GENERAL CHARACTERISTICS OF RESPIRATORY SYSTEM

primary function

oxygenate blood, excrete CO2

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**

- diagram
- 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

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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**

- enlongated, sightly 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 MEATUSES

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

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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 (6 pairs)	pig (5 pairs)	dog (2 pairs)	cat (2 pairs)
Maxillary				✔ - maxillary recess (communicate with nasal cavity) - carnassial tooth embedded lateral wall sinus ⇒ can infected	
- palatine	✔	✔			
- lacrimal		✔	✔		
- sphenoidal	✔	✔	✔		✔
- dorsal conchal		✔	✔		
Frontal	✔ conchofrontal	✔ - frontal, parietal, interparietal, part of temporal, occipital bones - **cornual** diverticulum in adults	✔ - frontal, parietal bones - large → difficult to stun mechanically	✔ - small, insignificant	✔ reduce blockage, infection → flush ethmoidal meatus via sinus
ethmoidal	✔				

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

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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 **audiotory (Eustachian) tube**

cartilaginous through open ventrally

keep middle air at surrounding pressure

horse: massive paired evagination ventrally, the gutteral 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

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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
- aryepiglotic 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

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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 larygeal 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 larygoplasty)
  - nerve grafting using omohyoideus
  - lateral ventriculectomy reduces roaring sound

larynx - BLOOD SUPPLY

2 arteries

▶ **cranial thyroid artery**

- from common carotid artery

▶ **cranial larygeal 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

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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 corver 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

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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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