How Do Fish Swim?

The density of water makes it very difficult to move in, but fish can move very smoothly and quickly.

A swimming fish is relying on its skeleton for framework, its muscles for power, and its fins for thrust and direction.

The skeleton of a fish is the most complex in all vertebrates. The skull acts as a fulcrum, the relatively stable part of the fish. The vertebral column acts as levers that operate for the movement of the fish.

The muscles provide the power for swimming and constitute up to 80% of the fish itself. The muscles are arranged in multiple directions (myomeres) that allow the fish to move in any direction. A sinusoidal wave passes down from the head to the tail. The fins provide a platform to exert the thrust from the muscles onto the water.
Thrust - force in animal’s direction

Lift - force opposite in right angles to the thrust

Drag - force opposite the direction of movement

** All lift forces cancel out over one complete tail stroke.

 Drag

Drag is minimized by the streamlined shape of the fish and a special slime fishes excrete from their skin that minimizes frictional drag and maintains laminar (smooth) flow of water past the fish.
Two swimming types in fishes:

Defined by their method of living, and reflected in their physiology.

- **Cruisers**: These are the fish that swim almost continuously in search for food, such as the tuna. Red Muscle—richly vascularized (blood-carrying capacity), rich in myoglobin (oxygen holder and transferor into the muscles active sites) *able to sustain continuous aerobic movement.

- **Burst Swimmers**: These fish usually stay relatively in the same place such as most reef fish.

**Fins**

Fins give a fish control over its movements by directing thrust, supplying lift and even acting as brakes. A fish must control its pitch, yaw, and roll.

- Caudal fin-- provides thrust, and control the fishes direction
- Pectorals-- act mostly as rudders and hydroplanes to control yaw and pitch. Also act as very important brakes by causing drag.
- Pelvic fins-- mostly controls pitch
- Dorsal/anal-- control roll
Caudal Fins

(Non-symmetrical heterocercal)

(Symmetrical homocercal)

Burst swimmers - efficient for acceleration

Cruisers - efficient at high speed

VARIATIONS IN BODY FORM

Fusiform

Attenuated

Depressed (flattened-dorso ventrally)

Compressed (flattened- side to side)
Fish shape has a great bearing on ability to move through the water.

- A tuna fish which has a fusiform similar to a torpedo can cruise through the water at very high speeds.
- The attenuated shape of the eel allows it to wiggle into small crevices where it hunts prey.
- The depressed shape of the angler fish is advantageous for its "sit and wait" strategy of hunting.
- The compressed shape found on many reef fishes such as the butter fish gives the fish great agility for movement around the reef and can support sudden bursts of acceleration.

**Fish Thermal Strategies**

In general, fishes are cold blooded. They derive their body heat from their environment and conform to its temperature. As water has a high heat capacity, it is able to easily suck any excess heat out of a fish and into the environment.

- **Ectothermic**: fish derive their heat from the environment
- **Poikilothermic**: fish conform to the heat in the environment

Some large, fast-swimming fish are not ectothermic. The tunas and mackerel sharks can actually have core body temperatures ten to twenty degrees celsius higher that the surrounding water. They are endothermic and derive their body heat from their metabolism, but they are still poikilothermic; their body temperature may be higher than the surrounding water, but they still conform to the temperature of the water, just 10-20 degrees above it.
They maintain a higher body temperature through the use of a specialized counter-current heat exchanger called a reta mirabile. These are dense capillary beds within the swimming muscle that run next to the veins leaving the muscles. Blood passes through the veins and arteries in a counter current (opposite) direction. The heat produced from the muscle contraction flows from the exiting veins into the incoming arteries and is recycled.

Why should they bother having an elevated body temperature? To increase the speed of the fish. The higher the body temperature, the greater the muscular power. Thirty degrees celsius is the optimum temperature for muscular speed. With increased speed, the tuna can capture the slower, cold blooded fish it prey upon. Tuna have been clocked at record speed of 50-70 mph!

Swim Bladders

Bony fish have swim bladders to help them maintain buoyancy in the water. The swim bladder is a sac inside the abdomen that contains gas. This sac may be open or closed to the gut. If you have ever caught a fish and wondered why its eyes are bulging out of its head, it is because the air in the swim bladder has expanded and is pushing against the back of the eye. Oxygen is the largest percentage of gas in the bladder; nitrogen and carbon dioxide also fill in passively.

**Physoclistous**- swim bladder is closed to the gut. The gas gets in through a special gas gland in the front of the swim bladder. Gas leaves the bladder through an oval body in the back of the swim bladder. The system works in a pretty miraculous way. Oval body, filled by venous blood - gasses leave here.

Gas gland, fed by arterial blood -gasses enter here inside the spots= giant secretory cells- secrete lactate -in capillary clusters rete mirabile
Increased lactate levels from the giant secretory cells lower the surrounding pH, causing the blood hemoglobin to dump off its oxygen. The oxygen diffuses back into the incoming capillary, increasing the partial pressure of oxygen in the incoming capillary. This continues until the partial pressure of the oxygen in the capillary is higher than that of the swim bladder (which has a high concentration of oxygen). This complex system is necessary because the concentration of oxygen is higher in the swim bladder than it is in the blood, so simple diffusion would tend to pull the oxygen out of the bladder instead of pushing it in. If the fish wants more buoyancy, it must tell its secretory cells to release more lactate. Since oxygen diffuses easily with oxygen-poor venous blood, the gas can be forced out.

*Fish that migrate vertically tend to have high oxygen levels in their bladders because it fills in faster and leaves faster.

*Fish that maintain a stable depth tend to have more nitrogen because it is inert, enters slowly, and exits slowly.
How Do Fish Swim - Questions

1. A swimming fish is relying on its skeleton for ______________, its muscles for ______________, and its fins for _________________.

2. Label the fish.

[Diagram of a fish with labels for various parts]
3. Label the diagram and describe forces of how a fish swims.

Drag is minimized by the ____________________ shape of the fish and
a special ______________ fishes excrete from their skin that
minimizes__________________ drag and maintains laminar
__________________ flow of water past the fish.

4. Label the diagram and fill in the missing words.

Drag is minimized by the ____________________ shape of the fish and
a special ______________ fishes excrete from their skin that
minimizes__________________ drag and maintains laminar
__________________ flow of water past the fish.
5. Describe the following swimming types.

   Crusiers:

   Burst Swimmers:

6. Fins give a fish control over its movements by directing ______________, supplying ______________ and even acting as ______________. A fish must control its __________, ________, and ________.

7. Label the diagram.

   __________

   __________

   __________
8. Label the diagram of the different caudal fin types.

_________  _________

_________  _________

Burst swimmers

_________

Cruisers

_________

9. Define each type of fin use.

- Caudal fin—

- Pectorals—

- Pelvic fins—

- Dorsal/anal—
10. Fish ______________ has a great bearing on ability to move through the water.

11. Label the types of body shapes

12. Fill in the missing words.

- A tuna fish which has a fusiform similar to a ______________ can cruise through the water at very ____________ speeds.

- The ________________ shape of the eel allows it to wiggle into small crevices where it hunts prey.

- The ________________ shape of the angler fish is advantageous for its "sit and wait" strategy of hunting.
The __________________ shape found on many reef fishes such as the butter fish gives the fish great agility for movement around the reef and can support sudden bursts of ____________________.

13. True or false: Fish are warm blooded.

14. Define each term.

Ectothermic:

Poikilothermic:

15. What is the reason that the core body temperature be higher?

**Swim Bladders**

16. Why do bony fish have swim bladders?

17. What gases fill the swim bladder?