COMPARATIVE VERTEBRATE HISTOLOGY: RESPIRATORY SYSTEM LABORATORY EXERCISES

I) Histology of gills.

CVH134, skate gill; **CVH65**, dogfish gill (elasmobranchs). In the dogfish gill the cartilagenous skeleton of the gill arch is visible. Orient yourself by eye on this slide by locating the arch, then find filaments and secondary lamellae. Examine the slide in the microscope under low power to identify structural features of the gill arch. In the skate gill specimen there are several filaments carrying many secondary lamellae. Can you find any cartilage associated with the gill in this slide? On both slides, look at the structure of secondary lamellae at higher magnification to determine epithelial features and characteristics of the vasculature. Can you identify pillar cells and epithelial cells? Where would you most likely find chloride cells (ionophores)? What are they doing here? What cell type is prominent in the epithelium at the tips of secondary lamellae on the skate gill?

CVH147, brook trout gill, **CVH185**, cunner gill, **CVH184**, monkfish gill (teleosts). One gill arch with two filaments is seen on the cunner and monkfish gill slides. For all three slides, analyze the histological structures of the filaments and secondary lamellae as you have done for the slides above; identify all of the cell types you would expect to be associated with these structures. There may be cartilage and possibly bone in the filaments in some slides. Think about what you know of the overall patterns of blood and water flow in gills, and try to integrate this information with the gill structures you can see on the slides. Can you determine the relative thickness of the blood-water barrier in these species of bony fish compared with that in the elasmobranchs? How would you compare the surface area available for gas exchange in the gills of fish of these two groups?

CVH99, lamprey gill (cyclostome): Examine this section first by eye to get oriented; this section has been cut horizontally through the head in the oro-pharyngeal region. Identify gill pouches; does your slide have any branchiopores (openings to the outside of the head)? Under the microscope, identify gill filaments on each side of the gill pouches. The walls between the pouches have no skeletal support but there are dorsoventral cartilagenous rods in the external body wall near each chamber opening; can you identify the cartilage? Can you see bundles of muscle fibres in the pouch walls? What type of muscle is this? How can you tell? What is its function? Examine filaments and secondary lamellae. What type of epithelium is present on their surfaces? Note the high degree of vascularization within the filaments. How does the anatomy of the gas exchange apparatus in the lamprey compare with those of elasmobranchs and teleosts? How would you describe the flow of water through the lamprey gas exchange system?

II) Cutaneous respiration

CVH32, frog skin. Some aquatic and semiaquatic animals use cutaneous respiration as an accessory to gill or lung breathing. For example many amphibians, such as frogs and salamanders, that live in relatively moist environments, have capillary networks in the skin that are close to the body surface to reduce the gas diffusion distance. These networks may consist of a series of short capillary loops extending from the extensive dermal capillary network into the epidermis. These "epidermal" capillaries are not truly within the epidermis (which is by definition avascular), but are surrounded by both the epidermal and vascular basement membranes, although these are too thin to be seen in this slide. Identify capillaries in the dermis to become familiar with their appearance and size, then look for examples within the epidermis. The relative numbers of these epidermal capillaries differ in different regions of the skin; there are more epidermal capillaries in skin on the ventral body surface than on lateral or dorsal surfaces. You may not see any examples in the sections on your slide if they were taken from the lateral or dorsal integumental regions.

III) Histology of lungs.

Review the histology of the mammalian lung (use your histology textbook and slides **59, 70, 109** and **142** from the Human slide boxes for this; also examine slides **56** and **202** to review the structure of the trachea). Review the wall structure of the various regions of the conducting portion, the overall organization of the gas exchange regions, and the alveolar septal wall structure, including Type I (squamous) and Type II (surfactant-secreting) pneumocytes. For these and the following slides, think about the differences and similarities of gross and histological anatomy of the lung among the vertebrate classes.

CVH97, turtle trachea cross-section. Compare the structure of the reptilian trachea with that of mammals. A respiratory epithelium is present in the trachea of lower vertebrates; review the characteristics of this type of epithelium (hint: what is the full descriptive name for this epithelium?).

The trends in lung development in the vertebrates are toward increased septation or subdivision of the air spaces (thus increasing surface area for gas exchange), increased vascularization of the walls of the air spaces, and a decrease in the diffusion distance for gas exchange. Look for signs of these trends as you investigate the slides below.

CVH20, frog lung. The primary bronchus opens into the central airway within the lung, which is not extensively subdivided. Note the thick walls of the lung septae. What tissue type is prominent within the septal walls, and what is its function? The septal walls are not completely covered in capillaries; what does this indicate about the overall capability of this type of lung for gas exchange? Many capillaries will have one or more nucleated erythrocytes (oval shape, pink to reddish cytoplasm) in their lumens. Examine at high power an area with several capillaries to see the blood-air barrier; can you identify epithelial cells with thin flanges covering the gas-exchange capillaries? What can you see of the conducting portion of the lung? What type of epithelium lines this portion?

CVH167, toad lung. The septal walls are thinner than in the frog lung, and the tissue may be relatively lightly stained. Only part of one lung is shown. The septation is greater than in the frog lung. How does the structure of the respiratory part of the lung differ from that in the frog?

CVH88, turtle lung (reptilian). The large central air chamber is not shown on this slide; this chamber is subdivided into spaces called faveoli which are then further divided into subfaveoli around the periphery, and this is the region from which the sections were taken. The most common shape of a subfaveolus is a blind-ended sac with a neck narrower than the gas exchange region. There are few or no capillaries close to the surface in the neck region of the septal wall, but there is a rich capillary network in the walls of the respiratory region. Examine the slide at low power to determine the overall organization of the airway subdivisions (it may be difficult to find a complete subfaveolus with a neck and an exchange region, depending on how your section was cut). At high power, examine the walls of the faveoli and subfaveoli. Can you find a transition zone between respiratory epithelium (remember, no gas exchange occurs across this type of epithelium) and the epithelium in the gas exchange region? How does the structure of the septal wall compare with that of septae in the gas-exchange area of the amphibian lung?

CVH109, 110, Bird lung. The sections are oriented to show transverse views of multiple parabronchi. Infundibuli are seen as irregularly shaped outpocketings from the lumens of parabronchi (some parabronchi may have erythrocytes or congealed blood plasma, stained pink, in their lumens; this is an artefact of preparing the slides). Is there any smooth muscle associated with the walls of the parabronchi? What might be the role of this tissue type in the lung? On your slide, find an infundibulum that narrows to an air capillary, and determine the changes in the structure of the epithelium as you follow the narrowing of the air passage. Blood capillaries tend to be smaller in diameter than the smallest air capillaries; have oval or round profiles without irregular outpocketings;have a different type of epithelial lining and wall structure than do air capillaries; and may contain erythrocytes. Can you determine the relationship between blood capillaries and the terminal portions of air capillaries? How does the blood flow through the gas exchange area of the bird lung, in relation to the flow of air?

CVH186, seal lung. The overall structure of the mammalian lung is similar in most species, as you will have seen in your review of the mammalian slides above. In aquatic mammals such as seals and whales, which spend most of their time underwater, the lungs are squeezed during diving as the external pressure increases. When this happens, the alveoli partially or completely collapse and the septal walls become stuck together. All mammalian lungs contain Type 2 pneumocytes which secrete surfactant, but the lungs of many diving mammals contain higher numbers of these cells. Surfactant is a thin, complex lipid-containing film that covers the air side of the alveolar epithelium and acts to lower surface tension. Thus when the animals return to the surface after a dive and take a breath of air, the surfactant aids the separation of the septal walls so that the alveoli can open again. This effect also occurs in newborn babies; surfactant in the liquid filling the lungs at birth helps the first breath of air to open the alveoli after lung fluid is evacuated. Compare the alveolar structure and cell types present in the seal lung with those of the other specimens of mammalian lung listed above.