1. **Wings create lift *because* they are curved on top and flat on the bottom. INCORRECT.**

Incorrect because only some wings look like that, while other wings are symmetrical (they're the same on top and bottom,) while still others are flat on top ...and curved on the bottom! And don't forget the hang-gliders and the Wright Brothers' flyer, both of which used thin fabric wings with equal curvature top and bottom. The lifting force does not vanish if an airplane flys upside-down. Explanations for flight involve other things, and not airfoil asymmetry.

2. **Part of the lifting force is due to Bernoulli effect, and part is due to Newton. INCORRECT**

Incorrect because ALL wings, regardless of shape or degree of tilt, must create 100% of their lift because of Newton. To say otherwise would mean that a wing could violate Newton's Laws! Yet at the same time, ALL wings create 100% of their lift because of the Bernoulli Equation. This is true because 100% of the lifting force comes from pressure differences on the wings' surfaces.

In fact, we can explain the lifting force by "Newton," by ignoring the pressure differences and instead measuring the dense deflected air and calculating the change in momentum.

And of course we can explain 100% of the lifting force by "Bernoulli", by looking at air speeds and then calculating the air pressure on every part of the wing surface. **See the NASA site.**

3. **To produce lift, the shape of the wing is critical. YES AND NO.**

Incorrect because aerodynamic scientists have found that there are two critical features of all airfoils: the trailing edge of the wing must be fairly sharp, and the trailing edge of the wing must be angled downwards. This is discussed in advanced textbooks in the chapters on circulatory flow, in the section on "Kutta Condition."

Static wings are allowed to have all sorts of crazy airfoil shapes, but if they don't have a downwards-tilted trailing edge which is sharp, they won't lift an airplane.

Other features of wing-shape are important but not critical. For example, in order to prevent stall, the leading edge of the wing must be fairly bulbous and the wing's upper surface must lack sharp curves as well as being fairly smooth (no bumpy screws or rivets allowed.) If the wing's leading edge is too sharp, or if its upper surface is made wrong, then the flow of air above the wing will break loose or "detach," and it will no longer be guided downwards by the upper surface. This problem is called a "stall," and during a stall the amount of lifting force contributed by the upper wing surface becomes very small.

4. **The Bernoulli effect pertains to the shape of the wing, while Newton's laws pertain to the angle of attack. INCORRECT.**

Incorrect because Newton's laws pertain to all features of the wing; both to wing shape and attack angle. Exactly the same thing is true of Bernoulli's equation: angle of attack is critical, but wing shape has effects too. Wings don't violate Newton's laws, and wings in conventional flight (slower than the speed of sound) don't violate Bernoulli's equation. See #2 above.

5. **Air which is divided by the leading edge must recombine at the trailing edge.** INCORRECT.

Incorrect, since wind tunnel experiments and aerodynamic math will both show that the upper and lower air flows do not recombine. See these wind-tunnel photos which illustrate this lack of recombining. Also see the NASA Site which debunks this widespread fallacy.

6. **In order to generate lift, the upper surface of an airfoil must be more strongly curved than the lower surface? INCORRECT**

Incorrect, since lift can be generated by symmetrical airfoil such as those used on acrobatic aircraft. Lift can also be generated by thin fabric airfoils, by sheets of paper (paper airplanes), by tilted pieces of flat plywood, or by "supercritical" airfoils which are more curved on the BOTTOM than the top.

9. **The upper surface of a wing will deflect air, but the lower surface is horizontal, so it has little effect.** INCORRECT.

Incorrect, but for an interesting reason.

If a thin flat wing deflects air downwards, diagrams show that the air above the wing and the air below the wing are equally deflected. Both the upper and lower surfaces create the lifting force.

If we then make this wing thicker and streamlined, the total amount of deflected air and the lifting force remain the same... but the air below the wing APPEARS less deflected, and the air above the wing appears more deflected. Also, the pressure below the wing APPEARS to provide less lift. This happens because a thick wing must push air out of its way, and as the flowing air splits up and down to make a space for the oncoming wing, air below the wing takes a straighter path. It takes a straighter path because the thickness of the wing bends air upwards at the same time as the tilt of the wing bends air downwards. This has no effect on the lifting force, since the air above the wing takes a more curved path, so THE PRESSURE DIFFERENCE REMAINS THE SAME AS IT WAS FOR A THIN WING. The thick wing is making us confused. The thick wing SEEMS to get more lift from the curved streamlines above the wing than from the straight streamlines below, but this is an illusion. The thick wing distorts the stream-lines. Examine the streamlines surrounding a thin wing to see the truth. The lift comes from the DIFFERENCE between the two flows, and changing the thickness of the wing will alter the appearance of the air flows without changing the difference or changing the lifting force.

3. **Flat thin wings generate lift entirely because of Newton; because they are tilted, while thick curved wings generate lift exclusively because of "Bernoulli Effect?" INCORRECT.**

Think a moment: if a wing
when a flat thin wing is given a positive angle of attack,
the air above the wing speeds up, and the air below the wing slows down. 100 percent of the lifting force can be explained using either the "Bernoulli effect" or the Newton/Coanda principles. These two simply are a pair of alternate viewpoints on the same situation, and it's *wrong* to try to break the lifting force into a separate percentage of "Bernoulli" force and an "attack angle" force.

- Asymmetrical airfoils produce lift because of their special shape, while symmetrical airfoils produce lift because they are tilted? INCORRECT.

- A symmetrical airfoil cannot create lift? INCORRECT

- Aircraft cannot fly upside down? INCORRECT

- The decreased pressure above an airfoil creates much more lifting force than the increased pressure below the airfoil. Since the decreased pressure above is supposedly caused by the Bernoulli effect, while the increased pressure below is supposedly caused by collision of air with the tilted wing, the "Bernoulli effect" supplies the lift. Therefore the "angle of attack" effects are of less importance and can be ignored in order to simplify the explanation? INCORRECT.

  Incorrect, because both the increased pressure below the airfoil and the decreased pressure above are created entirely by the Bernoulli effect. ALSO, both are caused by the angle of attack and the forces resulting from the deflection of massive air. 100% of the lifting force can be explained by appeals to the Bernoulli effect. But also 100% of the lifting force can be explain by the process of deflection of air by the wing. However, explaining the difference in air speed above and below the wing is not straightforward.

- The low pressure above an airfoil produces suction. The lifting force is an upwards suction force. INCORRECT.

  Incorrect. Air molecules produce pressure upon a surface by colliding with that surface. They do not attract that surface. In other words, SUCTION DOES NOT EXIST. When you suck air through a straw, you are lowering the pressure within the straw. There is no suction. Instead, the outside atmosphere PUSHES the air into the straw. So, while it is true that the pressure above the wing is low, it is not true that the lifting force is caused by suction. Instead, the lifting force is caused by the pressure-difference. If the pressure above the wing should fall, then the ambient pressure below the wing will force the airplane to move upwards.

- The air in front of the leading edge of an airfoil and the air behind the trailing edge are moving at zero degrees deflection? INCORRECT.

  Incorrect, since with a real aircraft, the air moves slightly upwards to meet the leading edge of the wing, but then it is projected greatly downwards from the trailing edge, creating a "downwash" flow. Although the "upwash" equals the "downwash" in a 2-dimensional wind tunnel experiment, this is not true in practice with real airplanes. (2D wind tunnels depict ground-effect flight, not normal flight.) With a real airplane flying high above the earth, if the "upwash" and the "downwash" flows were equal, yet the lifting force was non-zero, then this would totally violate the law of conservation of momentum. Unfortunately for the "airfoil-shape" camp, fundamental physics principles must be satisfied, and Newton's laws are not selectively violated by airfoils. In order to create an upwards lifting force, there must be a net downward acceleration of parcels of air. Planes fly by pushing air downwards, which creates a pressure difference across a wing. Air-deflection and pressure are linked. You cannot have one without the other.

- Airplane propellors, rudders, jet turbine blades, and helicopters all function by deflecting air to create force. They throw the air one way, and the air pushes them the other way. But airplane wings are different? Wings operate by a separate kind of physics, and are "sucked upwards" by the Bernoulli effect? INCORRECT.

  Incorrect, because the real world cannot tell the difference between an airplane wing and a helicopter blade. It does not know that a ship's rudder and an airplane wing are different. Wings, rudders, propellors, oars; all these devices work by identical principles: they throw massive fluid one way, and are thrown the other way by action/reaction forces. Bernoulli's equation does have bearing, since the action/reaction forces express themselves as a pressure difference across the surfaces of the object which deflects the fluid.

- An airfoil can generate lift without deflecting air downward? INCORRECT.

  Incorrect. If it did so, it would be staying in the air without ejecting mass downwards, and this would violate the Conservation of Momentum law. Yes, balloons remain aloft without ejecting mass, but balloons function via bouyancy forces, and an airplane wing obviously does not. Think about it: a helicopter hovers because it throws air downwards. Yet a 'copter blade is simply a moving wing! If wings did not fling air downwards, if wings remained aloft only through pressure differences, then helicopter blades would do the same, and there would be no downblast below a helicopter.

- An airfoil can generate a lifting force without causing a reaction force against the air? INCORRECT.

  Incorrect. If it did so, it would violate Newton's Third Law of Motion, the law of equal action and reaction forces.

- The majority of textbooks use the popular 'path length' or 'airfoil shape' explanation of lift, and it is inconceivable that this many books could be wrong. Therefore, the "path length" explanation is the correct one? INCORRECT.

Incorrect, this argument from authority is simply wrong. It is also dangerous, since it convinces us to never question authority and to close our eyes to authors' errors. If we trust the concensus agreements of others, then we become sheep which follow a leaderless herd. Beware of this habit! As the NASA space shuttle managers who closed their eyes to the Challanger booster seal problem found out, the real world is all too real. Nature ignores politics, and scientific facts are determined by evidence, not by majority votes.

- The 'Coanda effect' only involves narrow jets of air, and has little to do with airfoil operation, so its exclusion from explanations of lift is understandable and justified? INCORRECT.

  Incorrect, the Coanda effect involves the adhesion of a flow to a surface. It applies to ANY flowing fluid, not just to narrow jets. If the airflow across a wing did not adhere to the wing, the wing would be permanently in the 'stall' regiem of operation. During "stall", it would not deflect air across its upper surface, and it would produce a greatly diminished lifting force.

- There are two explanations of airfoil lifting force: angle of attack, and pressure differential. The 'pressure differential' explanation is correct, and the 'angle of attack' is misleading and can be ignored? INCORRECT.

  Incorrect. Both explanations are useful once the incorrect parts of the "path length" explanation have been removed. They are two different "mental models," they are two different ways of looking at one complicated situation. Paraphrasing the physicist R. Feynman: "Unless you have several different ways of looking at something, you don't really understand it." A complete understanding requires that we easily shift between alternate viewpoints. Wings really do produce lift when velocity differences create a vertically-directed pressure differential across their surface area. But also, they really do produce lift by reacting against air and driving it downwards. Unfortunately the airfoil-shape-based explanation has become connected with several incorrect add-on explanations; the "path-length" fallacy for example.

- An airfoil can generate lift at zero angle of attack? MISLEADING

  Not entirely wrong: depending on how we define 'angle of attack', a wing may be at zero angle of attack even though it obviously *acts* tilted and deflects the oncoming air downwards. This is a fight between semantics and reality. If the rear portion of a wing is tilted downwards and deflects the air downwards, shouldn't it by definition have a positive angle of attack?
  No, not if 'angle of attack' is measured by drawing a line between the tips of the leading and trailing edges of the wing crossection. If the leading edge is bulbous, then small details on the leading edge can radically change the location of the drawn line without radically changing the interaction of the wing with the air. If such a wing is then rotated to force it to take a "zero" angle, that rotation in reality tilts the wing to a positive attack angle and generates lift.

- Cambered airfoils produce lift at zero AOA, which proves that the "Newton" explanation is wrong? INCORRECT

  Incorrect. Air has mass, and this means that it has inertia. Because of inertia, an exhaust port can produce a narrow jet of air, yet an intake port cannot pull a narrow jet inwards from a distance. This concept applies to wings. When a cambered airfoil moves forwards at zero AOA (Angle of Attack,) air moves up towards the leading edge, and air also flows downwards off of the trailing edge. The air which flows downwards behind the wing keeps moving downwards, and so the rear half of the wing controls the angle of the downwash, while the leading edge has little effect. (In aerodynamics, this is called the "Kutta Condition.") In a cambered wing at zero AOA, the rear half of the wing behaves as an airfoil with positive AOA. On the whole, the cambered airfoil BEHAVES as if it has a positive AOA, even though the geometrical angle of attack is zero.

- A properly shaped airfoil gives increased lift because the air on the upper surface moves faster than the air on the lower? MISLEADING

  Not entirely wrong. This is only half the story. A properly shaped airfoil gives increased lift because the airflow does not easily "detach" from the upper surface, so the upper airflow can generate lift even at large angles of attack and at low aircraft speeds. A sheet of plywood makes a poor wing because the airflow will "detach" from the upper surface of the wood when the sheet is tilted more than a tiny bit. This is called "stall", and it causes the upper surface of the wing to stop contributing a lifting force. A properly designed wing must spread the net deflection of air widely across its upper leading surface rather than concentrating all the deflection at its leading edge. Hence, the upper surfaces of most wings are designed with the curvature which avoids immediate flow-detachment and stall. The shape of wings does not create lift, instead it only avoids stall.

- The "Newton" explanation is wrong because downwash occurs BEHIND the wing, where it can have no effects? Downwash can't generate a lifting force? INCORRECT.

  Wrong, and silly as well! The above statement caught fire on the sci.physics newsgroup. Think for a moment: the exhaust from a rocket or a jet engine occurs BEHIND the engine. Does this mean that action/reaction does not apply to jets and rockets? Of course not. It's true that the exhaust stream doesn't directly push on the inner surface of a rocket engine. The lifting force in rockets is caused by *acceleration* of mass, and within the exhaust plume the mass is no longer accelerating. In rocket engines, the lifting force appears in the same place that the exhaust is given high velocity: where gases interact inside the engine.

  And with aircraft, the lifting force appears in the same place that the exhaust (the downwash) is given high downwards velocity. If a wing encounters some unmoving air, and the wing then throws the air downwards, the velocity of the air has been changed, and the wing will experience an upwards reaction force. At the same time, a downwash-flow is created. To calculate the lifting force of a rocket engine, we can look exclusively at the exhaust velocity and mass, but this doesn't mean that the rocket exhaust creates lift. It just means that the rocket exhaust is directly proportional to lift (since the exhaust velocity and the lifting force have a common origin.) The same is true with airplane wings and downwash. To have lift at high altitudes, we MUST have downwash, and if we double the downwash, we double the lifting force. But downwash doesn't cause lift, instead the wing's interaction with the air both creates a lifting force and gives the air a downwards velocity (by F=MA, don't you know!)