

### GENERAL CHARACTERISTICS OF RESPIRATORY SYSTEM

#### primary function

oxygenate blood, excrete CO<sub>2</sub>

#### secondary functions

- olfaction
- phonation
- temperature regulation

#### structural evolution

- deny particulate matter
- maximize surface area for gas exchange
- warm and humidify air

### COMPONENTS MAMMALIAN RESPIRATORY SYSTEM

#### ▶ conducting component

- nose, nasal cavity, nasopharynx
- larynx
- trachea, bronchi, bronchioles

#### ▶ respiratory component

- respiratory bronchioles
- alveolar ducts and alveolar sacs
- alveoli

#### ▶ pumping mechanism

- diaphragm
- rib cage
- neurological control

### conducting component - NOSE

#### ▶ consists of

- external nose
- nasal cavities
- paranasal sinuses

▶ supported by *bone* and *cartilage*

▶ lined by *mucous membrane*

### nose - EXTERNAL NOSE

▶ **specific** to each species

▶ affected by

- shape of supporting lateral nasal cartilages
- skin type around nose

▶ supported by **lateral nasal cartilages**

- dorsal and ventral
- may have accessory cartilage
- extensions of nasal septum

### nose - EXTERNAL NOSE

▶ dog, cat, sheep, goat

- cartilage complete laterally
- thick, hairless skin or *planum nasale* confined to area around nostrils
- well-defined philtrum

▶ pig

- cartilage complete laterally
- extra support by rostral bone medially
- *planum rostrale* continuous with upper lip
- small philtrum

▶ ox

- cartilage complete laterally
- *planum nasolabiale* continuous with upper lip
- no philtrum

▶ horse

- small cartilage laterally
- extra *alar cartilage* supports dorsal, ventral, medial
- nothing laterally → nostrils can stretch
- horse must breath by nose
- normal skin around nostrils

### nose - EXTERNAL NOSE

provide moisture for nose

▶ in ruminant and pig - glands in planum

▶ in carnivores (no gland in planum)

- lateral nasal glands

- glands in septum

- lachrymal glands

### NASAL CAVITY

▶ **nasal septum**

*perpendicular plate*

- caudal

- continuous with cribriform plate (both ethmoid bone)

*cartilaginous nasal septum*

- rostral

- supported by vomer

▶ have **nasal conchae** (turbinate bones)

- thin complex, bony scrolls projecting from inside of lateral wall

- types: dorsal, (middle), ventral, ethmoidal

### nasal cavity - NASAL CONCHAE

▶ **dorsal nasal concha**

- elongated, slightly curled scroll

▶ **ventral nasal concha**

- tightly folded series of scrolls

- more extensive than *dorsal nasal concha*

♀ **mucosal folds**

- rostral to conchae

- **straight fold** is rostral extension of dorsal concha

- **alar fold** is rostral extension of ventral concha

**bulbous enlargement** - divert air and increase evaporation

supported by **alar cartilage** in horse

▶ **ethmoidal conchae**

- series of folding plates

- caudal part of nasal cavity

### nasal cavity - NASAL CONCHAE (cont)

- linked with ethmoid bone

- extend up into frontal sinuses

### nasal cavity - NASAL MEATUSSES

**spaces** between *roof and floor nasal cavity*, and *dorsal and ventral conchae*

3 meatuses

- dorsal nasal meatus

- middle nasal meatus

- ventral nasal meatus

in horse, **common meatus** between conchae and septum

### nasal cavity - ASSOCIATED STRUCTURES

▶ **INCISIVE DUCTS** (nasopalatine duct)

- paired

- connect oral and nasal cavities

- nasal opening - floor nasal cavity at canine level

- oral opening - **incisive papilla** - caudal to upper central incisors

▶ **VOMERONASAL ORGAN**

- paired blind sacs run caudally from incisive ducts to level P 2-4

- cartilage support

♀ **function of ducts**

- epithelium both respiratory and olfactory

- pheromones and flehmen

- taste and smell

▶ **LATERAL NASAL GLAND**

- serous gland, microscopic (not exist in ox)

- near nasomaxillary opening; duct opens into middle meatus near end straight fold

- humidify inhaled air; may aid function for vomeronasal organ

- humidify nose

- thermoregulatory support

▶ **NASOLACRIMAL DUCT**

- from medial canthus eye into nasal cavity

### nasal cavity - ASSOCIATED STRUCTURES (cont)

- drains eye to prevent weeping; humidify nose and nasal cavity
- often blocked brachiocephalic breeds

in horse - no oral opening

### nose - PARANASAL SINUSES

#### ► GENERAL CHARACTERISTICS

- air-filled spaces inside bones connected to nasal cavity
- lined by mucoperiosteum
- named after bones where they lie

#### ► FUNCTIONS

- lighten skull
- insulate nervous centers
- protect eyes, nasal passages and cranial cavity
- absorb shock
- amplify voice
- increase area olfactory membrane

#### ► CLASSIFICATION

- all species: **frontal and maxillary sinuses**
- vary in size, shape and other sinuses
- openings into nasal cavity **narrow**
- blocked by mucosal swelling
- prevent drainage

### paranasal sinuses

#### ► MAXILLARY SINUS

- largest
- communicate with middle meatus via nasomaxillary opening
- some species have diverticula into
  - hard palate – **palatine sinus**
  - sphenoid bone – **sphenoid sinus**
  - medial aspect orbit – **lacrimal sinus**
  - nasal conchae – **conchal sinus**

#### ► FRONTAL SINUS

### paranasal sinuses (cont)

- opens into *ethmoidal meatus* (horse - opens into caudal maxillary sinus)

### paranasal sinuses - SPECIES

	horse (4 pairs)	ox (8 pairs)	pig (5 pairs)	dog (2 pairs)	cat (2 pairs)
<b>Maxillary</b>				✓	
- palatine	✓	✓		- maxillary recess (communicate with nasal cavity)	
- lacrimal		✓	✓	- coronoid tooth embedded lateral wall sinus → can infected	
- sphenoidal	✓	✓	✓		✓
- dorsal conchal		✓	✓		
<b>Frontal</b>	✓	✓	✓	✓	✓
condrofrontal		- frontal, parietal, interparietal, part of temporal, occipital bones	- frontal, parietal bones	- small, insignificant	reduce blockage, infection → flush ethmoidal meatus via sinus
ethmoidal	✓	- <b>conchal</b> diverticulum in adults	- large → difficult to stum mechanically		

### conducting component - NASAL CAVITY - microanatomy

both 2 regions have different mucosae

#### ► RESPIRATORY REGION

- paranasal sinuses
- part of dorsal, all ventral conchae
- lateral, dorsal, ventral nasal wall and part of septum

#### ► OLFACTORY REGION

- ethmoturbinates
- part of dorsal conchae
- part of nasal septum
- vomeronasal organ

### nasal cavity - RESPIRATORY MUCOSA

#### ► EPITHELIUM

- ciliated pseudostratified columnar with goblet cells
- in paranasal sinuses - more cuboidal to squamous, less glands and goblet cells

#### ► LAMINA PROPRIA and SUBMUCOSA

- loose connective tissue blends with periosteum, perichondrium
- leukocytes (eosinophils and lymphocytes)
- simple branched tubuloacinar mixed nasal glands (less in sinuses)
- erectile venous plexuses with sphincters



### nasal cavity - OLFACTORY MUCOSA

#### ▶ EPITHELIUM

- yellowish pigmentation

- 3 cell types

**sensory (olfactory) cells** - bipolar neurons, thickness, long, non-motile cilia

**sustentacular (supporting) cells** - slender, many microvilli (no cilia)

**basal cells** - spherical

### nasal cavity - FUNCTIONS

▶ olfactory

▶ respiratory

- filter (dust, bacteria)

- adjust temperature and humidity

### conducting component - NASOPHARYNX

- air from nasal cavity to nasopharynx via **choanae (internal nares)**

- *choanae* separated by vomer and dorsal to palatine bone (hard palate)

- connected to middle ear by **auditory (Eustachian) tube**

cartilaginous through open ventrally

keep middle air at surrounding pressure

horse: massive paired evagination ventrally, the guttural pouches

### conducting component - LARYNX

- **short musculo-cartilaginous tube** (a bunch of articulating cartilages held together by muscles, ligaments and membranes)

- connects nasopharynx with trachea

- supported by **hyoid apparatus**

### larynx - HYOID APPARATUS

pair bones

- thyrohyoid bone (articulate with thyroid cartilage)

- basihyoid (unpaired, lie transversely)

- keratohyoid bone

- epihyoid bone

### larynx - HYOID APPARATUS (cont)

- stylohyoid bone

- tympanohyoid cartilage

### larynx - FUNCTION

#### ▶ respiration

- maintain air pathway

- regulate airflow to lungs

#### ▶ deglutition

- prevent aspiration of food, saliva, etc.

▶ support **olfaction** - direct air through nasal passage

▶ **intrathoracic pressure regulation** - act as a valve

▶ **phonation** - vocal folds

### larynx - CARTILAGES

many articulating cartilages with ligaments and muscles

4 main cartilages and 1 minor

- **epiglottis** (elastic cartilage)

- **thyroid** (hyaline cartilage, 2 lamina and central body, open dorsally)

- **cricoid** (hyaline cartilage, complete ring)

- **arytenoids** (paired, hyaline cartilage)

- *muscular process* - lateral, crest shaped

- *cuneiform process* - elastic cartilage, part of epiglottis in horse, absent pig and ruminants (= wedge shaped)

- *corniculate process* - elastic cartilage, horn shaped, dorsal

- *vocal process* - attachment vocal ligaments

- **interarytenoid** (hyaline cartilage, carnivores and pigs)

### larynx - ARTICULATIONS

3 articulations

- **cricothyroid** - simple rotation around transverse axis

- **cricoarytenoid**

- rotation around transverse and sagittal axes

- slide to bring arytenoids closer or further

- **thyrohyoid** - simple transverse axis

### larynx - LIGAMENTS

7 ligaments (intrinsic and extrinsic)

- cricothyroid
- cricotracheal
- vocal
- transverse arytenoid
- thyroepiglottic
- hyoepiglottic
- vestibular

### larynx - WALL OF THE LARYNX

#### PAIRED MUCOSAL FOLDS

##### ▶ vestibular fold

- from arytenoid to epiglottis
- enclose cuneiform process, vestibular ligament and ventricular muscle
- absent in ruminants

##### ▶ vocal fold

- from vocal process of arytenoid to body thyroid
- more medial than vestibular fold and encloses vocal ligament
- *glottis* have space between them

##### ▶ aryepiglottic fold

- lateral margin of epiglottis to arytenoid (dog and horse)
- lateral margin of epiglottis to cricoid (cat)
- lies dorsal to arytenoid and cricoid (pig and ruminant)
- forms boundary of laryngeal entrance

#### LATERAL VENTRICLE (SACCULE)

- deep blind-ending pocket lateral wall larynx
- only in dog, pig, horse
- entrance between vocal and vestibular folds (between split vocal ligament in pig)

(MEDIAN VENTRICLE) - pig, horse; base epiglottis

#### LARYNGEAL MUCOSA

- stratified squamous epithelium - rostral to vocal folds
- pseudostratified columnar ciliated epithelium caudally

### larynx - ARTICULATIONS

4 sections

#### ▶ ADITUS LARYNGIS

- entrance
- aryepiglottic fold, epiglottis, corniculate process

#### ▶ VESTIBULE

- from aditus to vocal folds
- vestibular folds and lateral ventricle

#### ▶ RIMA GLOTTIDIS

- vocal folds and vocal process

#### ▶ INFRAGLOTTIC CAVITY

- continuous with trachea

### larynx - MUSCLES

#### ♀ INTRINSIC MUSCLES

- control movement of cartilages relative to each other
- close or open glottis by abducting or adducting vocal folds
- all attach to processes of arytenoids and rotate them to tension vocal folds (except for cricothyroid muscle)

#### ▶ Abductors - open glottis

##### dorsal cricoarytenoid muscle

- dorsal cricoid to muscular process of arytenoid
- abduct ventral edge arytenoid, draw vocal fold ventrally

#### ▶ Abductors - close glottis

##### cricothyroid muscle

- from lat surface cricoid to lat surface thyroid
- draw thyroid and cricoid closer → tense vocal folds without abduction

##### lateral cricoarytenoid muscle

- from lateral rostral border cricoid to muscular process of arytenoid
- draw vent edge arytenoid ventrally and medially, adducting vocal cords

##### transverse arytenoid muscle

- from muscular process of arytenoid, passes dorsally to other arytenoid



### larynx - MUSCLES (cont)

- fine tunes other muscles

#### thyroarytenoid muscle

- from epiglottis and thyroid (internal midline) to muscular process arytenoid

- in dog and horse, divided into ventricularis rostrally and vocalis caudally

- caudal part associate with vocal ligament to form basis vocal fold

- adduct arytenoids

### larynx - MUSCLES

#### ♀ EXTRINSIC MUSCLES

- control movement of larynx relative to whole body

- connect with hyoid bones, pharynx, sternum

#### ▶ move larynx rostrally

##### - thyrohyoid muscle

- origin: hyoid apparatus
- insertion: thyroid cartilage

##### - hyoepiglottic muscle

- origin: hyoid apparatus
- insertion: epiglottis

- **geniohyoid muscle** (with stylohyoid, mylohyoid, stylopharyngeus, palatopharyngeus)

- not attach directly to larynx
- anchor hyoid apparatus rostrally

- rostral movement - important in swallowing (deglutition)

#### ▶ move larynx caudally

- \*\*sternothyroid muscle (with sternohyoid; omohyoid in horses)
- important in strenuous exercise

### larynx - INNERVATION

2 nerves, both branches of vagus nerve

#### ▶ cranial laryngeal nerve

- external cranial laryngeal nerve (motor to cricothyroid muscle)
- internal cranial laryngeal nerve

### larynx - INNERVATION (cont)

#### ▶ caudal laryngeal nerve (recurrent laryngeal nerve)

- motor to all intrinsic muscles (except cricothyroid)
- different paths in LnR sides

#### ♀ damage/degenerate left recurrent laryngeal nerve

→ left laryngeal paralysis

- problem for **dorsal cricoarytenoid muscle** (only abductor)

→ can't abduct left vocal cord during exercise →

→ make noise or 'roaring'

- graded and surgical correction

- 'tie-back' operation (prosthetic laryngoplasty)
- nerve grafting using omohyoideus
- lateral ventriculectomy reduces roaring sound

### larynx - BLOOD SUPPLY

2 arteries

#### ▶ cranial thyroid artery

- from common carotid artery

#### ▶ cranial laryngeal artery

- either from common carotid artery or external carotid artery

### conducting component - TRACHEA

♀ from larynx to principal bronchi

♀ non-collapsible, supported by cartilage

♀ 2 parts

#### ▶ cervical

- two third of esophagus (upper part) located dorsal to trachea, one third of esophagus (lower part) shifts to left side caudal

- go along with many nerves and vessels

#### ▶ thoracic

- dorsal to cranial vena cava

- divide into 2 branches to base heart at 4th-6th inter costal space

### trachea - STRUCTURE

#### ▶ tracheal cartilages

- hyaline
- C-shape, open dorsally

#### ▶ annular ligaments

- fibro- elastic connections between cartilages

#### ▶ trachealis muscle

- dorsal aspect (gap in rings)
- smooth
- external to ring carnivores; internal others

### trachea - MICROANATOMY

#### ▶ mucosa

- pseudostratified columnar ciliated epithelium with goblet cells
- lamina propria of loose, vascular connective tissue
- longitudinal folds

#### ▶ submucosa

- seromucous tracheal glands

#### ▶ musculo-cartilaginous layer

#### ▶ adventitia

### trachea - ROLE

#### ▶ rigid tube for air passes through (can collapse cause pathology)

#### ▶ flexible and extensible

- flexible cartilage; incomplete cartilage rings
- longitudinal mucosa fold; elastic tissue in submucosa

#### ▶ trap and remove fine particles

### RESPIRATORY COMPONENT

#### ▶ lungs

#### ▶ pleura - thin membrane cover lungs and lining thoracic cavity

#### ▶ in thoracic cavity

- thoracic inlet
- thoracic wall
- diaphragm

different to *thoracic cage*

### respiratory component - PLEURA

#### ▶ serous membrane

- serous layer
  - simple squamous epithelium
  - thin lamina propria

#### ▶ serous fluid/exudate

- lubrication

#### ▶ lines thoracic cavity, form pleural sacs (R > L)

- come together medially, form mediastinum

- push medially, bound by connective tissue

- contain trachea, oesophagus, heart, vessels, etc.

#### ▶ pleural cavity in each sac

#### ▶ lungs bud from trachea, push out into pleura → enveloped by pulmonary visceral pleura

#### ▶ form walls of pleural sacs (parietal pleura)

- costal pleura

- diaphragmatic pleura

- mediastinal pleura

#### ▶ lungs expand to fill pleural cavities

#### ▶ pleural space

- narrow space between visceral pleura and parietal pleura

- contains pleural fluid

visceral pleura - cover lungs

parietal pleura - line pleural cavity

### pleura - FUNCTION PLEURAL SPACE AND FLUID

#### ▶ make lungs stick to inside of thoracic cavity

- slight vacuum in pleural space

- inborn surface tension of fluid

#### ▶ seal → avoid thoracic wall movement during lung expansion

#### ▶ lubrication for lung movement against inside thoracic wall

### pleura - MEDIASTINUM

#### ▶ partition

- 2 serous membranes

- connective tissue

▶ contains all thoracic structures (except lungs, caudal vena cava and right phrenic nerve)

#### ▶ 3 parts

- cranial mediastinum (pre-cardiac)

- middle mediastinum (cardiac)

- caudal mediastinum (post-cardiac)

### conducting component - NASAL CAVITY - microanatomy

both 2 regions have different mucosae

#### ▶ RESPIRATORY REGION

- part of dorsal, all ventral conchae

### conducting component - NASAL CAVITY - microanatomy

#### ▶ CLASSIFICATION



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