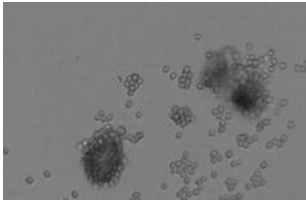


13.1 Biology of Flight



Mould spores



Dandelion



Butterfly



Black-headed gull

Birds fly through the air. Insects fly through the air. But does anyone sing about hazelnut pollen? Or birch seeds? Hardly. Just the same, this type of flight deserves to be examined just as carefully as the majestic flight of an eagle or an albatross.

It does not matter whether it is an animal or a plant: for millions of years now, nature has been using design principles which form the basis for amazing feats of flight and which are now found in modern aircraft construction. For instance, the unimposing birch seed is a paradigm for lightweight construction with a small body and large wing areas, giving it excellent flight characteristics. So the true pioneers of flight were not Montgolfier, the Wrights or Lilienthal, but mould spores, dandelions, dragonflies and hummingbirds, to name just a few.

As we will see, the topic of flight provides a fascinating foray through the realms of biology and is by no means restricted to ornithology – even though the achievements of migratory birds are amazing.

Biology also provides answers to the “why” of flight: it not only makes individual rapid locomotion possible (birds are one example), but also enables air transport of goods over vast distances – although the “goods” in this case are not suitcases and boxes, but embryos, germ cells and spores. Many plants have developed refined strategies, such as clearly marked landing areas, that help them to spread their genes over considerable distances. Insects are an example of this form of air transport and are rewarded for their work with sweet nectar.

The following learning modules allow us to obtain a better understanding of the biology of flight with the help of numerous experiments and observations.

13.2 Bird flight – the greatest air show on earth

Gliding, swooping, wheeling, hovering, landing with diving into water, taking off from water – the best pilot in the world comes nowhere near the flying skills of a bird. In this learning module, we will look at the biological imperatives underlying bird flight. The physical aspects are described in detail in section 7.

Task 13.2.1

A roasting chicken on the dissecting table • The “propulsion unit” of a bird is its flight musculature which moves its wings in such a way as to provide both lift and propulsion – and here it differs significantly from an aircraft. The economical lightweight construction includes not only the feathers (“wing material”), but also the supporting structure, in other words the skeleton. We do not need to sacrifice an eagle or an albatross to investigate the anatomical details: half a roast chicken from a food stall will do nicely as a specimen.

Materials: wash bowl, scalpel, half a roast chicken

Procedure: first the skin is removed completely and the layout of muscle groups is documented with drawings or photographs. The large breast muscle is dissected away with a sharp knife, starting from the carina (keel bone). The muscles (in other words the meat, including the small breast muscle) also need to be stripped away from the thighbone.

- Describe the position, size and function of the breast muscles and the carina, as well as the opposing movements of the wing.
- Cut a section of the thighbone of the chicken, describe its structure and explain how it relates to the flight capacity of the bird.
- Describe the wing position and movements in gliding and flapping flight.

Task 13.2.2

Examination of bird's feather • Materials: magnifying glass, microscope, set of scales, feather (approx. 15 cms long), cardboard

Procedure: the mass of the feathers and a piece of cardboard of similar size are determined for comparison. The feather is examined under the magnifying glass and the microscope at various magnifications.

- Using your fingers, check the cohesion of the parallel barbs of the feather.
- Draw barbs and barbules and describe their function for the wing.
- Give reasons for the difference in mass between feathers and cardboard strips.



Hummingbird hovering at a blossom

Wingspans

Hummingbird: 12 cm
White stork: 225 cm
Albatross: 350 cm

Wingbeats per s (max.)

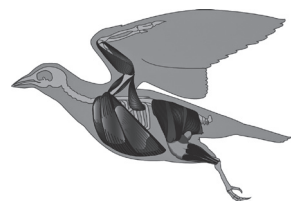
Hummingbird: 50–200
Sparrow: 10
Kestrel: 5
Swift: 12

Flying speed in km/h

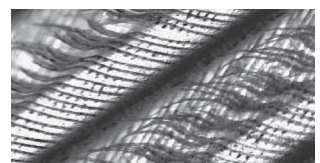
Sparrow: 40
Kestrel: 75
Swift: 130



Breast muscles of the hen

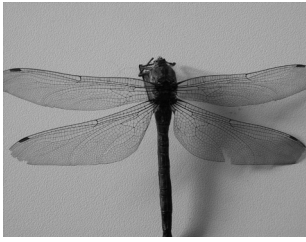


Breast muscles of the dove

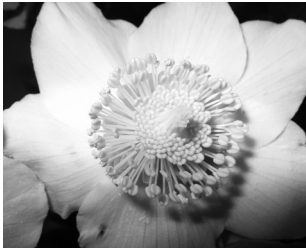


Barbs and barbules of a feather

13.3 Insects as flying sex ambassadors



Dragonfly



Blossom in normal light and in
UV light

Flying insects are of interest to our “flight” topic for two reasons: they achieved flight long before the birds, and they also have a unique cooperation with many plants: they transport germ cells in return for nectar, which is a bargain with reciprocal benefits. This does not apply to all insects but it is a useful arrangement for quite a number of species. Many flowering plants even use fluorescent markings to show flying insects where they should land. The way the wings function is also interesting, because they have no intrinsic muscles: they are moved passively by changes in the shape of the thorax, which contains longitudinal and transverse muscles. These produce the horizontal and vertical movements of the wings.

Task 13.3.1

Different kinds of wings • Materials: flying insects from the biology collection (e.g. dragonflies), microscope, cardboard, glue, scissors

- a| Examine insect wings under a microscope (lowest magnification) and identify differences between these and the wings of birds.
- b| Collect additional information on the topic of “indirect wing movements” and construct a simple model to illustrate it.

Task 13.3.2

Glowing runways • Materials: fresh flowers (preferably yellow) of various insect-pollinated plants, UV lamp, microscope lamp

Procedure: In a darkened room, the flowers are first exposed to UV light and then to visible light.

- a| Draw some striking flower markings that become visible under UV light.
- b| Find some information on the spectrum of light and the colour vision of bees.

Task 13.3.3

Bees as cargo planes for pollen • Materials: wild flowers, magnifying glass, camera with macro function, brushes, microscope, honey from a particular species of flowering plant (“single-flower honey”, e.g. rapeseed honey)

Procedure: observe how bees fly to flowers outdoors. For an analysis of the honey 1 g honey is diluted with a little water and a drop of the solution is placed on a glass slide for observation under the microscope.

- a| Photograph the pollen baskets of honeybees flying to and from the flowers.
- b| Use the magnifying glass to look for pollen on the stigmas of flowers that have been visited. Compare this under the microscope with pollen grains from the stamens of the same plant species.
- c| Estimate the proportion of foreign pollen in the single-flower honey that you have examined.



Bees pollinating

13.4 Maple and Co. – flying acrobats

Numerous flight movements can be seen from August to October amongst maples, lime trees, birches and other trees. Maple and lime seeds fly through the air like helicopters, while birch seeds glide vast distances in their thousands, over 300 km has been reported. The bright red berries of the mountain ash are scattered further afield by birds which excrete the hard kernels some distance away.

Conclusion: one can hardly accuse plants of being uncreative in their exploitation of the air for their dispersal. Mankind has learned a great deal from them. A separate branch of science, bionics, incorporates biological construction principles into technical products. For example, the bows of modern ships imitate the dolphin's beak, while the grooves in some aerodynamically efficient surfaces replicate the "riblets" of shark skin.

Task 13.4.1

Experimental flights with screws and discs • Material: fruits of maple, lime, birch, pine, poplar, dandelion etc.

Action: collect fruits, then draw or photograph them. The height of the class-room is sufficient for flight tests using limetree seeds, poplar and dandelion, but then use a window on the first or second floor for other tests (see box). The flight trajectories can be documented very clearly using a video camera with a large zoom area.

- a| Ascertain the rate of descent of the different fruits and their range.
- b| Describe relationships between the structure of the respective fruit and its flight performance.
- c| Compile information on the means of bionics for aircraft construction.

Task 13.4.2

Searching for the passenger • The tough seed coat conceals the seed itself – the part that needs to be dispersed by flight.

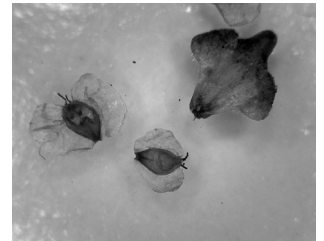
Materials: maple seeds, scalpel or knife, dissecting needles

Procedure: the blade is used to remove the tissue (epidermis) at the thickened part of the seed, and the brown, lentil-shaped seeds are cut out. The thin seed coat is also carefully removed. This reveals the plant embryo, which can now be further exposed by careful dissection with the needles.

- a| Draw the plant embryo. Name its parts and their functions.
- b| In the same way, examine the contents of other plant seeds.



Flying seeds from maple, lime and pine trees



Birch seeds with "hanger" (fruit scale)

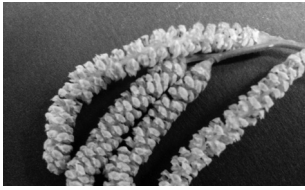
Sure Start

The flying seeds are put into a PVC tube about 2 m long and 4 cm in diameter, and one end is pushed out over the windowsill. Blow through the tube or tip it downwards, and the seed will be started on its flight without anyone having to lean out of the window.



The passenger: a maple embryo

13.5 Pollen flight – sex tourism in the plant kingdom?



Male catkin of the hazel bush



Hazel pollen under the microscope

The sun reveals all:

A ray of sunlight penetrates a dark room and shows up thousands of dust particles. In spring and summer the majority of this dust is made up of pollen grains.

Pollen from the Internet

A good overview of frequent pollen types can be found at: www.pollenundallergie.ch/index.cfm?parentsid=1214

Anyone who is allergic to pollen views the end of winter with mixed feelings, because it marks the start of the next pollen season. Thousands of pollen grains fly through the air and form thick, yellowish layers on window sills and ponds. But the earliest insects rapidly adapted themselves into flying transporters of flower pollen. What is this all about? Pollen grains are male germ cells, and all they are seeking is a female counterpart for sexual reproduction.

Task 13.5.1

Pollen under the microscope • Materials: brushes, transparent adhesive tape, microscope slide, microscope, methylene blue

Procedure: pollen dust is applied to a slide with a brush and placed under the microscope. Pollen frequency is demonstrated by attaching a strip of adhesive tape to a slide with its contact side facing up and exposing it to the outside air for 24 hours.

- Examine the pollen grains under the microscope. Stain the pollen nuclei with methylene blue. Make drawings. Pay particular attention to pollen with air sacs (conifers).
- Classify the pollen grains according to the plants which produced them.
- Determine the pollen density per square centimetre on the adhesive tape.

Task 13.5.2

Male blossom – a look inside the pollen hangar • Materials: stereo microscope, regular microscope, dissecting needles, male inflorescences (catkins) of hazel or birch (in Spring only)

Note: hazel and birch inflorescences and pollen will keep well in a glass jar sealed with a cloth and rubber bands. This makes you independent of the seasons.

Procedure: the inflorescences are examined with the stereo microscope and then dissected. Individual stamens should be examined under the microscope.

- Draw and describe the structure of the inflorescence and the individual flowers.
- Describe the content and function of the stamens.
- Only for those who are not allergic: release some pollen from ripe flowers by puffing or shaking.
- Explain why the hazel bush releases its pollen before budding.
- Collect information on the topic of pollen load and wind pollination. Give reasons in this connection as to why allergy sufferers are evidently unaffected by the pollen of other common plants such as roses or daisies.

13.6 Air-borne spore dispersal

There are more UFO's in one cubic metre of air than most people realise. For example, there are between 100 and 10,000 mould spores per cubic metre of air with even higher counts possible. The effects of mould spores that are invisible to the naked eye can be seen in the development of a mould colony. A week or more may elapse from the time a spore makes a successful "landing" on the appropriate substrate until a visible spot of mould appears, and so the experiment described below must be started at least two weeks before the start of the project.

Task 13.6.1

Showing the presence of mould spores • Materials: two Petri dishes, spatula, adhesive tape, microscope, water, alcohol, diet jam

Procedure: with a spatula, take samples from a freshly opened jar of jam, and spread evenly in two Petri dishes. Used Petri dishes should be thoroughly sterilised beforehand by wiping them out with alcohol. One dish is sealed with a lid immediately after adding the sample, while the other dish remains open for 24 hours and is then sealed in the same way. Any water lost during this time should be topped up. The experiment is finished when mould growth appears in the first Petri dish.

Transparent adhesive tape is pressed onto the mould spot for microscopy, and then fixed with the adhesive side down onto a slide previously moistened with a few drops of alcohol/water mixture (1:1). Low to average magnifications should be used.

- a| Examine mould, sporangia and spores under the microscope.
Make drawings.
- b| Find out about the structure, biological function, dangers and dispersal of moulds.
- c| Explain briefly the function of the jam samples in this experiment.

What are CFUs?

This abbreviation is short for "colony-forming units", that is, those spores or spore clusters that actually germinate. Non-germinating spores are not counted, so the total number of spores in the air is even larger.



Mould on a piece of toast with spores and spore carriers (sporangia)

Safety tip

Exposure to spores is reduced by covering them with alcohol and water and some of the germs are destroyed.