Virtual SKIES

Aviation Research
teacher guide

Activity II: Evolution of Flight

Well before man took to air, animals flew through the air. When man dreamed of flying, he dreamed of having wings, feathers, or flaps. Most flying machines are based on natural flying animals. Even today, scientists look to nature to come up with ways to innovate existing flying machines, or invent new ones.

Part A. What do you already know about flight?

1. Name 3 non-vertebrate flying animals.

____

____

____

2. Name 3 vertebrate flying animals.

____

____

____

3. Do you know of any flying plants?

4. What is flight? Describe flight as clearly as possible, in terms that an average adult could understand. You might mention the kinds of movements in flight, directions of movement, tools or appendages required, etc.

5. How is man-made flight similar and different from natural flight? What do you think scientists used as “model flyers” to design the first flying structures (that were able to fly or not)? You might think about legends, stories, and the history of flight.

Part B. Vertebrate Flight

Use the information on http://www.ucmp.berkeley.edu/vertebrates/flight/enter.html to answer the following questions about flight.

1. What are the 4 generalized levels of motion?

   a. ___________________________________

   b. ___________________________________

   c. ___________________________________

   d. ___________________________________

2. a) __P__________________ is defined by the angle between the ground and the path of descent. How big does this angle have to be? AT LEAST / LESS

   THAN ___________ degrees.

   b) Draw 2 pictures of something descending with some form of p________.

   The first picture should be "not p__________" and the second should be

   "p_________" based on the definition above. Be specific by labeling your figure.

   c) What non-human thing uses this level of motion?

   d) How does a p_____________ fall more slowly? Explain in words and draw 2 pictures to defend your explanation. One picture should be of a fast

   p_____________, and the second should be of a slow p____________. Label your drawing to show how drag and surface area are related to

   p____________.

3. a) ___G_______________ is defined by the angle between the ground and the path of descent. This angle has to be AT LEAST / LESS THAN ___________ degrees.

b) Draw 2 pictures to show what "not g___________" and "g_____________" are. Label your pictures.

c) This level of motion works by having an airfoil design that generates _______________. It is very important that this design be _____________ in order to keep drag to a minimum.

4. a) F_________________ is very explicitly defined at this web site. What is f__________ and why are the 2 other levels above not considered to be f____________?

b) By this definition, is the movement done by an airplane considered f____________?

c) Flapping wings provides ____________ which increases speed.

d) This level of motion evolved 3 times in vertebrates. What were the three animals it evolved in?

i. _________________________

ii. _________________________

iii. _________________________

5. a) S______________________ uses wind currents or thermals to keep an animal at a constant altitude.

b) This is considered to be the most advanced level of motion, for a variety of reasons. One of the main reasons is because it is very energy efficient, meaning few calories are used to remain in the air for a period of time or over a period of distance. Explain, using a specific example, why you might consider this to be the "most advanced" in terms of efficiency.

c) Why might you consider this to be the most advanced in terms of evolutionary history. Hint: Think about how this trait would appear in evolutionary history if it was an ancestral trait versus a newly evolved trait.

6. a) Although air is not water, air is _____________, just like water is. The force needed to deform a _______________ is dependent upon how fast the _______________ is deformed. In other words, the force needed to move the air is dependent on how fast the air is moved.

For instance, think about running in water (like you might do, in a pool). If you were running very slowly (walking) in the pool, you would notice that you would need to use more force to move your legs than you would if you were walking outside the pool. Think also about the kind of effort you must use to run even faster in the pool.

b) As you move faster in the pool, you must use MORE / LESS force.

c) Draw a picture of yourself walking or running forwards through a pool, to help illustrate the following components of flight. Include labels and arrows to show directions of force. Include the terms : drag, lift, thrust, and weight.

d) When is drag useful? Provide an example.

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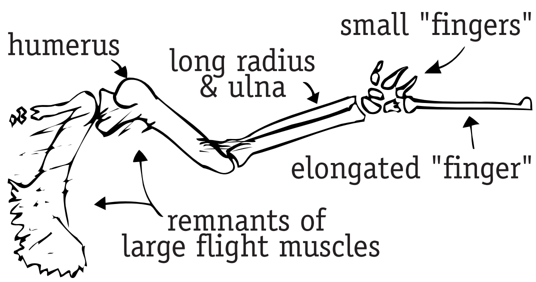
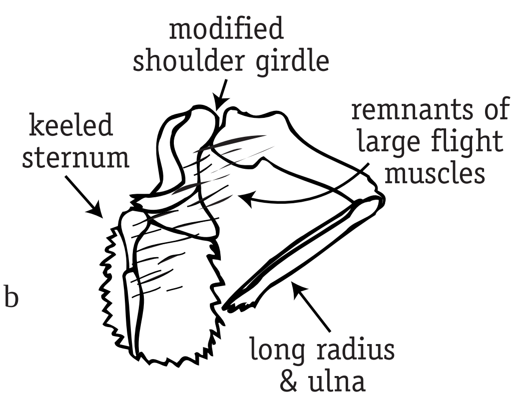
7. As a paleontologist, you discover parts of five different animal skeletons and would like to know if they are Gliders or Fliers. Use the following pictures to make your decisions.

a



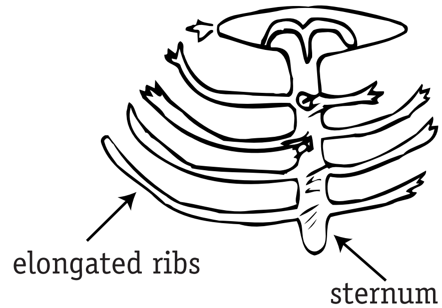
DORSAL VIEW

b



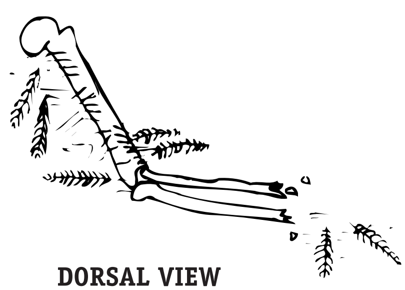
VENTRAL VIEW

c



VENTRAL VIEW

d



DORSAL VIEW

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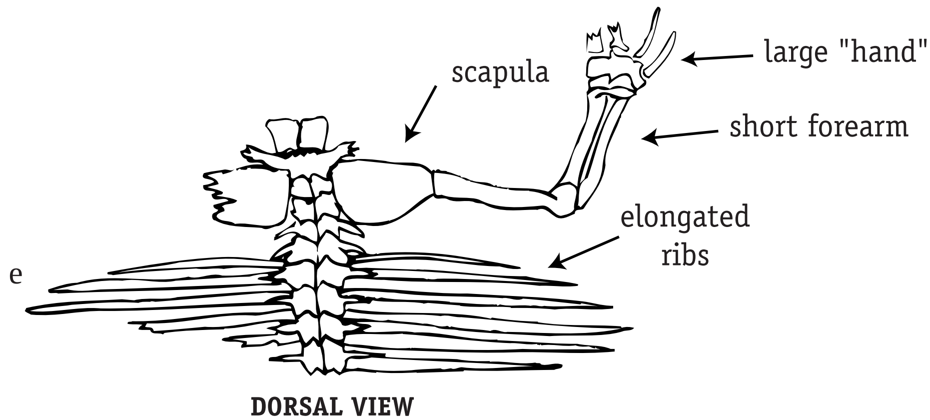

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8. How could one use aspect ratio to determine if the animal is a glider or flier? What would this look like?

9. If you were to observe 2 animals that you knew could move through the air using gliding or flying, but could not watch them doing either action, how might their behaviors on land indicate which type of animal each is?

10. Use the web site and any extra information (encyclopedia, other online sources, etc.) to (a) find a common name, (b) categorize into a lay-man's-termed group, (c) categorize as a type of mover, (d) identify a notable trait associated with its movement type, and (e) sketch a picture of the type of animal.

Organism	Common Name	Type of Animal	Glider, Parachuter, Soarer, or Flyer?	Trait that defines it as a g./p./s./f.
1. *Draco volans*	flying dragon	lizard	glider	elongated ribs
2.*Cynocephalus volans*	flying lemur	mammal (close to bats; not a lemur)	glider	elongated ribs and forearms
3. *Exocoetidae* family	flying fish	fish	glider	large pectoral fins (low aspect ratio)
4. *Rhacophorus pardalis*	arboreal frog	frog	glider & parachuter	large toe membranes
5. *Thoracocharax* sp.	Hatchet-fish	fish	glider	large pectoral fins
6. *Glaucomys volans*	Flying Squirrel	Mammal (rodent)	glider	span of tissue btwn all appendages
7. *Sturnus vulgaris*	Starling	Bird	flyer	all bird traits
8. Charadriiformes (Order)	Sea Gull	Bird	soarer, flyer	all bird traits

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11. How did flight evolve? The web site provides a 4-step plan for determining this. Describe each step in your own words.

12. It is thought that wings must have been exadaptations, or adaptations that are "co-opted from a previous use to a new use." What might have been the previous use for wings? List your best 5 ideas. Hint: Think of animals with large structures that appear like wings (rabbit's large ears, for example). Also think about some of our special gliders and parachutists!

1. ____

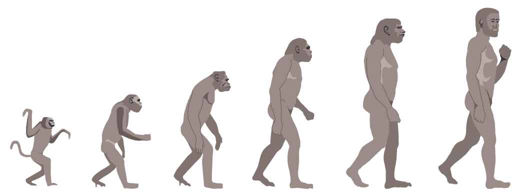
2. ____

3. ____

4. ____

5. ____

13. The scientists cited in this web site prefer 2 theories to explain how flight evolved. Use a series of cartoon frames to illustrate how flight is hypothesized to have evolved. Your cartoon should be like that below, showing gradual change over time. Be sure to include important “props” or environmental features in the background (for instance, trees) if they are important.



First Hypothesis:
Add more frames on another paper if needed.

Second Hypothesis:
Add more frames on another paper if needed.

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14. If flying were to evolve, it would have to not be selected against, but rather be selected for or provide a fecundity advantage.

In your own words, what are the five main hypotheses for how flight was selected for ("Why" it evolved)?

a. ____

b. ____

c. ____

d. ____

e. ____

15. It is very common for students to erroneously think that natural selection occurs because an organism wills it to occur. In your own words, provide a scenario, using the ideas about how and why flight evolved, above, in which the organism has willed the evolution of flight.

16. Now explain, based on what you know about the occurrence of mutation, reproductive rates, and other features of natural selection, why this scenario is erroneous.

Share your scenario with a classmate and have him/her describe what is erroneous. Share answers as necessary.

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17. a) Why is the evolution of flight called convergent?

b) How is this different from divergent?

c) How could you use a phylogeny or tree to illustrate convergent and divergent evolution?

18. The evolution of flight resulted in sudden adaptive radiation or macroevolution. Describe what this principle is, what it would look like on a phylogeny, and provide some ideas as to why such evolution could occur so quickly.

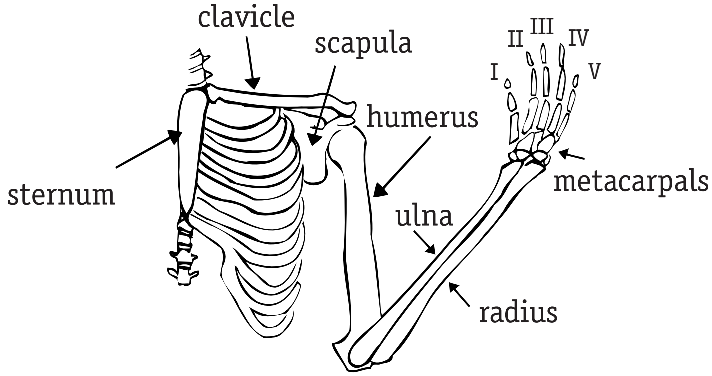
19. a) Pterosaurs are thought to have evolved through which of the two hypotheses you illustrated previously?

b) What evidence supports this?

20. Pterosaurs do not have feathers, but have other structures to support the wing. Describe them.

21. The pterosaur wing and torso have several components that a human arm has, which are shown below. Draw a pterosaur wing and label each component by drawing arrows tosimilar structures.

Human arm and torso



22. The pterosaur has a new bone that is not known to occur in other animals. What is it and what does it do? Label it on your drawing.

23. Why is the occurrence of this bone so noteworthy to scientists.

24. The avian wing and torso are also very similar to the human arm and torso. Continue your drawing from #21 by drawing an avian torso and wing. Be sure to label your parts.

25. The earliest known bird is ____.

26. There are 2 other lines of animals linked to the earliest known bird, which are useful to study to understand the evolution of birds. What are these two and how are they linked to the earliest known bird?

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27. a) By what hypothesis previously mentioned are birds thought to have evolved flight?

b) What evidence is there?

28. Why is the fact that a majority of modern birds live arboreally, poor evidence for the Tree-Down hypothesis as a means of flight evolution?

29. The clavicle is fused in birds, forming the furcula. What function does this bone have?

30. The furcula is first seen in Dromaeosaurs. What did it serve as, and why does this supply evidence of exadaptation?

31. The phalanges of the wing evolve, as well. Sketch the three “stages” of phalanges and label notable changes.

32. a) The evolution of flight in bats seems to have occurred according to which of the illustrated hypotheses?

b) What evidence is there for this?

33. Continue your torso and arm drawings with that of a bat. Label appropriate features.

34. a) The bat does not have a tail like birds, but instead has a uropatagium. What is this and what is its function?

b) Why does this serve as defense to the bat's evolution of flight according to the hypothesis named in question #32?

35. a) There is a bone in bats that may be analogous to a famous bone in pterosaurs. What is it and why might it be deemed analogous?

b) What further information should we obtain before we determine its analogy or homology with another bone?

36. Using the drawings you have produced of torso and arm/wing morphology, create a list, chart, or essay pointing out the main changes that must have occurred between organisms. You can place your list on a tree or juxtapose this information with that of a phylogeny, to get a sense of how much time passed between organisms, for such changes to take place. Add some of the transitional groups to your tree to see if you can pinpoint what morphological changes must have taken place first (assuming each feature will evolve only once).

Part C. Insect Flight

It may seem abnormal to include this section after vertebrate evolution has been discussed, because invertebrates came first, but the web resources for invertebrates are much less prevalent.

Use the web site http://parallel.park.org/Canada/Museum/insects/evolution/evolution.html to help you answer the following questions.

1. Insect evolution of flight probably occurred as an exadaptation. What is an exadaptation? Hint: see text in part B if you have forgotten.

2. What are wings thought to be derived from?

3. What might these flaps have initially been used for, before they were wings?

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Wings may have been used as sails or floats in the water, prior to their being used for flight. Today, stoneflies use wings as sails and other insects flap their wings in order to be propelled across the surface of the water (like a wind-powered boat).

4. The responses in questions #2 and #3 may cause you to think about another animal - a vertebrate without legs - that has “wings” which evolved in the same way and provide the same function.

   a) Which animal might this be, and how are its wings similar to the wings of invertebrates?

   b) Why is this of evolutionary significance?

5. What is the principal criterion for distinguishing insects at all hierarchical levels?

6. How does a bee’s vision differ from a human’s in terms of speed? Explain by using a specific example.

7. Why is this change in vision important for flying insects?

8. If the compound eye had not been so useful for finding food (thus eating and remaining healthy) and avoiding predators, it may not have lasted as a new mutation. (This is especially true if previous eyes were capable of seeing very well for large distances.) Why not? Hint: Consider the requirements for traits to be passed on from one generation to the other.

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9. Insects are fragile creatures, and almost anyone who has held a moth or butterfly knows that the wings are extremely fragile and without them the insect may die. What major adaptation has helped insects protect their wings?

10. Vertebrate wings have several structures to make them harder and less fragile. While birds have feathers, what do insects like Lepidoptera have?

11. What other adaptations involving wing appearance, have insects evolved to help protect themselves?

12. The ancestral flying insect had how many wings?

13. Diptera uses its front wings to flap, but its hind wings are used for something else. What is it?

14. Print the Flapping Flight pages from the web site and make a flip book so you can better understand this method of flight! Glue the printout to some stiff paper, then cut out each step in the dragonfly flight pattern, being careful to make each card the same size and orientation. Attach the cards together by sewing a binding or stapling your book. Books can be colored to emphasize specific wings and positions. Do the same for the locust, butterfly, and beetle illustrations.

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15. Most insects do not fold their wings during flight, like a bird can. Knowing this, if the insects were to flap up and down using only two wings, fully extended, without folding, significant drag would be produced in the upstroke, and the flight would require a lot of energy in tilting and down strokes to remain in the air.

a) However, insects like dragonflies have 4 wings and flap them in a way so drag is not the only force occurring in an up-down direction during an upstroke of one pair of wings. What is this way of flapping and how is it advantageous?

b) Other insects may have 4 wings, but beat them very differently than a dragonfly does. Explain how the locust, butterfly, and beetle flap their wings differently that each other and a dragonfly.

c) Why are these different methods advantages for each animal? Think about how each animal lives and what amount of their days are spent in the air.

Questions 16 to 21 refer to DIRECT MUSCULATURE.

16. Why is the Direct muscle system called "direct"?

17. The muscle system in insects is very similar to that in birds. Draw the rostral / cross-sectional view of the wings and muscles involved in flight for a bird, next to a copy or sketch of the drawings provided for insects. Label the drawing with important bones we have studied. Include important muscles or muscle groups if you know them.

18. What are the tergum and what are analogous structures in birds?

19. There are two groups of muscles associated with flight. What are they and where are they?

20. Draw a series of cartoons illustrating the job of each muscle by showing the length of the muscle (include a label) during different parts of flight. The muscle should extend or contract. (Extending is considered a resting phase or a passive process.)

1. Rest (no flight, or end of Down Stroke)	2. Upstroke	3. Transition (Upstroke finished)	4. Down Stroke

1. Should show both muscles extended.
2. Should show medial muscles contracted, lateral muscles extended.
3. Should show both muscles extended.
4. Should show medial muscles extended, lateral muscles contracted.

21. Why is this type of musculature disadvantageous?

Questions 22 through 26 refer to INDIRECT MUSCULATURE

22. Why is this system called “indirect”?

23. The tergum in this system is slightly different, in terms of what it attaches. Explain.

24. What are the two kinds of muscles in this system? Draw a picture and label it, like you did for the direct muscles. Be sure to show or explain the muscles’ different roles.

25. The reading on the web site suggests a hands-on demonstration with a tennis ball and pins, to help explain how this muscle system works. Use pictures and a paragraph or list to explain how the ball models this muscle system.

26. How is the indirect system better than the direct one?

27. Most insects don’t fold their wings during flight like a bird can, but they can twist and contort them. How does this work?

28. What do the authors say the bee and other insects use traditionally for navigation?

29. To orient using these objects and fly in a straight line, the Moth does what?

30. Why has this caused a problem for insects using the same navigational system, at night?

31. What are some environmental implications for this?

D. Genetics and Evolution

The method described in section B (question 11) is a traditional way of approaching evolution. However, with more genetic data available, and a clear link between development and genetics, evolutionary biologists are using more contemporary tools, linking modern-day mutants to archetypal mutants from long ago.

Well before genetics was understood, scientists worked with different groups of cells, understanding that certain groups of cells were precursors to certain structures (muscle and bone, for example). More specifically, scientists knew that cells from certain parts of the body were precursors for specific body parts. Observations of situations where cells were removed, transplanted, or marked indicated if cells were required for the formation of a specific structure.

1. Describe three kinds of tests you could do to see if a group of cells was solely responsible for limb formation. Draw cartoons for each test, below. (Hint: all three tests are mentioned in the last sentence of the paragraph above.)

Cartoon 1 describes: ____

Add more frames on another paper if needed.

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Cartoon 2 describes: ____

Add more frames on another paper if needed.

Cartoon 3 describes: ____

____

Add more frames on another paper if needed.

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Using all of these methods, scientists were able to isolate the region where wings and legs form and identify some of the key cell groups involved.

One of the most important cell groups in limb development is the AER (apical ectodermal ridge). The AER forms in birds and mammals. It begins forming through "communication" between the underlying mesoderm.

2. How might this communication take place? Are words exchanged?

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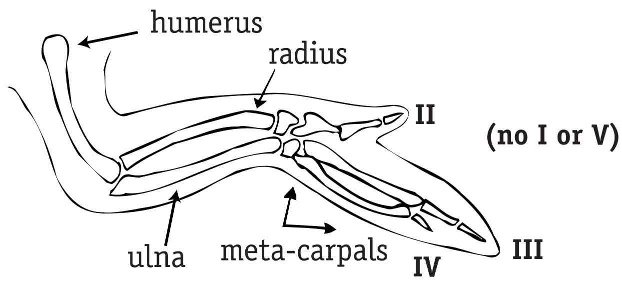
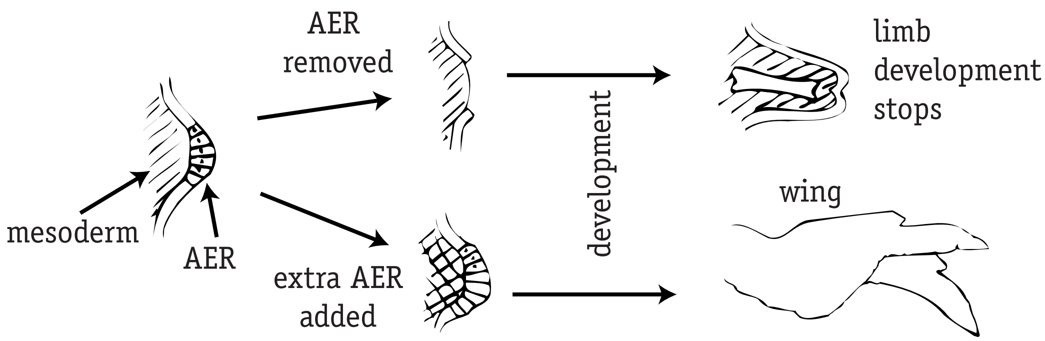
3. Use the following pictures to write a short sentence describing each situation and elucidating AER's role in wing formation.

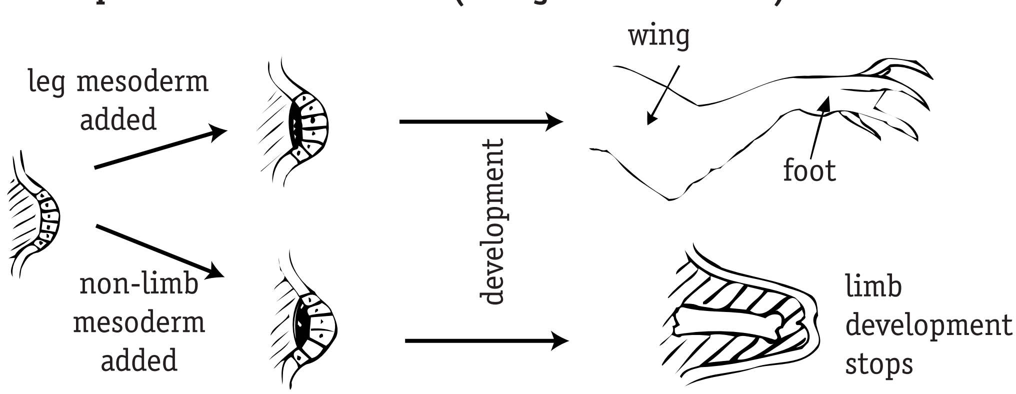
wild-type chick wing



AER experimental observations (changes in ectoderm)



AER experimental observations (changes in mesoderm)



a. ____

____

b. ____

____

c. ____

____

d. ____

____

4. Use your pictures from activity B to compare the flying animals and their wings. You will notice that in evolution of wings, the proximo-distal structures change. The "hand" that occurs in pterosaurs and avian precursors has been reduced and fused in modern bats and birds. It is easy to think of an ancestor as a tetrapod with 4 "legs" of similar appearance. Then, by the miraculous process of evolution, legs became winglike.

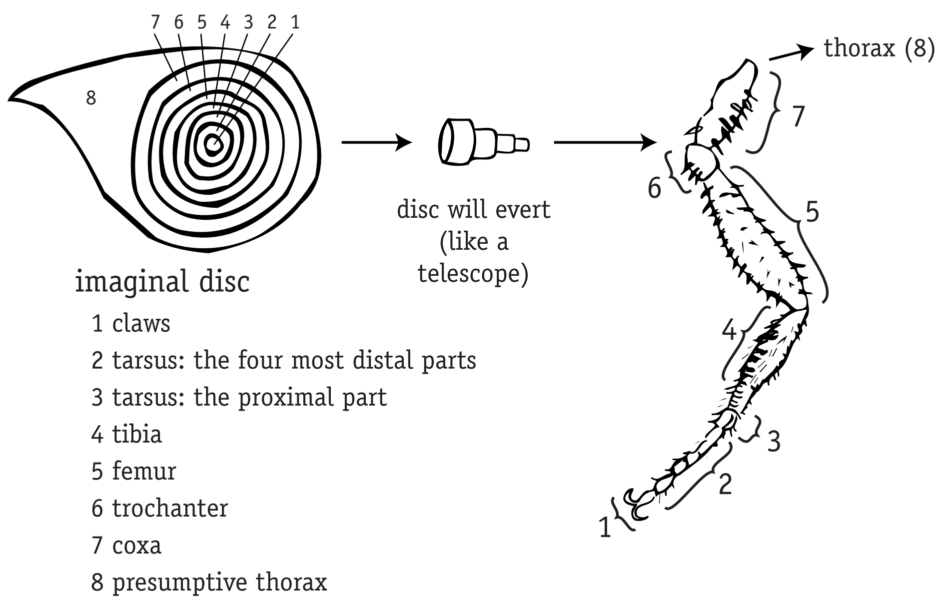
In a similar fashion to asking ourselves, "How does my body know to make a pinkie finger on one side of my hand and thumb on the other side?" We can also ask, "How does a chicken make a wing for one appendage and a leg for another?"

The previous problem provides a hint. Which situation and result from question #3 gives you an idea about how the developing limb's AER region for a pterosaur or Dromaeosaur was different from that of a normal chicken?

5. Why does the AER do what it does?

If you were to cut out a developing organism's polarizing zone and turn it 180 degrees, then reattach it, how would the resulting limb differ from a wild-type limb?

6. Insects provide another example of polarity or directionality playing a role in development. Several insect structures like antennae and wings form from imaginal discs. Each disc everts through development and elongates, eventually forming a body part.



In Drosophila (fruit flies), the imaginal discs have been studied extensively. It is known that different levels of the disc specify different structures, as shown in the figure above. This occurs through gene activation. In addition, homeotic genes determine the developmental fate of specific segments of the body. In other words, they specify body parts. These genes can work hand-in-hand to determine the developmental fate of a fly.

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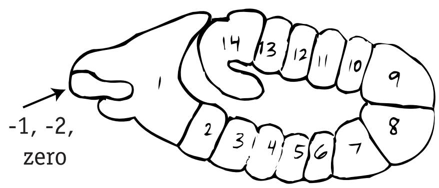
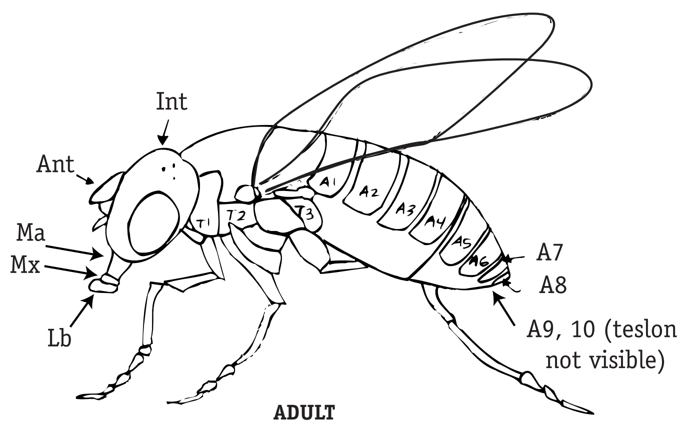
Below is a very simple picture of a fly and regions which express homeotic genes early in development. The genes shown are only a small fraction of the number of homeotic genes in a fly. Color code each region that is activated by a different gene. Use a key if your colors "black out" the gene name or region number.



BLASTODERM

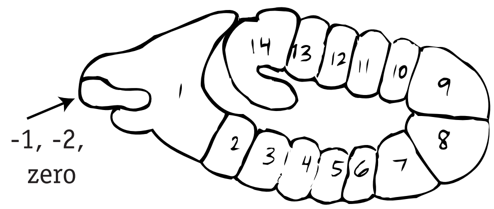


ADULT

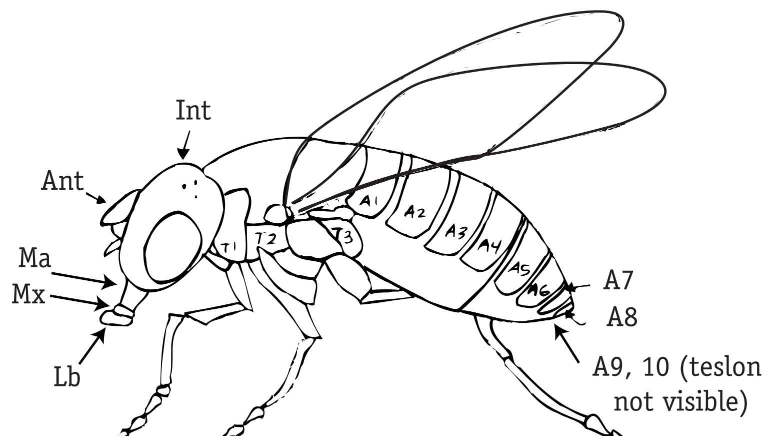
Gene	Expressed Region																
Adult Fly Region	Ant	Int	Ma	Mx	Lb	T1	T2	T3	A1	A2	A3	A4	A5	A6	A7	A8	A9, 10
Blastodermal Segment	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Labial		xxx															
Deformed			xxxxxxx														
Sex Combs Reduced				xxxxxxxxxxxx													
Proboscipedia					AAAAA												
Antennapedia						xxxxxxxxxxxxxx...											
Ultrabithorax							........xxxxx..										
Abdominal A									xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx...................								
Abdominal B												xxxxxxxxxxxxxxxxxxx					
Caudal																	xxxx

xx = strong expression .... = weak expression AAA= strong expression only in adults

Mutations involving these genes have been known to result in aberrant phenotypes. Using the information in the picture above, determine which gene is being expressed "erroneously" and where this is influential. On the extra copies of the fly and blastoderm, indicate gene expression by shading regions appropriately. Also make changes in phenotype on the adult.



BLASTODERM



ADULT

Phenotype a: two sets of wings formed in the second and third thoracic segments, respectively.

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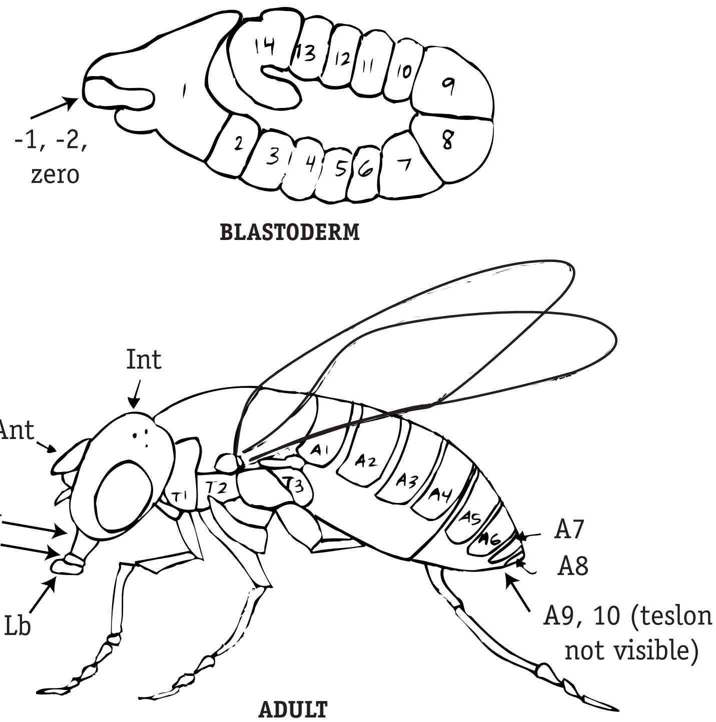
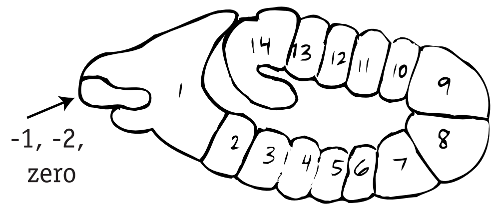
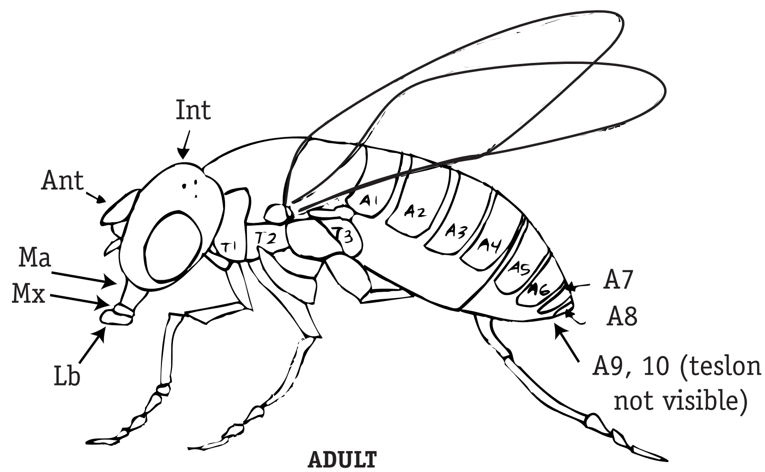
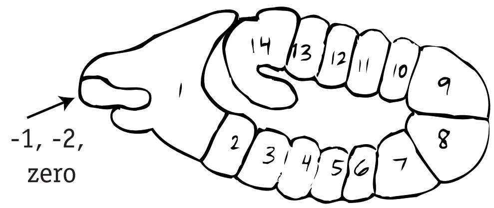


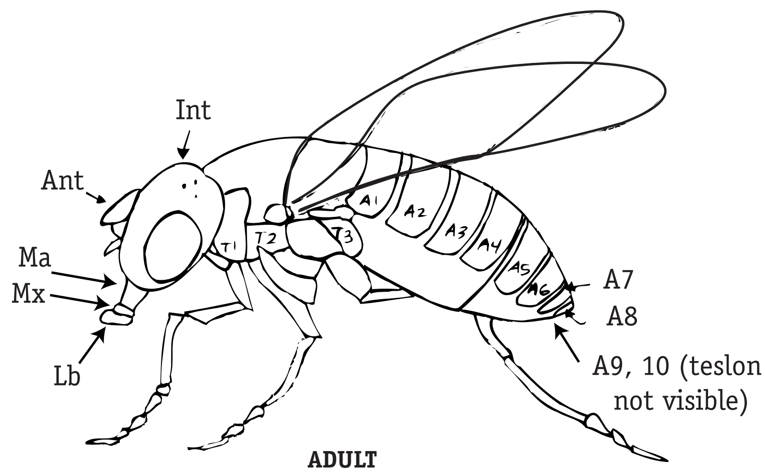
Phenotype b: Legs replace the labial palps of the mouth.





Phenotype c: Legs grow out of eye sockets, while eyes and other legs are normal.

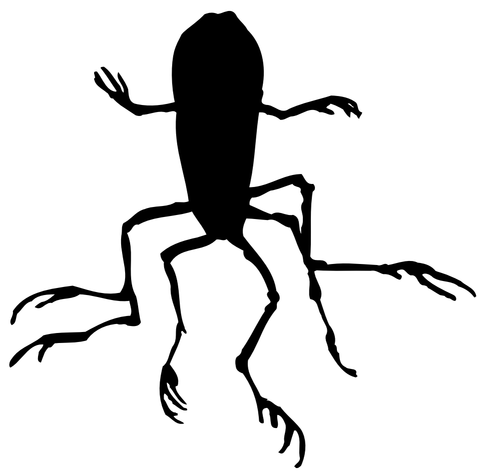




Phenotype d: Antennae grow out of region where legs would form (at imaginal discs), and there are also normal antennae on the head.

Conceptually, it seems pretty easy to sprout new legs, huh? But the real question is, how likely is this to occur in nature? The next question answers this question to some degree.

7. We can manipulate imaginal discs by cutting them. If most of the disc remains, a new limb or wing will form. This occurs in salamanders and frogs that can regenerate limbs. In vertebrates, the imaginal disc-like region is called a limb field. At a pond in Santa Cruz, California, many multilegged salamanders and frogs have been found on more than one occasion. These animals apparently were infested with parasitic trematode worms when in larval form. The eggs of the worms split the limb fields when the frogs and salamanders were forming.



There are everyday plants and animals that undergo processes of rebuilding themselves like this all the time. Can you think of examples of animals and/or plants that are capable of recreating portions of themselves when part of them is removed? What kind of requirements are there in order for this to work (how much of the body or what part of the body needs to be retained)?

Activity II: Evolution of Flight

8. As was already mentioned, communication between the AER and mesoderm is important. This communication can cause some interesting changes in limb formation as well. When the mesoderm induces too much AER, just as in a graft, extra digits occur on the limb. This mutation is called Polydactylous.

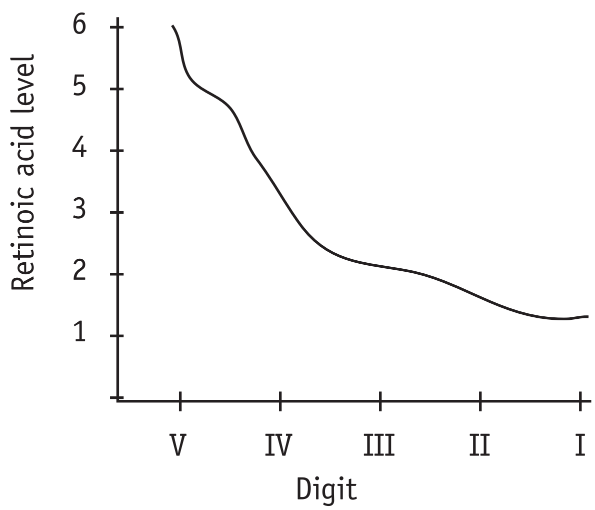
   If this were to occur in a human, what do you think the phenotype would look like? Draw a picture and explain your response. Keep in mind that polarity is still significant in development, even with this mutation.

9. As soon as cell groups were identified as being in some way responsible for limb development, scientists narrowed their focus to understand the specific chemicals involved in development. They found retinoic acid, a common chemical found in carrots, appeared to play a large role.

Retinoic acid produces a gradient across the limb. It is highest at the pinkie finger and lowest at the thumb. Retinoic acid binds cell receptors and causes the cells to express new sets of genes as a response.

The graph below illustrates relative quantity of retinoic acid and the feature to which it is related.

a) Determine which digits are the pinkie and thumb.



(circle one) I is a) pinkie or b) thumb?
V is a) pinkie or b) thumb?

b) If retinoic acid is doubled, what does the resulting hand look like, assuming 5 digits are still made?

c) If retinoic acid is halved from the original situation, what will the resulting hand look like, assuming 5 fingers are made?

10. Because the limb bud does not have a large retinoic acid content, it appears that retinoic acid is not the main chemical involved in inducing development of limbs. How could retinoic acid produce such effects when it is present only in small quantities in the limb bud?

How could we test your idea?

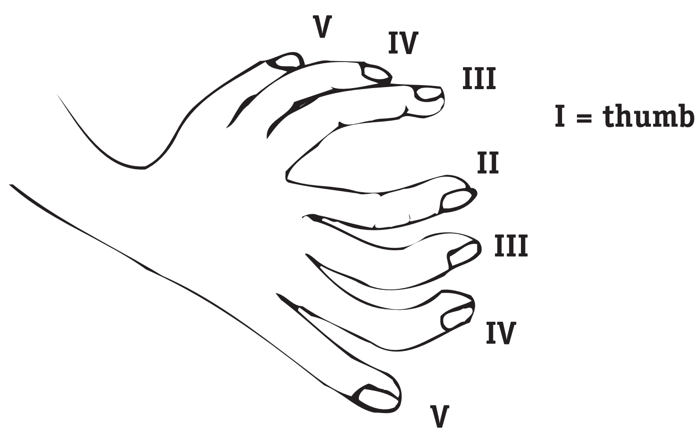
11. *Hedgehog* in Drosophila is a segment polarity gene that is thought to encode a diffusible protein that reacts with neighboring cells. Scientists used PCR to identify a homologous gene in chicks, called *sonic hedgehog*, that is localized exclusively to a polarizing region in the limb bud. *Sonic hedgehog*'s product has been classified as a secreted growth factor that binds receptors on cell membranes. It serves to organize limb axis formation. In studies, retinoic acid applied to this same polarizing region causes *sonic hedgehog* to become expressed.

How is this similar to your test? How is it different? What new questions are raised by these results?

Other studies show that *sonic hedgehog* can function in the absence of retinoic acid. Thus, the two chemicals may work together or apart, and appear to have similar functions.

12. It is relatively easy to find and create mutations in the laboratory, where they can be selected for and/or are not selected against, but how likely are they to occur in nature? An example follows.

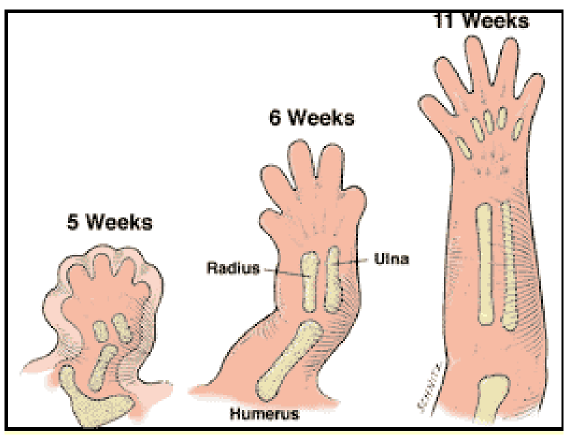
A condition similar to that seen in the AER grafting situation from question #3 in chickens was seen in a machinist from Boston. The man said that such a condition "not only helped him do his job, but also gave him certain advantages in playing the piano."



Now that you are an expert in genetics of this type of situation, what do you think caused this machinist's condition?

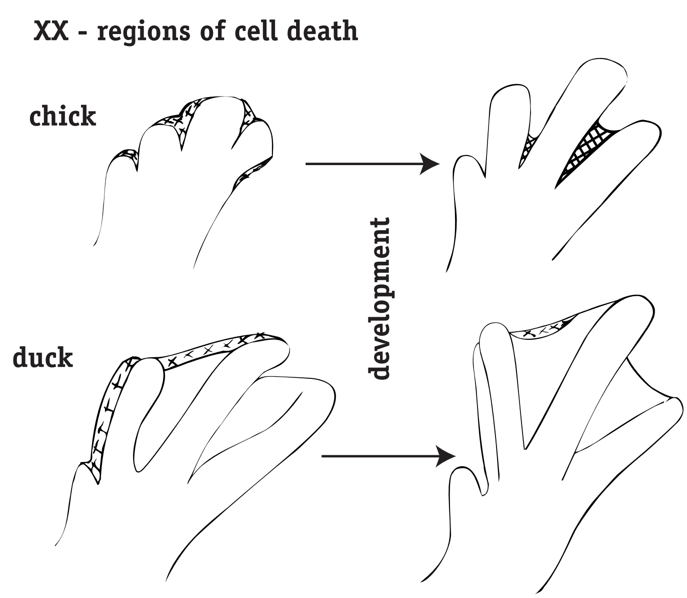
13. The bone structure of a wing on a chicken and the arm of a human are not very different. What is on the outside of the structure IS different, however. Extra tissue spans the distance between bones, providing more surface area on the appendage, which is essential for any of the flight-related motions. This brings us to ask: Could changes in the "webbing" of tissue be largely responsible for evolution of wings?

Perhaps. If it were, we would want to discover when "webbing" and "nonwebbing" occured. We use duck feet and human hands as examples. The development of the upper extremity in humans progresses through multiple stages beginning with the formation of the small arm bud 26 days after conception. Further development includes bud enlargement, neurovascular growth, and cartilage formation. By the 33rd day, the hand appears as a paddle which forms a basis for individual, separated digits through the death of interdigital ("between the fingers") tissue by the 54th day. The interdigital tissue is analagous to the embryonic "webbing" of duck limbs.



embryonic development of the human hand

14. One would also notice that some webbing is lost in duck embryos, but much more is lost in people. The regions where webbing is lost are very similar in both forms. Note the following illustration that shows cell death (de-webbing) in ducks and chickens. It occurs in a manner similar to people.



15. What does this indicate to you about the conserved nature of webbing regulation?

16. In question #14, the issue is the amount of webbing lost in various animals. A related issue may be the timing when de-webbing takes place. Heterochrony refers to a change in developmental time when an event occurs. How could the timing of de-webbing differ across our organisms? Use a specific time for each organism to make this example more tangible.

17. Complete the following statement, providing specific examples and reference to natural selection. Compared to evolution of a new structure, evolution in amount of webbing would be relatively likely to occur because ….

E. Animal Flight Mechanics

People have been attempting to fly for centuries, and flying birds and insects have proved the perfect inspiration. Most modern airplanes do not have flapping wings, and hence do not "fly" (by the biological definition), but still use other methods of movement borrowed from nature.

Use the web site http://www.catskill.net/evolution/flight/birdsfly/birdsfly.html to obtain answers to the following questions.

1. Which method of flight in a bird (Parachuting, Gliding, Soaring, or true Flight) is analogous to that done by an airplane?

2. In addition to forward motion, what are the three important motions for flight?

3. Why is twisting important for flying, specifically during flapping?

4. How is folding useful during flight?

5. How does a bird balance during flight?

At http://www.catskill.net/evolution/flight/freefly/freefly.html and http://www.catskill.net/evolution/flight/freebird/default.htm there are photos, videos, directions, and simple plans for making small ornithopters. There is also a fairly active chat room where issues regarding construction of ornithopters, modifications, and new research in flight are discussed.
At http://www.naturalflight.com/evolution/seagull.avi there are many movies of Ornithopters in action, including historic early flights and more modern ones.

At minimum, watch a few movies!