### Toothcarps - Cyprinodontiformes (8)

## Dichotomous key 2

### Species of industrially produced sturgeons (order Acipenseriformes) in Armenia

**1(2)** Gill membranes are joined together and form a free fold in the interbranchial space, without attaching to the interbranchial septum. The mouth is large and crescent-shaped. Barbels are long and reach the upper lip.

#### Beluga - *Huso huso* (1)

**2(1)** Gill membranes are conjoined to the interbranchial space and do not form a free fold. The mouth is small, slit-shaped and with a transverse cut. **3(4)** The lower lip is complete and uninterrupted in the middle. Barbels have tassels. The snout is of intermediate length.

#### Bastard sturgeon - *Acipenser nudiventris* (2)

**4(3)** The lower lip is interrupted in the middle.

**5(11)** The snout is conical and of intermediate length (i.e. not longer than 60% of the head), blunt or sharp at the end. **6(7)** There are more than 50 lateral bony scutes. Barbels usually have a well-defined tassel. The number of gill filaments on the first-gill arch is 16-23.

#### Sterlet - *Acipenser ruthenus* (3)

**7(6)** There are fewer than 50 lateral bony scutes. Barbels typically do not have a tassel. However, if they do, then the tassels are very small.

**8(9)** The body is covered with bony plates above the lateral bony scutes.

**9(10)** Irregularly placed large bony plates are present above the lateral bony scutes. The number of scutes is between 24 and 50. The lateral bony plates are covered with well-defined radially arranged layers.

#### Russian sturgeon - *Acipenser gueldenstaedtii* (4)

**10(9)** The body is covered with separate small star-shaped plates above the lateral bony scutes. The number of scutes is between 42 and 47. The radially arranged layers on bony plates are not well-defined. Gill filaments are fan-shaped and end in multiple branches.

#### Siberian sturgeon - *Acipenser baerii* (5)

**11(5)** The sword-shaped snout is elongated and comprises more than 60% of head length. Barbels have no tassels.

#### Starry sturgeon - *Acipenser stellatus* (6)

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## Dichotomous key 3

### Species of salmonids (order Salmoniformes) occurring in Armenia

**1(2)** The scales of the body are silver-colored. Jaws do not have teeth on them. The body has no dark spots.

#### Common whitefish - *Coregonus lavaretus* (1)

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**2(1)** The body has multiple dark spots. Jaws have teeth on them. **3(4)** The sides of the body have a broad reddish stripe with a colorful layer. The body, the head and the fins are covered with multiple tiny dark spots.

**Rainbow trout - *Oncorhynchus mykiss* (2)**

**4(3)** The sides of the body do not have a broad rainbow-tinted reddish stripe. **5(6)** The sides of the body and the dorsal fin are covered with large, dark, rounded spots of orange or red color. Each one of those spots is surrounded by a brightly colored ring.

**Brown trout - *Salmo trutta* (3)**

**6(5)** The body is covered with large black spots. The sides of the body sometimes lack red or orange spots. However, if they exist, then they are not surrounded by a bright-colored ring.

**Sevan trout - *Salmo ischchan* (4)**

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## Dichotomous key 4

### Species of catfish (order Siluriformes) occurring in Armenia

There is only one species of this order occurring in Armenia.

**Wels catfish - *Silurus glanis* (1)**

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## Dichotomous key 5

### Species of eels (order Anguilliformes) occurring in Armenia

There is only one species of this order occurring in Armenia.

**European eel - *Anguilla anguilla* (1)**

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## Dichotomous key 6

### Species of gobies (order Gobiiformes) occurring in Armenia

**1(2)** The first dorsal fin has a well-defined dark stripe. The second dorsal fin has 7-9 rays.

**Caucasian goby - *Knipowitschia caucasica* (1)**

**2(1)** The first dorsal fin does not have a dark stripe. Instead, it can have tiny spots arranged in 1 or 2 rows, which do not form a broad stripe. The second dorsal fin has 15-18 branched rays.

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**3(4)** The sides of the body do not have large dark spots. Sexually mature males have a black body during the mating season, while the contours of the second dorsal and anal fins are white or transparent.

**Kura goby - *Ponticola cyrius* (2)**

**4(3)** The sides of the body have 9-11 large dark spots. Sexually mature males are black or dark grey during mating season, while the contours of the second dorsal and anal fins are yellow.

**Monkey goby - *Neogobius fluviatilis* (3)**

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## Dichotomous key 7

### Species of perches (order Perciformes) occurring in Armenia

**1(2)** There is a well-defined dark stripe on the posterior of the first dorsal fin. The second dorsal fin does not have more than 15 branched rays. Lateral line continues on the dorsal fin. Jaws do not have fangs.

**European perch - *Perca fluviatilis* (1)**

**2(1)** The well-defined dark stripe on the posterior of the first dorsal fin is absent. The second dorsal fin has more than 16 branched rays. Lateral line continues on the caudal fin. The jaws have well-developed fangs.

**Pikeperch - *Sander lucioperca* (2)**

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## Dichotomous key 8

### Species of carps (order Cypriniformes) occurring in Armenia

**1(4)** The dorsal fin is long and has more than 12 branched rays.

**2(3)** The upper jaw has two pairs of barbels. Pharyngeal teeth are arranged in three rows.

**Common carp - *Cyprinus carpio* (1)**

**3(2)** Barbels are absent. Pharyngeal teeth are in a single row.

**Prussian carp - *Carassius gibelio* (2)**

**4(1)** The dorsal fin is short and has fewer than 12 branched rays.

**5(8)** The lateral line is incomplete. It is well defined only at the anterior.

**6(7)** There is a narrow blue-black stripe stretching through the midline of the caudal peduncle up to the base of the caudal fin. Pharyngeal teeth are in a single row. The upper jaw is longer than the lower jaw. Scales on the sides of the body are silver-grey or with a rainbow tint. Females have a long ovipositor during the mating season.

**European bitterling - *Rhodeus amarus* (3)**

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**7(6)** Scales on the sides of the body are silver-colored. The dark stripe on the caudal peduncle is absent. Pharyngeal teeth are typically in two rows. Upper and lower jaws are equal in size, or the lower jaw is longer than the upper jaw. Females lack a long ovipositor.

## **Sunbleak - *Leucaspius delineatus* (4)**

**8(5)** The lateral line is complete and stretches from the posterior of the head to the base of the caudal fin.

**9(23)** Barbels are present on the corners of the mouth or the jaws.

**10(17)** One pair of barbels is present on the corners of the mouth.

**11(16)** Barbels are short and do not reach the operculum.

**12(15)** The sides of the body lack large well-defined dark stripes. Scales on the sides of the body have a dark, thin contour.

**13(14)** The dorsal fin usually has 8 branched rays and a straight external contour. The scales on the side of the body have a goldish tint.

## **Khramulya - *Capoeta capoeta* (5)**

**14(13)** The dorsal fin usually has 9 branched rays and its external edge is slightly concave. Scales on the sides of the body are typically gray with a bluish tint.

## **Kaput - *Capoeta kaput* (6)**

**15(12)** There are dark rounded traces along the lateral line, possibly merged forming a long and narrow stripe, which stretches from the posterior of the operculum to the base of the caudal fin (these might not be well-defined on a carcass).

## **Artvin gudgeon - *Gobio artvinicus* (7)**

**16(11)** Barbels are long and reach the bones of the operculum.

## **South Caucasian gudgeon - *Romaniogobio macropterus* (8)**

**17(10)** There are 2-3 pairs of barbels.

**18(23)** There are 2 pairs of barbels.

**19(22)** The lateral line has fewer than 75 scales.

**20(21)** Body coloring is darker above the lateral line, but brighter below it. The body lacks dark spots or stripes.

## **Bulatmai barbel - *Luciobarbus capito* (9)**

**21(20)** Body coloring above and below the lateral line does not differ significantly. The body usually has irregularly distributed tiny dark spots and stripes. The lower lip has two lobes.

## **Kura barbel - *Barbus cyri* (10)**

**22(20)** The lateral line has more than 75 scales. The sides of the body are typically monochrome grey. Smaller individuals can have irregularly distributed small dark traces. The lower lip has three lobes.

## **Mursa - *Luciobarbus mursa* (11)**

**23(9)** Barbels are absent.

**24(27)** The anal fin is longer than the dorsal fin and has more than 16 branched rays. The body is wide and pressed on the sides.

**25(26)** The anal fin has 16-22 branched rays.

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## Silver bream - *Blicca bjoerkna* (12)

26(25) The anal fin has more than 25 branched rays.

## Common bream - *Abramis brama* (13)

27(24) The anal fin has fewer than 16 branched rays. The body is elongated.

28(37) The outer edge of the abdomen between pelvic and anal fins is not pressed on the sides and does not have a keel.

29(36) The lateral line has fewer than 50 scales.

30(33) The base of the dorsal fin starts on the same level as or more posterior to the base of the pelvic fin.

31(32) The mouth is subterminal. The upper jaw is longer than the lower jaw. Pharyngeal teeth are in two rows.

## Grass carp - *Ctenopharyngodon idella* (14)

32(31) The mouth is very small, it has a transverse cut and a superior position. The lower jaw is longer than the upper. Pharyngeal teeth are in a single row.

## Stone moroko - *Pseudorasbora parva* (15)

33(30) The base of the dorsal fin is more posterior than the base of the pelvic fins.

34(35) The mouth is subterminal and the upper jaw is longer than the lower. Pharyngeal teeth are in one row. The body is slightly pressed on the sides. The dorsal fin has 9-10 branched rays.

## Armenian roach - *Rutilus rutilus schelkovnikovi* (16)

35(34) The mouth is terminal. Jaws have equal length, or the lower jaw is slightly longer. Pharyngeal teeth are in two rows. The body is not pressed on the sides. The dorsal fin has 8 branched rays.

## Oriental chub - *Squalius orientalis* (17)

36(29) The lateral line has more than 50 scales. The mouth is inferior and the upper jaw is longer than the lower jaw. The sides of the body are covered with silvery scales.

## Kura nase - *Chondrostoma cyri* (18)

37(28) The part of the abdomen between pelvic and anal fins is pressed on the sides near the external edge and contains a keel.

38(41) The lateral line has more than 100 scales. The eyes are located below the midline of the body.

39(40) The keel is located between pelvic and anal fins. The pectoral fin reaches and sometimes passes the base of the pelvic fin. The sides of the body are frequently covered with irregularly spaced tiny dark spots.

## Bighead carp - *Hypophthalmichthys nobilis* (19)

40(39) The keel starts anterior to the pelvic fin. The tip of the pectoral fin does not reach the base of the pelvic fin. The sides of the body do not have small colored spots.

## Silver carp - *Hypophthalmichthys molitrix* (20)

41(38) There are fewer than 100 scales in the lateral line. Eyes are located near the midline of the body.

42(45) The lateral line has more than 60 scales.

43(42) The mouth is subterminal, and the upper jaw is longer than the lower. The last unbranched ray of the dorsal fin is thicker. The mouth is small.

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## **Blackbrow bleak - *Acanthobrama microlepis* (21)**

**44(43)** The mouth is terminal or supraterminal with the lower jaw longer than the upper. The last unbranched ray of the dorsal fin is not thicker than the rest. The mouth is large.

## **Asp - *Leuciscus aspius* (22)**

**45(42)** There are fewer than 60 scales in the lateral line.

**46(47)** There are multiple tiny dark spots both above and below the lateral line. The mouth is terminal, and jaws are of equal length.

## **Kura chub - *Alburnoides eichwaldii* (23)**

**47(46)** The lateral line is not surrounded from either above or below with dark spots. The mouth is supraterminal, and the lower jaw is longer than the upper.

**48(49)** The lateral line has 38-45 scales. The sides of the body lack the long stripe stretching from the posterior of the head to the caudal fin.

## **North Caucasian bleak - *Alburnus hohenackeri* (24)**

**49(48)** The lateral line has more than 45 scales. There is a long black stripe stretching from the head posterior to the base of the caudal fin.

## **Kura bleak - *Alburnus filippii* (25)**

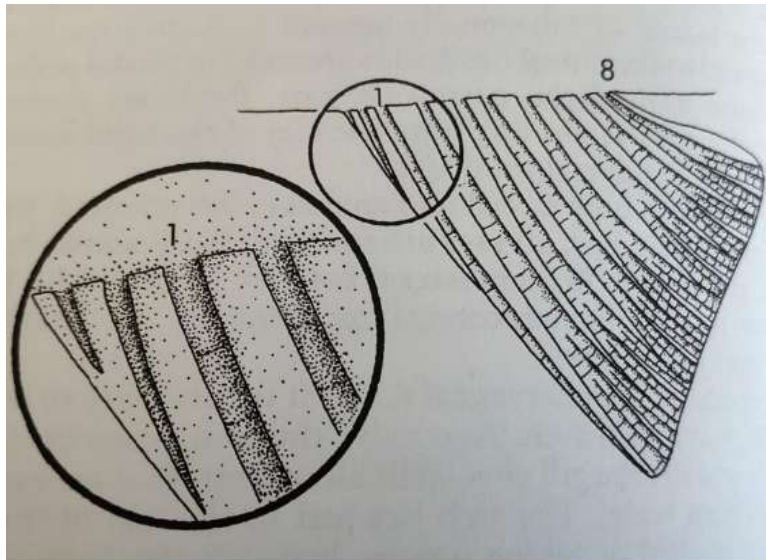
### **Dichotomous key 9**

#### **Species of toothcarps (order Cyprinodontiformes) occurring in Armenia**

There is only one species of this order occurring in Armenia.

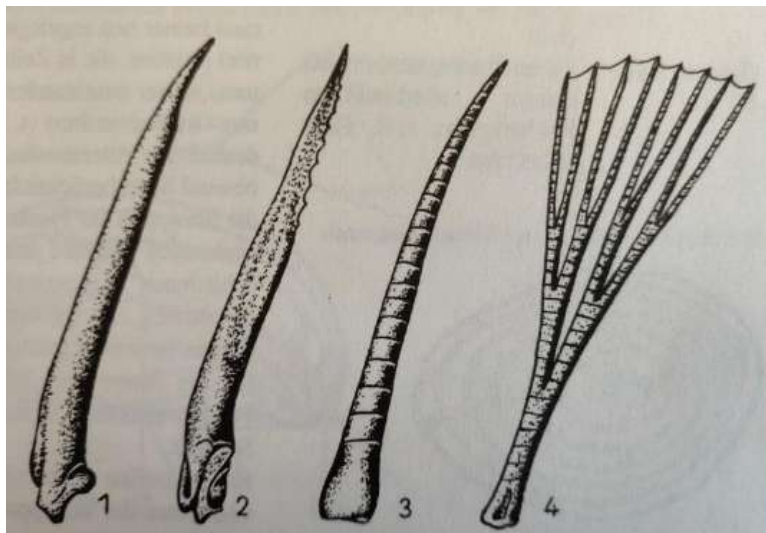
#### **Eastern mosquitofish - *Gambusia holbrooki* (1)**

## Appendix 2: Images



**Image 1. The shape and number of rays in the anal fin of fish:**

1. The third unbranched firm ray; 8. The last branched ray, which is split in two at the base (this ray is counted as one)



**Image 2. Shapes of rays in fish fins.**

1. Firm unbranched unsegmented ray; 2. Firm unbranched toothed ray; 3. Firm segmented ray; 4. Branched ray



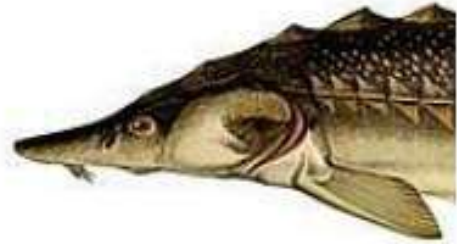
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A



B



C



D



E

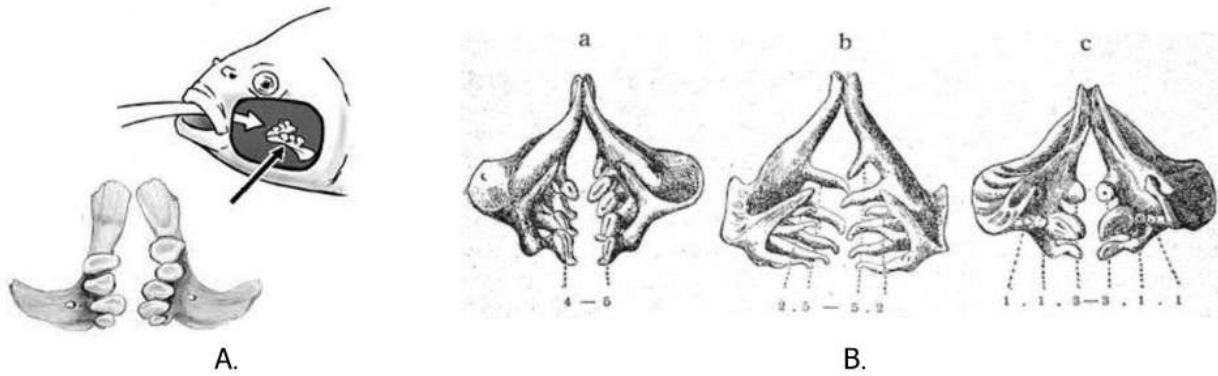
**Image 3. Possible positions of the mouth of fish**

Superior mouth (A), Inferior mouth (B), Terminal mouth (C), Subterminal mouth (D), Supraterminal mouth (E)

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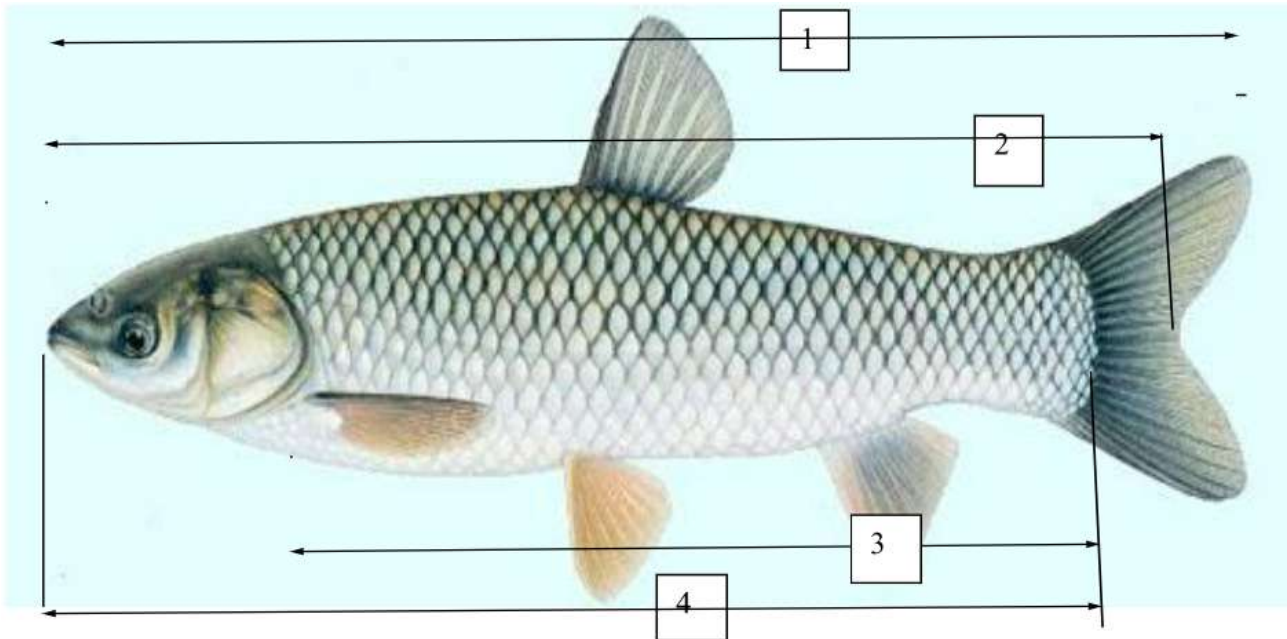


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**Image 4. Pharyngeal teeth of fish (A) and their arrangement (B).**

a. one row; b. two rows; c. three rows



**Image 5. Definitions of length for the fish body**

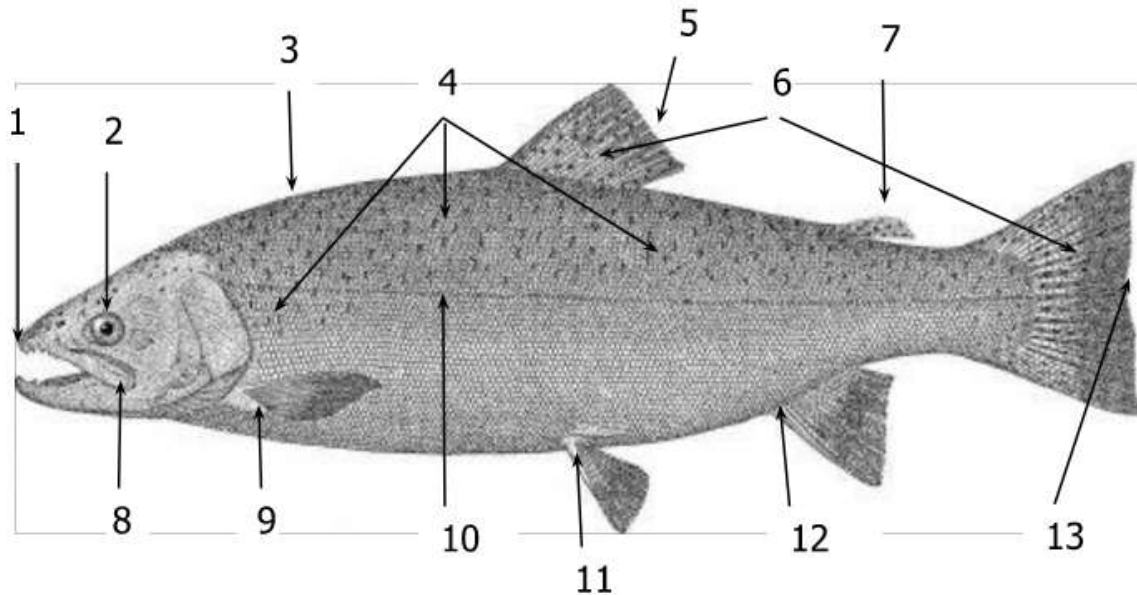
1. Total body length; 2. Fork length; 3. Industrial length; 4. Standard length

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**Image 6. External diagnostic features for identifying fish.**

- 1.** Position of the mouth; **2.** Position of the eyes; **3.** The contour of the back; **4.** The shape, color and number of spots on the body; **5.** Position of the dorsal fin on the back; **6.** Presence of spots or stripes on dorsal and caudal fins; **7.** Presence of the adipose fin; **8.** The length of the upper jaw (maxilla); **9.** Position of the pectoral fin; **10.** Characteristics of the lateral line; **11.** Position of the base of pelvic fins; **12.** Position of the base of the anal fin; **13.** The shape of the caudal fin

## Appendix 3. Images



**Image 1.** Brook salmon *Salvelinus fontinalis*



Atlantic salmon *Salmo salar*

**Image 2.** Atlantic salmon *Salmo salar*



Brown trout *Salmo trutta*

**Image 3.** Brown trout *Salmo trutta*