**Question #1: Briefly explain how each contributes to the overall success of Insects:

Part 1)** Ability to survive in challenging terrestrial environments

The more environments that any species can occupy increases that species success. This happens because they are able to take advantage of more food and resources that other species cannot (because it is too difficult to survive there). This is important because there is less competition for the food and resources. We see this for insects in land environments that are difficult to survive in such as the desert. Two examples of this are the scorpion and the dung beetle.

**Part 2)** Body Segments, Exoskeleton, Jointed Appendages

**Body Segments**—the segments increase flexibility and mobility (the ability to move around). They are also important because each segment is specialized for different functions. Specialization is very important in the evolution of complexity. Think about the simplest examples of ingestion/digestion seen in sponges. Think about when a digestive tract with only one opening as in cnidarians (jellyfish). Then think about our digestive system. It is highly specialized where each section/portion has a specific function. Now think back to the fact that having the insect body plan (head, thorax, and abdomen) allows specialization of each body segment. (How this works will be discussed in the question about modular body plan)

**Exoskeleton**—Allows life to leave the water. Water supports organisms and helps them keep their shape/move around. With an exoskeleton animals were able to move around and maintain their shape outside of the water. We have seen hydrostatic skeletons in other land invertebrates such as annelids, nematodes, and molluscs. The exoskeleton of insects allows more protection from:

1. Water loss
2. Internal damage of vital organs. (the exoskeleton is thickest covering the brain)
3. Many insects can fly, (This is the first time an animal has been able to occupy the air!)

**Jointed Appendages**—Allows movement in on land in a different way than seen with the annelids/nematodes/flatworms/molluscs. They have protection from the exoskeleton AND they also have joints that can bend covered in a thin layer of exoskeleton!

**Part 3)** Flight, waterproof cuticle, complex life cycle

**Flight**—many adult insects can fly and have one or two pairs of wings. This allows them to:

1. Spread out! This is important so they mate with insects that have DNA different than theirs. It is also important because they decrease competition over food and mates in a small space.
2. Wings arose from a mutation in the cuticle. (if you forget the cuticle, it secretes (makes) the exoskeleton) This means that insects grew wings from a mutation on their surface and NOT in a limb. If you think about bats and birds, they got wings from a mutation in their limbs….so they lost their “arms” …imagine if bats and birds had four limbs AND wings!!! That would be a completely different world!

**Waterproof Cuticle**—they can live on land without drying out and losing all of their water. The moisture that they have inside of their body stays there because it cannot evaporate through the exoskeleton.

**Complex Life Cycle**—most insects go through metamorphosis (either complete or incomplete). If we think of the example of a butterfly…there is the larval stage (caterpillar) and the adult stage (the butterfly).

The larval caterpillar has two jobs:

1. Eat
2. Grow

The adult butterfly has two jobs:

1. Spread out (disperse)
2. Reproduce (make more)

You remember how specialization is important (discussed in 1st question above)? Well it is almost like the larval caterpillar is specialized for its two jobs, and the adult butterfly is specialized for its two jobs. They don’t compete with each other. The caterpillar doesn’t even eat the same food as the butterfly. This is good because they won’t compete against each other for food. If they had to compete, less would survive to reproduce.

**Part 4)** Short generation time and large # of offspring

**Short generation time**—this is talking about the time it takes for an insect to emerge from an egg and grow old enough to reproduce. In humans this takes many years. In insects this is very very short…like weeks to days! This means it doesn’t take long to get more insects. That means that there are more mutations occurring simply because the sheer quantity of insects being produced through reproduction. When you hear the word mutation do you automatically think of something bad? Well, mutations can be either, good or bad. Wings were a mutation in the cuticle. Grasshopper jumping legs were also a mutation. Mutations drive evolution! The good ones help animals to survive. (natural selection)

**Large Number of Offspring**—this means that when insects do have babies, they are having a TON. For many insects this could be 100-500 eggs over their lifetime. For others like the African Termite Queen the number can be as large as 10 million!!! So if you take into account the short time it takes for insects to grow old enough to have babies and then add the fact that they are producing TONS of them, you can see how there would be a LOT of mutations happening. Because there are so many mutations, odds are many will be beneficial, helping insects to survive and reproduce.

**Question #2:** Describe and explain in detail how metamorphosis contributes to the success of insects.

\*See complex life cycle above\*\*

**Question #3:** What is a modular body plan? How does the modular body plan connect to the success of insects?

When an insect is still an embryo (before it emerges from an egg) it has many identical segments. As genes are turned on (called homeotic genes) they give the identical segments different instructions telling them to fuse into the three distinct regions known as the head, thorax, and abdomen. Each one of these units (head, thorax, and abdomen) is thought of as a module….A little unit that functions alone and has its own instructions. This is very useful in terms of mutations that can happen. Remember this sentence from above:

“So if you take into account the short time it takes for insects to grow old enough to have babies and then add the fact that they are producing TONS of them, you can see how there would be a LOT of mutations happening. Because there are so many mutations, odds are many will be beneficial, helping insects to survive and reproduce.”

Well now there are even more mutations that can occur to help the insect. Each segment can have a mutation that doesn’t occur in the other segments. If this was a bad mutation…it might not be so bad that the insect dies and it would only be found on one segment. If the mutation was helpful, it will likely appear in future generations of that species.

Remember this section from above? Think about what you just learned as you reread it. Can you see how much this increases evolutionary success of insects!

1. Wings arose from a mutation in the cuticle. (if you forget the cuticle, it secretes (makes) the exoskeleton) This means that insects grew wings from a mutation on their surface and NOT in a limb. If you think about bats and birds, they got wings from a mutation in their limbs….so they lost their “arms” …imagine if bats and birds had four limbs AND wings!!! That would be a completely different world!

**Question #4:** Explain how each contributes to the overall success of Insect Flight.
Rank them based on your own opinion of which features of these features is most important for the success of Insect Flight.
This would be the order I would use…there is no one correct answer here.

1) Only invertebrates that can fly

* If there were many others there would be more competition which would decrease their success

4) Wings are an extension of the cuticle. This means they can fly without sacrificing legs

* Allows “grace” on the ground (walking) and in the air unlike birds/bats

3) Wings serve as dispersal and escape

* Less die because they can fly away to escape
* They can access more resources by flying great distances
* They can increase the diversity of the gene pool by mating with insects further from the insects they “grew up” around. This speeds up mutations and evolution.

2) Most adults have one to two pairs of wings

* I don’t know much about this besides the fact that wings are mainly seen in ADULTS. Not before metamorphosis. This is significant in terms of the complex life cycle and the specialization of the bodies of the larva (eat/grow) and adult (disperse/reproduce)
* Points if you find other reasons!!