Exploration Connection: How propellers work

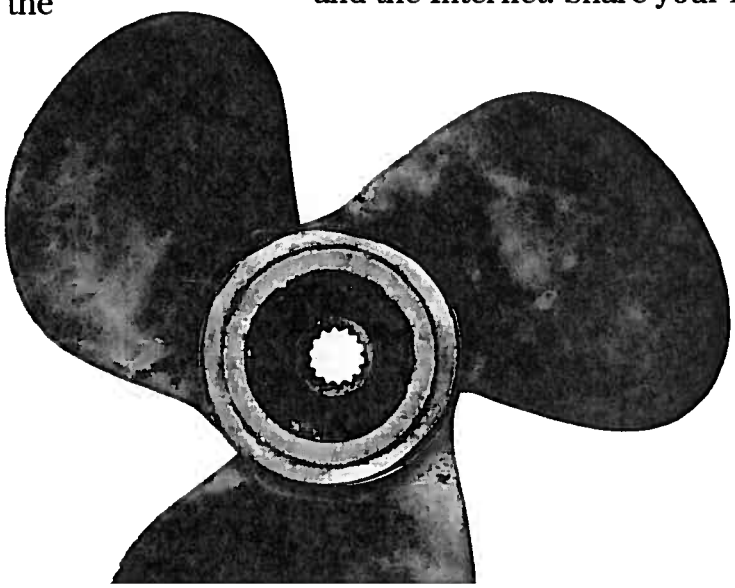
An airplane speeds along the runway. When it is going fast enough, it takes off. How does a propeller make the aircraft move forward in the air?

The airplane's engine turns the propeller and, as it turns, the propeller pushes air backward. This backward flow of air results in a reaction force that moves (thrusts) the aircraft forward.

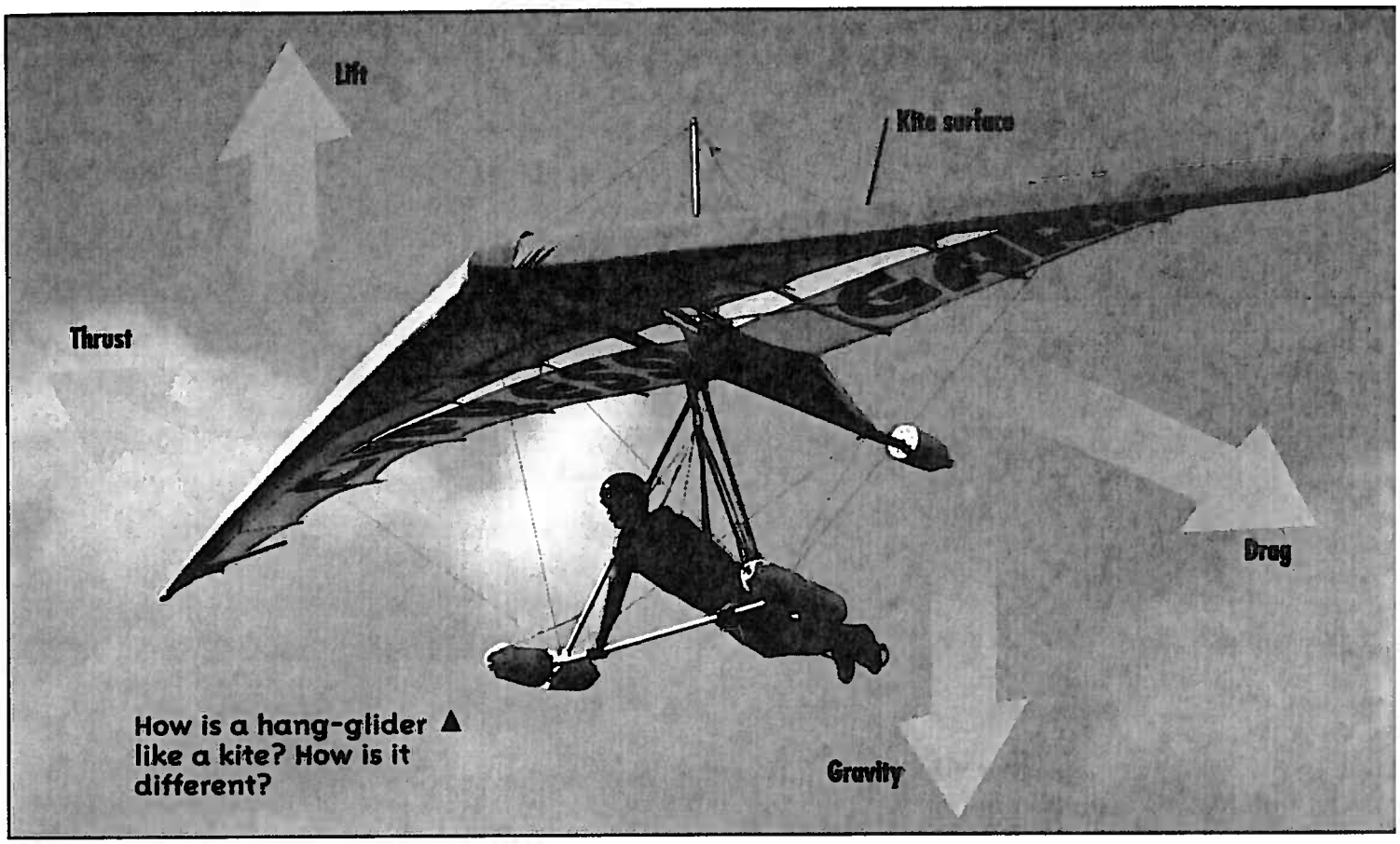
A propeller is just a special, spinning wing oriented so that the lift it produces becomes thrust. If you look at the cross-section of a propeller, you will find that it has an airfoil shape and an angle of attack. Look at the propeller pictured above. You can see that the angle of attack changes along the length of the propeller—the angle is greater toward the centre because the speed of the propeller through the air is slower close to the hub.

Many larger aircraft have more elaborate three-blade or four-blade propellers. These have mechanisms that let the pilot adjust the propeller's angle of attack depending on air speed and altitude. The best-known types of propellers are those that drive ships and airplanes. Airplane propellers and ship propellers work in much the same way, but they produce motion in different fluids.

- How does a propeller move a boat forward?
- What other sources of thrust do marine vehicles use? Find out more about marine propulsion, using reference books, CD-ROMs, and the Internet. Share your findings.



Be careful cutting plastic. The edges can be very sharp.



How is a hang-glider ▲ like a kite? How is it different?

Exploration Connection: Gliding flight

The same forces that affect birds, airplanes, and spacecraft affect objects that glide, rather than fly, through the air. The photo shows how these forces work with and against each other to make a hang-glider soar in the sky—for a time.

As with an airplane, gravity tries to hold a hang-glider down; lift tries to push it up. Thrust pushes it forward; drag slows it down. Because a hang-glider has no engine, it doesn't produce thrust itself, so drag and gravity eventually take over and the hang-glider comes down.

For a kite, thrust is produced by tension on the string. When lift is equal to the downward force of the string, combined with gravity, and drag is equal to thrust, a kite can fly at a constant height and speed. If one or more of the forces changes, the loss of balance causes the kite—or any gliding object—to vary its altitude, direction, or speed.

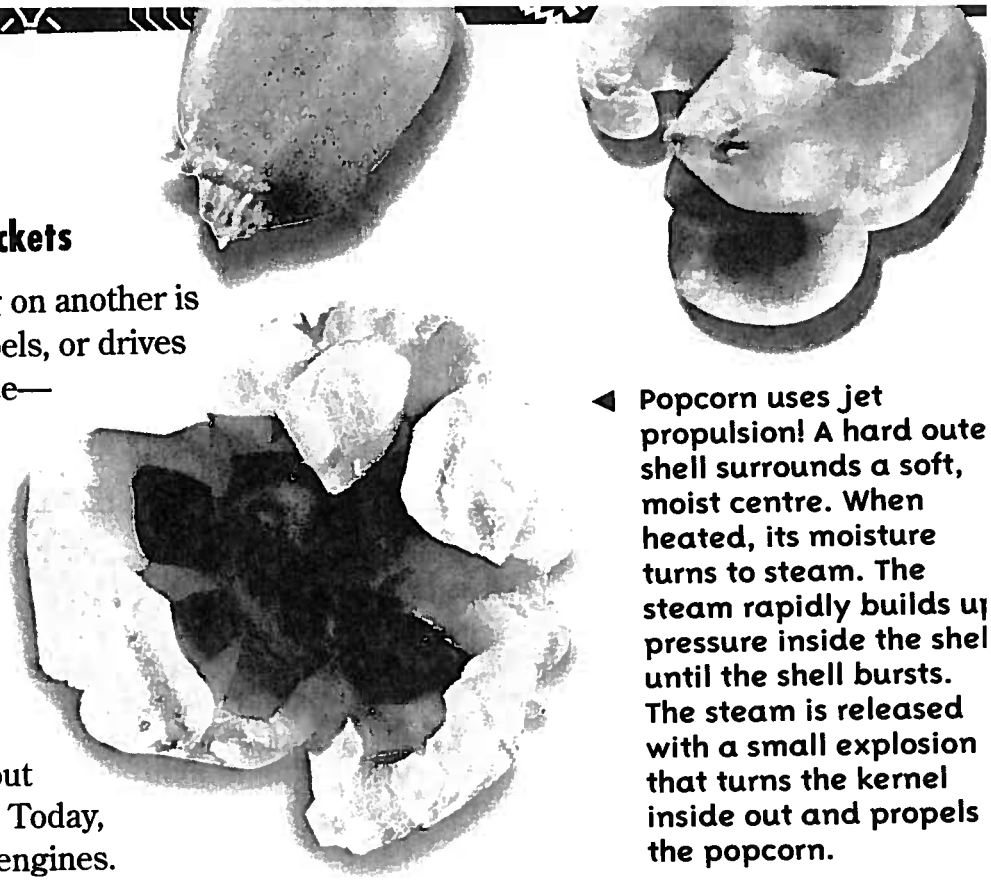
Both a string kite and a hang-glider fly in a state of equilibrium when the four forces are balanced and the angle of attack is correct. Control of a hang-glider comes from changing the position of the bar on the harness, or shifting weight. But how do you control a string kite? How can the string change the balance of forces?

- What would happen if you changed the weight of the kite you made, or the length of its tail, or the positioning of the thread? **Try it!**
- How would a change in wind speed affect the flight of your kite? Or, what if your kite had a curved surface instead of a flat one?

Exploration Connection: Thrusting ahead with jets and rockets

The force of one thing pushing on another is called **thrust**. Thrust is what propels, or drives forward, a flying creature or device—like the force of a jet engine on a large airliner. The engine's thrust has to move the airliner upward and forward faster than gravity and drag can pull it down or push it back.

The first jet engine, a small toy-like device powered by escaping steam, was invented about AD 60 by Hero, a Greek scientist. Today, the majority of airplanes have jet engines.



◀ Popcorn uses jet propulsion! A hard outer shell surrounds a soft, moist centre. When heated, its moisture turns to steam. The steam rapidly builds up pressure inside the shell until the shell bursts. The steam is released with a small explosion that turns the kernel inside out and propels the popcorn.

In a jet engine, air enters and is compressed. Fuel is then added, and the fuel-and-air mixture is ignited. The hot, expanding gases that result push hard against the front of the engine and bounce back, shooting out through the rear exhaust and pushing the plane forward. Jet-propelled planes fly at much higher speeds than those propelled in other ways—some even faster than sound.

But people who dreamed of travelling in space needed something even faster to overcome the pull of gravity and drag. They set out to design a machine that could go straight up through the atmosphere, very fast and with tremendous thrust. It would have to go from standing still to more than 40 000 km/h in just a short time! And because an airplane needs air to fly in and there is no air in space, this machine would have to carry its own fuel, as well as oxygen to burn it. The answer was a rocket.

Scientists believe that the Chinese invented rockets, but they don't know exactly when. Already in AD 1232, Chinese armies were using "arrows of flying fire"—probably rockets.

A rocket engine can produce more power for its size than any other kind of engine—3000 times more than an automobile engine the same size. Some rockets that shoot fireworks into the sky are only about 60 cm long. Rockets that carry missiles are 15 to 30 m long. Rockets that lift artificial satellites into orbit around Earth are even larger and more powerful.

To find out about jets and rockets, you can:

- investigate the history of jets, rockets, or space flights and make an illustrated timeline;
- research applications of jet propulsion in nature and create a class book;
- research and report on possible propulsion methods of the future;
- watch a model rocketry demonstration, or help build a model rocket.

List at least three safety rules you would set for the pilots of jet planes.

BALLOON ROCKETS

Sketch of Rocket (include how and where the paper and straw are taped)

Our plan:

Reflection—Write a paragraph concerning what you know about thrust and flight, (consider the experiments you saw today and the notes you have taken).