LABOKLIN
LABORATORY FOR CLINICAL DIAGNOSTICS

COMPENDIUM

2024/25

www.laboklin.com

Photos: Envato Elements (Cover), BD (blood culture bottles), Laboklin As of: December 2023

Dear colleagues,

Which test should be used for which purpose and what is important to know? The new Compendium provides answers to these questions by explaining the tests and methods, areas of application and how to interpret the findings. We hope you will find it useful.

What can Laboklin do, how fast and how much does it cost? These questions are answered in the Prices and Services catalogue which you will receive, as usual, in the middle of the year. The necessary price increases will have been included by then and – much more important – further additions to the services will have been made, because better is the enemy of good.

How can we work together? There is a nationwide courier service which you can request "the old-fashioned way" by telephone or simply by using "MyLab" which is available 24/7 and, of course, by e-mail. Or you just call during our laboratory opening hours. Online orders can be placed quickly and easily via the practice programmes or via "MyLab". Invoicing is done as you wish, either charging the owner of the patient or the practice. Our monthly collective invoices automatically take into account any turnover discounts. Because we do not want to tie you down with contracts, we want you to be able to entrust your samples to whoever you think suits best.

What help does the laboratory provide for communicating with the animal owner? We have the vbd website which provides comprehensive information about vector-borne diseases in various travel destinations, including regional and seasonal specifics. And we also have the 4Paws app which can be used to set reminders for drug administration or test frequencies as well as to request specific information on allergies or travelling. What is new: You enter the country and travel dates and the app reminds you when check-ups are due.

What help does the laboratory offer for working with the lab? You and your team can use the LaboRef app from Laboklin to quickly get answers about reference ranges, not only for dogs, cats and horses, but also for small mammals. The training programme at the Laboklin Academy offers something for the entire practice team – whether it is expert panels for colleagues or certificate courses for veterinary assistants, on-site events such as the Skin Day or exam preparation for veterinary assistants.

Of course, we do not operate in a vacuum: Our quality is **accredited** to the highest standards, so you can rely on the quality of our laboratory services. We are constantly improving, which has already earned us the title as one of the **100 most innovative companies in Germany** twice. We continue to learn and train – as a CCI training centre for several professions, as a training centre for various veterinary specialties and as a training centre for the European College of Veterinary Clinical Pathology (ECVCP). Thus, we believe that we are well prepared to meet your future needs. Our mission: Times are changing – and so are the demands that practices place on laboratories. What stays the same: A good laboratory is able to help the practice. That is why we want to keep supporting you.

With best regards from the laboratory,
Your Laboklin team

Dr. Elisabeth Müller
CEO LABOKLIN GmbH & Co. KG

LABOKLIN at a Glance

LABOKLIN GmbH & Co. KG is accredited according to DIN EN ISO/IEC 17025:2018

An overview of LABOKLINs range of services

Profiles and screenings
- Small animals
- Small mammals
- Birds
- Reptiles
- Horse
- Ruminants
- New World camels
- Pig
- Amphibians
- Fish

Blood examinations
- Allergy
- Endocrinology
- Function tests
- Haematology
- Immune status
- Clinical chemical parameters
- Serology/Infectious diseases
- Diagnosis of leukaemia/lymphoma
- Tumour markers

Hereditary diseases
- Dog
- Cat
- Horse
- Cattle
- Pig
- etc.

Microbiology and parasitology
- Bacteriology
- Mycology
- Virology
- Parasitology
- Maldigestion/Malabsorption
- Dysbiosis/Microbiome analysis
- Autovaccines etc.

Pathology
- Histopathology
- Immunohistology
- Cytology
- Exsudate/Transudate
- Cerebrospinal fluid
- Synovia
- Other aspirates
- Tumour genetic tests

PCR detection
- Dog
- Cat
- Small mammals
- Birds
- Reptiles
- Horse
- Ruminants
- New World camels
- Pig
- Amphibians
- Fish
- etc.

Other genetic examinations
- Sex determination in birds
- Breed analysis
- Identity and parentage
- DNA profile
- Species differentiation
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Water Tests
- Water of aquarium/ponds

Hygiene
- Hygiene examinations
- Profiles

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Abbreviations/Additional Information Concerning the Test Descriptions

Sample quantities
The indicated sample quantities are minimum quantities. Please note that larger minimum quantities may be required, depending on the type of test tube used (see Chapter 1.1.4, p. 19).

Sample material/Further information
Below you will find a list of our abbreviations. You will also find these abbreviations on our submission forms. The required materials for the individual tests are indicated in this compendium but may (for lack of space) not (all) be listed on the submission forms.

, (comma)	Information connected with comma: you can choose which sample material you want to submit (see p. 26)
+	Information connected with "+": you must submit all of these sample materials
!	refrigeration required (see Ch. 1.10.2, p. 32)
A	swab without medium
AM	abortion material
AP	contact plates
AS	ascites
B	bees
BAL	bronchoalveolar lavage
BI-D	bioindicator steam steriliser
BI-H	bioindicator dry heat steriliser
BL	bee larvae
BS	blood smear
CB	citrate blood
CP	citrate plasma
CSF	cerebrospinal fluid
EB	EDTA blood
EP	EDTA plasma
F	feather
FA	faeces
FG	liquid
FGW	formalin-fixed tissue
FL	fleas
FNA	fine-needle aspiration
GW	tissue
H	urine
HA	hairs
HB	heparin blood
HP	heparin plasma
HS	urolith
HSD	urine sediment
HT	skin
K	scab
KM	bone marrow
KW	aqueous humour
L	liver
Ln	lymph node
LQ	CSF
LSP	pulmonary lavage
M	spleen
MH	morning urine
Mi	milk
MSP	gastric lavage
N	kidney
NaFB	sodium fluoride blood
NSP	nasal lavage
OT	specimen slide
PSP	preputial lavage
S	serum
Sp	sperm
SV	synovia

TaM	tank milk
TBS	tracheobronchial secretion
TM	swab with medium
TSP	tracheal lavage
V	vomit
W	water
Z	tick

Test methods

AAS	atom absorption spectrometry
CEDIA	cloned enzyme donor immunoassay
cELISA	competitive ELISA
CLIA	chemiluminescence assay
CFT	complement fixation test
ddPCR	droplet digital PCR
EIA	corresponds to ELISA
ELISA	enzyme linked immunosorbent assay
FAVN	fluorescent antibody virus neutralisation
FLP	fragment length polymorphism
FTIR	Fourier transform infrared spectrometry
GCMS	gas chromatography-mass spectrometry
HAH	haemagglutination inhibition assay
HPLC	high performance liquid chromatography
ICA	immunochromatography assay
ICPMS	inductively coupled plasma mass spectrometry
IFAT	indirect fluorescent antibody technique
ISE	ion-selective electrodes
LCMS	liquid chromatography-mass spectrometry
MALDI-TOF	matrix-assisted laser desorption/ionisation – coupled time of flight mass spectrometry
MAT	microscopic agglutination test
NIRS	near-infrared spectroscopy
PARR	polymerase chain reaction for antigen receptor rearrangements
PCR	polymerase chain reaction
RBT	Rose-Bengal test
RIA	radioimmunoassay
SAFC	sodium acetate-acetic acid-formalin concentration
STRs	short tandem repeats (microsatellite analysis)
VNT	virus neutralisation test

Other abbreviations

AB	antibodies
AG	antigen
bdw	body weight
rpm	revolutions per minute
*	partner laboratory

Numbers in the test descriptions

(1)	Specifications apply to testing with method (1)
(2)	Specifications apply to testing with method (2)
(3)	Specifications apply to testing with method (3)

Duration The specified standard testing times apply from the date of arrival of the samples at Laboklin.
"Days" means "working days". Due to delays in transport, test duration may take longer for tests which are carried out by a partner laboratory.
The specified test durations are supplied without liability.

Species

Large animals	Horses and farm animals
Small mammals	Rabbit, guinea pig, rat, mouse, hamster, ferret, chinchilla and other small mammals which are kept as pets. In individual cases, tests for small mammals may also be applicable for small wild mammals (e.g. hedgehogs).
Small animals	Dog and cat
New World camels	Llama, alpaca; Being polygastric, New World camels may appear under the heading "ruminants".
Farm animals	Ruminants and pigs

Further notes

The obligation to notify the authorities upon suspicion of a disease applies to Germany.

The obligation to notify the authorities upon diagnosis of a disease applies to Germany.

>	greater than
<	less than

1 Pre-analytics

1.1 Blood, Plasma, Serum Samples

The first step in the process of examining a sample is the pre-analysis. Pre-analysis includes all steps from patient preparation, specimen collection and transport of the sample to the lab to the preparation of the sample for analysis.

1.1.1 Preparation of the Patient

Before taking a blood sample, the patient should normally fast for 10 – 12 hours, provided the physiology of the species concerned permits this. Otherwise, faulty results are to be expected, especially for cholesterol, glucose and TLI. In addition, parameters such as α-amylase, ALT, AST, bilirubin, total protein, triglycerides, serum bile acids, urea, leukocytes and calcium can be affected.
In horses, ruminants, New World camels and small mammals, prolonged periods of fasting are not recommended and fasting blood samples are not common. For special tests (e.g. insulin and glucose for the diagnosis of Equine Metabolic Syndrome), horses should not be given any concentrated feed, oats or access to pasture 4 – 6 hours before the blood sample is taken but may continue to eat hay. Ferrets should fast for a maximum of 2 to 4 hours prior to insulinoma diagnosis.
It is advisable to inform the owner about the influence of physical activity or stress on the results of a blood examination. Particularly muscular enzymes such as CK, LDH and AST can show increased levels in serum after physical exertion. Additionally, glucose and lactate can also show elevated serum levels.

Before doing any **allergy tests**, including feedstuff tests, any administration of corticosteroids should be stopped. To do so, the following withdrawal times are recommended:

- local/topical corticosteroids: 2 – 4 weeks
- oral corticosteroids (e.g. Prednisolone): up to 8 weeks
- depot cortisone preparations (e.g. Voren®): up to 3 months

If these times cannot be observed, false negative results are possible. If there is a positive result, the reaction class must be assessed taking into account the previous administration of cortisone.
Please note that other itch-suppressing medication may also have a negative impact on the allergy test. Our allergy team will be pleased to advise you.
Allergy tests should be performed during the season or at the end of the season and not earlier than one month after the onset of the clinical signs, as the test may be false negative if performed out of season.

1.1.2 Which Sample?

Details on the recommended material (blood, serum, plasma) for the requested test can be taken from our test descriptions or the submission form. For labelling the sample, it is also necessary to indicate the sample type (see Chapters 1.9, p. 26 and 1.10, p. 29).

Whole blood samples

EDTA blood (EB)

- For doing a blood count, EDTA blood is the most suitable material in mammals (however, for birds and reptiles it is heparin blood, see below).
- For the serological examination of the blood type, EDTA whole blood is needed as well.
- As the cells in the sample are not stable, EDTA samples for haematological tests should not be older than 48 hours.
- For most PCR analyses and genetic tests, EDTA blood is required.
- To determine certain parameters such as ACTH , CPSE (prostate), normetanephrine/metanephrine ratio, parathyroid hormone-related protein*, taurine or pro-BNP, only EDTA plasma which was promptly centrifuged and cooled can be used to obtain reliable results.

Heparin blood (HB)

- To collect heparin samples, lithium heparin (LiHep) tubes are available.
- For doing a blood count in reptiles and birds, lithium heparin blood should generally be used.
- Since the amount of blood is often very low in small mammals, reptiles and birds, lithium heparin tubes are particularly suitable, as heparin whole blood can be used to do the blood count and heparin plasma to determine clinical chemistry parameters as well as T4.
- For the PCR, lithium heparin whole blood should only be used under exceptional circumstances, as lithium heparin can inhibit the PCR and might thus lead to false negative results.

Citrate blood (CB)

- To determine the coagulation parameters, only the appropriate citrate tubes should be used. For getting a correct evaluation, their shelf life may not be exceeded. It is also necessary to have an exact mix ratio of 1:10 (1 part citrate + 9 parts blood).
- For correctly performing platelet function tests, citrate whole blood is required.

Sodium fluoride blood (NaFB)

- Sodium fluoride inhibits enzyme activities which lead to a reduction of some parameters. It should be used for the correct determination of glucose and lactate.
- Make sure to observe the fill level when using sodium flouride tubes. Because of the smaller sample volume that is expected in small mammals, it is also possible to submit either serum which was promptly centrifuged and separated (after 30 minutes) or plasma (immediately).

Plasma

- Samples are drawn into tubes **with** anticoagulants (heparin, EDTA, citrate).
- Fill volume: Fill the sample tubes exactly up to the mark. If the quantity is too small or too large, results may be incorrect.
- Can be centrifuged immediately after collection (10 min, 2000 g).
- Remove the supernatant by pipette and transfer it into an uncoated test tube, then indicate the sample materials on the test tube or use the appropriate bar code label (see Chapter 1.10, p. 29)
- Please note: The additives limit the number of analyses!
- Heparin plasma (HP) is needed for many clinical-chemical examinations. HP cannot be used for agglutination tests.
- The collection of EDTA plasma (EP) for clinical-chemical and/or serological parameters should only take place in exceptional cases, as EDTA disturbs through various mechanisms the measurement of individual parameters such as calcium, magnesium and AP. Likewise, potassium cannot be determined when using EDTA plasma, since EDTA is added as K-EDTA.
- Some coagulation parameters can only be analysed using citrate plasma (CP). Performing platelet function tests using centrifuged citrate plasma is not possible.

Serum

- Samples are drawn into tubes **without** anticoagulants.
- Allow to stand for 30 – 60 min.
- Centrifuge for 10 min at 2000 g.
- Remove the supernatant by pipette and transfer it into an uncoated test tube, then label the test tube.
- For the correct determination of individual parameters, only serum should be used (see detailed descriptions provided for the individual parameters).
- Sending non-centrifuged samples should only be done exceptionally (e.g. in case of a very low sample quantity), as the transport might result in cell damage and thus lead to haemolytic serum.

An overview of the different tubes can be found in Chapter 1.9, p. 26.

1.1.3 Factors Interfering with Analysis

Haemolysis

Haemolysis is caused by leakage of intracellular components of the erythrocytes such as phosphate, iron, potassium and especially haemoglobin due to a damage of the cell membrane. Haemoglobin causes a red colouration of serum/plasma which primarily interferes with the photometric testing done in clinical chemistry.

Lipaemia

Lipaemia refers to the milky/turbid discolouration of serum/plasma due to triglycerides. It is mostly caused by diet- or stress-related factors. Lipaemia can also occur as a result of endocrinological diseases like Cushing's syndrome or hypothyroidism.
Lipaemic samples often complicate the measurement of certain clinical parameters, e.g. bilirubin.

Icterus

Icterus is a yellowish discolouration of serum/plasma. Excess amounts of bilirubin, which is the reason for the yellow colouring, are normally caused by a medical condition and cannot be influenced. Very severe icterus may sporadically affect certain parameters. The yellow colouration is physiological in horses.

Interfering factor	Parameter	Level
Haemolysis	LDH, HBDH, CK, AST, bilirubin, creatinine, PO4, K, Fe, fructosamines	↑
Haemolysis	Ca, glucose, Mg	↓
Lipaemia	ALT, AST, GLDH, γ-GT, AP, bilirubin, creatinine, haemoglobin	↑
Lipaemia	amylase, Na, Cl, K	↓

Medicine	Parameter	Level
Penicillin G	K	↑
Tetracyclines	PO4	↑
Tetracyclines	K	↓
Salicylates	CK, AP, glucose, Na, total protein	↑
Salicylates	K, Ca	↓
Corticosteroids	CK, AP, glucose, Na, total protein	↑
Corticosteroids	K, Ca	↓
Phenylbutazone	Ca, Na	↑
Barbiturates	CK	↑
Halothane anaesthesia	CK, PO4	↑

Glucose infusion	glucose	⬆
Glucose infusion	PO4	⬇

1.1.4 Specific Features

Blood counts
- EDTA or lithium heparin blood
- When collecting the sample, discard the first 0.5 ml of blood, if possible, as they contain an increased amount of coagulation factors, or first obtain a serum sample.
- Let the blood run down slowly on the side of the sample tube.
- Pay attention to the fill volume! Preferably fill up to the mark, since an insufficient volume can result in changes in cell morphology. Do not overfill the tube in any case, as the sample might clot.
- After drawing the sample, tilt the test tube carefully several times. Do not shake it.
- When requesting haematological analysis, a blood smear should always be supplied in addition to whole blood.
- Do not store blood smears in the refrigerator and not close to formalin.
- Pack the samples frost-proof in winter; possibly cool them in summer.
- Reliable results can only be obtained from samples not older than 48 hours.

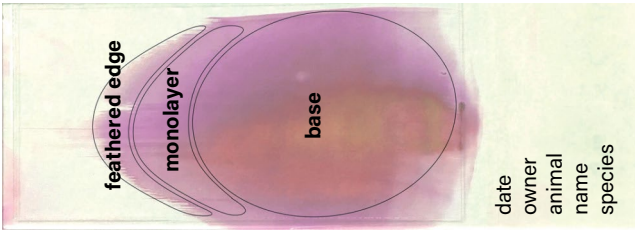


Image of a blood smear showing the base, monolayer and feathered edge as well as the labelling, stained with Diff-Quik.

Clinical chemistry of serum or heparin plasma
Prompt centrifugation of the samples will lead to better test results, as it reduces the risk of haemolysis caused by transportation. However, serum should be allowed to stand for a minimum of 30 min to ensure a complete clotting of the sample.
Serum samples can also be shipped frozen; they will then reach the laboratory cooled. Repeated freezing/thawing, though, should absolutely be avoided.

Determination of glucose and lactate
- Requires sodium fluoride blood or sodium oxalate blood or serum which was promptly centrifuged.

- **Fill volume:** Fill the sample tubes exactly **up to the mark**. If the quantity is too small or too large, results may be incorrect.

Coagulation parameters

- Determination is carried out using sodium citrate plasma which is obtained from citrate blood with the mix ratio being 1:10 (1 part citrate + 9 parts blood). Centrifugation should take place promptly (< 1 hour) at the practice. When testing for the von Willebrand antigen, it is imperative to do this promptly after collection. For further information, see also Chapter 1.1.2, p. 16.
- If commercial citrate-treated tubes are used, the expiry date needs to be checked before collecting the sample. Expired tubes may no longer be used, as skewed results are to be expected. When drawing the sample, special attention must be paid to the **exact fill level** (marking on the tube).
- If no commercial tubes are available, sodium citrate 3.13% can be drawn into a syringe.
- No heparinised needles or catheters may be used.

Sample collection for bone marrow cytology

- Sample material from the first aspirate should be used to prepare the smears for cytological examination (avoid contamination with peripheral blood).
- The syringe used for aspiration should be preloaded with an anticoagulant. The aspirate should be placed into an EDTA, lithium heparin or citrate tube at the latest immediately after the puncture and then inverted well to avoid clots.
- To prepare a smear, the aspirate is put in a Petri dish and gently inverted in order to find the bone marrow spicules.
- The spicules are each placed on a slide and carefully spread to form a monolayer.
- The remaining aspirate is then put back into the tube (wetted with the same anticoagulant) and sent in as well.
- In addition, peripheral blood is collected in a tube, a blood smear is prepared and both are also sent to the laboratory.

Sample material

- When requesting several services, it is necessary to submit **two samples of the same material** if freezing or exclusion of air is required for one of the services and it is also a service provided by a partner laboratory (marked with *). For example, when requesting ionised calcium* (exclusion of air required and also a service by a partner laboratory) and another parameter in serum, two serum samples must always be sent in, as one serum sample is forwarded to the partner laboratory without being opened.

1.2 Microbiology

- It is important to collect samples as sterile as possible to avoid contamination with physiological flora.
- Swabs for bacteriology (aerobic and anaerobic microbes) and for mycology should be sent with a transport medium ("swab with medium" = TM) to protect the microbes during shipment.
- For swabs without transport medium, see Chapter 1.6 PCR, p. 24
- If both a culture and a PCR test should be done, it is necessary to send in 2 swabs (one swab with and one without transport medium).
- Urine should be sent in a sterile tube using a swab with transport medium or using Uricult, always in combination with a urine sample. If cystocentesis urine is sent in, please make sure to remove the needle.
- Hairs and/or skin scrapings (without the scalpel!) for the diagnosis of dermatophytes are best sent in a sterile container, a paper bag or in aluminium foil.
- For sending faeces/excrement, special transport tubes should be used, no bags or gloves tied with a knot; also avoid the use of glass containers.
- **Blood culture bottles can be ordered with prior written notice (subject to a charge).** Information on the different blood culture bottles available can be found in Chapter 14.1, p. 252 under the service Blood Culture.
- For all swabs for bacteriology, the **location** (sampling site) and the **species** must be indicated on the submission form. This is, for example, necessary for the evaluation of antibiograms, but also if respiratory pathogens like Bordetella bronchiseptica and Histophilus somni are suspected, as special culture media are required!
  For the detection of Histophilus somni and Mannheimia haemolytica, a deep swab needs to be taken.

1.3 Hygiene

The **test materials** and the instructions will be sent to you after we have received your submission form. Samples can be collected up to the expiration date of the test kit, or up to a maximum of 3 days for test sets designed for devices for cleaning and disinfecting surgical instruments as long as the kit is stored according to the specifications in the accompanying documents.
For monitoring the **surface disinfection** you will be provided with contact plates.
The surfaces to be sampled have to be cleaned and disinfected and must be well dried before sampling. The contact plates, which need to be labelled on the bottom, need to be stored at room temperature and returned to the laboratory within 24 hours together with the filled-in submission form.

The bioindicators necessary for evaluating the proper functioning of the **sterilisers** can be applied right in the device together with the regular sterilisation material. After testing, these bioindicators and the positive control need to be stored at room temperature and sent promptly to the laboratory together with the filled-in submission form.

For testing the disinfection of **endoscopes**, two swabs with medium, two rinse samples and a water sample from the endoscopy water bottle are required for each endoscope. As described in the instructions, it is necessary to store the collected samples at room temperature and return them to the laboratory within 24 hours.

For testing **devices for cleaning and disinfecting surgical instruments**, the test set components (bioindicators and transport controls) must be requested from the laboratory and can be stored at 7 °C to 10 °C for a maximum of 3 days before use. Once the hygiene tests have been completed, the components need to be stored at room temperature and sent to the laboratory within 24 hours together with the filled-in submission form.

If you participate regularly (2x a year) in these hygiene tests, you will get a **certificate** stating the successful annual monitoring of your device (steriliser, endoscope, device for cleaning and disinfecting surgical instruments) or the surface disinfection test.

1.4 Water Examination

To take water samples from **aquariums/ponds** for testing **chemical water parameters**, you need a non-sterile glass or plastic container (e.g. a 500 ml bottle which previously contained water).
To obtain a representative sample without any air included, collect the sample approximately in the middle of the **aquarium** and close the container under water.
Samples from **ponds** should be taken in an area of the pond with little water flow, not close to the filter and not directly underneath the surface.
If possible, avoid larger pieces of dirt in the sample.
When shipping the samples, cooling is recommended. Please indicate on the submission form whether it is a freshwater or a saltwater sample.

1.5 Histology and Cytology

1.5.1 Histology and Immunohistochemistry

When submitting tissue samples for histopathological and immunohistochemical examinations, the following points must be observed:
- artefact-free extraction of a typical lesion sufficient in size (diameter > 0.5 cm)
- immediate fixation (4% neutral buffered formaldehyde ≙ 10% formalin)
- preparation of an anamnesis including diagnostic task and clinical picture
- shipment in a suitable container (available from us free of charge)
- Immunohistochemistry can always be done after histopathology with the material supplied.

Detailed explanations:
As a sample, a representative piece of tissue free of preparation artefacts (e.g. disruption, squashing, electrocoagulation) should be taken. The diameter of the sample should not be less than 0.6 cm. An exception to this are samples which, for technical reasons, cannot be obtained otherwise (such as endoscopically taken stomach biopsies). Furthermore, it should be borne in mind that samples which are too small only provide little information, whereas samples that are too large cannot be fixed properly. Pieces of tissue with an edge length of 1 cm are recommended. However, this might vary depending on the lesion to be examined, the sampling site and the diagnostic task.
Small lesions should be placed centrally so they are not overlooked and thus truncated during preparation. If in doubt, several samples should be collected.

1.5.2 Skin Punches

As skin samples, punch biopsies of all dermal layers with a diameter ≥ 0.6 cm are to be submitted. Primary lesions from several locations should be selected. The biopsied area should not be pre-treated by scraping or shaving. The anamnesis should contain all relevant data which might be important for the diagnosis. It is recommended to use our submission form Pathology, which especially focuses on skin and tumour diagnostics, but also leaves room for any other type of anamnesis.

1.5.3 Cytology

Samples can primarily be taken by puncture (with or without aspiration) or by wipe test. Fine needle aspiration is the most common technique. A thin hollow needle (G22 – G27) is used with or without (needle-alone) being attached to a syringe. With the syringe attached, a vacuum is created and, if possible, the tissue should be punctured several times in different directions. Before detaching the needle, the vacuum must be released to avoid the material receding into the syringe. The material obtained is then pressed out of the needle onto the side of a glass slide. A second slide is placed flat at a right angle on top of the first one and is then carefully pulled away across the slide.
If the sample is more liquid, a steeper angle (45°) – like in a blood smear (see Chapter 3.1, p. 36) – should be applied.
For the cytological examination of aspirates, excretions or secretions, the fluids obtained are centrifuged at 2500 – 3000 rpm for three to five minutes. The supernatant is decanted and the sediment is carefully spread like a blood smear and shipped air-dried. Please indicate on the submission form whether it is a sediment smear or a fresh specimen. If the aspirates are sent directly, uncoated and EDTA tubes should be used as test vessels.
For bronchial, conjunctival and vaginal cytology, the swab obtained (cytobrush) should be rolled onto a glass slide, not smeared.

All smears should generally be sent in air-dried, but unfixed. If desired, the smears can already be stained at the practice (please note: do not use a cover glass). The most important point is to create a thin smear consisting of only one layer (monolayer). The most common reason for getting a limited quality up to not being able to assess at all are smears that are too thick.

1.6 Polymerase Chain Reaction (PCR)

PCR is a very sensitive and specific method for the **direct detection** of infectious agents. Via PCR, gene sequences characteristic for the respective pathogen are reproduced and detected – if necessary, even of pathogens which are no longer viable. The sample material that must be supplied for the PCR highly depends on the pathogen to be detected and the present signs or the diagnostic task. Depending on how the pathogen has spread in the body and its excretion, different sample materials are suitable.

At this stage of infection, pathogens causing viraemia, parasitaemia or bacteraemia can be detected directly in an **EDTA blood sample** (EB). Lithium heparin is less suitable as an anticoagulant, as it can inhibit the PCR. **For blood samples or other liquid samples, an amount of at least 0.2 ml is required.**

In contrast to bacterial culture/mycological examinations, for PCR tests it is recommended to use sterile **swabs without transport medium** ("swab without medium" = A, "dry swab"). If the concentration of the pathogen is low, swabs in a medium can lead to false negative results. There are a few exceptions where a special transport medium is required. For collecting the sample, the swabs can be moistened with physiological saline solution. For PCR tests, so-called cytobrushes (brush swabs) are also suitable, which can be shipped in an uncoated sterile tube.

For the detection of pathogens in faeces, a sample of approximately the size of a hazelnut is needed. For some agents (e.g. coronavirus, Tritrichomonas foetus) we recommend collecting faecal samples for 3 days, since these pathogens are excreted intermittently in the faeces.
Further sample materials, e.g. skin biopsies, organ material, urine, synovial fluid, CSF, bone marrow aspirates and lymph node aspirates, for PCR tests are best sent in sterile, uncoated test vessels. Fixation solutions such as formalin or the like can lead to DNA degradation, PCR inhibition and thus to false negative results.
Samples do not normally need to be sent cooled. Until it is dispatched, the sample material can be stored in the refrigerator at 2 – 8 °C. Repeated freezing/thawing should absolutely be avoided.

Please note: Creating an antibiogram is not possible after doing a PCR test.

1.7 Genetic Testing

As sample material for the molecular genetic detection of hereditary diseases, for parentage analysis as well as for the genetic determination of coat colours and blood groups, **EDTA whole blood samples (approx. 1 ml)** are suitable. Alternatively, in dogs and cats, buccal swabs, so-called cheek swabs, can be used. For each animal, **2 buccal swabs** (wi-

thout transport medium) or 1 special swab should be supplied. To create DNA profiles and parentage reports in dogs and cats, we recommend to always send in a blood sample. For all genetic testing in horses, it is sufficient to supply about **20 hair roots** from mane or tail for DNA isolation.

EDTA blood is the most suitable sample material. It is absolutely essential to use EDTA as anticoagulant. Lithium heparin or citrate are unsuitable as anticoagulants, as they may inhibit the subsequent PCR. In very rare cases, haemolysis induced by transport or extreme stress during sample collection might lead to the situation that no result can be obtained. However, the percentage of blood samples which cannot be evaluated is extremely low, being < 1%.

Buccal swabs, often incorrectly called saliva samples, are very suitable sample materials for genetic testing in dogs and cats, as long as the sampling procedure is performed correctly observing the following rules:

1. The animal should not have eaten anything for about 1 hour prior to the sample collection. It should be ensured that puppies and kittens have not been nursed for a minimum of 2 hours, as otherwise maternal cells might skew the results.
2. When taking the sample, it should be scrubbed strongly at the inside of the cheek to make sure that enough cells of the oral mucosa and thus genetic material is attached to the swab. Genetic testing can only be conducted if enough genetic material adheres to the swab. Generally, saliva alone is not sufficient. However, there should not be any blood on the swabs!
3. In order to prevent the growth of bacteria and mould, the swabs should be dried for about 2 – 4 hours after collecting the sample. This is done best by keeping the test tubes a little open for a while.

As there is considerably less cell material available from mucosal swabs compared to blood samples, it is not always possible to isolate enough DNA from buccal swabs for a genetic test. This applies to about 5% of the submitted buccal swabs. We recommend sending two buccal samples per animal, so there is more material available for testing.

Special swabs are required for certain tests such as the LaboGeneticsXXL package. They are also suitable for the Premium SNP DNA profile. Please note that we still recommend an EDTA blood sample for both tests. For the recommended tests, you can order special swabs from us free of charge. In order to take the special swabs correctly, the following aspects must be observed in addition to the fasting period and the specific requirements when taking a buccal swab (see points 1 and 2 in the previous section on buccal swabs):

Hold the tube upright and unscrew the cap. Avoid any contact with the liquid. Should there be any contact with the skin, rinse immediately with plenty of water. After collecting the sample, insert the swab into the tube. Break it off at the predetermined breaking point, replace the cap, close the tube tightly and place it in the outer packaging provided by Laboklin.

There is **one** special swab provided for each animal.

For horses, **hair roots** can be used to perform genetic examinations. To do so, about 20 pulled mane or tail hairs are needed. If samples are taken from various animals, hands must be cleaned thoroughly after each sampling – even a single hair of a different animal can skew the result.
Hairs can, for instance, be shipped in little plastic bags or in envelopes. It is, however, absolutely necessary to make sure that the hairs are put in a closed envelope, separate from the submission form, when sent in.

There should not be any blood samples sent in for cattle from multiple births because of a possible blood chimerism, but if the test allows it, hair roots, sperm or tissue samples can be used. One exception to this is the freemartin test, for which a blood sample is mandatory.

If you wish to supply sample materials different from those listed above for performing genetic tests, please contact us before sending the samples.

1.8 Sample Material/Shipping Material

Note regarding the sample materials listed in the test descriptions from Chapter 3 onwards:

If the abbreviations are separated by a comma, you can choose the material which is easiest for you to collect from the given list. When collecting sample material for the detection of a pathogen using PCR, you should preferably collect that material from the listed alternatives which is likely to have the highest concentration of pathogens.
If the specifications are connected by one or more "+", both or all the materials joined with "+" need to be provided for determining all the parameters of the selected testing block.
The materials required for the individual tests are also indicated on the submission forms, however, for lack of space, not always completely.

The **following sample** and **shipping containers** are available for the collection and transport of the samples. They are **consecutively numbered**. These are not order numbers; you will find the order numbers under "MyLab", on the submission forms or on the special order form for shipping material.

(1) EDTA tube#

EB = EDTA blood: It can be shipped in this tube (+ No. 8).
EP = EDTA plasma: EDTA blood has to be centrifuged and the supernatant needs to be transferred into a neutral tube (e.g. Eppendorf tube). It must then be marked accordingly as EP or labelled with the appropriate bar code.

(2) Heparin tube#

HB = Heparin blood: It can be shipped in this tube (+ No. 8).
HP = Heparin plasma: Heparin blood has to be centrifuged and the supernatant needs to be transferred into a neutral tube (e.g. Eppendorf tube). It must then be marked accordingly as HP.

(3) NaFB = Sodium fluoride blood
With NaFB samples, too, please pay attention to the labelling.

(4) S = Serum#
To collect serum, the coagulated blood should be centrifuged at 2000 g 30 minutes after being collected. The supernatant should then be transferred into a neutral tube or another serum tube (remove beads before!) and marked accordingly as serum or labelled with the appropriate bar code.

(5) Citrate tube#
CB = Citrate blood: It can be shipped in this tube (+ No. 8).
CP = Citrate plasma: The sample should be centrifuged and the supernatant needs to be transferred into a neutral tube (e.g. Eppendorf tube).
It must then be marked accordingly as CP.

(6) Salivette®
for collecting saliva samples

(7) Blood smear
Blood smears should always be sent in air-dried, unfixed and unstained. For transportation, the depicted transport covers (shipping containers) are suitable. Before transport, store at room temperature (may not be cooled).

(8) Shipping containers for blood tubes or urine tubes

(9) TM = Swab with transport medium
(**orange:** thin swab, Amies medium clear;
black: thick swab, Amies with charcoal)

(10) A = Swab without transport medium, (dry swab)

(11) Shipping container for swabs with/without medium

(12) Urine tube (suitable shipping container see No. 8)

(13) Container for histology (formalin tube with shipping container)

(14) Faeces tube with shipping container

(15) Set of blood culture bottles (aerobic and anaerobic)

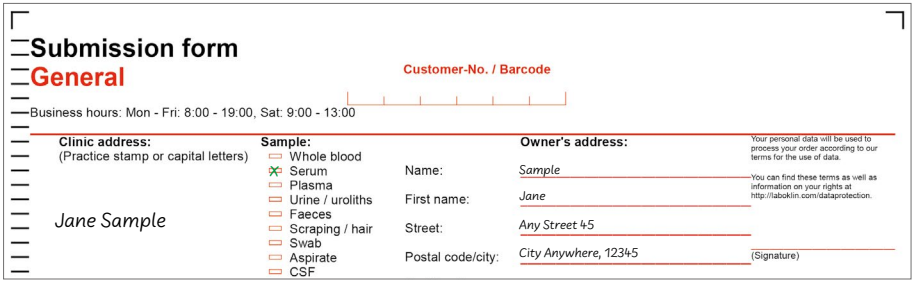
(16) Blood culture bottle Peds Plus™

On special request, **small test tubes** (see each of the tubes shown on the left) are provided for collecting small amounts of EDTA blood, EDTA plasma, heparin blood, heparin plasma, citrate blood, citrate plasma and serum, e.g. from small mammals. If required, please **order** these **small test tubes** by **e-mail** or **telephone only.**

At your express request (information by telephone or e-mail), we can also send you vacuum tubes for the examination of blood samples at Laboklin.

1.9 Labelling

- The name of the animal or the owner and, for farm animals, the ear tag number(s) should be clearly marked on the submission form and the sample. Alternatively, bar code labels can be used to unmistakably identify the sample and the form – they will automatically be sent along when submission forms are ordered. For farm animals, there are special sample lists for the submission of several samples, even from different animals in a livestock.
- For function tests, also indicate the respective time of sampling.



Submission form

General

Customer-No. / Barcode

Business hours: Mon - Fri: 8:00 - 19:00, Sat: 9:00 - 13:00

Clinic address:
(Practice stamp or capital letters)

Jane Sample

Sample:
- ☐ Whole blood
- ☒ Serum
- ☐ Plasma
- ☐ Urine / uroliths
- ☐ Faeces
- ☐ Scraping / hair
- ☐ Swab
- ☐ Aspirate
- ☐ CSF

Owner's address:

Name: *Sample*
First name: *Jane*
Street: *Any Street 45*
Postal code/city: *City Anywhere, 12345*

Your personal data will be used to process your order according to our terms for the use of data.
You can find these terms as well as information on your rights at http://laboklin.com/dataprotection.

(Signature)

Jane Sample Veterinarian
Any Street 45
City Anywhere, 12345

05000

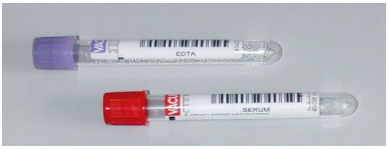
Patient / Name
Material: EDTA, Serum
05000-01440 … 05000-01445

Bar code labels:

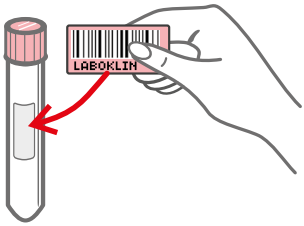
On one sheet, you will find the labels for 6 patients one below the other. For each patient, there are labels for your laboratory journal, the submission form and to mark the sample tubes/vessels to be sent.

There is a pre-printed label for serum and EDTA; for any other label, the material must be added in handwriting.

Please stick the bar code exactly over the tube label so that the content is still visible through the uncovered areas.

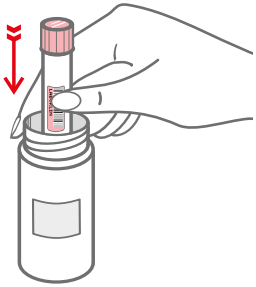


Labelling of samples and shipping materials

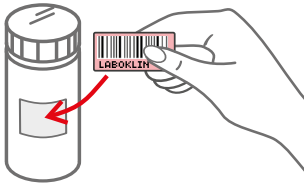


Step 1
Stick the bar code onto the test tube

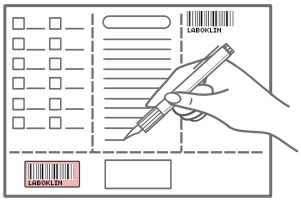
Step 2
Fill the test tube



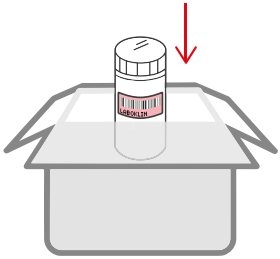
Step 3
Test tube into shipping container



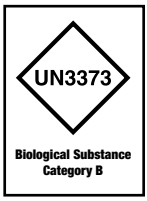
Step 4
Additional bar code onto the shipping container



Step 5
Completely fill in submission form and, if necessary, sample list



Step 6
Put sample and submission form and, if necessary, sample list, with sufficient cushioning material into the envelope/cardboard box



Step 7
Please choose the correct label and stick it on the box

Exempt Animal Specimen

Step 8
Pay attention to correct shipping information

1.10 Packaging and Transport

1.10.1 Packaging Requirements

Please remember to pack your shipment according to EU regulations (European Agreement concerning the International Carriage of Dangerous Goods by Road, ADR, and International Air Transport Association, IATA):
Generally, transport containers that are transparent, break-proof and contain absorbent material for leakage protection should be used and then packed, together with the submission form and cushioning material (not provided by the lab), in the transport (courier) box (min. dimension of 100x100x100 mm). Volume restriction: sample of 1000 ml (applies to liquid samples) or a total weight of 4 kg (applies to illiquid samples). LABOKLIN provides such protective outer packaging free of charge.

There are 2 possible **categories of samples.** The outer package needs to be tagged according to the respective category with the labels shown in the illustration above.
An **exempt animal specimen** is a patient sample for which there is minimal likelihood that pathogens are present (e.g. blood, serum or formalin-fixed tissue samples). Classification must depend on professional judgement which is based on the anamnesis, the signs, the patient's individual circumstances and local endemic conditions. In case of doubt, it is recommended to ship as infectious substance of Category B.
Infectious category B samples (swabs, urine, faeces etc.) must be marked as "Biological substance, Category B" and "UN 3373"; while the specification "UN 3373" needs to be in a rhomb of at least 5 cm x 5 cm of size. The edge of the rhomb must be at least 2 mm wide and the letter height of both specifications must be at least 6 mm.

Important:
The sender is liable for the goods to be transported (i.e. sender is liable to recourse in case of damage/costs caused by samples that are not properly packed).
If requirements are not met, there is a risk of your shipment being returned to you by the courier company.
Please adhere to your local national regulations as well as to the EU regulations concerning the transport of the biological samples no matter whether you send them per post or courier. In different countries different rules can apply.

Please do not to leave any needles in the sample tubes!
Do not seal the tubes!
If protective covers/transport containers are used, the lids will remain securely closed.

For shipment from a non-EU country, please contact LABOKLIN in advance.
Should you have any other questions, please do not hesitate to contact your local LABOKLIN representative or contact us directly: service@laboklin.com.

1.10.2 Transport of Cooled or Frozen Samples

For certain tests, it is necessary to cool or freeze the samples after collection. The cold chain must not be interrupted **until the sample arrives at the laboratory.**

Information on which samples need to be sent refrigerated is provided with the respective services. In this compendium, it is done in text form, on the submission forms, it is marked in a specific way – as explained in Chapter 1.10.2.2. All information given refers to direct shipments to Bad Kissingen; there may be different cooling/freezing requirements for shipments to other Laboklin laboratories. The requirements for each laboratory are shown on the national submission forms and in the Prices and Services catalogue.

1.10.2.1 Shipping Material and Preparation for Refrigerated Transport

The samples are neither refrigerated during transport by post nor by courier. Therefore, send samples which need to be cooled/frozen with a **cold/ice pack** and, if necessary, in an additional **polystyrene box**.

You can purchase a special box from Laboklin; it consists of a polystyrene box and a special sample cooling/freezing pack, which can be used to cool 2 sample tubes all around. When you purchase this box, it will be personalised for your practice/clinic and will be returned to you free of charge each time we receive your samples. We will also return the cold packs, if they are labelled sufficiently (turnaround time approx. 10 working days).

To prepare the transport of refrigerated samples, please pre-cool the samples as well as the cooling material for 1 – 2 hours, as the cooling/freezing capacity of the cold/ice pack and box alone is not enough to adequately refrigerate or freeze samples. The cooling material can also be frozen before shipping refrigerated samples – only when shipping a whole blood sample for doing a blood count, contact between the sample and the frozen material must be avoided.

Before **transporting frozen samples**, the cooling material AND the samples must be stored in the freezer at approx. -20 °C for at least 10 hours.

1.10.2.2 Information on Submission Forms about Cooling Samples

Samples that need to be refrigerated are marked with "!" behind the name of the service. If freezing is required, it is explicitly stated. If there is a mark for refrigeration in services that require the submission of several materials, often only one of them needs to be cooled. In this case, there is an additional "!" behind the material that must be cooled.

If all of the materials which need to be submitted must be refrigerated, you will find the "!" mark only behind the name of the service.

Example:

"Pre-OP Screening !	CP!+S+EB/1ml"
	→ only citrate plasma must be sent in refrigerated

If at least refrigeration is required but freezing is preferred, the note "preferably frozen" is added to the "!". Currently, this applies to online submission forms (and the Prices and Services catalogue); for printed submission forms, please refer to the information sheet on the critical parameters in pre-analysis.

Examples:

"Behaviour Profile (dog) !	S+EB/3ml"
(preferably frozen)	→ serum and EDTA blood must be at least refrigerated when shipped, if possible even frozen
"Equine Cushing/PPID Profile !	EP!+S!+NaFB/2ml"
(S preferably frozen)	EDTA plasma must be sent in refrigerated and serum needs to be refrigerated or better frozen

Please note: If a blood count is requested in addition to this service, EB and a blood smear are also required. They may not be frozen under any circumstance!

1.11 Reordering Tests

Stating the diagnostic reference number, you can request additional tests for sample material that has already been sent in if

- reordering is done within the sample storage period (see below)
- the sample contains sufficient material
- the maximum sample age that may be indicated for the newly requested test is not exceeded (e.g. for morphology, flow cytometry). Generally, parameters with special requirements for pre-analytics (refrigerated or frozen) cannot be reordered.

Reordering can be done

- by e-mail to nachbestellung@laboklin.com
- by MyLab
- by telephone +49 971 7 20 20 via the switchboard or as part of our specialist counselling
- by fax on +49 971 6 85 46
- by post

For reorders that shall be invoiced to the animal owner/bearer, please read the notes in Chapter 26.

Storage periods depend on the type of sample material and the purpose of the submission, i.e. the type of test that was originally requested. The periods specified below apply to samples tested in Bad Kissingen (as of December 2023).

Storage after clinical-chemical examinations, allergy tests, serological examinations (antibody detection; antigen detection, except those from faeces):
- serum, heparin plasma, citrate plasma, EDTA plasma: 14 days
- EDTA blood, heparin blood: 7 days
- urine: 7 days
- uroliths: 7 days (in most cases, however, the material is needed completely for analysis)
- punctures and CSF: 7 days
- blood smears: 14 days

Storage after bacteriological, mycological and parasitological examination (detection by culture, all types of faecal analysis incl. antigen detection from faeces), tests for maldigestion:
- faeces: 7 days
- skin/hair, swabs, urine, milk: 14 days
- punctures: 4 weeks
- isolated pathogens: 7 days

Storage after pathogen detection using PCR:
- independent of the sample material (blood, CSF, urine, swabs, tissue, feather, etc.): 2 – 3 weeks
- extracted DNA/RNA: 1 year
- Please note that extracted DNA/RNA is only suitable for reorders of further tests using PCR/genetic methods, but not for tests that require microbial growth. It is therefore not possible to request an additional resistance test if the sample had been sent in for PCR pathogen detection.

Storage after histopathological examination:
- wet material (tissue samples): 3 weeks
- cytology – object slides/cytology – samples: 3 weeks
- paraffin blocks: 3 years
- sections: 5 years

Storage after testing for hereditary diseases or coat colours/determination of breed, parentage:
- extracted DNA: at least 5 years

Storage after sex determination in birds:
- extracted DNA: 1 year

2 Profiles and Screenings

Laboklin offers numerous **profiles** and **screenings** with complementary parameters. These include clinical chemistry profiles and screenings, serological profiles, symptom-based pathogen profiles as well as travel profiles, toxicological and heavy metal screenings. Compared to ordering the parameters individually, they offer a significant price advantage and facilitate the compact request of many parameters for complex diagnostic tasks, e.g. by combining clinical chemistry parameters with serological diagnosis of pathogens and/or direct pathogen detection by PCR in one profile. The compilation of the profiles and screenings is regularly adapted to new findings.

Our profiles and screenings are specifically compiled for the following **species**:

- dogs, cats
- horses
- camelids
- ruminants
- pigs
- small mammals
- birds
- reptiles, amphibians, fish (incl. quarantine profiles and hibernation profiles)

All compilations of our profiles/screenings are sorted by species in the current **Prices and Services catalogue** and on our **Laboklin website** in the separate "Services" section.

The profiles for the following categories can also be found in this compendium:

- ➢ Allergy profiles — see Chapter 6, p. 72
- ➢ Hygiene profiles — see Chapter 23, p. 406
- ➢ Aquarium/pond profiles — see Chapter 22, p. 405
- ➢ PCR profiles — see Chapter 13.5 Pathogen Detection Profiles, p. 240
- ➢ Faecal profiles — see Chapter 16 Tests for Indigestion and Diarrhoea, p. 278
- ➢ Cytology profiles — see Chapter 18.3 Cytology, p. 283

3 Haematology

For abbreviations and additional information concerning the test descriptions see p. 13 and following.

3.1 Blood Cells

Complete **Blood Count**	
Material	EB 1 ml (+ blood smear) Small mammals: EB, HB 0.5 ml (+ blood smear) Birds, reptiles, amphibians, fish: HB 0.5 ml (+ blood smear)
Method	Mammals: flow cytometry Birds, reptiles, amphibians, fish: flow cytometry, leucocyte count and leucogram: microscopy
Species	Mammals, birds, reptiles (fish, amphibians on request)
Duration	1 day
Note	▪ A leucogram is done in addition to a small blood count; and in dogs, cats and some small mammals, reticulocytes and their haemoglobine concentration (CHr) are determined. ▪ For reliable results, the sample should not be older than 48 hours. ▪ If possible, an air-dried, unstained and unfixed blood smear should be submitted in addition to EB or HB in case further examinations are necessary. ▪ In turtles, tortoises and some bird species (corvids, hornbills, ostriches, cranes, some duck species), determination from EB is not possible due to the cell lysis effect.

Small **Blood Count**	
Material	EB 1 ml (+ blood smear) Small mammals: EB, HB 0.5 ml (+ blood smear)
Method	Flow cytometry
Species	Mammals
Duration	1 day
Note	▪ For reliable results, the sample should not be older than 48 hours. ▪ Small blood count includes erythrocytes, leucocytes, thrombocytes, haemoglobin and haematocrit.

Blood Smear, Cytological (Morphology)	
Material	Blood smear + EB 1 ml Small mammals: blood smear + EB, HB 0.5 ml Birds, reptiles: blood smear + HB 0.5 ml
Method	Microscopy
Species	Dog, cat, horse, small mammals, birds, reptiles, others on request Fish, amphibians on request
Duration	1 – 2 days
Note	▪ The morphology of the peripheral blood cells is assessed. ▪ Heparin blood is not recommended in mammals as there is a risk of artefacts. ▪ An additional CBC is needed for full information. ▪ For a diagnostically conclusive interpretation, please provide the **medical history, diagnostic task** and **previous findings**. ▪ Dog: For the microscopic examination of **Pelger-Huët anomalies**, fresh, evaluable blood smears from a clinically healthy animal are required. When ordering via a printed submission form, please indicate that Pelger-Huët anomaly is suspected. The test is offered as a separate service in the online submission form.

Bone Marrow Cytology	
Material	Bone marrow smear (up to 10 slides) + bone marrow aspirate (see Chapter 1.1.4, p. 20) + peripheral blood: blood smear + EB 1 ml
Method	Blood count: flow cytometry Cytological assessment of bone marrow: microscopy
Species	Dog, cat, horse, others on request
Duration	2 – 4 days
Note	▪ For diagnostically conclusive findings, a **detailed clinical history** with diagnostic task **must** be supplied! ▪ Cellularity as well as cell morphology in the bone marrow are assessed for special diagnostic tasks such as cytopenia (anaemia, leukopenia, thrombocytopenia) of unspecified cause or haematopoietic neoplasms. ▪ A current corresponding blood count is required for a complete diagnosis.

Leucogram	
Material	EB, HB 1 ml (+ blood smear) Small mammals: EB, HB 0.5 ml (+ blood smear) Birds, reptiles, amphibians, fish: HB 0.5 ml (+ blood smear)
Method	Mammals: flow cytometry Birds, reptiles, amphibians, fish: microscopy

Species	Mammals, birds, reptiles (fish, amphibians on request)
Duration	1 day
Note	▪ Determination of a differential blood count is only useful if the total leukocyte count is known. ▪ In turtles, tortoises and some bird species (corvids, hornbills, ostriches, cranes, some duck species), a determination from EB is not possible due to the cell lysis effect.

MCV, MCHC, MCH,

Material	EB 1 ml
Method	Flow cytometry
Species	Dog, cat, horse, ruminants, pig, others on request (not birds, reptiles, amphibians, fish)
Duration	1 day
Note	▪ The calculated erythrocyte indices help to differentiate between causes of anaemia. ▪ Since the cell volume of erythrocytes varies with the ageing of the blood, the indices have to be interpreted with caution in shipped samples.

Reticulocytes

Material	EB, HB 0.5 ml
Method	Flow cytometry
Species	Dog, cat, small mammals, small ruminants, pig, others
Duration	1 day
Note	▪ Reticulocytes are juvenile erythrocytes – determining their number is necessary to be able to differentiate between regenerative and non-regenerative anaemia. ▪ For reliable results, the sample should not be older than 48 hours. ▪ In dogs, cats, rabbits and guinea pigs, the haemoglobin concentration of reticulocytes (CHr) is measured additionally.

Thrombocytes/Platelets

Material	EB, if applicable HB 1 ml
Method	Flow cytometry
Species	Mammals
Duration	1 day
Note	▪ The most common coagulation disorders in dogs are caused by thrombocytopenia. A platelet count is recommended prior to planned surgery. ▪ Low counts are also seen in cases of tick-borne infections and travel-related diseases.

- Platelet aggregates in the sample can cause pseudothrombocytopenia.
- Validity check by microscope for platelet concentrations <90 G/l or <60 G/l (equidae).
- No microscopic platelet count.
- Detection of thrombocyte antibodies: see Chapter 7, p. 86.

3.2 Coagulation

Valid results can only be obtained if the **shelf life** of the **citrate tube** has not been exceeded and the **fill level** has been correctly observed after collection (also see Chapter 1.1.2, p. 16 and Chapter 1.1.4, p. 20).

Important: The centrifuged **citrate plasma** must be put in an **uncoated tube without anticoagulant** (also see Chapter 1.1.2, p. 17).

Activated **Clotting Time**

This test can be performed by veterinarians in their own practice. The appropriate tubes (ACT tubes) are subject to a fee and can be ordered from us. Please pay attention to the detailed instructions for use included in the delivery.

D-Dimers

Material	CP (1 part citrate + 9 parts blood) 0.5 ml (cooled). Please note the introduction to this chapter!
Method	Chronometric
Species	Dog, cat, horse
Duration	1 – 2 days
Note	D-dimers are generated by lysis of cross-linked fibrin. D-dimers are, for example, detectable if there are internal bleedings as well as in surgical interventions and neoplasia. Particularly high amounts of D-dimers are generated in case of thromboembolism and disseminated intravascular coagulation (DIC). In diagnostic work, D-dimers are mostly used for DIC. D-dimers are a parameter of the DIC Profile.

Factor VIII

Material	CP (1 part citrate + 9 parts blood) 0.5 ml (immediately centrifuged, cooled). Please note the introduction to this chapter!
Method	Chronometric
Species	Dog
Duration	1 day

Note
- Factor VIII deficiency is the most common single factor deficiency and the cause of haemophilia A.
- The determination of single factors is only useful if there are changes in partial thromboplastin time.

Factor IX

Material: CP (1 part citrate + 9 parts blood) 0.5 ml (immediately centrifuged, cooled). Please note the introduction to this chapter!
Method: Chronometric
Species: Dog
Duration: 1 day

Note
- Haemophilia B is a congenital deficiency in factor IX activity, which occurs less frequently than haemophilia A.
- The determination of single factors is only useful if there are changes in partial thromboplastin time.

Factor XI

Material: CP (1 part citrate + 9 parts blood) 0.5 ml (immediately centrifuged, cooled). Please note the introduction to this chapter!
Method: Chronometric
Species: Cat
Duration: 1 – 2 days

Fibrinogen

Material: CP (1 part citrate + 9 parts blood) 0.5 ml (cooled). Please note the introduction to this chapter!
Method: Chronometric
Species: Dog, cat, horse, cattle
Duration: 1 day

Note
- Determination is recommended if disseminated intravascular coagulation or hypofibrinogenaemia are suspected.
- As fibrinogen is an acute-phase protein, the concentration will rise in case of acute inflammation.

Prothrombin Time (PT)

Material: CP (1 part citrate + 9 parts blood) 0.5 ml (cooled). Please note the introduction to this chapter!
Method: Chronometric
Species: Dog, cat, horse, others on request
Duration: 1 day

Note — This test comprises the coagulation factors of the extrinsic system. It has to be taken into account, however, that levels may be normal in chronic coagulation. PT is used as diagnostic aid in suspected poisoning with vitamin K antagonists (coumarin and warfarin derivatives) and for therapy monitoring while vitamin K is administered.

Partial Thromboplastin Time (PTT)

Material — CP (1 part citrate + 9 parts blood) 0.5 ml (cooled).
Please note the introduction to this chapter!
Method — Chronometric
Species — Dog, cat, horse, cattle, others on request
Duration — 1 day

Note
- PTT is used to monitor coagulation factors of the intrinsic system and can be used as global test to identify coagulopathies.
- An isolated prolongation of PTT without changes in the PT may indicate a factor deficiency (factor VIII, IX, XI and XII). Haemophilia A or B can be identified by determining the concentration of single factors (VIII, IX).

Thrombin Time

Material — CP (1 part citrate + 9 parts blood) 0.5 ml (cooled).
Please note the introduction to this chapter!
Method — Chronometric
Species — Dog, cat, horse, others on request
Duration — 1 day

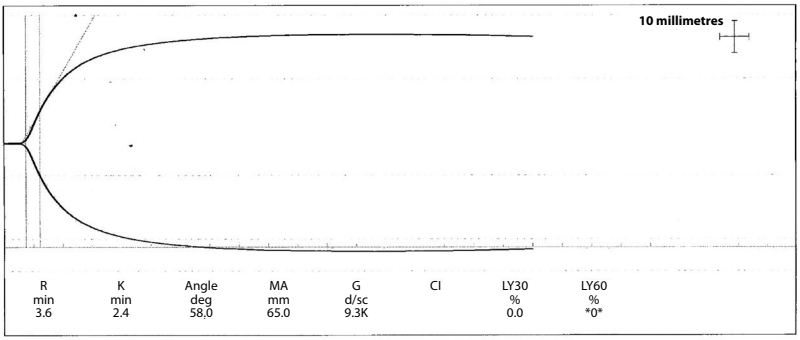
Note
- This test covers the third phase of coagulation, the change from fibrinogen to fibrin.
- It is recommended for monitoring the treatment with heparin or streptokinase as well as in cases of suspected disseminated intravascular coagulation (DIC) or intoxication with vitamin K antagonists. Temporarily lowered concentrations of fibrinogen are seen after intensive surgery as well as in cases of DIC.
- If DIC is suspected, the DIC Profile may be used to confirm or disprove the diagnosis.

Thrombocyte Antibodies ➢ **see Chapter 7, p. 86**

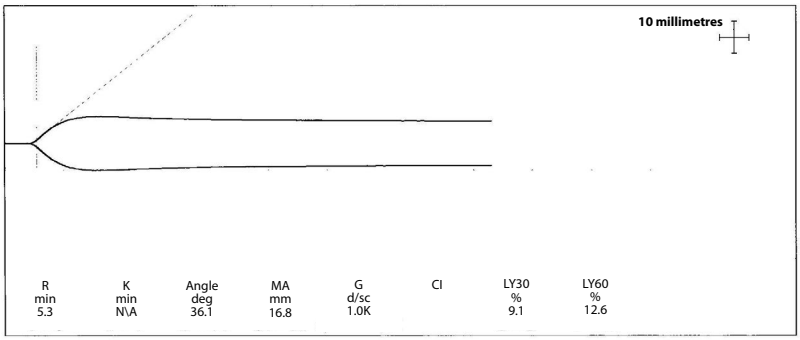
Thromboelastography	
Material	CP (1 part citrate + 9 parts blood) minimum 2 ml (here, the fill level required for each citrate tube must exactly be adhered to – if necessary, send in several tubes)
Method	Thromboelastography
Species	Dog, cat, horse, cattle, others on request
Duration	1 – 2 days
Note	▪ For the maximum **age of the sample**, see specification on the **submission form**. ▪ Global test to determine coagulation disorders, including DIC and thrombocytopathies. ▪ If DIC is suspected, the DIC Profile is also available for diagnostic assessment.

Von Willebrand Antigen	
Material	CP (1 part citrate + 9 parts blood) 0.5 ml (promptly centrifuged, pipetted off; please pay attention to the note on the submission form regarding the temperature during storage/transport!). Please note the introduction to this chapter!
Method	Photometry
Species	Dog
Duration	1 day
Note	▪ Determination of the von Willebrand antigen is used for further evaluation of coagulation disorders. ▪ The von Willebrand disease (vWD) has been described in many dog breeds; only genetic testing can detect whether the disease is carried.

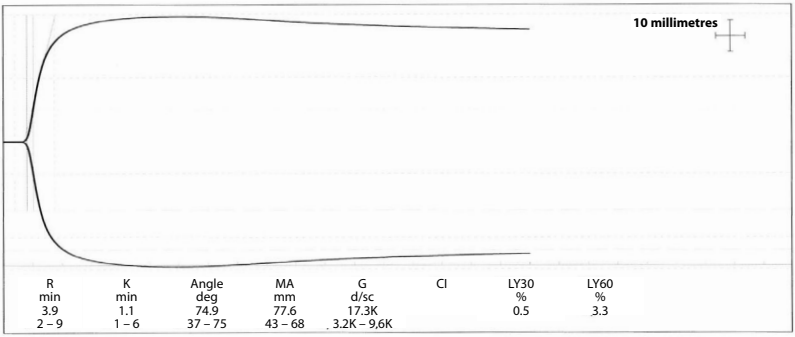
normal coagulation



hypo-coagulability



hyper-coagulability



Thromboelastography
Tracing of clot formation and lysis (y axis: amplitude, x axis: time).
R indicates the time until the initiation of clot formation, K and Angle deg. (angle alpha) are measures for clot kinetics, MA and G for clot strength.
Hypocoagulability results in a reduction of the maximum amplitude, whereas hypercoagulability causes the maximum amplitude to be greater than in normal coagulation.

3.3 Blood Grouping

Blood Group	
Material	EB 1 ml
Method	Agglutination test for determining the serological blood group
Species	Dog, cat
Duration	1 day It is possible to send out rapid blood typing tests for dogs and cats for use in the practice. If umbilical cord blood is used, it is important to avoid contamination with the mother's blood.
Note	**Dog:** ▪ DEA 1 positive/negative ▪ Prior to blood transfusions, it is necessary to test donor and recipient animals for blood group compatibility. (see Crossmatch Test) **Cat:** ▪ A, B, C (formerly AB) ▪ In cat breeds, the blood groups of the parent animals should be determined before mating in order to avoid neonatal iso-immune haemolytic anaemia. Genetic testing in A animals is indicated to detect carriers of the recessive B gene. **Profiles:** ▪ Serological blood grouping is also part of the Blood Donation Profiles dog and cat.

Genetic **Blood Groups (cat)**	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All In European Shorthair, there may be discrepancies between serology and genetics!
Duration	3 – 5 days
Note	The AB system is the major blood group system in domestic cats. The most common blood types are A and B. Cats with blood type B usually have high anti-A antibody titres and cats with blood type A usually have low anti-B antibody titres. Some breeds have the rather rare blood type C (also called blood type "AB"). Cats with blood type C do not have anti-A or anti-B antibodies and are thus universal receivers in case of blood transfusions. Genetic blood grouping in cats allows for genetic differentiation of the serologically determined blood group before breeding. This

makes it possible to identify the recessive b allele which is associated with the B serotype. Cats with two copies of the b allele have blood type B. Genetically, a cat with blood type A may either be a homozygous AA or a heterozygous Ab carrier. Genetic testing is therefore recommended to clarify the genetic basis of A and C (AB) cats. (see also Chapter 20.3.1, p. 369)

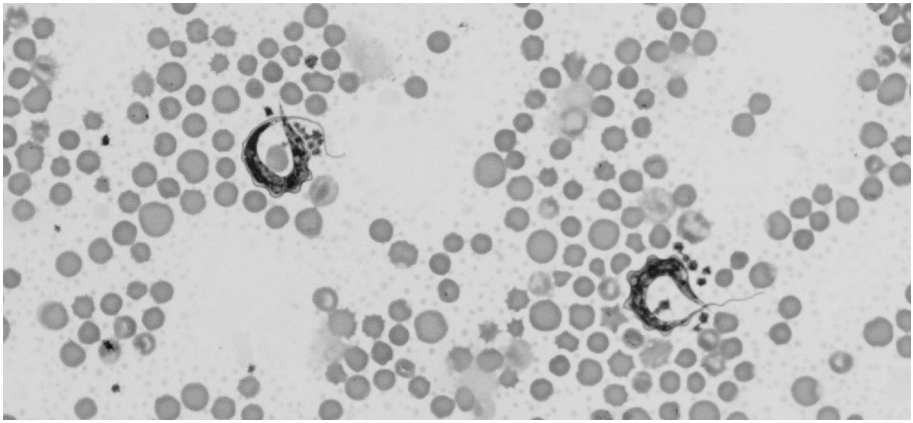
Crossmatch Test	
Material	Dog, cat: EB 1.5 ml (For the maximum **age of the sample**, see **submission form**.) Horse: EB 3 ml + S 3 ml (For the maximum **age of the sample**, see **submission form**.)
Method	Dog, cat: immunochromatography Horse: flow cytometry
Species	Dog, cat, horse
Duration	1 – 2 days
Note	▪ Please contact us before taking samples. ▪ Testing for possible negative effects between donor and recipient blood. ▪ Dog and cat: To ensure a safe whole blood transfusion, the test includes the major and minor crossmatch test. (Major crossmatch test: donor erythrocytes + recipient plasma; Minor crossmatch test: recipient erythrocytes + donor plasma) ▪ Crossmatch tests for dogs and cats can also be sent out for use in the practice.

3.4 Blood Parasites

Babesia – Microscopic ➢ **see Chapter 13.4.3, p. 217**

Blood Parasites – Microscopic	
Material	EB 1 ml + blood smear Birds: EB, HB 0.5 ml + blood smear Reptiles: HB 0.5 ml + blood smear
Method	Microscopic
Species	Mammals, birds, reptiles
Duration	1 – 2 days
Note	▪ Please note that, in mammals, smears from HB may not always be suitable due to the formation of artefacts. ▪ Testing is particularly useful in acute stages of the disease.

Microfilaria – Knott Test ➢ **see Chapter 13.4.8, p. 229**



Trypanosoma theileri in cattle

4 Clinical Chemistry

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

4.1 Enzymes

ALT (GPT)
Alanine Aminotransferase (Glutamate Pyruvate Transaminase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, mouse, ferret, birds, reptiles, ruminants, New World camels, pig
Duration	1 day
Note	In contrast to horses and pigs, this parameter is liver-specific in dogs and cats. ALT is found only in the cytoplasm, therefore even minor cell damage may cause elevated levels. Isolated elevations also occur in case of portosystemic shunt.

α-Amylase

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ The enzyme is elevated in the acute phase of pancreatitis for 3 – 5 days. Slight elevations also occur due to diseases of other organs and in case of renal dysfunction. As the enzyme is also produced in the liver and small intestine, it is not pancreas-specific. Therefore, its suitability for diagnosing pancreatitis is limited. ▪ In order to confirm the diagnosis of pancreatitis, determination of PLI is recommended (see PLI).

AP (Alkaline Phosphatase)

Material	S 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day

Note

- The enzyme is found in almost all organs. AP is diagnostically especially significant in diseases of the skeletal and the hepatobiliary system. In dogs, there is also steroid-induced AP, which particularly plays a role in the diagnosis of hyperadrenocorticism (Cushing's disease).
- In the context of bone diseases, high levels are present in case of ostitis deformans, which allows to differentiate from osteoporosis. In bone tumours, increases in activity are measured whose extent correlates to the osteoblast activity (very high levels in osteosarcoma, hardly any increases in benign tumours). Rachitis and osteomalacia have elevated levels with decreased calcium levels.
- Increased levels may indicate cholestasis.
- **Young animals:** physiological concentration up to 2.5-fold.
- **Dog:** Diagnosis of corticosteroid-induced AP is possible by determining the heat-stable isofraction.
- **Cattle:** The AP level ante partum allows to assess the risk of parturient paresis.

AP (heat-stable 65 °C)
(heat-stable **Alkaline Phosphatase)**

Material	S 0.5 ml
Method	Photometry
Species	Dog; not relevant for other species
Duration	1 day

Note

- The heat-stable isoenzyme of AP is induced by endogenous steroid hormones or by cortisone therapy and can be used to diagnose overtreatment with steroids.
- Only useful in combination with the determination of the "total AP" if it is elevated. With the sum of all isoenzymes of AP ("total AP") and the heat-stable AP, the residual activity of AP can be determined in percentage.

AST (GOT)
Aspartate Aminotransferase (Glutamate Oxaloacetate Transaminase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day

Note

- Elevated levels can be caused by diseases of various parenchymatous organs but also by muscle damage. If the latter, it cannot be distinguished between damage of skeletal muscles and cardiac muscles. A simultaneous increase of CK indicates a myogenic origin.

- **Cat:** sensitive marker of hepatopathies; to differentiate muscle damage, CK levels should be determined additionally.
- **Horse:** indicates lesions of the skeletal muscles (in combination with other parameters, for example LDH, CK) or the liver.

Cholinesterase

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ In case of an intoxication with organophosphates and phosphoric acid esters, the enzyme is blocked and its activity in the blood plasma decreases. ▪ **Birds:** liver-specific, decreased in hepatic diseases

CK (Creatine Kinase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	The highest enzyme activity by far is found in the skeletal muscles, followed by brain tissue and cardiac muscles. All conditions that cause destruction of muscle cell membranes result in elevated serum concentrations (e.g. myopathies, traumata due to injuries or i.m. injections and after intensive training). Preanalytically, haemolysis also leads to elevated levels. Brain tissue damage does not cause increased serum levels because of the impermeability of the blood-brain barrier.

GLDH (Glutamate Dehydrogenase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ The enzyme is liver-specific and located in the mitochondrion. Thus, elevations are indicative of massive destruction of liver cells and necrobiotic processes, especially in the centrilobular area. If levels of GLDH are increased, but at the same time ALT levels are changed only slightly, it indicates chronic inflammation of the liver.

- **Dog:** Single values have no diagnostic significance. Slight elevation of GLDH and stronger elevation of transaminases indicate acute disease of the liver. Opposite enzyme activity indicates chronic processes.
- **Cattle:** Levels depend on stage of lactation.
- **Rabbit:** GLDH is the most sensitive liver enzyme – an acute parameter (acute hepatopathy with centrolobular damage; strong increase in activity in anorexia, intoxication).

Glutathione Peroxidase (GPx)

Material	EB, HB 0.5 ml (whole blood only)
Method	Photometry
Species	Horse, ruminants, others on request
Duration	1 – 2 days
Note	• GPx can only be determined in unclotted EDTA or heparin whole blood samples, because the value is linked to the haemoglobin concentration. • GPx is an antioxidant. • As a selenium-containing enzyme, the GPx level indicates the supply of selenium to the animal within the last few weeks. Thus, GPx cannot indiate an acute undersupply of selenium. An over-supply cannot be diagnosed by determining the GPx level.

γ-GT (γ-Glutamyl Transferase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, horse, ruminants, New World camels, pig
Duration	1 day
Note	• Although this membrane-bound enzyme is not liver-specific, elevations occur almost exclusively in diseases of the liver and bile ducts. • **Horse:** Elevated concentrations are indicative of cholestasis. Increased levels may also be seen in other diseases with liver involvement, such as colic, enteritis and the like. • **Cattle:** The γ-GT level strongly correlates with the degree of hepatic fatty degeneration and the degree of swelling of the liver and the edge of the liver. Decreased levels of this enzyme indicate insufficient intake of colostrum in calves up to an age of approximately 1 week.

α-HBDH (α-Hydroxybutyrate Dehydrogenase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ This isoenzyme of LDH is found in many kinds of tissue, especially in cardiac and skeletal muscles and in the liver; the activity of α-HBDH varies depending on the species. ▪ If α-HBDH in the LDH/α-HBDH ratio is disproportionately increased, it indicates possible damage of the cardiac muscle. Determination of c-Troponin I concentration has replaced the analysis of α-HBDH in case of this indication, though. ▪ Proportional or slight elevations of the enzyme point to other causes (e.g. liver damage, damage of skeletal muscles, haemolysis and others). In this case, CK and AST levels should be considered.

LDH (Lactate Dehydrogenase)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ LDH is composed of 5 isoenzymes. It is found in many organs, mainly in the liver, in cardiac and skeletal muscles. High concentrations of LDH are also present in erythrocytes, so that even slight haemolysis in serum or plasma may cause elevated values. ▪ Elevations occur in case of myopathies, cardiomyopathies and liver diseases. ▪ The ratio of α-HBDH to LDH can indicate problems of the cardiac or skeletal muscles.

Lipase (DGGR)

Material	S (EP, HP) 0.5 ml
Method	Photometry (using DGGR reagent)
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, others on request
Duration	1 day
Note	▪ Measurement mainly covers the activity of pancreatic lipase, but also the lipase activity in other tissues (stomach, small intestine). A threefold increase in value indicates acute pancreatitis.

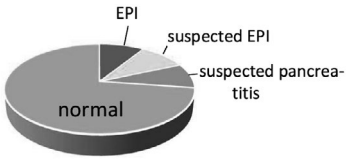
- In order to confirm the diagnosis of pancreatitis, pancreatic lipase immunoreactivity (PLI) should be determined.
- **Horse:** Pancreatitis can occur along with colic or other gastrointestinal diseases. Elevated lipase levels are also found in horses engaged in high-performance training.

PLI (Pancreatic Lipase Immunoreactivity)

Material	S 0.5 ml
Method	ELISA
Species	Dog, cat
Duration	1 – 2 days
Note	▪ Detection of specific pancreatic lipase in suspected pancreatitis. The determination of pancreatic lipase in the serum of dogs and cats is considered to be the most sensitive non-invasive marker for the diagnosis of pancreatitis. As part of an inflammatory reaction, the pancreatic acinar cells are destroyed leading to an increase in the pancreatic lipase concentration in the serum.

TLI Test (Trypsin-like Immunoreactivity)

Material	S 0.5 ml
Method	CLIA (dog), ELISA (cat)
Species	Dog, cat
Duration	Dog: 1 day, cat: 2 – 3 days
Note	▪ Most sensitive test for the detection of exocrine pancreatic insufficiency. ▪ Renal insufficiencies may lead to increased TLI values. ▪ Dogs and cats **should** fast for 12 hours prior to sampling.



TLI results:
With 8.9%, exocrine pancreatic insufficiency (EPI) is not uncommon in cats of all ages.

4.2 Substrates

Albumin

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, ferret, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ Hypoalbuminaemia results from loss of albumin (kidney, intestine, haemorrhage), albumin synthesis disorder (liver) and, to a mild

extent, inflammation. Albumin is a negative acute-phase protein. Cattle: hypoalbuminaemia, particularly in hepatic diseases, reduced feed intake and inflammation
- Increased levels are mainly found as relative hyperalbuminaemia in case of dehydration.
- Due to species-specific peculiarities, serum protein electrophoresis should be preferred to chemical measurement in birds, reptiles and some small mammals,

Bile Acids

Material	S 0.5 ml (fasting required for omnivores and carnivores)
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, birds, reptiles, horse, cattle
Duration	1 day
Note	- Serum bile acid concentration correlates with liver function. In contrast to the determination of ammonia, which needs to be performed immediately after sampling, this parameter is very stable. - Elevation of bile acids can also indicate the existence of a portosystemic shunt. - Single determinations may be within the reference range despite a disease being present; the performance of a bile acid stimulation test is therefore preferable – except in horses. - **Please note** that omnivores and carnivores must fast for 12 hours before sampling.

Bilirubin (total)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, horse, ruminants, New World camels, pig
Duration	1 day
Note	- The breakdown of haemoglobin and other cytochromes produces bilirubin. Its glucuronidation is intrahepatocellular (= direct bilirubin) and it is excreted through the intestines. Visible icterus correlates with concentrations of 17 µmol/l or more, except in horses (horse: > 75 µmol/l). - Prehepatic icterus: Excessive haemoglobin concentration causes increased levels of indirect bilirubin (= not glucuronidated). - Intrahepatic icterus: Damage of liver cells causes increase in both direct and indirect bilirubin. - Posthepatic icterus (rare): Increase in direct bilirubin caused by retention of bile.

- **Cattle:** Total bilirubin has a strong negative correlation with blood glucose levels and hence is a sensitive indicator for imbalances in the composition of food rations. Strong increase occurs due to microhaemolysis as part of septicaemia, e.g. in case of mastitis, endometritis or salmonellosis, and is prognostically unfavourable.

Bilirubin II (direct)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rat, ferret, horse, ruminants, New World camels, pig, others on request
Duration	1 day
Note	In the liver cells, bilirubin II is formed from bilirubin I by glucuronidation. Determination is only useful in case of elevated levels of total bilirubin. Measurement can be strongly affected by lipaemia.

Cholesterol

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ Cholesterol is formed mainly in the liver and in the mucosa of the small intestine and serves as starting material for many compounds which are synthesised in the liver (e.g. bile acids and steroid compounds). ▪ In cattle, cholesterol levels correlate with feed intake and milk yield. ▪ **Please note:** Omnivores and carnivores should not eat for 12 hours prior to sampling!

Cholesterol: HDL (High Density Lipoproteins)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	All
Duration	1 – 2 days

Cholesterol: LDL (Low Density Lipoproteins)

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	All
Duration	1 – 2 days

Creatinine

Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, horse, ruminants, pig
Duration	1 day
Note	▪ In addition to SDMA, creatinine is the most specific indicator for renal function. However, due to the reserve capacity of the kidneys, elevated levels only occur if the kidney damage exceeds 70%. Lipaemia and haemolysis can cause false elevation of values. In well-muscled or trained dogs, creatinine may be slightly increased physiologically, without there being a renal dysfunction. ▪ Protein/creatinine ratio in the urine (midstream urine or urine from cystocentesis) and SDMA serve for an early detection of renal dysfunction. ▪ **Cattle:** An increase in creatinine is an important indicator for insufficient feed intake or body weight loss.

Fibroblast Growth Factor 23 (FGF23)

Material	S 0.5 ml
Method	ELISA
Species	Dog, cat
Duration	1 – 6 days
Note	▪ FGF23 is a parameter for the advanced diagnosis of nephropathies. ▪ FGF23 can already indicate a change in phosphate metabolism in the early stages of chronic kidney disease.

Fructosamines

Material	S 1 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, horse, cattle, others on request
Duration	1 day
Note	▪ Fructosamines are formed by an irreversible binding of glucose to serum proteins (glycosylation). ▪ Determination is used for the diagnosis and long-term monitoring of patients with diabetes mellitus, as the glucose bound to serum proteins reflects the average glucose level of the past 3 weeks. A distinction between spontaneous, stress-induced hyperglycaemia and diabetes mellitus is possible as well. Increased levels can also be found in case of hyperproteinaemia. ▪ Low fructosamine levels are associated with protein deficiency, increased protein metabolism or, in cats, also with hyperthyroidism. ▪ **Horse:** often increased in case of EMS.

Glucose

Material	NaFB, S 1ml or CSF
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, mouse, ferret, birds, reptiles, horse, ruminants, pig
Duration	1 day
Note	▪ Increased glucose levels occur in case of diabetes mellitus but also in CNS diseases, pancreatitis and Cushing's disease/PPID. Levels particularly increase due to stress and after administration of glucocorticoids. ▪ Diseases of the liver, Addison's disease and insulinoma may cause hypoglycaemia. ▪ Medicines that can lead to hypoglycaemia include: antihistamines, beta blockers, anabolic steroids. ▪ **Dog:** Starving young dogs of toy breeds tend to develop life-threatening hypoglycaemia in stress situations. ▪ **Horse:** The determination of glucose levels is a necessary part of the diagnosis of Equine Metabolic Syndrome (EMS). For further information, please see "Insulin" (Chapter 8, p. 91). ▪ In **cattle,** hypoglycaemia indicates ketosis due to energy deficiency; the additional determination of β-HBA is needed. Hyperglycaemia is caused by stress and endotoxaemia. ▪ The semi-quantitative detection of glucose in urine is part of the Urinalysis (see Chapter 5, p. 68).

HDL ➢ see Cholesterol, p. 54

β-Hydroxybutyrate (β-HBA)

Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, ruminants, New World camels
Duration	1 day
Note	▪ Ketone bodies are formed in the organism during the degradation of fatty acids. ▪ **Ruminants:** The determination of β-HBA provides an indication of energy supply and can be used for diagnosing ketosis. **Cattle:** increased ketone body levels in ketosis resulting from an energy deficiency, in alimentary ketosis (too much concentrated feed) or secondary (e.g. in case of abomasal displacement). **Small ruminants:** for the diagnostic assessment of gestational toxicosis ▪ **Dog/cat:** increased levels in uncontrolled or poorly controlled diabetes mellitus and in diabetic ketoacidosis

Indoxyl Sulfate

Material	S 0.5 ml (fasting required)
Method	HPLC
Species	Dog, cat
Duration	5 days
Note	▪ When breaking down tryptophan, intestinal bacteria form indole, which is metabolised in the liver to indoxyl sulfate. ▪ Indoxyl sulfate is a uraemic toxin which is physiologically excreted by the kidneys. In renal dysfunction, serum levels increase. Increased indoxyl sulfate levels then lead to further damage of the renal parenchyma, in addition to numerous other damages in the organism, and thus result in the progression of renal dysfunction.

Lactate

Material	NaFB 0.5 ml
Method	Photometry
Species	Dog, cat, horse, cattle, pig
Duration	1 day
Note	▪ Anaerobic degradation of glucose leads to the formation of lactate. Elevated lactate concentrations may be caused by increased formation of lactate due to a higher glucose uptake or increased glycogenolysis (e.g. diabetes mellitus), impaired metabolisation (hypovolaemic, cardiovascular or neurogenic shock) or enhanced formation due to oxygen deficiency in the tissue (fitness level, increase of lactate in immature neonates). ▪ **Cattle:** Elevation occurs in case of ruminal acidosis, circulatory disorders, severe pneumonia.

LDL ➢ see Cholesterol, p. 54

NEFA (Non-Esterised Free Fatty Acids)

Material	S, HP 0.5 ml
Method	Photometry
Species	Ruminants, New World camels, pig
Duration	1 day
Note	The degradation of adipose tissue releases NEFA. They are a quick and sensitive marker of nutritional deficiency or of reduced feed intake in case of stress situations or disease, and serve to estimate e.g. the fat mobilisation in a catabolic metabolic state.

Protein (Total Protein)

Material	S, EP, HP, CSF 0.5 ml, H
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ Absolute hyperproteinaemia usually occurs due to chronic infection, relative rises are common in case of fluid loss. Absolute hypoproteinaemia occurs due to nephropathies, blood loss or intestinal loss of protein into the third space, relative reductions in total protein only in case of increased hydration. In cerebrospinal fluid, however, elevated protein levels are seen in inflammatory and tumorous brain diseases. Interpretation urine: see protein/creatinine ratio Chapter 5, p. 68. ▪ Electrophoresis is used to separate the protein fractions.

SDMA (Symmetric Dimethylarginine)

Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, horse
Duration	1 day
Note	SDMA is formed during protein degradation, is excreted by the kidneys and is used in laboratory diagnosis for the early detection of renal dysfunction (= GFR still > 30%), even in the creatinine-blind range. In cats, a significant inverse correlation between the glomerular filtration rate and SDMA has been described. Determining the SDMA concentration is recommended if an early stage of renal dysfunction is suspected, e.g. because of beginning polyuria/polydipsia.

Taurine

Material	EP 1 ml (promptly centrifuged, pipetted off; please pay attention to the note on the submission form regarding the temperature during storage/transport!)
Method	LCMS
Species	Dog, cat
Duration	1 – 5 days
Note	Chronic taurine deficiency causes dilatative cardiomyopathy in cats. In general, most commercial diets contain sufficient amounts of taurine. Taurine deficiency may be caused by chronic malabsorption or by homemade rations.

Triglycerides	
Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, pig
Duration	1 day
Note	▪ Triglyceride levels are influenced by food intake and metabolic status, among others. Synthesis takes place in the liver, small intestine and adipose tissue. ▪ **Dog:** elevation e.g. postprandial, diabetes mellitus, hypothyroidism, hypercortisolism, acute pancreatitis. ▪ **Horse:** Hyperlipidaemia in EMS, PPID (Cushing's disease), fasting. Clinically relevant in hyperlipaemia syndrome and metabolic syndrome. ▪ **Cattle:** Lipid mobilisation syndrome

Troponin I	
Material	S 0.5 ml (promptly centrifuged, pipetted off; please pay attention to the note on the submission form regarding the temperature during storage/transport!)
Method	CLIA
Species	Dog, cat, horse, rabbit, llama, alpaca
Duration	1 day
Note	Acute myocardial cell damage (highly specific myocardial parameter). An increase may indicate cardiomyopathy and should be further clarified by echocardiography.

Urea	
Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, reptiles, horse, ruminants, pig
Duration	1 day
Note	▪ Urea is the most important degradation product of the protein metabolism in mammals. Serum levels depend on renal function and extrarenal factors (diet, increased protein degradation). Thus, creatinine should always be checked in parallel. ▪ In **cattle**, the urea level serves mainly as an indicator for energy supply. ▪ Urea is the most important renal parameter in **aquatic and sea turtles** and other **aquatic reptile species, amphibians and fish.**

Uric Acid	
Material	S, EP, HP 0.5 ml
Method	Photometry
Species	Dog, birds, reptiles
Duration	1 day
Note	▪ **Dog**: Due to a metabolic disorder, increased levels of serum uric acid (hyperuricosuria) can occur especially in Dalmatians. Uric acid concrements in the urine and a characteristic brownish-yellowish discolouration of the coat (Bronzing syndrome) are of clinical significance. This metabolic disorder is mostly of genetic origin which can be confirmed with the genetic test "Hyperuricosuria (HUU/SLC)" (see Chapter 20.2.1, p. 318). ▪ **Birds:** Concentrations above 500 µmol/l indicate nephropathies or exsiccosis. ▪ **Birds/Reptiles:** The levels of uric acid vary, depending on various factors, such as feed intake, protein content of the ration, season and species. Uric acid is the most important renal parameter in birds and terrestrial reptile species.

4.3 Minerals and Trace Minerals

Calcium (Ca)	
Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, pig
Duration	1 day
Note	▪ Calcium measurement from EDTA plasma is not possible. ▪ More than 99% of the body's calcium is stored in the bones. Calcium is, for example, involved in the transmission of nerve impulses, in muscle contractions and blood clotting. ▪ Hypercalcaemia occurs in hyperparathyroidism, but also due to tumours (malignant lymphoma, carcinoma) (see also PTH-rp, Chapter 8, p. 93). ▪ Nutritive hypercalcaemia in small mammals is partly due to vitamin D3-independent intestinal absorption. ▪ Hypocalcaemia is often the cause of parturient paresis in cattle and of an increased tendency for seizures in small animals. ▪ In case of concurrent hypoalbuminaemia, the calcium level should be corrected. **Calculation:** Corrected calcium level (mg/dl) = serum calcium level (mg/dl) – (0.4 x serum protein (mg/dl)) + 3.3

Calcium, ionised*	
Material	S, HP 0.5 ml (promptly centrifuged, pipetted off and under exclusion of air)
Method	ISE
Species	Dog, cat, birds, reptiles, horse, others on request
Duration	2 – 3 days
Note	▪ Ionised Ca represents the biologically active part of the total calcium. ▪ The sample should be collected **without air** (vacutainer system). The instructions can be requested from us.

Chloride (Cl)	
Material	S, HP 0.5 ml
Method	ISE
Species	Dog, cat, ferret, birds, reptiles, horse, ruminants, pig, others on request
Duration	1 day
Note	▪ It is the most important extracellular anion and decisive for maintaining the osmotic balance. ▪ Decreased levels occur in diseases which cause hyponatraemia, e.g. vomiting, abomasal reflux in case of abomasal displacement diarrhoea, and metabolic alkalosis. ▪ **Ruminants:** Increased levels are found in all diseases which also cause hypernatraemia. The most common causes are dehydration and hyperchloremic metabolic acidosis.

Cobalt (Co)	
Material	S, H 1 ml
Method	ICPMS
Species	Horse, ruminants, New World camels, others on request
Duration	1 week
Note	▪ Central component of vitamin B12 (cobalamin), which is formed in ruminants by ruminal bacteria. ▪ Cobalt deficiency: reduced growth rate, milk yield and reproductive performance, coarse coat, cachexia, anaemia

Copper (Cu)	
Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, horse, ruminants, New World camels, pig, others on request
Duration	1 day

Note
- Copper is a component of various enzymes. Decreased levels can lead to depigmentation as well as growth and reproductive disorders.
- **Dog:** In the copper storage disease in Bedlington Terriers, copper serum levels are usually normal, elevated levels can only be detected in liver tissue. For the genetic test for copper storage disease in Bedlington Terriers, Doberman and Labrador Retriever see Chapter 20.2.1, p. 301.
- **Sheep:** In newborn lambs, copper deficiency leads to CNS symptoms. Oversupply, e.g. caused by mineral supplement for cattle, leads to intoxication in sheep.

Iodine (I)

Material	S 1 ml
Method	ICPMS
Species	Dog, cat, horse, cattle, others on request
Duration	Approx. 3 days
Note	In cattle, iodine deficiency has been reported to result in goitre formation, fertility problems, abortions, decline in libido, reduced semen quality and hairlessness.

Iodine/Creatinine Ratio

Material	Urine 1 ml
Method	ICPMS, photometry
Species	Dog, cat, horse, others on request
Duration	Approx. 3 days
Note	Studies in different animal species show that the iodine/creatinine ratio better reflects the alimentary iodine supply than the determination of blood iodine levels.

Iron (Fe)

Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, pig
Duration	1 day

Note
- It is impossible to determine iron levels from EDTA plasma.
- Iron is found in the body in the form of haemoglobin and myoglobin. Furthermore, it is a component of various enzymes. In serum, iron is mainly bound to transport proteins.
- Elevated serum iron levels occur due to the destruction of liver parenchyma (acute hepatitis, cirrhosis). In case of rarely occurring

haemochromatosis and in connection with increased serum levels, deposits are formed in the liver and muscles.
- Decreased levels are often associated with anaemia but also with infections, malignant tumours and nephrosis.
- Iron is a negative acute-phase marker, i.e. in acute inflammation there is a relative or absolute decrease in serum levels.

Magnesium (Mg)

Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	- Magnesium is essential for the energy metabolism of the cells and for neuromuscular transmission. - Hypermagnesaemia may occur in case of Addison's disease; hypomagnesaemia is the most common cause of grass tetany in cattle and can also be found in case of renal dysfunction.

Manganese (Mn)

Material	S 0.5 ml
Method	ICPMS
Species	Dog, horse, ruminants, New World camels, pig, others on request
Duration	2 – 3 days
Note	- Determination is useful in case of suspected undersupply or intoxication. Undersupply may be caused by increased levels of iron in drinking water, as iron is antagonistic to manganese. Manganese deficiency in cattle mainly causes dysfunctions in skeletogeny and fertility disorders.

Inorganic **Phosphate (PO4)**

Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	- Increased values are found physiologically in young animals. - Hyperphosphataemia is simulated by haemolysis/in haemolytic samples. - The most common causes of pathologically elevated serum levels are kidney diseases (not in horses) and hyperthyreosis in cats. - Hypophosphataemia may be present in some endocrinopathies.

- **Reptiles:** The Ca/P ratio should be approximately 2:1.
- **Cattle:** Hypophosphataemia can lead to chronic rumen acidosis, impaired digestion and recumbency. Hyperphosphataemia causes calcinosis.

Potassium (K)	
Material	S, HP 0.5 ml
Method	ISE
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ Potassium is the most important intracellular cation. ▪ Potassium levels are only significant if the serum has promptly been separated. ▪ Pseudohyperkalaemia may occur due to the release of potassium from platelets, leukocytes and erythrocytes. Preanalytically, haemolysis also leads to falsely elevated levels. ▪ The main causes of hyperkalaemia are oliguria and Addison's disease. ▪ The main causes of hypokalaemia are vomiting or abomasal reflux, diarrhoea, renal dysfunction, Cushing's disease/glucocorticosteroid therapy. ▪ **Cave:** Even in case of absolute potassium deficiency, serum levels may stay within reference range for some time! ▪ **Cattle:** Elevated levels of potassium may lead to reproductive disorders and recumbency if there is a relative sodium deficiency at the same time.

Selenium (Se)	
Material	S, EP, HP 0.5 ml
Method	AAS
Species	Dog, cat, horse, ruminants, New World camels, pig
Duration	1 – 2 days
Note	▪ Selenium deficiency may cause nutritional muscular dystrophy in foals. Special emphasis should therefore be placed on the selenium supply of brood mares. ▪ In **cattle**, selenium deficiency can lead to fertility disorders and a weakened immune system. In calves, a weak sucking reflex and white muscle disease are of relevance.

Sodium (Na)

Material	S, HP 0.5 ml
Method	ISE
Species	Dog, cat, rabbit, guinea pig, rat, ferret, birds, reptiles, horse, ruminants, New World camels, pig
Duration	1 day
Note	▪ Sodium is the most important extracellular cation. In dogs and cats, sodium is excreted mainly by the kidneys. ▪ The main causes of hypernatraemia are loss of water without concurrent loss of electrolytes (diabetes insipidus, diabetes mellitus), retention of sodium (mineralocorticoids) or a high sodium intake with food without the possibility of water uptake. ▪ The main causes of hyponatraemia are Addison's disease, diarrhoea, vomiting, or diuretics.

Sodium/Potassium Ratio (Na/K Ratio)

Material	S, HP 0.5 ml
Methode	ISE
Species	Dog, cat
Duration	1 day
Note	Slight hyponatraemia may be tolerated in small animals as long as the Na/K ratio is > 27:1. If the ratio is < 27:1, Addison's disease is suspected (clarification by ACTH stimulation test).

Zinc (Zn)

Material	S, HP 0.5 ml
Methode	Photometry
Species	Dog, cat, birds, horse, ruminants, New World camels, pig, others on request
Duration	1 day
Note	▪ Marked zinc deficiency causes parakeratosis of the skin and mucous membranes. In **cats**, coat changes are mainly described. Serum zinc levels are not necessarily decreased in case of zinc responsive dermatosis. This clinical picture is also relevant in **New World camels**. ▪ In **farm animals**, zinc deficiency leads to reduced feed conversion and performance depression, changes in skin and claws, parakeratosis (especially in small ruminants) as well as growth retardation and fertility disorders (incl. underdeveloped reproductive organs). ▪ **Birds:** to diagnose intoxication

5 Urinalysis

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

Kidney Profiles ➢ **see Prices and Services catalogue**

Kidney-specific individual parameters that are determined from blood (e.g. Indoxyl sulphate, SDMA) ➢ **see Chapter 4.2, p. 52**

BRAF Mutation (Urinary Bladder/ Urethral Carcinoma) ➢ **see Chapter 18.5, p. 285**

COLA Test (cystine, ornithine, lysine, arginine)

Material	Urine 3 ml (frozen)
Method	LCMS
Species	Dog, cat
Test frequency	1 x per week
Note	▪ Quantitative determination of the amino acids cystine, ornithine, lysine and arginine. ▪ For the diagnosis of cystinuria in different breeds. ▪ Elevated in case of nephropathy, glomerulonephritis and renal amyloidosis, among others. ▪ Additionally, a urine sediment and the determination of the pH value are recommended.

Fanconi Screening

Material	Urine 5 ml (frozen)
Method	LCMS
Species	Dog
Test frequency	1 x per week
Note	▪ Quantitative determination of the amino acids threonine, glutamine, proline, glycine, alanine and of the glucose concentration in the urine. ▪ For the diagnosis of Fanconi syndrome in dogs. ▪ Additional urinalysis/sediment is recommended. ▪ For the genetic test in Basenji see Chapter 20.2.1, p. 311.

Fractional Electrolyte Excretion (FE)

Material	Urine 0.5 ml + S (non-haemolysed) 0.5 ml, samples collected at the same time
Method	Photometry
Species	Horse
Duration	1 day

Note

- The FE of Na, K, P, Cl are examined.
- If the electrolyte excretion is put into relation with the creatinine excretion (here GFR = excretion), it indicates the FE of the electrolyte.
- The FE is used to diagnose a dysfunction of the renal tubules. In horses with healthy kidneys, the net excretion of an electrolyte in the urine is regulated by the glomerular filtration rate and the tubular reabsorption. If tubular reabsorption fails, the FE of one or more electrolytes usually increases and its FE values will be above the normal range.

γ-GT/Creatinine Ratio

Material	Urine 1 ml
Method	Photometry
Species	Horse
Duration	1 – 2 days
Note	Shows the early stage of a tubular disease and is indicated in case of acute disease.

Microalbumin

Material	Urine 0.5 m
Method	Photometry
Species	Dog, cat
Duration	1 – 2 days

Note

- It is considered an early way to diagnose renal dysfunction.
- In contrast to the determination of the U-P/C ratio (see below), this test is also useful in patients with no clinical signs.
- Relatively insensitive test which may also yield positive results in case of inflammatory diseases (e.g. borreliosis, leishmaniosis).
- Sample must not contain any blood.

NABE (Net Acid-Base Excretion) Fractionated auch aus SW entfernen?

Material	Urine 15 ml, fresh, refrigerated and under exclusion of air
Method	Titration
Species	Cattle
Duration	2 – 3 days

Note
- Please fill the sample container to the brim so that no air is contained.
- NABE values provide information about the acid-base status. Together with the blood parameters ketone bodies (ß-HBA) and free fatty acids (NEFA), NABE represents the minimum spectrum of metabolic control in cattle. NABE values must be analysed in the context of feed intake, stage of lactation and the herd.

Protein/Creatinine Ratio (U-P/C)

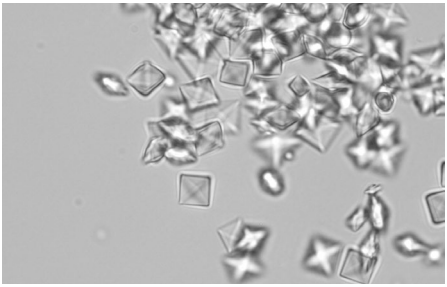
Material: Urine 1 ml
Method: Photometry
Species: Dog, cat, horse
Duration: 1 day

Note
- Parameter for early diagnosis of renal dysfunction and protein loss via urine.
- Not conclusive in case of bloody urine or active sediment. In this case, there is no correlation between U-P/C and renal function.
- Increased values can also be caused by fever, bacterial and inflammatory processes without there being renal dysfunction.

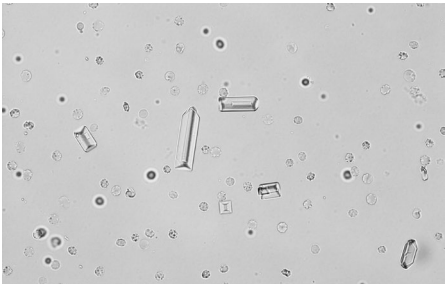
Urinalysis incl. Sediment

Material: Urine 5 ml
Method: Dry chemistry, photometry, microscopy
Species: Dog, cat, rabbit, guinea pig, horse, ruminants, pig, others on request
Duration: 1 – 2 days

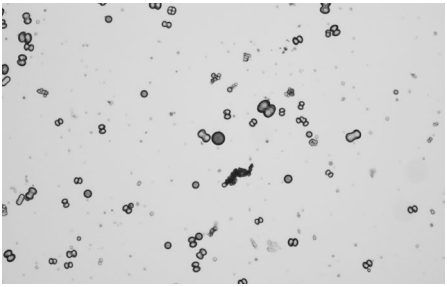
Note
- Semi-quantitative measurement of clinical chemical and cellular parameters (protein, haemoglobin/myoglobin, pH value, bilirubin, urobilinogen, glucose, nitrite, ketone bodies as well as erythrocytes, leukocytes, bacteria, yeasts, cylinder, epithelia, crystals) and measurement of the specific gravity.
- Diagnostic clarification of urinary tract diseases and superior diseases (liver or kidney disease or metabolic disorders) which may lead to changes in urination (polyuria, stranguria and oliguria).
- If the dog is being treated with allopurinol, please indicate it on the submission form.
- This test is also offered in combination with a urine culture test (bacteriology). In this case, 6 ml of urine or 5 ml of urine + swab with medium or 5 ml of urine + Uricult are needed for the examination.
- When combined with bacteriology, the test duration is 2 – 3 days or 1 – 3 days if Uricult is submitted.
- For the bacteriological examination, collecting urine by cystocentesis is the most suitable method.
- If characteristic crystals (see figure on the next page) are found in the sediment, the animal species, urine pH and specific gravity



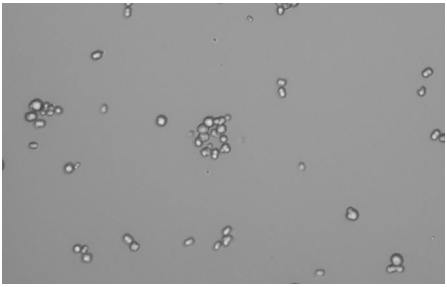
calcium oxalate



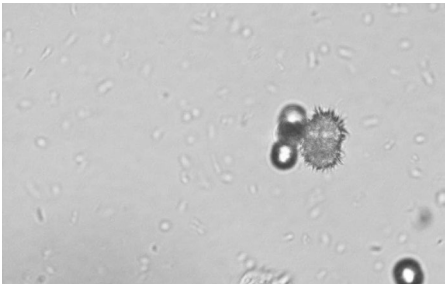
struvite



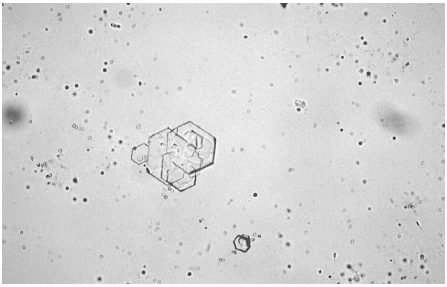
calcium carbonate/calcium oxalate



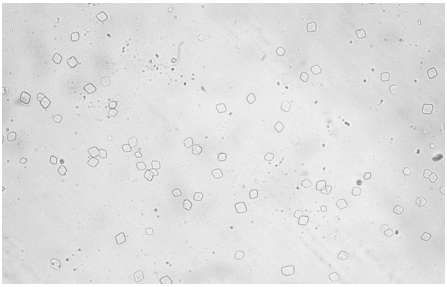
ammonium monourate



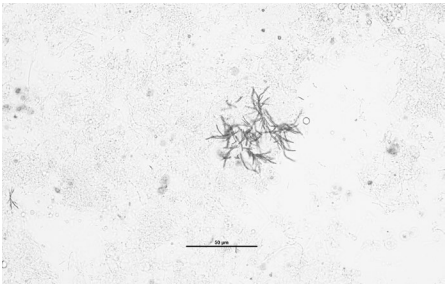
ammonium biurate



cystine



uric acid



bilirubin

Crystals from urinary sediment (microscopy, 40x obj.) resp. ammonium biurate 100x obj.

should be included to draw clear conclusions about the chemical composition. Larger concretions can be analysed by FTIR (see Urinary Calculi).

Digital Urinary Sediment - Image Analysis

The image upload in "MyLab" allows you to quickly get a veterinary diagnosis of digital images with unclear findings from your practice. You can upload up to 4 images with your diagnostic task via the **image analysis "Digital Urinary Sediment"** in the password-protected area of our "MyLab" website. You will receive the laboratory findings by e-mail, usually on the same day.

Urinary Calculi

Material	Calculi, concretions, dry min. 5 g
Method	Infrared spectroscopy (FTIR)
Species	Dog, cat, rabbit, guinea pig, reptiles, horse, ruminants, others on request
Duration	1 day
Note	The analysis of concretions is necessary for a targeted dietary therapy and for prophylaxis. Depending on the chemical composition, urinary calculi produce characteristic curves in infrared spectroscopy (see figure for examples). The analysis is also suitable for the description of other concretions such as gallstones. If you have special material or special questions, please consult the laboratory.

Urine Bacteriological Culture ➢ see Chapter 14.1, p. 254

Urine Protein Electrophoresis

Material	Urine 1 ml
Method	Agarose gel electrophoresis
Species	Dog, cat, others on request
Test frequency	1 x per week
Note	▪ Differentiation of glomerular and interstitial/tubular nephropathies. ▪ Only useful in case of increased U-P/C ratio. ▪ Not recommended if urine is contaminated with blood or if prostate cysts are suspected. ▪ Visualisation of protein bands – free kappa light chains and free lambda light chains which can be associated with Bence-Jones proteins. Direct detection of **Bence-Jones proteins** should be done for confirmation and can be requested separately.

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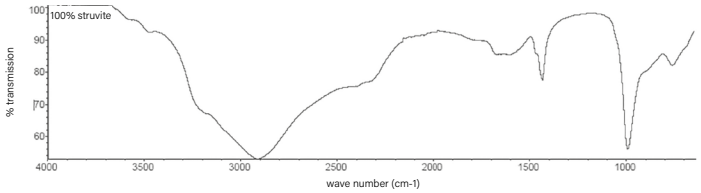
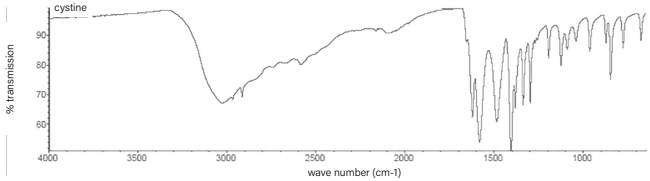
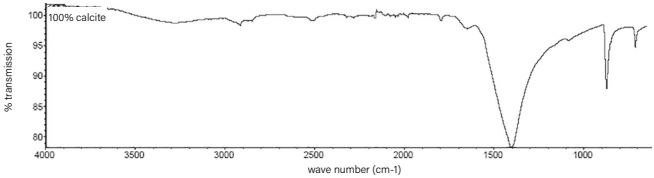
FTIR spectrum of struvite



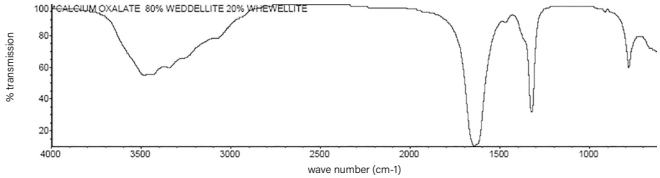
FTIR spectrum of cystine



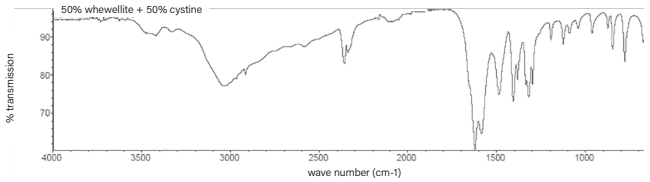
FTIR spectrum of calcium carbonate



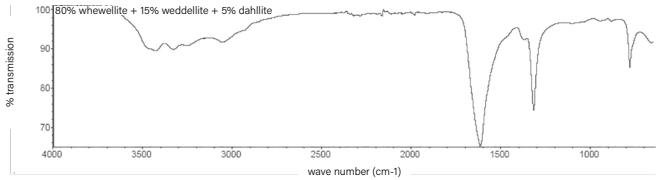
FTIR spectrum of calcium oxalate



FTIR spectrum of calcium oxalate and cystine



FTIR spectrum of calcium oxalate and dahllite



Analysis of urinary calculi by infrared spectroscopy:
FTIR spectra of struvite, cystine, calcium oxalate, calcium carbonate and mixed forms
Recording the transmission of infrared light at specific frequencies. Transmission is directly related to the oscillation energy of the molecular binding.
There are characteristic curves for each type of calculus – including mixed forms.

6 Allergy

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

6.1 Allergy Testing

Allergy Profiles (Dog/Cat)
The tests included in the profiles are listed individually after the allergy profiles in this chapter.

Allergy Profile Skin (horse)

Material	S 3 ml
Parameter	Seasonal, Perennial, Insect, Food Panel

Allergy Profile Respiratory (horse)

Material	S 1 ml
Parameter	Seasonal, Perennial Panel

Food Allergen Profile (dog, cat)

Material	S 1.5 ml
Parameter	Food Allergens Basic, Extended and Exotic

Pruritus Profile – Large (dog)

Material	S 3.5 ml
Parameter	Seasonal and Perennial Panel, Food Allergens Basic and Extended, sarcoptes antibodies, flea saliva

Pruritus Profile – Small (dog)

Material	S 2.5 ml
Parameter	Allergy Screening Test, sarcoptes antibodies

Pruritus Profile – Medium (dog, cat)

Material	S 2.5 ml
Parameter	Seasonal and Perennial Panel, Food Allergens Basic and Extended

Allergy screening tests/main allergy tests

Allergy Screening Test

Material	**Dog, cat:** S 2 ml **Horse:** S 1.5 ml
Method	**Dog, cat:** ELISA, Fcε-receptor technology **Horse:** ELISA
Species	Dog, cat, horse
Duration	2 days
Note	▪ Cost-effective screening test to determine for which allergen group the main test should be performed or whether it is already possible to test again after cortisone administration. ▪ The pollen, mite and mould groups are tested in all species. ▪ **Dog, cat:** including flea saliva ▪ **Horse:** including insects ▪ Ideal testing time at the time of exposure (no earlier than 3 – 4 weeks after the onset of the signs). All samples sent in are stored by us for 14 days. Hence, in this time frame, if there has been a positive test result, it is possible to request further tests from a sample sent in for a screening test.

Perennial Panel (dog, cat)

Material	S 0.5 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	2 days
Note	Differentiation or detection of individual mould and mite allergens. Moulds: Alternaria alternata, Aspergillus fumigatus, Cladosporium herbarum, Penicillium notatum Mites: Dermatophagoides farinae, Dermatophagoides pteronyssinus, Acarus siro, Tyrophagus putrescentiae

Perennial Panel (horse)

Material	S 0.5 ml
Method	ELISA
Species	Horse
Duration	2 days
Note	Differentiation or detection of individual mould and mite allergens. Moulds: Alternaria alternata, Aspergillus fumigatus, Aspergillus niger, Cladosporium sp., Epicoccum sp., Helminthosporium sativum, Penicillium sp., Fusarium spp., Ustilago sp., Rhizopus sp.

Mites: Dermatophagoides farinae, Dermatophagoides pteronyssinus, Acarus siro, Tyrophagus putrescentiae, Glycophagus domesticus, Lepidoglyphus destructor

Seasonal Panel (dog, cat)

Material	S 1 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	2 days
Note	Differentiation or itemisation of seasonal allergens. Pollen: 6-grass mix (orchard grass, perennial ryegrass, Timothy grass, meadow fescue, Kentucky bluegrass, meadow soft grass), rye, mugwort, ragweed, English plantain, nettle, common sorrel, birch, hazel, willow Ideal testing time at the time of exposure (no earlier than 3 – 4 weeks after the onset of the signs) The Seasonal Panel for dogs and cats also includes the CHO test and, if necessary, blocking of antibodies directed against cross-reactive carbohydrate determinants (anti-CCD IgE).

Seasonal Panel (horse)

Material	S 0.5 ml
Method	ELISA
Species	Horse
Duration	2 days
Note	Differentiation or itemisation of seasonal allergens. Pollen: 6-grass mix (orchard grass, perennial ryegrass, Timothy grass, meadow fescue, Kentucky bluegrass, meadow soft grass), rye, mugwort, lamb's quarters/goosefoot, English plantain, nettle, sorrel, dandelion, rape, ragweed, hazel, alder, poplar, birch, beech, willow

Insect Panel (horse)

Material	S 1 ml
Method	ELISA
Species	Horse
Duration	3 days
Note	Detection of individual allergens of black fly (Simulium sp.), mosquito (Culex sp.), horsefly (Tabanus sp.), housefly (Musca sp.), biting midges (Culicoides sp.).

PAX complete	
Material	S 0.5 ml
Method	ELISA (microarray)
Species	Dog, horse
Duration	2 – 4 days
Note	The Pet Allergy Xplorer (PAX) test analyses over 200 allergen extracts and molecular components with CCD blocking for food and environmental allergens. The test is available separately for either food or environmental allergens or as a combined service.

Further main tests

Feathers/Hairs/Epithelia	
Material	S 0.5 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat, horse
Duration	7 days
Note	Detection of single **epithelial allergens**: cat, dog, rabbit, guinea pig, parrot feathers, feather mix

Flea Saliva (IgE)	
Material	S 0.5 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	2 days
Note	A combination of flea saliva and recombinant flea saliva allergen is used as allergen.

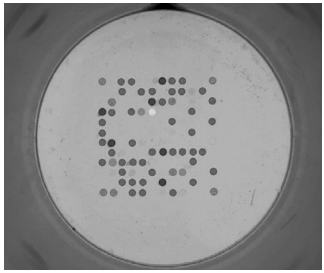
Food Allergens Basic	
Material	S 0.5 ml
Method	ELISA (microarray)
Species	Dog, cat
Duration	2 days (dog), 2 – 4 days (cat)
Note	▪ Determination of IgG and IgE antibodies against 19/16 single allergens. Dog: beef, pork, lamb, chicken, turkey, duck, soy, wheat, corn, rice, egg, milk, barley, potato, oats, whiting, salmon, rabbit, deer Cat: beef, lamb, pork, chicken, turkey, duck, potato, soy, wheat, corn, rice, egg, milk, salmon, tuna, whiting ▪ Basis for the specific selection of suitable dietary components for an elimination diet.

Food Allergens Exotic

Material	S 0.5 ml
Method	ELISA (microarray)
Species	Dog, cat
Duration	7 days
Note	▪ Determination of IgE and IgG antibodies in dogs and cats against 15 "exotic" single allergens (trout, goat, camel, buffalo, quail, hermetia, sweet potato, sunchoke, buckwheat, bean, carrot, pumpkin, zucchini, pea, yeast). ▪ Basis for the specific selection of suitable dietary components for an elimination diet.

Food Allergens Extended

Material	S 0.5 ml
Method	ELISA (microarray)
Species	Dog, cat
Duration	7 days
Note	▪ Determination of IgE and IgG antibodies against 8 single allergens which are fed rather infrequently. Dog: horse, ostrich, wild boar, reindeer, amaranth, millet, kangaroo, parsnip Cat: horse, ostrich, wild boar, reindeer, amaranth, millet, venison, rabbit ▪ Basis for the specific selection of suitable dietary components for an elimination diet.



Microarray technology:
A variety of allergens and reference controls are placed in a well of the plate. Each allergen has a specific position in the well and is tested in triplicate.

Food Panel

Material	S 1 ml
Method	ELISA
Species	Horse
Duration	7 days
Note	▪ Determination of IgE and IgG antibodies against 8 single alimentary allergens (soy, molasses, oats, corn, barley, wheat, barn, lucerne.) ▪ Basis for the specific selection of suitable dietary components for an elimination diet.

Hymenoptera*

Material	S 0.5 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	10 days
Note	Detection of individual allergens of bee, wasp, hornet and paper wasp. This service also includes the CHO test and, if necessary, blocking of antibodies directed against cross-reactive carbohydrate determinants (anti-CCD IgE).

Insect Panel (dog, cat)

Material	S 0.5 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	7 days
Note	Detection of individual allergens of deerfly (Chrysops), mosquito (Culex sp.), horse fly (Tabanus sp.), stable fly (Stomoxys sp.) and cockroach (Blatella germanica).

Malassezia

Material	S 0.5 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	7 days
Note	▪ Detection of a sensitisation (IgE) to Malassezia. ▪ Can be added to the ASIT.

Mediterranean Panel

Material	S 2 ml
Method	ELISA, Fcε-receptor technology
Species	Dog, cat
Duration	7 days
Note	Detection of individual Mediterranean allergens: ▪ **Perennial allergens** (Mites: Dermatophagoides farinae, Dermatophagoides pteronyssinus, Acarus siro, Tyrophagus putrescentiae. Moulds: Alternaria alternata, Aspergillus fumigatus, Penicillium notatum) ▪ **Seasonal allergens** (Timothy grass, perennial ryegrass, Bermuda grass, yellow dock, English plaintain, mugwort, lamb's quarter/goosefoot, pellitory, dandelion, nettle, ragweed, olive, cypress, pine tree, plane tree, common privet, birch)

- Ideal testing time at the time of exposure (no earlier than 3 – 4 weeks after the onset of the signs.)
- This service also includes the CHO test and, if necessary, blocking of antibodies directed against cross-reactive carbohydrate determinants (anti-CCD IgE).

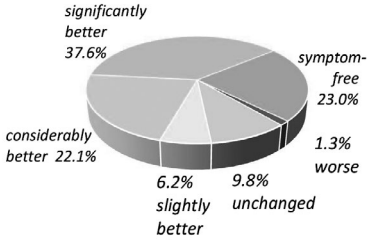
6.2 Allergen-specific Immunotherapy

Allergen-specific Immunotherapy (ASIT)

Material	Not necessary
Species	Dog, cat, horse
Duration	Approx. 2 – 3 weeks

Note

- Hyposensitisation to seasonal or perennial antigens according to test outcome.
- Please note: Food and Hymenoptera allergens cannot be added to the therapy!
- Therapy has to be carried out fo at least one year, if successful, it is continued for a lifetime (patient-specific solutions).
- The composition of an ASIT can also be done on the basis of any other test result (e.g. intradermal testing).
- A maximum of 8 allergens or allergen mixtures per set; if more than 8 allergens/mixtures are needed, the allergens will be spread over a double set (2 sets), for which the double price of a single set is charged.
- Please enclose a **veterinary prescription** with your order!
- The starter set will last for approx. 6 months, the refill set for approx. 10 months.



Dog: 89% success if ASIT is started within 2 years of the onset of the disease.

Sign	Success ASIT
Pruritus	75 %
Respiratory disease	80 %
Respiratory disease within 2 years	86 %

Impressive success rates of ASIT in **horses**, especially in respiratory diseases and if therapy is started after a short duration of disease.

6.3 Digital Material on Allergies

App "4Paws"

The Laboklin app „4 Paws" for animal owners reminds users of vaccinations, drug administration and allergy treatments. It thus ensures adherence to the treatment plan and is particularly helpful in allergy treatment. Additionally, diagnoses and other important data about the animal can be saved in the app in compliance with data protection regulations. When travelling, the app reminds you of recommended preventive measures and follow-up examinations. Information on vector-borne pathogens found in the travel destination is available in the "Fact Sheets" provided in the app.
The app can be installed for free from the app stores.

7 Immunological Tests/Markers for Inflammation

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

2M Antibodies (Masticatory Muscle Myositis)*

Material	S 0.5 ml
Method	RIA
Species	Dog
Duration	10 days
Note	Antibodies are determined against type 2 muscle fibres, which are mainly found in the masseter and temporalis muscles. Clinically, these animals are characterised by atrophy of these muscle groups.

Acetylcholine Receptor Antibodies

Material	S 1 ml
Method	IFAT
Species	Dog
Duration	1 – 2 days
Note	▪ This test is used to detect myasthenia gravis in dogs. In this disease, antibodies against acetylcholine receptors are formed. It is characterised by weakness of the striated muscles which is enhanced by stress. ▪ The weakness of the muscles may be generalised or locally limited to few muscle groups, such as those of the oesophagus (megaoesophagus).

Antinuclear Antibodies (ANA)

Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, cat, horse
Duration	1 – 2 days
Note	This test is used for the serological detection of autoimmune diseases (e.g. lupus erythematodes). If the test yields a negative result, a biopsy should be taken and examined, as the serological testing can be negative especially in case of local changes. Low positive titres may also occur in many general diseases.

Coombs Test (direct)

Material	EB 0.5 ml
Method	Agglutination
Species	Dog, cat, horse
Duration	1 day

Note
- This test is used for the detection of autoimmune haemolytic anaemia (AIHA).
- Positive reactions also occur in almost all infections with blood parasites.
- A negative Coombs test does not completely rule out AIHA.

C-reactive Protein (CRP)

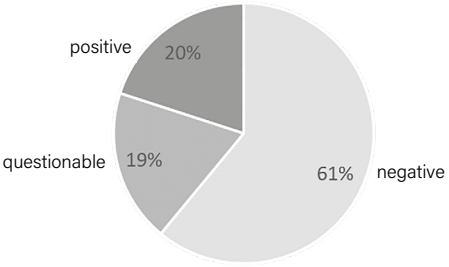
Material	S, CSF 0.5 ml
Method	Photometry
Species	Dog
Duration	1 day

Note: Inflammatory mediator (acute-phase protein) that is used to diagnose non-obvious inflammation and for therapy monitoring.

Gluten Sensitivity

Material	S 0.5 ml (cooling preferred)
Method	ELISA
Species	Dog
Duration	5 days

Note
- Detection of IgA against tissue transglutaminase and IgG against modified gliadin peptides.
- Gluten and its subfraction gliadin are found in wheat, spelt, rye and barley.
- Gluten intolerance leads to different clinical pictures depending on the breed: gluten-sensitive enteropathy in the Irish Setter and canine epileptoid cramping syndrome (CECS, Spike's disease, paroxysmal gluten-sensitive dyskinesia) in the Border Terrier. Mixed forms and gluten intolerance in other breeds have been described in the literature.
  In one study, Laboklin was able to prove a clear or questionable gluten sensitivity in 39% of the dogs (see figure). The affected breeds were mainly mongrels, French Bulldogs, German Shepherds and Labrador Retrievers.



Gluten sensitivity in the diagnosis of food allergies

Haptoglobin	
Material	S, HP 0.5 ml
Method	Photometry
Species	Dog, cat, ruminants, New World camels, pig, others on request
Duration	1 day
Note	Haptoglobin is an acute-phase protein. Its levels increase due to inflammation. Haptoglobin is much more sensitive than fibrinogen.

Cellular **Immune Status**	
Material	EB, HB 3 ml (For the maximum **age of the sample**, see **submission form**.)
Method	Flow cytometry
Species	Dog, cat, horse
Duration	1 – 2 days
Note	▪ The cellular immune status includes a complete blood count as well as the determination of B-cells (CD 21+), T-cells (CD3+, CD5+), T-helper cells (CD4+) and cytotoxic T-cells (CD8+). ▪ In **dogs,** determination of the immune status is useful for monitoring leishmaniasis. Furthermore, the immune status can be helpful for monitoring pyoderma (German Shepherd), demodicosis and systemic lupus erythematodes as well as T-cell deficiency. ▪ In **cats,** the cellular immune status is used to determine the current phase of the disease in FIV-positive animals. The test is also used in FIV-positive cats with stomatitis. ▪ In **horses,** it is used to clarify frequent and prolonged infections.

Immunoglobulin A (IgA)	
Material	S 0.5 ml
Method	ELISA
Species	Dog
Test frequency	2 x per week
Note	▪ In animal serum, IgA is found in lower concentrations than the other immunoglobulins. It is considered the most important immunoglobulin in the outer conjunctival secretions and in the urine, and is present in secretory form. ▪ In dogs, IgA is a diagnostic marker of steroid-responsive meningitis-arteritis.

Immunoglobulin G (IgG)

Material	S 0.5 ml
Method	Capillary electrophoresis
Species	Dog, cat, horse, foal, cattle, calf, sheep, lamb, goat, goat kid, New World camels, cria, pig, piglet
Duration	1 – 2 days, newborns: 1 day
Note	▪ IgG is the strongest immunoglobulin fraction in blood serum. The greatest significance of IgG lies in the antibody-mediated immune response. Due to its small size, IgG can diffuse from the capillaries and, thus, has an additional relevance in immune reactions in tissue spaces and on the body surface. ▪ **Newborns:** At birth, foals, calves, lambs, kids, crias and piglets have only marginal IgG content in the blood. They mainly take up IgG via the colostrum. IgG content is therefore an indicator for a sufficient supply of colostrum. ▪ **Foals:** The lack of maternal antibodies is one of the most important predisposing factors for infectious diseases in foals. IgG determination in the blood of newborn foals allows for a timely diagnosis – before infections occur – as well as the initiation of therapeutic measures. ▪ IgG for newborns and for adults can be requested via separate service IDs.

Immunoglobulin M (IgM)

Material	S 0.5 ml
Method	Photometry
Species	Dog, cat, pig and others
Duration	2 days
Note	Most notably, the importance of IgM lies in the mediation of the primary immune response. IgM is also involved in the secondary immune response but its significance is lower. The secondary immune response is mainly mediated by IgG.

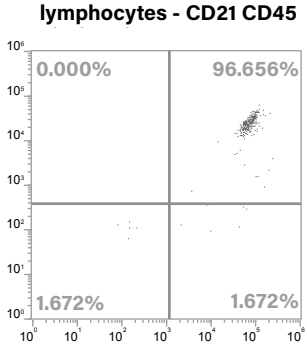
Insulin Antibodies ➢ **see Chapter 8, p. 91**

Leukaemia Immunophenotyping

Material	Lymph node aspiration (in an NaCl/serum mix, should be sent in a mix ratio of 50:50), peripheral blood (EB, HB 2 ml; for the maximum **age of the sample**, see **submission form**) + cytology/blood smear
Method	Flow cytometry
Species	Dog, cat, horse
Duration	1 – 2 days

Note

- It is recommended to send in more sample material if possible. Up to 5 ml of sample volume are required if the total leukocyte count is low.
- With > 30.000 lymphocytes or positive clonality in the PARR test (see Chapter 18.4, p. 285), leukaemia immunophenotyping may allow to differentiate between lymphoproliferative neoplasia (lymphoma or leukaemia; B- and T-cell) and myeloid leukaemia. In dogs, it can additionally be differentiated between acute and chronic forms. This differentiation provides an indication of prognosis and treatment.Leukaemia immunophenotyping is also part of the Leukaemia/Lymphoma Profile.



Scatterplot of lymphocyte immunophenotyping
The lymphocyte population in this example is positive for the pan-leukocyte marker (CD45) and the B-cell marker (CD21). Here, it is a B-cell lymphoma.

Leukaemia/Lymphoma Profile

Material	Lymph node aspiration (in an NaCl/serum mix, should be sent in a mix ratio of 50:50), peripheral blood (EB, HB 3 ml; for the maximum **age of the sample**, see **submission form**) + cytology/blood smear
Species	Dog, cat, horse
Parameter	Complete blood count (if peripheral blood is supplied), cytology/ cytological blood smear, leukaemia immunophenotyping (by flow cytometry; myeloid and lymphoid cells), progenitor cells (depending on species), clonality (by PARR)
Duration	2 – 5 days
Note	▪ It is recommended to send in more blood, if possible, as immunophenotyping requires up to 5 ml of sample volume if the total leukocyte count is low. ▪ For a complete evaluation in case of suspected leukaemia, the leukaemia profile is always recommended and should be interpreted in correlation with the clinical picture and history. ▪ See also Leukaemia Immunophenotyping ▪ See also Lymphocytes Clonality (Chapter 18.4, p. 285).

Rheumatoid Factor (Waaler-Rose Test)

Material	S 0.2 ml
Method	Haemagglutination
Species	Dog, cat
Duration	1 – 2 days
Note	▪ This test can be used to determine rheumatic locomotor disorders. It should be performed during an acute episode because serology might yield negative results in symptom-free episodes. ▪ A negative test result does not rule out rheumatoid arthritis. The test can also be positive in patients with infectious, inflammatory and neoplastic diseases as well as in healthy animals. The result must always be correlated with the clinical picture.

Serum Amyloid A (SAA)

Material	S 0.5 ml
Method	Photometry
Species	Cat, horse, cattle, others on request
Duration	1 day
Note	▪ Non-specific inflammatory parameter (acute phase protein). ▪ An increase may indicate an inflammatory process, neoplasia or tissue damage. This parameter is particularly suitable for therapy monitoring. ▪ For equids and cattle, SAA can also be requested in combination with the large screening.

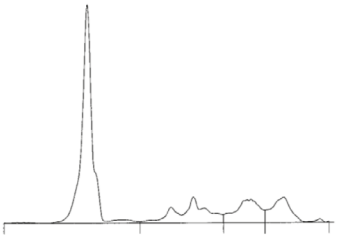
Serum Protein Electrophoresis

Material	S, EP, HP 0.5 ml, birds and reptiles: S, HP 0.5 ml
Method	Capillary electrophoresis
Species	Dog, cat, rabbit, ferret, birds, reptiles, horse, cattle, others on request
Duration	1 – 2 days
Note	▪ Includes the separation of the protein fractions albumin, α-, β-, γ-globulins and the albumin-globulin ratio. The protein fractions are also represented in form of a graph (see **figures**). ▪ Acute inflammation leads to an increase in the α- and/or β-globulin fraction. Polyclonal hypergammaglobulinaemia is caused by infectious, immune-mediated or neoplastic diseases. Especially in case of feline infectious peritonitis (FIP), the test is used to support the clinical suspicion. ▪ Albumin, α- and β-globulin fractions are lowered in case of severe liver diseases. ▪ When using plasma, an additional small peak in the β-globulin fraction is possible due to coagulation factors.

Thyroglobulin Antibodies ➢ **see Chapter 8, p. 98**

Thrombocyte Antibodies (Platelet Antibodies)

Material	EB, HB 0.5 ml (For the maximum **age of the sample**, see **submission form**)
Method	Flow cytometry
Species	Dog, cat
Duration	1 – 2 days
Note	▪ If possible, it is recommended to send at least 1 ml EB as the required sample amount depends on the total platelet count. ▪ There are two possible ways for the development of thrombocyte antibodies: – Autoantibodies against platelets are formed. Only in this case, a positive test result can be expected. – Platelet damage due to immune complex diseases can secondarily also lead to the formation of antibodies against platelets. ▪ Evaluation: ≤ 10% negative, > 10% positive ▪ Detection of platelet antibodies is also part of the Thrombocytopenia Profile



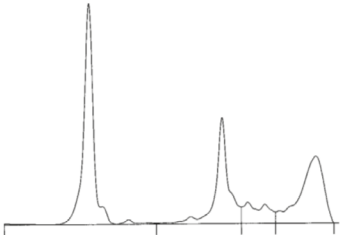
Capillary electrophoresis

Fraction	%	g/l
Albumin	56.7	37.54
Alpha	17.2	11.39
Beta	13.8	9.14
Gamma	12.3	8.14

Dog:	
Alb:	47-59%
α glob:	9-15%
β glob:	14-24%
γ glob:	8-18%

Alb/glob = 1.31
Total protein: 66.2 g/l

normal electrophoresis



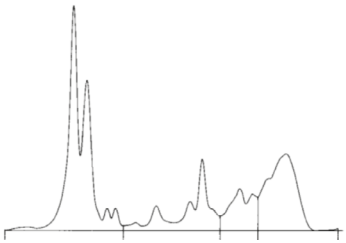
Capillary electrophoresis

Fraction	%	g/l
Albumin	40.2	42.57
Alpha	23.9	25.31
Beta	8.3	8.79
Gamma	27.6	29.23

Cat:	
Alb:	45-60%
α glob:	8-15%
β glob:	10-20%
γ glob:	10-28%

Alb/glob = 0.67
Total protein: 105.9 g/l

pronounced α2 peak, polyclonal γ peak
suspicion: acute infectious process



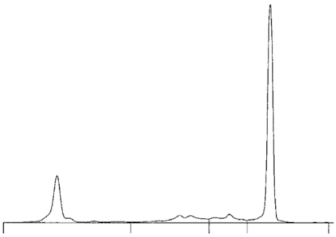
Capillary electrophoresis

Fraction	%	g/l
Albumin	45.4	31.05
Alpha	16.9	11.56
Beta	11.4	7.80
Gamma	26.3	17.99

Horse:	
Alb:	45-60%
α glob:	10-20%
β glob:	10-25%
γ glob:	8-22%

Alb/glob = 0.83
Total protein: 68.4 g/l

split albumin peak
frequently found in ponies in case of lipoproteinaemia



Capillary electrophoresis

Fraction	%	g/l
Albumin	22.1	28.20
Alpha	10.6	13.53
Beta	7.5	9.57
Gamma	59.8	76.30

Cat:	
Alb:	45-60%
α glob:	8-15%
β glob:	10-20%
γ glob:	10-28%

Alb/glob = 0.28
Total protein: 127.6 g/l

monoclonal gammopathy
in leukaemoid disease

Serum protein electrophoresis – examples for normal results, lipoproteinaemia, suspected acute infection and leukaemoid disease

8 Endocrinology/Tumour Markers

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

ACTH (Adrenocorticotropic Hormone)	
Material	EP 0.5 ml (centrifuge, pipette off and cool promptly after collection)
Method	CLIA
Species	Dog, horse, others on request
Duration	1 day
Note	Indications: Diagnosis of PPID (Cushing's disease) in horses and therapy monitoring of dopamine receptor antagonists in horses Differentiation of primary or secondary Addison's disease in dogs.

AFP ➢ see Tumour Marker AFP, p. 98

Aldosterone	
Material	EP 0.5 ml (centrifuge, pipette off and cool promptly after collection)
Method	LCMS
Species	Dog, cat, others on request
Duration	7 days
Note	Diagnosis of hyperaldosteronism due to unilateral tumours of the adrenal cortex; common signs are hypertension, acute vision loss, hypokalaemic polymyopathy.

Androstenedione	
Material	S 0.5 ml (centrifuge, pipette off and cool promptly after collection)
Method	ELISA
Species	Dog, ferret
Duration	2 – 5 days
Note	Used for detecting an endocrine active hyperplasia/neoplasia of the adrenal gland.

Anti-Müllerian Hormone (AMH)	
Material	S 0.5 ml (centrifuge, pipette off and cool promptly after collection)
Method	CLIA
Species	Dog, cat, rabbit, horse, cattle, others on request
Duration	1 day

Note	AMH is secreted in the granulosa cells of the maturing follicle and the Sertoli cells in the testes. It is, thus, a highly sensitive marker for the diagnosis of granulosa cell tumours, cryptorchidism, differentiation castrated/intact.

pro-**BNP (B-Type Natriuretic Peptide)**	
Material	EP 0.5 ml (promptly centrifuged, pipetted off; please pay attention to the note on the submission form regarding the temperature during storage/transport!)
Method	ELISA
Species	Dog, cat
Test frequency	2 x per week
Note	▪ The concentration of BNP depends on changes in blood pressure in the ventricle. Its determination mainly serves the early diagnosis of dilated cardiomyopathy. The myoendocrine cells of the heart start to secrete BNP as soon as the myocardium exhibits vasodilative wall tension. BNP increases the renal excretion of sodium and water, lowers the intracardiac pressure and has vasodilatory effects. ▪ This test is suitable as a screening test for elder patients or predisposed breeds (e.g. Doberman).

CEA ➢ see Tumour Marker CEA, p. 99

Cortisol	
Material	S, EP 0.5 ml (horse: serum only)
Method	CLIA
Species	Dog, cat, rabbit, guinea pig, rat, mouse, ferret, horse, ruminants, New World camels, others on request
Duration	1 day
Note	▪ Depending on the clinical issue, the following **Function Tests** (see Chapter 9, p. 101) can be performed: ACTH stimulation test Dexamethasone suppression test (low or high dose) ▪ Determination of cortisol following administration of Vetoryl; see **Vetoryl Therapy Control** in this chapter. ▪ Single value determination has extremely low diagnostic value.

Saliva **Cortisol**	
Material	Saliva 0.1 ml
Method	ELISA
Species	Guinea pig, others on request

Duration	on request
Note	▪ Only on request. ▪ Test vessels will be provided. ▪ Measurement also possible as part of an ACTH stimulation test. ▪ **Guinea pig:** Measurement also possible as part of an ACTH stimulation test or a dexamethasone suppression test for the diagnosis/therapy monitoring of Cushing's syndrome.

CPSE (Canine Prostate-Specific Arginine Esterase)

Material	S, EP, HP 0.5 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Method	ELISA
Species	Dog, male
Duration	1 – 5 days
Note	▪ Elevated levels indicate the presence of benign prostatic hyperplasia. ▪ In differential diagnosis, prostatitis or prostate neoplasia can also lead to an increase. To confirm the diagnosis, an ultrasound, fine-needle aspiration, testing for BRAF mutation or a prostate biopsy are recommended.

Erythropoietin

Material	S 0.5 ml (promptly centrifuged, pipetted off and frozen)
Method	ELISA
Species	Dog, others on request
Test frequency	1 x per week
Note	Used for the diagnosis of renal-related non-regenerative anaemia and to confirm or exclude polycythaemia.

fT3 and fT4 ➢ see below T3 and T4, p. 95

IGF-1 (Insulin-like Growth Factor 1, STH Equivalent)

Material	S 0.5 ml (centrifuge, pipette off and cool promptly after collection)
Method	CLIA
Species	Dog, cat, others on request
Duration	1 day
Note	▪ Secretion is stimulated directly by the somatotropic hormone (= growth hormone), IGF-1 can therefore be interpreted as equivalent to STH. ▪ Indications are growth disturbances in young animals, changes in coat structure, acromegaly in adult animals, therapy-resistant diabetes mellitus in cats.

- Single value: only slightly decreased in case of growth disturbances; if the result is questionable, a function test should be performed (xylazine stimulation test/STH stimulation test).
- In cattle, IGF-1 is suitable as a laboratory parameter for the early diagnosis of ovarian cysts and laminitis.

Insulin

Material	S 1 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Method	CLIA, ELISA (cat only)
Species	Dog, cat, horse, others on request
Duration	1 day
Note	▪ In case an insulinoma is suspected; concentration is only diagnostically conclusive if glucose is determined at the same time. ▪ 12-hour fasting period prior to sampling (no longer recommended for horses, but no concentrated feed or cereal grains – only hay.) ▪ Dog: Determine insulin/glucose ratio or AIGR (amended insulin/glucose ratio). An insulin/glucose ratio < 52 or an AIGR < 30 are considered normal, see also Function Tests, Chapter 9, p. 101. ▪ Equine metabolic syndrome (EMS): EMS leads to a disorder of carbohydrate and fat metabolism with insulin dysregulation (ID). Increased insulin secretion (partly) compensates for decreased insulin efficiency. Insulin-dysregulated horses therefore have considerably increased fasting insulin levels. At the same time, fasting glucose is physiological (compensated) or elevated (not compensated). Further test: Oral Glucose Test with Insulin Determination (see Chapter 9, p. 107). ▪ Simultaneous measurement of the glucose level makes it possible to calculate the proxies - insulin/glucose ratio - reciprocal inverse square of insulin (RISQI) – "insulin sensitivity" - modified insulin-to-glucose ratio (MIRG) – "β-cell function (pancreas)"

Insulin Antibodies*

Material	S 0.5 ml (cooled)
Method	ELISA
Species	Dog, cat
Duration	14 – 21 days

Normetanephrine/Metanephrine*

Material	EP 5 ml (promptly centrifuged, pipetted off and frozen)
Method	HPLC
Species	Dog, others on request
Duration	5 – 8 days
Note	▪ Normetanephrine and metanephrine are metabolites of adrenaline and noradrenaline. High levels, particularly of normetanephrine, are indicative of the presence of pheochromocytoma. ▪ Reference values only available for dogs.

Normetanephrine/Metanephrine-Creatinine Ratio*

Material	Urine 10 ml (cooled, acidified (pH <2))
Method	HPLC
Species	Dog, others on request
Duration	5 – 8 days
Note	High ratios of normetanephrine to creatinine and of metanephrine to creatinine are indicative of the presence of pheochromocytoma.

Oestradiol-17β

Material	S 0.5 ml
Method	CLIA
Species	Dog, cat, rabbit, ferret, horse, cattle, others on request
Duration	1 day
Note	▪ Testing for oestradiol-17β is done in case of disorders of the sexual cycle (repeated determination), neoplasia of the ovaries, ovary cysts, suspected Sertoli cell tumour. ▪ In dogs and ferrets, permanently elevated levels can lead to thrombocytopenia and anaemia due to bone marrow depression. ▪ **Male dogs:** often feminisation syndrome if levels are elevated. ▪ **Ferrets**: part of the Ferret Profile for the diagnosis of hyper-adrenocorticism.

Oestrone Sulphate (= E1S)

Material	S 1 ml
Method	LCMS
Species	Horse, donkey, llama, alpaca, others on request
Duration	5 days
Note	In pregnant mares, oestrone sulphate is secreted in increasing concentrations from the 50th day onwards. The oestrone sulphate level drops to baseline level after abortion or resorption within a few days. Reliable diagnosis is possible from day 110 onwards.

- **Mare:** To determine an intact pregnancy
- **Llama/alpaca:** Diagnosis of late pregnancy (from 10th/11th month onwards). In the earlier stages of pregnancy, we recommend to determine progesterone.

PAG (Pregnancy-Associated Glycoproteins)	
Material	S, HP 1 ml
Method	ELISA
Species	Cattle, sheep, goat
Duration	2 – 3 days
Note	Can be used to determine pregnancy in cattle and goats from the 28th day and in sheep from the 35th day after conception.

Parathormone (PTH)	
Material	S 1 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Method	CLIA
Species	Dog, cat, horse, others on request
Duration	1 day
Note	▪ Determination is used to diagnose hyper- or hypoparathyroidism. ▪ Concentration should only be assessed when ionised Ca (and possibly phosphate) levels are determined simultaneously. ▪ Possible causes for high levels of PTH are low levels of calcium, e.g. in case of renal dysfunction, and disorders of vitamin D metabolism.

Parathormone-rP (Parathormone-related Protein)*	
Material	EP 1 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Method	RIA
Species	Dog, cat
Duration	10 days
Note	▪ PTHrP is a parathormone-like protein. ▪ The hormone is formed physiologically during growth and during pregnancy. ▪ This parameter should not be used to diagnose pregnancy, as the cut-off value depends on several factors and varies between individuals. ▪ Pathologically, it is secreted by different tumours, e.g. by some kinds of lymphoma, lymphosarcoma and anal sac carcinoma.

PMSG = eCG (Pregnant Mare Serum Gonadotropin resp. Equine Chorionic Gonadotropin)

Material	S, HP 0.5 ml
Method	ELISA
Species	Horse, donkey
Test frequency/ Duration	Horse 2 x per week Donkey 7 – 10 days*
Note	▪ Determination of pregnancy between day 45 and 100. ▪ PMSG can be detected for a while after resorption or abortion, although there is no live foetus anymore.

Progesterone

Material	S 0.5 ml
Method	CLIA
Species	Dog, cat, horse, cattle, sheep, goat, alpaca, others on request
Duration	1 day
Note	▪ Measurement is performed to monitor luteal function. ▪ Can be used during early pregnancy to confirm conception in cattle, horse, sheep and goat. However, as there are also increases in progesterone levels in the regular cycle, this difference is only diagnostically useful during the cycle-dependent decrease in progesterone. In horses and cattle, only samples which were taken on the 18th and 19th day after ovulation are useful and only prove that the animals are not in heat again at the expected time. Progesterone is not specific to pregnancy. The test cannot differentiate as to whether the corpus luteum has formed during the cycle or as a result of gestation. ▪ **Llama/Alpaca:** Diagnosis of pregnancy from the 21st day of gestation onwards. In late pregnancy (10th/11th month), the determination of oestrone sulphate is also possible. ▪ **Female dog:** Determination of the ovulation time, determination of the optimum time for mating, diagnosis of corpus luteum insufficiency (repeated determination).

17 OH-Progesterone

Material	S 0.5 ml
Method	ELISA
Species	Dog, ferret, others on request
Test frequency	2 x per week
Note	▪ Clarification of adrenocortical hyperplasia and neoplasia in ferrets and dogs.

- In female animals in the luteal phase, high concentrations may be measured.
- In case of doubt, it is necessary to perform an ACTH stimulation test.

Serotonin

Material	S 0.5 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Method	HPLC
Species	Dog, others on request
Test frequency	1 x per week
Note	▪ At least 6 hours of **fasting** before sample collection. ▪ The test will not be performed if the samples do not arrive well-cooled at the laboratory (shipping is recommended in a styrofoam box with 2 – 3 frozen cold packs). ▪ For the clarification of behavioural disorders. Decreased serotonin levels have been found in case of aggression as well as in separation anxiety and other behavioural problems. ▪ The additional determination of serotonin can be helpful in diagnosis and therapy monitoring. ▪ The determination of serotonin levels is also part of the Behaviour Profile (dog).

T3 (Total Triiodothyronine)

Material	S 0.5 ml
Method	CLIA
Species	Dog, horse, cattle, New World camels, others on request
Duration	1 day
Note	▪ **Additional parameter** for the diagnosis of hyperthyroidism or hypothyroidism as the peripheral transformation of T4 to T3 only takes place when necessary and T3 is only secreted thyroidally to a small extent. ▪ If presence of T4 antibodies is suspected. ▪ Therapy monitoring: Blood sampling 3 hours after oral intake of T3 medication (dog).

f**T3 (Free Triiodothyronine)**

Material	S 0.5 ml
Method	CLIA
Species	Dog, cat, horse, New World camels, others on request
Duration	1 day

Note T3 in the serum is 99.7% reversibly bound to transport proteins. fT3 levels correlate with metabolic activity. Measuring free T3 is indicated when changes in the concentration of transport proteins for T3 result in changes in total T3 concentration.

T4 (Total Thyroxine)

Material S, HP 0.5 ml resp. 0.4 ml (small mammals)
Method CLIA
Species Dog, cat, rabbit, guinea pig, ferret, birds, reptiles, horse, cattle, New World camels, others on request
Duration 1 day

Note
- **Dog:** For the diagnosis of hypothyroidism. As a single value, it has only limited diagnostic significance. It should therefore always be determined in conjunction with fT4 and TSH or a functional test should be carried out (see Chapter 9, p. 101).
- **Cat:** For the diagnosis of hyperthyroidism, which is the most common hormonal disease in elder cats and which entails extensive sequelae (tachycardia, chronic diarrhoea, cachexia). Usually sufficient as a single parameter, in questionable cases, TSH and fT4 can be determined additionally.
- **Therapy monitoring dog/cat:** Blood sampling 4 – 6 hours after administration of thyroxine (dog), therapy monitoring 2 – 4 weeks after the start of treatment.
- **Birds and reptiles:** Values are physiologically often very low (below the detection limit of the test system used); in this case, determination of fT4 is recommended.
- **Horse:** If (very rarely occurring) hypothyroidism is suspected, determination of T4 and T3 with a subsequent TRH stimulation test is recommended.

fT4 (free Thyroxine 4)

Material S (possibly HP) 0.5 ml or 0.4 ml (small mammals)
Method CLIA
Species Dog, cat, rabbit, guinea pig, horse, New World camels, others on request
Duration 1 day

Note
- Single value determination: fT4 and fT3 are both strongly affected by the current metabolic state.
- Just like T4, fT4 is affected by underlying diseases.
- Fasting for 10 hours prior to sampling is recommended (omnivores and carnivores only).
- In cases of doubt: TRH stimulation test or, in dogs and cats, measure TSH concentration.

f**T4 Dialysis***	
Material	S 0.5 ml (promptly centrifuged, pipetted off and frozen)
Method	Equilibrium dialysis
Species	Dog, cat
Duration	10 – 14 days

Testosterone	
Material	S 0.5 ml
Method	CLIA horse/small mammals: LCMS
Species	Dog, cat, rabbit, guinea pig, ferret, horse, cattle, pig, others on request
Duration	1 day resp. 2 – 3 days (horse, small mammals)
Note	▪ Used for checking the endocrine testicular function, for the diagnosis of ovarian tumours in mares and to differentiate between cryptorchid and castrated male animals.

Thymidine Kinase	
Material	S 0.5 ml (centrifuge, pipette off and cool promptly after collection)
Method	CLIA
Species	Dog, cat, rabbit, guinea pig, ferret, horse, others on request
Duration	1 day
Note	▪ Thymidine kinase is an enzyme which helps introduce the nucleoside thymidine into the DNA by converting deoxythymidine to deoxythymidine phosphate (dTMP). It is thus essential for DNA synthesis. ▪ The activity of serum thymidine kinase 1 (sTK1) correlates closely with DNA synthesis and cell proliferation. The main indications for the determination of thymidine kinase in malignant haematopoietic neoplasms are therapy monitoring and early detection of relapse. ▪ Thymidine kinase is mainly excreted renally. Therefore, if levels are increased, it is necessary to exclude impaired renal function in differential diagnosis. ▪ Patients with hepatic cirrhosis may also show elevated concentrations. ▪ Growing patients physiologically have higher concentrations. ▪ Thymidine kinase is also part of the profile Tumour Diagnostics.

Thyroglobulin Antibodies (TgAb)

Material	S 0.5 ml
Method	ELISA
Species	Dog
Duration	1 – 2 days
Note	▪ For the diagnosis of autoimmune thyroiditis. ▪ Elevated levels of thyroglobulin antibodies also occur in clinically healthy dogs. ▪ The detection of thyroglobulin antibodies is also part of the Thyroid Profile (dog) and of the screening profiles fT4 + TSH + Thyroglobulin Antibodies (dog) and T4 + TSH + Thyroglobulin Antibodies (dog).

Thyroid-stimulating Hormone (TSH)

Material	S 0.5 ml
Method	CLIA
Species	Dog, cat
Duration	1 day
Note	▪ **Dog:** For the diagnosis of hypothyroidism only useful if T4 or fT4 are determined simultaneously, as TSH values are within the normal range in > 25% of the dogs with hypothyroidism. ▪ Therapy monitoring during diagnostic treatment. The dosage of thyroid hormones administered should be reduced if the concentration is < 0.03 ng/ml. ▪ **Cat:** For therapy monitoring.

Tumour Marker AFP (Alpha Fetoprotein)

Material	S (possibly also EP, HP) 1 ml
Method	CLIA
Species	Dog, cat, horse, others on request
Duration	1 day
Note	▪ To some extent, slightly increased values also occur in case of benign liver diseases in dogs. ▪ In case of hepatopathies, values are not or only slightly elevated. ▪ In case of liver tumours, values are slightly to significantly elevated. ▪ Values are increased physiologically during pregnancy. ▪ **Therapy monitoring:** In case of previous positive findings after surgical and/or chemotherapy, concentration should be within normal range. Relapse monitoring (every 6 months). Elevated in mares with placentitis.

Tumour Marker CEA (Carcinoembryonic Antigen)

Material	S (possibly also EP, HP) 1 ml
Method	CLIA
Species	Dog, cat, others on request
Duration	1 day
Note	▪ Values increase due to tumours of the gastrointestinal tract and the mammary glands, but also due to inflammatory processes. ▪ **Therapy monitoring:** In case of previous positive findings after surgical and/or chemotherapy, concentration should be within normal range. Relapse monitoring (every 6 months).

Tumour Test: Nu.Q®

Material	EP 0.5 ml (fasting required, refrigerated)
Method	ELISA
Species	Dog
Duration	On request
Note	▪ To determine the concentration of nucleosomes, which are increasingly released during apoptosis; small amounts can also be detected in healthy organisms. If there is massive cell death (e.g. in neoplasia), they accumulate. ▪ Indications: mainly haematopoietic neoplasms in therapy monitoring and early detection of relapse (e.g. lymphoma, haemangiosarcoma) ▪ Patients who are eligible for the test are "clinically healthy" and without inflammatory disease. ▪ Recommendation: 4 hours fasting before sample collection

Vetoryl® Therapy Control

Material	S 0.5 ml
Method	CLIA
Species	Dog
Duration	1 day
Parameter	1 x cortisol (before the administration of Vetoryl) 2 x cortisol (pre- and post-pill determination, 2 x pre-pill determination)
Note	▪ For monitoring Vetoryl treatment on day 28 in case of hyperadrenocorticism. ▪ Determination of 2 x pre-pill: collection 1 hour before and directly before pill administration. This sampling scheme is especially recommended for animals in which previous therapy monitoring pre- and post-pill did not produce sufficiently clear results and if fluctuations before pill administration are suspected.

- If the time of taking the pills has to be changed because of the blood sampling, it needs to be done at least one day in advance.
- An additional determination of cortisol 3 hours after the administration of the pill can further facilitate the analysis – pre- and post-pill determination: before and 3 hours after the administration of Vetoryl.
- Separate cortisol reference values apply for monitoring Vetoryl (pre-pill: 14 – 50 ng/ml, post-pill: 14 – 23 ng/ml).
- Not suitable for patients in poor general condition and for animals from which blood cannot be sampled stress-free. In these cases, the ACTH stimulation test is still recommended.

9 Function Tests/Calculations

The patients (omnivores and carnivores) should have fasted for at least 12 hours prior to every function test. Stress and excitement should be avoided.
In horses, fasting is only necessary in exceptional cases!

ACTH Stimulation Test	
Diagnosis	▪ Initial diagnosis of Addison's disease ▪ Iatrogenic Cushing's disease ▪ Cushing's disease ▪ Horse: to clarify Addison's disease/iatrogenic Cushing's disease
Species	Dog, cat, horse, guinea pig others on request
Material	S 2 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ **Dog:** injection of 5 µg ACTH/kg as Cosacthen® i.v./i.m. ▪ **Cat:** injection of 5 µg/kg Cosacthen® i.v./i.m. (Addison's disease only) ▪ **Guinea pig:** baseline cortisol, 20 IU ACTH/animal, 2nd sample collection after 4 hours ▪ **Horse:** injection of 100 IU ACTH i.v. (only hypoadrenocorticism) ▪ Second blood collection 1 hour post ACTH injection = stimulation value in dogs and cats ▪ Second blood collection 2 hours post ACTH administration = stimulation value in horses
Parameter to be determined	Cortisol
Interpretation	▪ Addison's disease/iatrogenic Cushing's disease: cortisol concentration post stimulation < 10 ng/ml (20 ng/ml in 8% of the cases, in central Addison's disease, a moderate stimulation > 20 ng/ml can be expected in dogs). ▪ In Cushing's disease (hyperadrenocorticism), the cortisol concentration post stimulation exceeds 150 ng/ml or is more than 3 times the baseline value, as long as it is in the middle of the normal range. Chronic stress and other underlying diseases (e.g. diabetes mellitus) can also lead to an abnormal ACTH response. According to the literature, a stimulation value > 220 ng/ml is, to a very high percentage, associated with Cushing's disease. ▪ It should be noted that approx. 15% of the dogs with pituitary and approx. 40% of the dogs with adrenal hyperadrenocorticism show a normal, i.e. not significantly elevated increase. ▪ For the interpretation of therapy monitoring in Cushing's disease see Vetoryl Therapy Control (see Chapter 8, p. 99). ▪ **Horse:** In healthy animals, the cortisol level increases by approximately 80%; horses with hypoadrenocorticism show very low baseline values which do not or only slightly increase after stimulation.

- **Guinea pig:** for therapy monitoring of Cushing's disease; at the time of diagnosis, it is not possible to differentiate between pituitary and adrenal Cushing's disease; there are no reference values available.

ACTH Stimulation Test Extended

Diagnosis	▪ Endocrine-active adrenal neoplasia, adrenal hyperplasia ▪ Early Cushing's disease
Species	Dog
Material	S 2 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ Injection of 5 µg ACTH/kg as Cosacthen® i.v./i.m. ▪ Second blood collection 1 hour post ACTH injection = stimulation value
Parameters to be determined	Cortisol and 17-OH-progesterone
Interpretation	▪ Corresponds to the basic ACTH Stimulation Test regarding the interpretation of cortisol. ▪ To clarify steroidal adrenal pathologies, cortisol and 17-OH-progesterone can be determined simultaneously. This is also possible in case of questionable results when determining the cortisol level after ACTH stimulation. ▪ In dogs with physiological steroid hormone synthesis, the concentration of 17-OH-progesterone increases to up to 180 ng/dl in the ACTH stimulation test. ▪ Dogs with a possible imbalance in the synthesis, which is found, for example, in case of enzyme defects or adrenal tumours, show an increased baseline concentration and significant hyperstimulation. ▪ Dogs with pituitary-dependent hyperadrenocorticism also show hyperstimulation. If the cortisol level is also significantly increased after stimulation, it indicates classic hyperadrenocorticism. ▪ Because of the test properties, patients that are already being treated with Vetoryl® cannot be tested for 17-OH-progesterone.

Bile Acid Stimulation Test

Diagnosis	Detection of a portosystemic shunt
Species	Dog, cat
Material	S 2 x 0.5 ml
Test procedure	▪ First serum sample = value after fasting (10 h) ▪ Feeding of 100 g meat plus 5 g fat/10 kg bdw ▪ Second serum sample 2 hours after feeding = post prandial value
Parameter to be determined	Bile acids

Interpretation	Stimulation values > 50 µmol/l are indicative of a portosystemic shunt, stimulation values > 40 µmol/l are considered suspicious.

Protein-corrected **Calcium Concentration**

Diagnosis	▪ Hypercalcaemia that is not caused by hyperparathyroidism can typically be attributed to tumours. ▪ Hypocalcaemia often causes seizure disorders in small animals. ▪ If hypoalbuminaemia or hyperproteinaemia exists, the calcium value should be corrected.
Species	Dog, cat
Material	S 0.5 ml
Parameter to be determined	Calcium, total protein
Calculation	Protein-corrected **calcium concentration** (mg/dl) = serum calcium level (mg/dl) - (0.04 x serum protein (g/l)) + 3.3

Cortisol Creatinine Ratio

Diagnosis	Diagnosis of Cushing's disease including differentiation between adrenal and pituitary forms
Species	Dog
Material	Morning urine 1 ml
Test procedure	▪ Collection of morning urine day 1 = sample 1 ▪ Collection of morning urine day 2 = sample 2 ▪ Administration of dexamethasone on day 2: orally 3 x 0.1 mg/kg bdw throughout the day ▪ Collection of morning urine day 3 = sample 3
Parameters to be determined	Cortisol, creatinine
Interpretation	▪ Interpretation of the ratio of day 1 and day 2: < 40: Normadrenocorticism, Cushing's disease is unlikely. 40 – 60: Questionable result > 60: Hyperadrenocorticism is possible and should be verified by a low-dose dexamethasone test. ▪ Interpretation of the ratio of day 3: (An increased ratio on day 1 and day 2 is a prerequisite) > 50% of the average value of the first two samples indicate a cortisol-producing adrenocortical tumour. The presence of non-suppressible pituitary Cushing's disease is possible. < 50% of the average value of the first two samples indicate a pituitary-dependent Cushing's disease or another disease which causes increased cortisol secretion (diabetes, stress, gastrointestinal diseases, diseases with protein loss).

Dexamethasone Suppression Test (high dose) ➢ **see below Dexamethasone Suppression Test (low dose)**

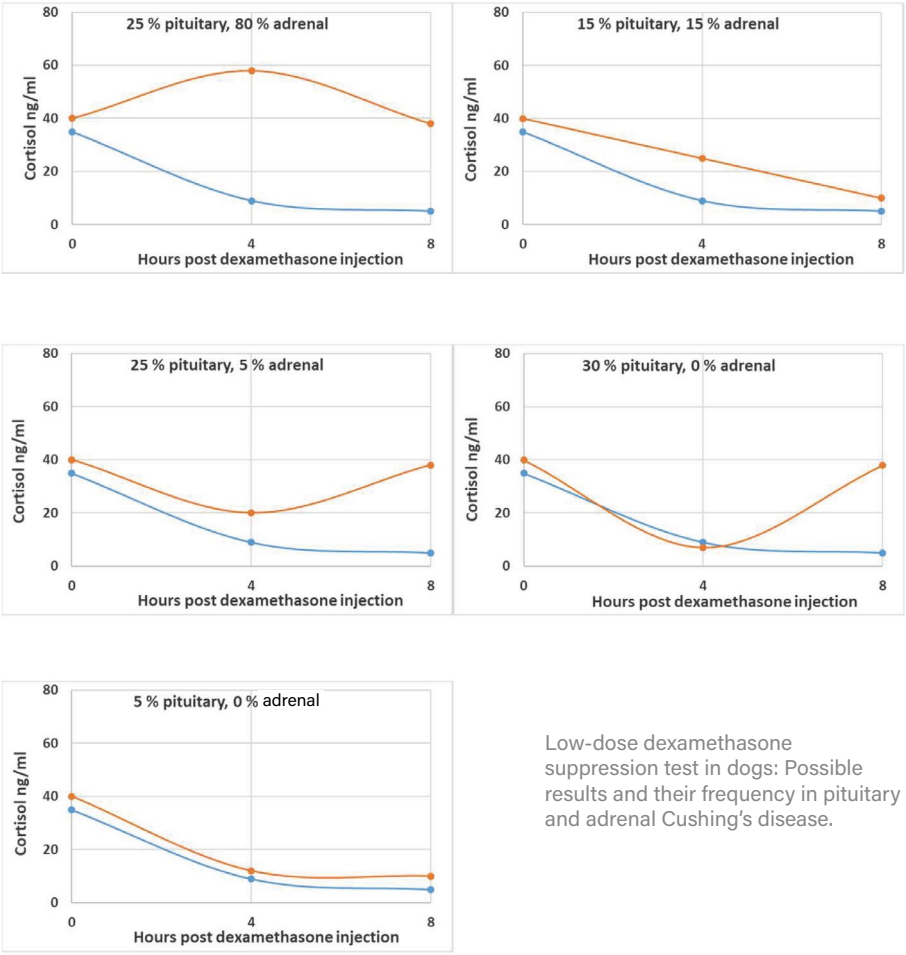
Dexamethasone Suppression Test (low dose) Cat	
Diagnosis	Screening test to confirm the diagnosis of Cushing's disease
Species	Cat
Material	S 2 x 0.5 ml or 3 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ Injection of 0.1 mg of dexamethasone/kg bdw i.m. or i.v. ▪ Blood collection 4 hours post injection = 1st suppression value ▪ Blood collection 8 hours post injection = 2nd suppression value
Parameter to be determined	Cortisol
Interpretation	▪ Normal: baseline value in reference range or slightly elevated (due to stress), 4 hours post injection reduction by 50% or to < 10 ng/ml and 8 hours post injection to < 10 ng/ml (> 1 µg/dl). ▪ Cushing's disease: baseline value in reference range or elevated and one or both suppression values > 10 ng/ml. ▪ The additional blood collection 4 hours p.i. gives information on whether Cushing's disease is pituitary or adrenal. ▪ Pituitary: baseline value in reference range or elevated, 4-hour value reduced by 50% or to < 10 ng/ml and 8-hour value > 10 ng/ml. ▪ Adrenal tumour: baseline value in reference range or elevated, no adequate reaction to the administration of dexamethasone after 4 and 8 hours.

Dexamethasone Suppression Test (low dose) Dog, guinea pig	
Diagnosis	Screening test to confirm the diagnosis of Cushing's disease
Species	Dog, guinea pig
Material	S 2 x 0.5 ml (dog) or 3 x 0.5 ml (dog, guinea pig)
Test procedure	▪ First blood collection = baseline value ▪ Injection of 0.01 mg of dexamethasone/kg bdw i.m. or i.v. ▪ Blood collection 4 hours post injection = 1st suppression value ▪ Blood collection 8 hours post injection = 2nd suppression value
Parameter to be determined	Cortisol
Interpretation	**Dog:** ▪ Normal: baseline value in reference range or slightly elevated (due to stress), 4 hours post injection reduction by 50% or to < 10 ng/ml and 8 hours post injection to < 10 ng/ml. ▪ Cushing's disease: baseline value in reference range or elevated and one or both suppression values > 10 ng/ml.

- The additional blood collection 4 hours p.i. gives information on whether Cushing's disease is pituitary or adrenal.
- Pituitary: baseline value in reference range or elevated, 4-hour value reduced by 50% or to < 10 ng/ml and 8-hour value > 10 ng/ml.
- Adrenal tumour: baseline value in reference range or elevated, no adequate reaction to the administration of dexamethasone after 4 and 8 hours.

Guinea pig:

- Evaluation: adequate suppression and interpretation as in dogs, reference values not available.



Low-dose dexamethasone suppression test in dogs: Possible results and their frequency in pituitary and adrenal Cushing's disease.

Dexamethasone Suppression Test (low dose) Horse (Overnight Dexamethasone Suppression Test)	
Diagnosis	PPID (Cushing's disease)
Species	Horse
Material	S 2 x 0.5 ml or 3 x 0.5 ml
Test procedure	▪ First blood collection = baseline value (blood sampling at around 4 – 6 pm) ▪ Injection of 2 mg/50 kg bdw of dexamethasone i.v. ▪ Blood sampling approx. 15 hours after administration of dexamethasone (at around 8 – 10 am) = 1st suppression value – may be omitted ▪ 2nd suppression value after approx. 18 – 20 hours (at around 10 am – 1 pm) – obligatory ▪ Because of the circadian rhythm, the indicated times of the day should be observed.
Parameter to be determined	Cortisol
Interpretation	▪ PPID: one or both suppression values > 10 ng/ml ▪ Cave: In late summer/autumn, healthy horses, too, possibly suppress insufficiently.
Note	PPID (pituitary pars intermedia dysfunction), formerly called Cushing's disease in horses is caused by "pituitary adenoma" (hyperplasia of the pars intermedia). The hyperplastic cells have no cortisol receptors, that is why in PPID, the exogenous administration of dexamethasone does not suppress the endogenous secretion of corticoids as it does in healthy horses.

Dexamethasone Suppression Test (high dose)	
Diagnosis	Differentiation between adrenal and pituitary Cushing's disease
Species	Dog, cat
Material	S 2 x 0.5 ml or 3 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ Injection of 0.1 mg (dog) or 1.0 mg (cat) of dexamethasone/kg bdw i.m. or i.v. ▪ An additional sample 4 hours post injection gives information concerning a delayed decrease of cortisol. ▪ Blood sample 8 hours post injection = suppression value
Parameter to be determined	Cortisol
Interpretation	▪ Pituitary: one or both suppression values < 10 ng/ml (in rare cases suppression values > 10 ng/ml) ▪ Adrenal: both suppression values > 10 ng/ml

Oral **Glucose Test 1 with Insulin Determination**	
Diagnosis	Equine metabolic syndrome (EMS)
Species	Horse
Material	S 1 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Test procedure	Fasting required, only reduced feeding of hay/straw. In the morning (1) 1 g/kg bdw of glucose or (2) 0.5 g/kg bdw of glucose per os (can be done by the animal owner) Sample collection after 2 hours
Parameter to be determined	Insulin
Method	CLIA
Interpretation	Depending on the test, healthy horses stay below these cut offs: (1) < 85 mU/l insulin (2) < 68 mU/l insulin EMS horses show significantly higher values.

GnRH Stimulation Test	
Diagnosis	▪ Detection of endocrine active tissue of the gonads (ovary, testis) ▪ Ovarian remnant syndrome (dog) ▪ Cryptorchidism
Species	Dog, rabbit, horse
Material	S 2 x 1 ml
Test procedure	**Dog (female)** ▪ First blood collection = baseline value (oestradiol) ▪ Injection of 0.32 µg of GnRH buserelin (Receptal®)/animal i.v. ▪ Second sample after 3 hours = stimulation value **Dog (male)** ▪ First blood collection = baseline value (testosterone) ▪ Injection of 0.32 µg of GnRH buserelin (Receptal®)/animal i.v. ▪ Second sample after 1 hour = stimulation value **Rabbit (male):** ▪ First blood collection = baseline value (testosterone) ▪ Injection of 0.8 µg of GnRH buserelin (Receptal®)/animal i.m. ▪ Second sample after 1 hour = stimulation value **Rabbit (female)** ▪ First blood collection = baseline value (progesterone) ▪ Injection of 0.8 µg of GnRH buserelin (Receptal®)/animal i.m. ▪ Second sample after 5 – 7 days = stimulation value **Horse (male):** ▪ First blood sample in the morning = baseline value (testosterone) ▪ Injection of 0.04 mg of GnRH/horse i.v. ▪ Second sample after 1 hour = stimulation value

Parameters to be determined	Oestradiol (female dog) or testosterone (male dog, male horse, male rabbit) or progesterone (female rabbit)
Interpretation	▪ In dogs, cats and rabbits, the determination of the AMH level (see Chapter 8, p. 88) largely replaces the GnRH Stimulation Test. ▪ **Female dog:** depending on the current cycle phase – significant increases are only expected in diestrus and late anoestrus. ▪ **Intact male dog:** post stimulation concentrations > 1 ng/ml of testosterone are expected. ▪ **Rabbit:** Stimulation values of > 1 ng/ml of testosterone or > 4 ng/ml of progesterone indicate hormone-producing tissue. ▪ **Horse:** depending on the clinical issue

HCG Stimulation Test Small Animals

Diagnosis	▪ Detection of endocrine active tissue of the gonads (ovary, testis). ▪ Ovarian remnant syndrome (dog) ▪ Cryptorchidism
Species	Dog, cat, rabbit
Material	S 2 x 0.5 ml
Test procedure	**Dog (male/female)** ▪ First blood collection = baseline value (male dog: testosterone, female dog: oestradiol) ▪ Injection of 500 IU of HCG (Ovogest®)/animal i.v. ▪ Second sample after 1 hour = stimulation value (perhaps additional sample after 30 minutes) **Rabbit (male):** ▪ First blood collection = baseline value (testosterone) ▪ Injection of 250 IU of HCG (Ovogest®)/animal i.m. ▪ Second sample after 1 hour = stimulation value **Rabbit (female):** ▪ First blood collection = baseline value (progesterone) ▪ Injection of 250 IU of HCG (Ovogest®)/animal i.m. ▪ Second sample after 5 – 7 days = stimulation value
Parameters to be determined	**Dog/cat:** testosterone (male) or oestradiol (female) **Rabbit:** testosterone (male) or progesterone (female)
Interpretation	▪ In most cases, the determination of the AMH level (see Chapter 8, p. 88) provides comparable information. ▪ **Male dog:** post-stimulation testosterone concentrations > 1.0 ng/ml indicate that there is testicular tissue. ▪ **Female dog:** Stimulation of oestradiol secretion strongly depends on cycle phase. Significant increases are expected in diestrus and late anoestrus. ▪ **Rabbit:** Stimulation values of > 1 ng/ml of testosterone or > 4 ng/ml of progesterone indicate hormone-producing tissue.

HCG Stimulation Test Horse	
Diagnosis	▪ Detection of endocrine active tissue of the gonads (testis) ▪ Cryptorchidism
Species	Horse
Material	S 2 x 0.5 ml
Test procedure	▪ First blood collection = baseline value (testosterone) ▪ Injection of 5000 – 10000 IU of HCG (Ovogest®)/animal i.v. ▪ Second sample after 1 hour = stimulation value
Parameter to be determined	Testosterone
Interpretation	▪ **Stallion:** Testosterone concentrations between 0.05 and 0.1 ng/ml after stimulation are considered as borderline and need further clarification – e.g. by determining the anti-Müllerian hormone. Higher values indicate the existence of testicular tissue. In most cases, the determination of the AMH level (see Chapter 8, p. 88) provides comparable information.

Insulin Glucose Ratio	
Diagnosis	Calculated parameter for the detection of an insulinoma **Horse:** measure of pancreatic beta-cell activity
Species	Dog, cat, horse
Material	S 1 ml (promptly centrifuged, pipetted off and at least refrigerated – preferably frozen)
Test evaluation	**Dog, cat:** ▪ Ratio = (serum insulin (µU/ml) x 100)/(serum glucose (mg/dl)) ▪ Modified ratio (AIGR = amended insulin glucose ratio) = (serum insulin (µU/ml) x 100)/(serum glucose (mg/dl) – 30) **Horse:** ▪ Ratio = (serum insulin (µU/ml) x 100)/(serum glucose (mg/dl))
Parameters to be determined	Insulin, glucose
Interpretation	**Dog/cat:** Ratios of < 52 or an AIGR < 30 are considered normal. **Horse:** Values ≥ 6 indicate increased pancreatic beta-cell activity.

Insulin Tolerance Test with Glucose Determination	
Diagnosis	Insulin resistance
Species	Horse
Material	NaFB 1 ml
Test procedure	▪ Fasting not required ▪ Blood sample taken to determine baseline glucose (sample 0) ▪ Then i.v. injection 0.10 IU of insulin/kg bdw

- Repeat sampling to determine glucose after 30 min.
- Then feed promptly!

Parameter to be determined: Glucose
Method: Photometry

Interpretation: Healthy horses have blood glucose levels of < 50% of the initial value 30 min after the injection of insulin and these levels should have risen back to the initial level at the latest after 2 hours.
Cave: risk of hypoglycaemia in insulin-sensitive horses

STH (GH) Stimulation Test

Diagnosis: Determination of IGF-1 as indirect parameter for the secretion of growth hormones; IGF secretion is stimulated directly by the growth hormone (GH).
- Changes are caused by STH deficiency and STH reactive dermatosis (without decrease of STH).
- Perform function test after exclusion of other endocrinological causes as reference range and pathological range overlap.

Species: Dog, cat
Material: S 0.5 ml (centrifuged, cooled)
Test procedure:
- First blood collection = baseline value
- Injection of xylazine (100 µg/kg) i.v.
- Second blood collection after 30 minutes = stimulation value

Parameter to be determined: IGF-1

Interpretation: A significant increase is expected:
- > 2 times if baseline value is low
- > 1.5 times if baseline value is high

Note: The determination of IGF needs to be requested individually for every blood sample and will be invoiced per sample.

Oral **"Sugar" (Test Karo Light Syrup®) with Insulin Determination**

Diagnosis: Insulin dysregulation (ID)
Species: Horse
Material: S 1 ml (centrifuge, pipette off and cool promptly after collection)
Test procedure:
- Fasting required, only reduced feeding of hay/straw.
- Give 0.15 or 0.45 ml/kg bdw of Karo Light Corn Syrup® per os
- Blood collection after 60 and/or 90 min to determine insulin

Parameter to be determined: Insulin
Method: CLIA

Interpretation	Insulin levels above 45 µU/ml using a Karo Light dosage of 0.15 ml/kg and insulin levels above 63 µU/ml using a Karo Light dosage of 0.45 ml/kg indicate insulin dysregulation.

TRH Stimulation Test Dog (3 x fT4)

Diagnosis	▪ Hypothyroidism ▪ The test is a compromise between the single determination of T4, fT4 and TSH and the TSH stimulation test.
Species	Dog
Material	S 3 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ Injection of TRH i.v. (100 µg up to 3 kg bdw, 200 µg with a bdw > 3 kg) ▪ Second sample after 90 min = 1st stimulation value ▪ Third sample 3 hours post injection = 2nd stimulation value
Parameter to be determined	fT4
Interpretation	▪ Euthyroid: at least 1 x > 25 pmol/l ▪ Questionable: at least 1 x 20 – 25 pmol/l, all other samples < 25 pmol/l ▪ Hypothyroid: all samples < 20 pmol/l

TRH Stimulation Test Dog (2 x T4)

Diagnosis	▪ Hypothyroidism ▪ The test is a compromise between the single determination of T4, fT4 und TSH and the TSH stimulation test.
Species	Dog
Material	S 2 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ Injection of TRH i.v. (100 µg up to 3 kg bdw, 200 µg with a bdw > 3 kg) ▪ Second sample 4 hours post injection = stimulation value ▪ Determination of T4 in first and second sample
Parameter to be determined	T4
Interpretation	▪ Euthyroid: elevation of T4 concentration by at least 0.5 µg/dl to at least 2.5 µg/dl ▪ Questionable: elevation of T4 concentration by less than 0.5 µg/dl to > 2.5 µg/dl or by more than 0.5 µg/dl but to < 2.5 µg/dl

TRH Stimulation Test Dog, Extended (2 x T4 + 2 x TSH)

Diagnosis	Hypothyroidism
Species	Dog
Material	S 3 x 0.5 ml

Test procedure	▪ First blood collection = baseline value ▪ Injection of TRH i.v. (100 µg up to 3 kg bdw, 200 µg with a bdw > 3 kg) ▪ Second sample 20 min post injection ▪ Third sample 4 hours post injection = stimulation value
Parameters to be determined	▪ T4 (samples 1 and 3) ▪ TSH (samples 1 and 2)
Interpretation	▪ T4 (see above) ▪ The stimulation value is of limited significance if there is no TSH rise after 20 min.

TRH Stimulation Test Horse (2 x T4)

Diagnosis	Hypothyroidism
Species	Horse
Material	S 2 x 0.5 ml
Test procedure	▪ First blood collection = baseline value ▪ Injection of TRH 0.5 mg/pony up to 1 mg/horse, slowly i.v. ▪ Second sample 4 hours post injection = stimulation value
Parameter to be determined	T4
Interpretation	Euthyroid: 2- to 3-fold rise after 4 hours

TRH Stimulation Test Horse (2 x ACTH)

Diagnosis	▪ PPID (Cushing's disease) ▪ Test with high sensitivity and specificity; indications: if the results of ACTH determination or of the suppression test do not correlate with clinical findings or are not conclusive.
Species	Horse
Material	EP 2 x 0.5 ml (centrifuged, pipette off and cool promptly after collection)
Test procedure	▪ First blood collection = baseline value ▪ Slow injection of 1 mg of TRH i.v. horses > 250 kg (horses < 250 kg: 0.5 mg) ▪ Second sample exactly 10 min post TRH injection = stimulation value
Parameter to be determined	ACTH
Interpretation	▪ Cut off value 10 min after stimulation: < 100 pg/ml; borderline: 100 – 220 pg/ml; positive: > 200 pg/ml ▪ These values are valid for the months of January to June. From July to December, the test can only be used to identify healthy horses, as many false positive results may occur during these months.

Xylazine Stimulation Test ➢ see STH Stimulation Test, p. 110

10 Vitamins

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

β-Carotene

Material	S, HP 0.5 ml
Method	HPLC
Species	Cattle, others on request
Duration	1 – 2 days
Note	In cattle, β-carotene deficiency can lead to fertility disorders.

Folic Acid

Material	S (possibly also EP, HP) 0.5 ml
Method	CLIA
Species	Dog, cat, others on request
Duration	1 day
Note	▪ Can be used to differentiate between malabsorption and bacterial overgrowth or abnormal bacterial colonisation of the small intestine. ▪ Haemolysis is seen as the cause for falsely elevated values of folic acid.

Vitamin A

Material	S, EP, HP 1 ml
Method	HPLC
Species	Dog, cat, horse, cattle, others on request
Duration	3 days

Vitamin B1

Material	EB, HB 1 ml (whole blood only, at least refrigerated – preferably frozen)
Method	HPLC
Species	Dog, cat, others on request
Duration	5 days
Note	▪ Analysis must be requested within one day after the samples have arrived at the laboratory. ▪ Calf, lambs: cerebrocortical necrosis (CCN) often based on thiamine deficiency

Vitamin B2

Material	EB, HB 1 ml (whole blood only, at least refrigerated – preferably frozen)
Method	HPLC
Species	Dog, cat, others on request
Duration	5 days
Note	Analysis must be requested within one day after the samples have arrived at the laboratory.

Vitamin B6

Material	EB, HB 1 ml (whole blood only, at least refrigerated – preferably frozen)
Method	HPLC
Species	Dog, cat, others on request
Duration	5 days
Note	▪ Analysis must be requested within one day after the samples have arrived at the laboratory. ▪ Vitamin B6 deficiency can lead to hyperexcitability and behavioural problems. In case of hypothyroidism, the occurrence of behavioural problems, in particular anxious behaviour, is being discussed. ▪ The determination of vitamin B6 is also part of the Behaviour Profile (dog).

Vitamin B12

Material	S (or possibly HP) 0.5 ml
Method	CLIA
Species	Dog, cat, horse, cattle, others on request
Duration	1 day
Note	▪ Can be used to differentiate between malabsorption and bacterial overgrowth or abnormal bacterial colonisation of the small intestine. ▪ To clarify the need for a parenteral substitution of B12 in exocrine pancreatic insufficiency. ▪ **Cattle:** Synthesis of vitamin B12 in the rumen can only take place insufficiently if too little cobalt is ingested with the feed. Vitamin B12 deficiency leads to disorders of the energy metabolism with lack of appetite, apathy, growth and performance depression and anaemia as well as possible diarrhoea.

Vitamin D (25 OH)

Material	S (or possibly HP) 0.5 ml
Method	CLIA
Species	Dog, cat, birds, reptiles, ruminants, others on request
Duration	1 day

Vitamin D3 (1,25 OH2)*

Material	S 1 ml
Method	CLIA
Species	Dog, cat
Duration	1 – 3 days

Vitamin E

Material	S, EP, HP 1 ml
Method	HPLC
Species	Dog, cat, horse, cattle, sheep, others on request
Duration	3 days
Note	Concentration in horses living in a stable 1 – 2 mg/l, when grazing 2 – 3 mg/l; in cattle > 3 mg/l.

Vitamin H (Biotin)*

Material	S 1 ml
Method	ELISA
Species	Horse
Duration	10 days

Vitamin Profiles ➢ **see Prices and Services catalogue**

11 Drug Level

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

Bromide	
Material	S, EP, HP 1 ml
Method	ICP MS
Species	Dog, cat
Duration	4 days
Note	**Therapy monitoring** under bromide treatment. Determination can be done at the earliest 6 weeks after starting therapy. Lower drug levels are required during combination therapy with phenobarbital.

Cyclosporine	
Material	EB 1 ml (whole blood only)
Method	CLIA
Species	Dog, cat
Duration	1 – 2 days
Note	**Therapy monitoring:** Determination is suitable for monitoring treatment with cyclosporine.

Digoxin	
Material	S 1 ml
Method	CLIA
Species	Dog, cat, others on request
Duration	1 day
Note	**Therapy monitoring** at the earliest 7 days after initial application and approx. 6 – 8 hours after the last drug administration.

Levetiracetam	
Material	S 1 ml
Method	LCMS
Species	Dog
Test frequency	1 x per week
Note	▪ **Therapy monitoring**, effective levels only determined for dogs. ▪ Clinical signs should be considered when adjusting treatment. ▪ Blood sampling preferably right before the administration of medication.

Phenobarbital	
Material	S (possibly also EP, HP) 1 ml
Method	CLIA
Species	Dog, cat
Duration	1 day
Note	**Therapy monitoring:** Determination is suitable for monitoring phenobarbital and primidone therapy. In dogs, primidone is immediately metabolised to phenobarbital. Determination should take place at the earliest one week after starting long-term therapy. Sampling can be done regardless of when the drug is administered.

Especially for horses, there is a series of drug level tests available as part of the doping analysis. We will be pleased to answer any questions that you may have.

- Screening for doping-relevant substances
- Antiphlogistics Screening
- Glucocorticoid Screening
- NSAID Screening
- Sedativa/Tranquilizer
- Stimulants
- Tricyclic antidepressants

12 Intoxication

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

Hypoglycin A	
Material	S 1 ml (refrigerated or frozen)
Method	LCMS
Species	Horse
Duration	1 – 2 days
Note	Hypoglycin A is found in the seeds of various maple species (***sycamore***, box elder and Japanese maple) and is one of the causes of atypical myopathy (seasonal pasture myopathy) in horses. Atypical myopathy leads, for example, to generalised weakness, stiffness, colic, increased respiratory and heart rate and myoglobinuria and is often fatal.

α-Chloralose	
Material	S, urine 0.5 ml
Method	LCMS
Species	Dog, cat
Duration	2 – 3 days
Note	α-chloralose is an over-the-counter poison for pest control. α-chloralose has a narcotic effect and impairs thermoregulation. It can lead to severe hypothermia, neurological signs, salivation, hypoglycaemia and circulatory failure and can result in death.

Colchicine	
Material	Urine 1 ml
Method	LCMS
Species	Horse, donkey, cattle, small ruminants and others (e.g. dogs after medication)
Duration	2 – 3 days
Note	Colchicine is the main toxin of the **meadow saffron**. Horses and other grazing animals can ingest it via hay and silage or directly on the pasture. Colchicine poisoning leads to severe salivation, (bloody) diarrhoea, ataxia and colic and can lead to death from respiratory paralysis. For horses, colchicine is categorised as a doping-relevant substance.

Heavy Metal Toxicity Screening ➢ **see Prices and Services catalogue**

Lead	
Material	EB, HB at least 1 ml (whole blood only)
Method	AAS
Species	Dog, cat, small mammals, birds, reptiles, horse, cattle, others on request
Duration	1 – 2 days
Note	Because it is stored in the bones, lead can only be detected in higher concentrations in the blood in case of acute poisoning. Over 95% of lead in the blood is bound in erythrocytes, so as test material, whole blood is absolutely necessary. An elevated iron level in the serum is an additional indication of possible lead poisoning.

Poison Screening*	
Material	Urine, (vomit/stomach contents, serum, blood (EB)) 5 ml
Method	GCMS
Species	Dog, cat, horse, farm animals, others on request
Duration	7 – 10 days
Note	Global screening test, qualitative detection of, for example, coumarin derivatives. A written medical history is a must; please add information about medication prior to sample collection.

Senecio – Test for Pyrrolizidine Alkaloids	
Material	at least 1 ml urine
Method	LCMS
Species	Horse, ruminants, others on request
Duration	2 – 3 days
Note	Senecio species, especially the well-known **ragwort** (Senecio jacobaea), are a common problem in grass, hay and silage, as they contain a large amount of different pyrrolizidine alkaloids as cumulative hepatotoxins. The detection of the toxins senecionine and senecionine-N-oxide indicates the oral ingestion of toxic plant parts within the last hours to days.

Thallium (Rodenticide)	
Material	S, urine 1 ml, hairs
Method	ICPMS
Species	Dog, cat, horse, cattle, others on request
Duration	1 week
Note	Thallium is a cumulative cytotoxin that can cause systemic intoxication. Cases of acute intoxication can be detected using serum, urine or hairs.

13 Infectious Diseases: Pathogenic Agents and Antibody Detection

For abbreviations and additional information concerning the test descriptions see p. 12 and following.

13.1 Viruses

The following pages will provide you with details about the diagnosis of viral infections. You will get information on the required material, the method used, the species examined and on the duration of the test. Antibody and antigen detection are included as well as molecular biological methods (PCR, realtime PCR, droplet digital PRC) and pathology (histology, cytology) for pathogen detection.

If the listed diagnostic procedures cannot be used in viral infections in **reptiles** or have not yielded any findings that match the clinical picture, we also offer virus cultivation by means of **cell culture**. For this, we need tissue or a swab, each put into **cell culture medium** (which we can provide you with) or, if need be, in some sterile physiological saline solution. For cell culture, samples should be sent refrigerated; the test duration is expected to be at least 4 weeks. There will be no further reference to this examination option in this document.

13.1.1 Adenoviruses

Adenoviruses are non-enveloped double-stranded DNA viruses, which are characterised by a high tenacity. They belong to the linear double-stranded DNA viruses. Adenoviruses are strictly host-specific and only in exceptional cases infection of related or unrelated animal species occurs. Adenoviruses mostly cause mild respiratory symptoms and are involved in many multifactorial disorders.

Dog

Hepatitis contagiosa canis (HCC)

HCC is caused by **canine adenovirus 1 (CAV-1).** The virus is shed in urine and faeces and transmission occurs directly or indirectly. After oronasal infection, the virus first multiplies in the tonsils and subsequently in the endothelium of the blood vessels, in hepatocytes as well as in cornea and uvea. Deposition of immune complexes can result in glomerulonephritis and uveitis with a corneal oedema (“blue eye”). HCC can be acute or chronic. Especially in unvaccinated puppies, HCC can take a peracute or acute course and can be fatal. Not only dogs, but also all other species of the family Canidae are susceptible to an infection with CAV-1.

As consistent vaccination against HCC has been carried out in Germany for some time now, the virus CAV-1 has largely disappeared from dog populations and is only detected occasionally. However, CAV-1 still occurs in Eastern European countries.

Infectious laryngotracheitis
Infectious laryngotracheitis is caused by **canine adenovirus 2 (CAV-2).** The virus has a strong affinity to the epithelia of the respiratory tract and is a component of the "kennel cough complex".

Reptiles
Adenoviruses, which have mostly been documented in lizards and snakes, play an important role in reptiles. Literature particularly describes adenoviruses in bearded dragons (Pogona). The clinical picture is often non-specific. In **Pogona,** mainly young animals are affected. Clinical signs which are often seen are anorexia, apathy, diarrhoea and opisthotonus. Boas, colubrids and vipers belong to the **snake** families that are often affected. Gastrointestinal symptoms are very typical. The liver, too, is very frequently affected. Transmission probably occurs through the faeces, but also a vertical transmission is being discussed.

Guinea pig
Guinea pig adenovirus (GPAdV) has an incubation period of 5 – 10 days (detection by PCR on nasal mucous membranes between days 6 – 15 after infection) and can cause non-purulent necrotising bronchitis and bronchiolitis. The adenovirus is transmitted by direct contact between animals. Shedding of the virus via oral/nasal secretions and faeces has been described. Especially young and immunocompromised animals are susceptible to the virus. Clinical signs may include inappetence, nasal discharge and tracheobronchitis. In some cases, an infection may result in peracute death. A high mortality rate is mainly seen in young animals.

Birds
Adenovirus infections are often subclinical in adult birds, but can lead to severe disease in young birds or immunocompromised animals. As with reptiles, the clinical picture is non-specific. Depending on the serotype, different signs such as reduced food intake, loss of performance (in commercial poultry), hepatitis, respiratory signs, diarrhoea, etc. can be observed – adenoviruses are very often involved in multifactorial disorders.

Adenovirus – Pathogen Detection		
Material	**Dog:**	CAV-1: EB, tissue (e.g. liver), urine, (faeces) CAV-2: swab without medium (e.g. eye, nose, pharynx), bronchoalveolar lavage
	Guinea pig:	swab without medium from the mucous membranes (mouth, pharynx, trachea), tissue (e.g. lungs), faeces
	Birds:	swab without medium (cloaca or pharynx), tracheal lavage, tissue (e.g. intestine or liver)
	Reptiles:	swab without medium (cloaca), tissue (intestine, liver)

Method	Realtime PCR (dog), PCR (guinea pig, birds, reptiles)
Species	Dog, guinea pig, birds, reptiles
Duration	1 – 3 days (dog) 2 – 4 days (birds, reptiles)

Adenovirus – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, rabbit*, guinea pig*, rat*, mouse*, others on request
Duration	1 – 2 days (dog) 2 – 3 days (small mammals)*
Note	Dog: Differentiation between infection and vaccination can only be done by testing serum pairs. Because of extensive vaccination, the disease has become extremely rare.

13.1.2 African Horse Sickness Virus (AHSV)

African horse sickness (AHS) is an endemic viral disease in Equidae particularly in Central Africa; sporadic outbreaks have been observed in the Middle and the Near East as well as in Southern Europe (export-relevant test). Generally, the disease is transmitted by Culicoides spp. or by Culex, Anopheles, Aedes and ticks. All secretions, intestines and the blood of infected animals are infectious. A distinction is made between a subclinical, febrile form, a subacute cardiac form, an acute pulmonary form and a mixed form; CNS manifestation is rare. All organ manifestations are accompanied by oedema and haemorrhage. The mortality rate is 70 – 95% in horses, approximately 50% in mules and about 10% in donkeys.
In Germany, the disease is **notifiable upon suspicion**.

AHSV – Antibody Detection*	
Material	S 2 ml
Method	cELISA
Species	Equids
Duration	5 – 7 days

13.1.3 Arenaviruses

Inclusion body disease of boid snakes (IBD) is caused by arenaviruses and particularly affects **boas and pythons.** Clinical signs comprise tremor, opisthotonus and loss of the reflex to turn. In young animals, it is often an acute infection with a mortality rate of nearly 100%. In adult animals, the course of the disease is usually chronic and protracted. Early signs are a slight tremor of the head, apathy and less flickering of the tongue.

Progression of the disease is often faster in pythons than in boas. Many times, regurgitation is the first clinical sign in boas. In pythons, the typical course of the disease is stomatitis accompanied by progressive pneumonia, which, showing signs of CNS disease, leads to death. Over the past years, an increase of the disease has been observed in boas, whereas it does not occur as often in pythons anymore. To date, little is known about the transmission in reptiles. Transmission through close contact as well as through mites is being discussed. In some cases at least, a vertical transmission from infected parents to young animals seems to occur.
Diagnosis is either made through the detection of the characteristic intracytoplasmic inclusions in the tissues of affected animals or through the detection of **reptarenaviruses** using PCR. In both cases, detection is easier in boas; in pythons, inclusions as well as the virus are often only found in the brain. Particularly in boas, inclusions can be detected histologically, most notably in the pancreas, liver, kidneys, oesophageal tonsils and the brain. The same organs are suitable for PCR virus testing. In live animals, inclusions and viral RNA can be detected through blood smears or whole blood as well as through biopsies of the liver, kidney or the oesophageal tonsils. Especially in boas, oesophageal swabs are very useful for PCR virus detection.

Arenaviruses/IBD – Pathogen Detection	
Material	EB, tissue (e.g. liver, pancreas, kidney, brain), swab without medium (oesophagus)
Method	PCR, cytology, histology
Species	Snake (boa, python)
Duration	1 – 3 days
Note	The PCR detects different reptarenaviruses. These viruses of the family Arenaviridae are associated with the inclusion body disease (IBD) in boid snakes (boas, pythons). A negative test result does not completely rule out IBD, as there may be other virus variants, which have not yet been described, leading to this disease.

Aujeszky's Disease Virus ➢ see Herpesviruses, p. 142

13.1.4 Avipoxvirus

Poxvirus (Orthopoxvirus) see ➢ Orthopoxvirus, p. 153

Avipoxviruses are normally only known as pathogens which cause **avian pox** in birds. They occur in many different bird species. Susceptibility of domestic and wild birds to avian pox infections is only partly understood. Avipoxviruses are primarily transmitted through insects and aerosols. Breeders also become infected through contaminated animals or food and possibly through blood-sucking parasites as well. Introduction into the population mainly happens when buying additional animals or following exhibitions. In wild birds, infection also occurs directly when picking each other's beaks.

There are different characteristic forms. The cutaneous form is the most common one and is characterised by papular efflorescences of the non-feathered skin areas (eyes, beak, comb, lower legs). Mild forms often develop benign skin tumours (head, legs) as a result of the long convalescence period (weeks/months).
The mucous form is characterised by similar lesions on the mucosa of the beak cavity, tongue, pharynx or larynx (fowlpox). The septicaemic form typically displays general symptoms such as ruffled feathers, somnolence, cyanosis and anorexia without exterior pox lesions. Avian pox infections are usually not fatal (exception: canarypox => usually fatal). In Germany, there is an **obligation to notify the authorities** when avipoxviruses are detected.

Poxvirus (Avipoxvirus) – Pathogen Detection	
Material	Crusts/skin material from skin lesions, tissue (pigeon: small intestine, canary: oesophagus)
Method	PCR
Species	Birds
Duration	1 – 3 days
Note	The diagnosis can also be made by the histological detection of inclusion bodies.

13.1.5 Bluetongue Virus (BTV)

Bluetongue virus (BTV), an Orbivirus, is transmitted by biting midges and causes bluetongue disease in cattle, sheep and goats. Bluetongue disease first occurred in Germany in 2006. So far, serotypes 6 and 8 have been recognised in Germany. Bluetongue disease is characterised by fever, circulatory disorders, head oedema, and ulcerations of the mucosa of the head as well as the teats and the feet. The disease can also be accompanied by severe pneumonia. In sheep, the mortality rate can be 50%. Llamas and alpacas may become infected, too. In Germany, the disease is **notifiable upon suspicion**.

Bluetongue Virus (BTV) – Pathogen Detection	
Material	EB, tissue (liver, spleen)
Method	Realtime PCR
Species	Ruminants
Duration	1 – 3 days
Note	Detection of BTV 1 – 24

13.1.6 Borna Disease Virus

Mammals

Numerous species of mammals are susceptible to this virus. It is of clinical relevance particularly in horses (where it is referred to as "heated head disease") and in sheep. Cattle, goats and New World camels can also contract the disease. In cats, only one case of Borna disease has been confirmed after the "staggering disease" has recently been attributed to the rustrela virus (see p. 166).

Borna disease viruses have a strong neurotropism and trigger non-purulent meningoencephalitis, associated with anorexia, apathy, somnolence and multiple neuronal dysfunctions. Animals suffering from Borna disease develop motor and behavioural disorders.

Shrews constitute the virus reservoir. They are asymptomatic but infected for life. Other mammals such as horses and sheep as well as humans may be dead-end hosts. The modes of transmission have not yet entirely been clarified; infection probably occurs through the nerve endings of the nasal and pharyngeal mucosa.

According to current knowledge, dead-end hosts do not shed the virus. No natural infections of mammals by horses, sheep or humans have been confirmed. Experimental infections from horse to horse (sheep to sheep, cat to cat) are possible.

In horses and sheep, in addition to the signs listed above, a lowered head posture, separation from the herd, empty chewing and salivation have been described and, at a later stage, recumbency and flailing movements. A seasonal increase of the disease from March to September has been described in horses and sheep.

There is often little or no immune response, which makes it difficult to diagnose by testing for antibodies. The incubation period is unknown. The progression of a clinically manifested infection is fatal (duration of the disease usually 1 – 3 weeks). Clinically inapparent infections are also possible. In humans, encephalitis caused by Borna disease virus has so far been almost always fatal. Up to now, only a few of these cases have been described.

Since 2020, Borna disease virus infections in domestic mammals have been **notifiable upon diagnosis** in Germany.

Birds

Proventricular dilatation disease (PDD) is a globally distributed, serious disease particularly affecting psittacines (large parrots) like macaws, amazons or grey parrots. In 2008, identification of the previously unknown avian Borna virus (ABV) in birds infected with PDD was achieved for the first time. An etiological relationship could then be proven in infection experiments.

PDD either affects the gastrointestinal tract, the central nervous system or both areas. This means, on the one hand, there may be digestive disorders such as diarrhoea, vomiting or regurgitation as well as anorexia and the excretion of undigested seeds in faeces. On the other hand, PDD can manifest itself through neurological dysfunctions like ataxia and coordination disorders, tremor or paresis. Both symptom complexes are associated with depression, general weakness and excessive loss of weight.

In addition to peracute and acute deaths, especially in older birds, chronic progressions of the disease can also be observed. Moreover, clinically inapparent birds can be infected with the virus. Breeding flocks and new additions should thus be tested for an infection with ABV.
Avian Borna viruses are RNA viruses which show high genetic divergence. A negative result does therefore not entirely rule out PDD, as there may be other virus variants, which have not yet been described, leading to this disease.
The safest way to detect an ABV infection requires a combination of antibody and pathogen detection. In some birds, only viral RNA can be detected, in others only anti-ABV antibodies are detectable, while others again react positively on both tests. Both test results should always be interpreted together with the clinical signs.

Borna Virus – Pathogen Detection	
Material	Mammals: CSF, tissue (brain), EB ml (viraemia), intraocular fluid (horse), retina (horse) Birds: swab without medium (crop AND cloaca), tissue (brain, gastrointestinal tract)
Method	Realtime PCR
Species	Cat, psittacines (esp. large parrots), ruminants, New World camels
Duration	1 – 3 days
Note	PCR detects the strains parrot bornavirus PaBV-1, PaBV-2, PaBV-4 and PaBV-7.

Borna Virus – Antibody Detection*	
Material	S 0.5 ml
Method	IFAT Birds: ELISA
Species	Dog, cat, birds, horse, sheep, others on request
Duration	1 week

13.1.7 Bovine Respiratory Syncytial Virus (BRSV)

Bovine respiratory syncytial virus (BRSV) is an enveloped RNA virus of the family Paramyxoviridae and causes respiratory tract diseases in cattle. It is mainly calves that develop this disease. Infection primarily occurs in the winter months and is characterised by sudden fever, slight hyperpnoea, apathy, rhinitis and cough. Mild bronchiolitis, multifocal lesions and interstitial pneumonia with syncytia formation will develop. The duration of the disease is 3 – 10 days. In severe cases, it can result in death, otherwise the fatality rate is low. Persistent infections have been described; they may be the reason for maintaining the infection within a herd.
In cattle, BRSV is involved in enzootic bronchopneumonia; it predisposes calves and lambs to the adherence of Mannheimia haemolytica.

There are different vaccines available. However, reinfections may occur after some months.

BRSV – Pathogen Detection	
Material	Swab without medium (nose, pharynx), lavage sample, tissue (e.g. trachea or lung)
Method	Realtime PCR
Species	Cattle
Duration	1 – 3 days
Note	Particularly in the first phase of infection, BRSV can be detected by means of PCR. This pathogen detection can be requested individually and it is also part of the PCR test Bovine Respiratory Profile 1 (see Chapter 13.5.4, p. 249).

BRSV – Antibody Detection	
Material	S, HP 1 ml
Method	ELISA
Species	Cattle
Duration	3 – 5 days
Note	This antibody detection is part of the serological Bovine Respiratory Profile (see Chapter 13.5.4, p. 249).

13.1.8 Bovine Viral Diarrhoea Virus (BVDV)

Bovine viral diarrhoea virus, a pestivirus, is the causative agent of bovine viral diarrhoea/mucosal disease (BVD/MD) in cattle, two diseases that are prevalent worldwide. Sheep, goats, wild ruminants and pigs are also susceptible to the virus. BVD virus has 2 genotypes (BVDV1 and BVDV2) and the biotypes cytopathogenic (cp) and non-cytopathogenic (ncp).
Infection in cattle results in different symptoms depending on the time of infection.
Transient infections (temporary infections of already born animals) are often asymptomatic, but may lead to diarrhoea, fever, cough and erosions of the mucous membrane particularly in calves, and to reduced milk yield, fertility disorders (repeat breeding, abortions) and malformations (e.g. oculo-cerebellar syndrome) in cows. Transiently infected animals temporarily shed the virus to a certain extent (nasal discharge, saliva, faeces, semen).
Persistently infected calves (PI animals) develop during the infection of the mother between the 40th and the 120th day of gestation, because the immune system of the calf does not recognise the virus as "foreign". PI calves are usually born without abnormalities and shed large quantities of the virus in all secretions and excretions

throughout their lives. PI animals are typically seronegative, but can also form antibodies after being infected with a heterologous BVD strain.
If a PI animal is additionally confronted with a cp virus strain through mutation of the prenatally acquired strain or a new, postnatal infection, it will develop a severe and always fatal **MD.**
In Germany, the disease is **notifiable upon suspicion**.

BVDV – Pathogen Detection	
Material	EB, milk, faeces, tissue (e.g. ear tissue tag samples, spleen, brain, abortion material)
Method	Realtime PCR
Species	Cattle
Duration	1 – 3 days

BVDV – Antibody Detection*	
Material	S, milk 0.5 ml
Method	ELISA
Species	Cattle
Duration	5 days

13.1.9 Caliciviruses

Caliciviruses see also
- ➢ *European Brown Hare Syndrome Virus (EBHSV), p. 139*
- ➢ *Rabbit Haemorrhagic Disease Virus (RHDV), p. 162*

There are numerous strains of **feline calicivirus (FCV)** with only slight serological differences but large genetic divergence, resulting in wide variations in virulence. Signs of FCV may vary from inappetence and fever to joint pains and muscular pain. In rare cases, interstitial pneumonia occurs. The typical proliferate and exudative ulcers in the oral cavity are often aggravated by secondary bacterial infections, i.a. with pasteurella.

Calicivirus Cat (FCV) – Pathogen Detection	
Material	Swab without medium (conjunctiva, oral cavity or pharynx), EB (only during the viraemia phase)
Method	Realtime PCR
Species	Cat
Duration	1 – 3 days
Note	Due to genetic divergence, not all strains can be detected by means of PCR. Detection in the blood is only possible during the viraemia phase.

Calicivirus Cat (FCV) – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Cat
Duration	1 – 2 days
Note	Differentiation between infection and vaccination is usually only possible by analysing serum pairs (taken 3 – 4 weeks apart from each other). Therefore, detection by PCR is preferable.

13.1.10 Caprine Arthritris Encephalitis Virus (CAEV)

The pathogen which causes caprine arthritis encephalitis (CAE) is a retrovirus and belongs to the genus **Lentivirus**, just like the maedi visna virus. It is a viral disease in goats which causes encephalitis, arthritis and/or mastitis, depending on the age of the animals affected. Development of clinical signs is slow. Neurological changes and interstitial pneumonia will result in ataxia, lameness, paralysis and respiratory distress. Only about one third of the seropositive animals will contract the disease.
The main transmission route is an infection of newborn animals via the colostrum. A horizontal and intrauterine transmission is possible, but of secondary importance.

CAEV – Antibody Detection	
Material	S 0.5 ml
Method	ELISA
Species	Goat
Duration	3 days
Note	▪ Particularly in affected herds, detection serves to eliminate positive carrier animals. Positive animals are considered to be infected and potentially shedding (especially when lactating). Negative animals should be checked regularly (at least annually) since recent infection or low antibody titres can mimic a pathogen-free condition. ▪ In goats and sheep, the ELISA test detects antibodies against lentiviruses, which can cause CAE in goats and Maedi/Visna in sheep.

13.1.11 Carp Edema Virus (CEV)

Carp Edema Virus was first described in Japan in 1974 and in Germany in 2014 and belongs to the family Poxviridae. Three different CEV lines have been identified that can lead to clinical signs in koi carp and carp. **Koi sleepy disease** normally occurs at a range of 15 – 25 °C, but especially in carp, temperatures may also be much lower.

The incubation period depends on the water temperature. Signs are lethargy and lying motionless on the ground. Additionally, there may be erosive or haemorrhagic skin lesions with oedema of the underlying tissue as well as an excessive production of mucous on skin and gills. Secondary infections are possible.
In differential diagnosis, koi herpesvirus (KHV), spring viraemia of carp (SVC), a high organic load of the water and infestation with ectoparasites need to be considered.

Carp Edema Virus (CEV) – Pathogen Detection	
Material	Tissue (gill biopsy)
Method	Realtime PCR
Species	Fish
Duration	1 – 3 days

13.1.12 Chronic Bee Paralysis Virus (CBPV)

Chronic bee paralysis virus is an RNA virus which, so far, cannot be assigned to any family. This virus affects adult bees. Infected animals are unable to fly, they crawl on the ground, often have a bloated abdomen and diarrhoea; the affected bees die 5 – 10 days after the onset of the disease. **Loss of hair** and an asymptomatic progression are possible. Transmission occurs through bee faeces. Whether the Varroa mite is involved in spreading or in worsening the course of the disease is debatable. There are often self-healing processes in the colonies. If the progress is particularly severe, an artificial swarm can be created with brood hatched in an incubator.

Chronic Bee Paralysis Virus (CBPV) – Pathogen Detection	
Material	Bee heads
Method	Realtime PCR
Species	Bees
Duration	1 – 3 days

13.1.13 Circoviruses

Dog

Canine Circovirus

Canine circovirus was first detected in canine blood samples in the USA in 2012/2013 and was described in a dog with necrotising vasculitis and granulomatous lymphadenitis. In a subsequent study, it was mainly found in faecal samples from dogs with diarrhoea. In 2014, it was detected in Italy and in 2015 in Germany as well. Circoviruses can also be found in healthy dogs; further studies will be necessary to clarify questions on the pathogenesis and epidemiology.

Dog circovirus should be considered in the differential diagnosis in case of diarrhoea/vomiting, fatigue, hepatic diseases, haemorrhage and vasculitis. Co-infections with other, mainly enteropathogenic agents are frequently observed. Similarly, an infection with canine circovirus can further complicate other infectious diseases.

Psittacidae

Psittacine Beak and Feather Disease (PBFD)

PBFD is characterised by an impaired growth of the beak, the feathers and claws. The disease is globally distributed; more than 40 species of macaws, agapornis, grey parrots, amazons and parakeets are affected.

Nestlings mostly die peracutely, while the course of the disease is acute in fledglings. Animals show clinical signs of lethargy, loss of appetite as well as vomiting and/or diarrhoea. Death is possible within 1 – 2 weeks. Changes in the developing feathers are pathognomonic – but usually only visible in chronic forms. Symmetric feather loss occurs or the feathers get stuck in the shaft and will then break off. Lesions on the beak and, rarely, on the claws will only occur later on.
Transmission of the virus mainly takes place horizontally. The virus is spread with the faeces, the shedding of developing feathers and with the crop content of feeding parent birds. Thus, nestlings can be infected very early on. Vertical transmission is also possible, but of secondary importance. Here, hatching birds are infected through egg shells that are contaminated with circoviruses.

Pigeon

Pigeon Circovirus (PiCV)

Circovirus infections mainly occur in pigeons aged 6 weeks to 12 months **(young pigeon disease syndrome)**. The clinical picture is non-specific; signs include lethargy, anorexia, diarrhoea, wasting and PBFD-like changes in the feathers. The disease is accompanied by immune suppression, and organ alterations occur, particularly in the central immune system and the spleen. In addition to the clinically manifest form especially in young pigeons, there is also a high number of subclinically or persistently infected animals.

Pig

Porcine Circovirus 2 (PCV-2)

Porcine circovirus type 2 (PCV-2) is associated with the so-called **post weaning multisystemic wasting syndrome (PMWS)**. PMWS is usually observed in weaners and less frequently in suckling piglets. Affected animals show a progredient loss of weight as well as respiratory disorders with coughing, which are often complicated by secondary bacterial infections. PCV-2 can be detected in the tissue of infected piglets by means of PCR. In conjunction with PMWS, co-infections of PCV-2 with porcine parvovirus or PRRSV are being discussed.

Circovirus – Pathogen Detection PCV-2 (pig)		
Material	**Dog:**	faeces, EB (viraemia), tissue (esp. liver, lymphoid tissue, intestine, kidney)
	Psittacidae:	2 – 3 feather shafts (recently plucked), blood (1 – 2 drops on a filter paper), (faeces)
	Pigeon:	2 – 3 feather shafts (recently plucked), swab without medium (cloaca), blood (1 – 2 drops on a filter paper, viraemia!), faeces, tissue (bursa Fabricii, spleen, liver)
	Pig:	EB, swab without medium (nose or pharynx), lavage sample (BAL), tissue (e.g. lung, trachea, abortion material or foetal organs)
Method	Realtime PCR (dog, Psittacidae, pig)/PCR (pigeon)	
Species	Dog, Psittacidae, pigeon, pig	
Duration	1 – 3 days	
Note	The PCR test Circovirus (PBFD) for Psittacidae does **not** detect circovirus infections of other groups of birds.	

13.1.14 Coronaviruses

SARS-CoV-2 see ➢ *Chapter 13.1.47, p. 167*

Coronaviruses are enveloped RNA viruses which have club-shaped appendages on their surface that look like a crown under the electron microscope and have thus given the virus family its name. As they are genetically highly variable, transmission of coronaviruses to and among different species is possible. They belong to a large group of RNA viruses that can cause respiratory and/or enteral diseases in various animal species and in humans.

Dog

An infection with **canine (enteric) coronaviruses (CCoV, CCV, more recently also CECoV)** is usually asymptomatic or may lead to mild, non-haemorrhagic diarrhoea. In puppies, however, severe courses of the disease with haemorrhagic gastroenteritis are possible. Loss of intestinal villi, flattening of the epithelial cells of the small intestine and detachment of the goblet cells occur. The most noticeable signs are vomiting and watery to bloody diarrhoea, accompanied by severe dehydration. The virus is excreted via the faeces; the duration of excretion is usually less than two weeks.
CCV is also infectious to other canids as well as to cats and pigs, but the pathogenicity of these species is not yet known.
Canine respiratory coronavirus (CRCoV) was first detected in a dog in 2003. It appears to have originated from bovine coronavirus, since both viruses share very close similarities. In general, respiratory coronavirus can frequently be detected in the majority

of dogs suffering from kennel cough (also known as canine infectious respiratory diseases (CIRD) complex).
In many dogs with mild or moderate signs, such as cough or nasal discharge, but also in asymptomatic dogs, the virus can mainly be found in the trachea.

Cat

There are two pathotypes of feline coronaviruses **(FCoV)**: For one, they occur as weakly virulent enteric FCoV. These viruses are merely "diarrhoea pathogens" which infect the intestinal epithelial cells. For another, there is a form altered by mutations in the spike protein which can replicate massively in macrophages and thus cause feline infectious peritonitis (FIP), which is often fatal.
A cat from a multi-cat household is more likely to excrete the virus than a cat from a single-cat household. The higher the infection pressure, the more likely it is that enteric coronaviruses mutate and cause FIP.
According to different studies, 1 – 12% of the cats infected with FCoV actually develop FIP. In the past, FIP was thought to have two different manifestations: the wet (exudative) and the dry (granulomatous) form. It is now assumed that every FIP infection will sooner or later become "wet". Clinically, the signs of FIP range from pyogranulomatous swelling of the serosa and organs (especially liver, spleen and lungs) to severe polyserositis with the formation of highly viscous effusions (ascites, but also thoracic/pleural effusions). Cats often develop anaemia with icterus, emaciation and high fever. There may also be CNS symptoms and, due to the deposition of precipitates, uveitis.
A positive titre indicates that the cat had been in contact with coronaviruses. This is the case with most adult animals. In a clinically healthy animal, high titres are usually not important. They do not suggest that this cat will contract FIP. Shedders of enteric FCoV can be identified by PCR from faecal samples, mutated FCoV are no longer excreted with the faeces. In animals suffering from FIP, there are often only low to negative antibody titres. In this case, the antibodies have been bound in immune complexes; thus, antibodies are no longer detectable. For further evaluation, a serum protein electrophoresis and the determination of the albumin/globulin ratio can be included. Diagnostic information is provided by an increase in the gamma globulin fraction and an albumin/globulin ratio below 0.6. In addition, PCR for FCoV from effusions or tissue can be an important indicator of FIP and, in combination with electrophoresis (and the Rivalta test or cytology), can contribute to the diagnosis.

Ferret

Ferret enteric coronavirus can cause epizootic catarrhal enteritis (ECE) in ferrets with mucoid, greenish, malodorous diarrhoea, especially in adult animals. It is shed in saliva and faeces.
Ferret systemic coronavirus can cause a disease similar to FIP, which mainly affects ferrets under 18 months of age. Signs may be non-specific (including diarrhoea, weight loss, lethargy, hyporexia/anorexia, vomiting). In some cases, neurological signs, such as paresis, ataxia, tremor or seizures, can be observed.
Information on the detection of SARS-CoV-2 can be found in Chapter 13.1.47, p. 167.

Horse

Equine coronavirus **(ECoV)**, a beta coronavirus, was first detected in the USA in 1999 in the faeces of a foal suffering from diarrhoea. Recent studies in the USA, Japan and Europe confirm it is associated with fever, colic and diarrhoea particularly in adult horses. Infections caused by ECoV mostly occur in the cold season (November to May); involvement of the respiratory system has not yet been proven.
Clinical signs include anorexia, lethargy, fever and changes in faecal consistency. Diarrhoea and mild colic symptoms may also occur. Neurological abnormalities (ataxia, depression, recumbency) have rarely been described, they were, however, secondarily caused by hyperammonaemia. The blood count shows leukopenia (neutropenia/lymphopenia) and hypoalbuminaemia.
Infections with ECoV seem to be self-limiting but can be secondarily complicated (e.g. dehydration or intestinal displacement). Transmission is mainly via the faecal-oral route.

Cattle and Wild Ruminants

Bovine coronaviruses **(BCoV)** cause enteric and respiratory diseases in cattle and wild ruminants. These include calf diarrhoea, winter dysentery in adult cattle and respiratory diseases in cattle of different ages.

Pig

In pigs, coronaviruses cause highly contagious, sometimes epidemic **transmissible gastroenteritis (TGE)**. TGE virus presents an economic problem in all countries with intensive pig production. Loss of income occurs in the affected farms as a result of piglet losses, growth retention and reduced weight gain.

An infection with porcine coronavirus leads to a local infection of the intestinal tract, mostly in the jejunum and ileum. As the disease progresses, the villous epithelium is rapidly lost. Clinically, this is manifested in a watery malodorous diarrhoea. In Germany, TGE is **notifiable upon diagnosis**.

Coronavirus – Pathogen Detection		
Material	**Dog:**	CCoV: faeces CRCoV: swab without medium (pharynx, nose, trachea), BAL
	Cat:	Qualitative detection: FCoV: faeces/ FIP: puncture fluid, CSF, EB, intraocular fluid, tissue (e.g. kidney or omentum) Quantitative detection: faeces, puncture fluid, EB
	Ferret:	faeces, EB (viraemia phase), CSF (neurological abnormalities), tissue (intestine, lymph nodes)
	Horse:	faeces
	Cattle:	faeces, swab without medium (nose), tissue (e.g. lung)
	Pig:	faeces, tissue (e.g. intestine)
Method	Realtime PCR;	
Species	Dog, cat, ferret, horse, cattle, pig	

Duration 1 – 3 days

Note
- In small animals, a pooled faecal sample is recommended as this increases sensitivity.
- **Cat – quantitative PCR**: Quantification can be ordered separately as a single service and can also be requested following a qualitative PCR.

  Cat:
  - Faeces: Detection of enteric FCoV for assessing the infection pressure in the group and to help decide on possible rehabilitation. A cat is considered free if PCR was negative in 3 tests at weekly intervals and each time pooled faecal samples from 3 days were examined.
  - Puncture fluid: a high number of viruses detected in the abdominal and/or thoracic effusion strongly indicates FIP (always in conjunction with other diagnostic parameters such as protein electrophoresis, albumin/globulin ratio)
  - EDTA blood: alternative sample material if there is no effusion (note: possibly lower sensitivity and viraemia phase with enteric FCoV)
- **Ferret:** differentiation between enteric and systemic coronaviruses is performed automatically.
- Pathogen detection by means of an antigen test is part of the Virological Faecal Profile (EIA) or the Calf Faecal Profiles.
- **For pathogen detection of SARS-CoV-2 see Chapter 13.1.47, p. 167**

Feline Coronavirus (FCoV) – Antibody Detection

Material S, HP, Ascites 0.5 ml
Method ELISA (cat);
Species Cat
Duration 1 – 2 days

Note A positive titre merely confirms contact with coronaviruses.

13.1.15 Cytomegalovirus

Cytomegaloviruses belong to the herpesviruses and have been detected in different rodents. They are considered strictly host-specific. In guinea pigs, salivary and lacrimal glands become inflamed and respiratory symptoms may occur as well. In rare cases, there might also be signs of paralysis.

Cytomegalovirus – Antibody Detection*	
Material	S 0.5 ml
Method	IFAT
Species	Guinea pig
Duration	3 – 5 days

13.1.16 Deformed Wing Virus (DWV)

Deformed wing virus (DWV) is an RNA virus from the genus Iflavirus, which causes wing deformities in adult honey bees. All developmental stages can be affected. If already the larva is infected, it will develop crippled wings, a bloated abdomen and discolouration during metamorphosis, and the animal dies shortly after emerging. The virus causes a latent infection that persists. Thus, bees without any symptoms can still be carriers. The Varroa destructor mite is among the vectors of this virus and its move to other colonies poses a major problem in the spreading of the disease. There is no causal therapy.

Deformed Wing Virus (DWV) – Pathogen Detection	
Material	Bees
Method	Realtime PCR
Species	Bees
Duration	1 – 3 days

13.1.17 Distemper Virus

Canine distemper virus (CDV) belongs to the genus Morbillivirus (measles-distemper-rinderpest group). All animals of the families Canidae (such as dog, fox, wolf), Procyonidae (like raccoon and panda), Mustelidae (such as ferret, badger, marten) and Felidae (tiger, lion) can get infected. Distemper is enzootic worldwide. Transmission takes place orally or airborne via secretions and excretions of infected dogs or clinically healthy carriers. Intrauterine infections are also possible. Distemper is a febrile general disease with an acute to subacute course. A respiratory, an intestinal, a central nervous and a cutaneous form of the disease can be distinguished.
Virus excretion begins after approx. 7 days (up to 60 to 90 days p.i.), during which a typical cyclic infection with leukocyte-associated (possibly also non-cell-bound) viraemia occurs. Depending on the ability of the immune system to produce neutralising antibodies, distemper can take a mild or fatal course.

Distemper Virus – Pathogen Detection	
Material	Qualitative PCR: swab without medium (eye, nose, pharynx or tonsil), EB (viraemia), CSF, urine, faeces Quantitative PCR (dog): swab without medium

Method	Realtime PCR
Species	Dog, ferret, big cats, racoon, other species
Duration	1 – 3 days
Note	Dog: Quantitative PCR can also be requested following qualitative PCR. The pathogen load can indicate whether the viruses are field or vaccine viruses. A high viral load indicates a field infection, even if the dog has previously been vaccinated with live vaccine against distemper. A low pathogen load denotes a vaccine strain, if a distemper vaccination was given in the last few weeks. Otherwise, it may be a beginning or abating field infection. For medium viral load, we offer Distemper Virus-Vaccine PCR – unless vaccination was carried out with Vanguard (Zoetis).

Distemper Virus – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, ferret, raccoon, others on request
Duration	1 – 2 days
Note	Detection can be done in CSF, serum or plasma. Vaccine and infection titres in serum can only be differentiated by testing serum pairs, while in CSF, only infection titres are present and therefore individual samples are diagnostically conclusive (no blood in the sample!).

13.1.18 Equine Arteritis Virus

Equine Viral Arteritis (EVA) is a worldwide distributed, contagious viral infection of Equidae caused by the equine arteritis virus (EAV). Confirmed outbreaks seem to have increased in recent years. The majority of naturally acquired infections is subclinical; however, seroconversion still occurs. When clinical signs appear, they vary in type and severity: fever, depression, anorexia and peripheral oedema, conjunctivitis ("pink eye"), urticaria and abortion. In young animals, pneumonia and pneumoenteritis may also be seen. The virus is mainly transmitted through ejaculate. Persistently infected carrier stallions carry the virus in their accessory sex glands and intermittently shed it in the genital secretions. Geldings, prepubescent stallions and mares cannot be carriers. Especially in animals with systemic disease, excretion can also occur through other body secretions, such as aerolised secretions of the respiratory tract, urine, abortion material, etc.
In Germany, when EVA is detected in Equidae (horses, donkeys, etc.), there is an **obligation to notify the authorities.**

Equine Arteritis Virus – Pathogen Detection	
Material	Swab without medium (conjunctiva, pharynx), EB (viraemia), sperm, urine, abortion material
Method	Realtime PCR
Species	Horse, donkey, other Equidae
Duration	1 – 3 days

Equine Arteritis Virus – Antibody Detection	
Material	S 0.5 ml
Method	VNT
Species	Horse
Duration	5 days
Note	▪ This detection is mainly required for export. It may be necessary to test paired samples after 3 – 4 weeks. ▪ Differentiation between vaccine and infection titre is not possible!

13.1.19 Equine Infectious Anaemia Virus (EIAV)

Equine infectious anaemia (EIA) is a worldwide distributed disease in Equidae, caused by a retrovirus, with acute lethal to chronic recurrent forms. Characteristic signs are recurrent fever, anaemia, thrombocytopenia, distal oedema and considerable weight loss. Transmission takes place via infected blood, blood-sucking insects, iatrogenic through infected injection equipment, but also intrauterine.
Once infected horses remain infectious and seropositive throughout their lives. All horses older than 6 months that are seropositive are thus considered carriers; younger horses can be seropositive through maternal antibodies. Normally, the incubation period is 1 – 3 weeks, but may also last up to 3 months.
In Germany, there is an **obligation to inform the authorities upon suspicion,** as EIA is an **epizootic disease!**

Equine Infectious Anaemia Virus – Antibody Detection	
Material	Agar gel diffusion test (Coggins test): S 0.5 ml cELISA: S 2 ml
Method	Agar gel diffusion test (Coggins test), cELISA
Species	Horse, other Equidae
Duration	Agar gel diffusion test (Coggins test): 3 days cELISA: 1 – 2 days
Note	▪ First antibodies can be detected 2 – 3 weeks post infection. If the results of the serological examination are negative but animals are suspected of being infected, the test should be repeated, possibly several times, at intervals of 3 to 4 weeks.

- In Germany, the authorities must be notified of a positive Coggins test. A positive cELISA must be confirmed by a Coggins test.

13.1.20 European Brown Hare Syndrome Virus (EBHSV)

European brown hare syndrome (EBHS), also called viral hepatitis of hares, is a disease of the hare species Lepus europaeus and Lepus timidus.
The disease was first described in Scandinavia in the 1980s and has since occurred in numerous European countries; several cases have been reported in Germany as well. The causative agent of EBHS is a calicivirus (genus Lagovirus), which only causes the disease in hares. As far as is known, rabbits (and other animal species, too) are not affected. The virus is shed in all secretions and excretions and is very environmentally stable. Transmission presumably occurs directly, particularly faecal-orally or indirectly through contaminated water and feed. The disease is peracute to acute and is characterised by a very high morbidity and mortality rate (up to 100%). If at all possible, signs are rarely observed in free-living wildlife. They include: weakness, apathy, disorientation, loss of shyness and movement disorders (e.g. paralysis of the hind legs). There is no known therapy.

EBHS Virus – Pathogen Detection	
Material	Faeces, tissue (e.g. liver), (urine)
Method	Realtime PCR
Species	Hare (not rabbit!)
Duration	1 – 3 days

13.1.21 Feline Immunodeficiency Virus (FIV)

Feline immunodeficiency virus (FIV) belongs to the family Retroviridae. It is closely related to the human immunodeficiency virus (HIV) but is not infectious for humans. Since FIV is mainly transmitted through bite injuries, the prevalence of infected animals is highest in the group of uncastrated male cats over five years. FIV infection is spread worldwide. The prevalence in Germany is at approximately 3 – 5.5%. The virus persists for life. It has a clear tropism for T lymphocytes and macrophages. Similar to the clinical symptoms of HIV-infected patients, the course of FIV infection is often divided into four stages, with the final stage resembling human AIDS. However, transitions are smoother and the phase with no clinical signs is often longer than in humans. Detection should be performed, among others, in chronic recurrent and treatment-resistant infections, particularly in the oral cavity and the respiratory tract.

FIV Provirus – Pathogen Detection	
Material	EB
Method	Realtime PCR, qualitative or quantitative*

Species	Cat
Duration	Qualitative PCR: 1 – 3 days Quantitative PCR: 7 – 14 days
Note	Quantitative PCR: estimation of provirus load (therapy monitoring).

FIV – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	ELISA
Species	Cat
Duration	1 day
Note	A positive result indicates FIV infection, but positive titres are also possible in kittens with maternal antibodies. In questionable cases (exclusion of false positive results), the test should be repeated after 2 – 4 weeks. Further validation can be provided by an FIV blot at a partner laboratory. In an FIV blot, separate antibody detection of two antigens typical for FIV is performed. A negative result does not completely rule out an infection. False negative results can, for example, occur at the beginning or at the final stage of the disease.

13.1.22 Feline Leukaemia Virus (FeLV)

Like feline immunodeficiency virus (FIV), feline leukaemia virus (FeLV) belongs to the retroviruses. Prevalence of FeLV in Germany is low, but FeLV still occurs. Not only cats, but also other felids are susceptible to FeLV. In particular, kittens and cats from multi-cat households but also cats with a history of foreign travel are affected, as FeLV is transmitted directly from cat to cat. The main source of transmission is saliva, but other secretions and excretions can also be infectious. In most cases, cats develop an oropharyngeal infection. The virus penetrates the mucous membranes and multiplies there as well as in the tonsils and the retropharyngeal lymph nodes. While some cats with abortive infection are able to fight the virus in a way that no viraemia occurs, other cats develop viraemia which can be detected by an antigen test. If it can be overcome by the cat, it is called transient viraemia. It is therefore always advisable to retest a cat that is positive in the antigen test at a later time. However, some cats do not succeed in fighting off the virus sufficiently, so that the bone marrow becomes infected as well. As a result, provirus PCR is positive, regardless of whether the virus continues to circulate in the blood (progressive infection) or not (regressive infection).
Cats with progressive infection usually have the worst prognosis, younger animals are more often affected by progressive infection than older ones.

FeLV Provirus – Pathogen Detection	
Material	EB, bone marrow
Method	Realtime PCR
Species	Cat
Duration	1 – 3 days
Note	Detection of provirus can confirm a positive antigen result. Regressive infections can also be detected if no antigen is present in the blood.

FeLV – Antigen Detection	
Material	S, EP, HP 0.5 ml
Method	ELISA
Species	Cat
Duration	1 day
Note	In order to distinguish abortive from progressive infections, a positive detection should always be checked. This can be done after 4 – 6 weeks at the earliest, but better after 16 weeks. As this is an antigen detection, a "cross reaction" in vaccinated cats can be excluded.

FIP ➢ see Coronaviruses, p. 132

13.1.23 Feline Morbillivirus (FeMV)

Feline morbillivirus (FeMV) is a member of the Morbillivirus genus in the Paramyxoviridae family. which also includes canine distemper virus, rinderpest virus and small ruminant morbillivirus (peste-des-petits-ruminants virus), measles virus in humans and cetacean morbillivirus in marine mammals. Infection with FeMV is associated with chronic tubulointerstitial nephritis, which leads to chronic kidney disease, one of the most common causes of death in older cats. FeMV was first discovered in China in 2012 and has since been detected worldwide. It is currently assumed that there are two different FeMV genotypes (FeMV-1 and FeMV-2), which probably lead to different clinical manifestations. Concerning the pathogenesis, it is still unclear whether FeMV infections directly cause chronic kidney disease or whether the virus primarily affects kidney tissue that is already damaged. It seems that FeMV is not only limited to cats, as it has also been detected in opossums with pneumonia and nephritis as well as in dogs. In dogs, however, the virus has so far only been described as part of kennel cough (canine infectious respiratory disease complex).

Feline Morbillivirus (FeMV) – Pathogen Detection	
Material	Urine (at least refrigerated – preferably frozen)
Method	Realtime PCR

Species	Cat
Duration	1 – 3 days
Note	Due to the instability of RNA viruses in feline urine, it is recommended to send in samples which are fresh and possibly frozen.

13.1.24 Hantavirus

In rats and mice, hantaviruses lead to a persistent infection and it is assumed they are permanently excreted in the urine as well as through faeces and saliva, without the animals showing any symptoms. Hantaviruses are specific to individual rodent species and only very rarely spread to other species. Rodents are infected in the burrow, in territorial fights or while rearing the young.
It is a zooanthroponosis which leads to severe medical conditions in humans. In Europe, the clinical picture is mainly dominated by fever and nephropathies (dialysis required) or haemorrhages.

Hantavirus – Antibody Detection*	
Material	S 0.5 ml
Method	IFAT
Species	Rat, mouse
Duration	3 – 5 days

13.1.25 Herpesviruses

Herpesviruses cause epidemic as well as latent or persistent diseases in almost all animal species. The name is derived from the Greek word “herpein” (to creep). Common to all herpesviruses is lifelong latency in the host organism.

Herpesviruses dog

The so-called “puppy death” in dogs is caused by canine herpesvirus 1 (**CHV**-1). Puppies under 3 weeks of age die of haemorrhagic systemic disease. There is massive lytic virus replication at a subnormal body temperature of 36 – 37 °C and death occurs within 48 hours. The morbidity rate is 100%, the mortality rate is almost 95%!
Older puppies usually show mild respiratory symptoms, that is why an aetiological involvement in kennel cough complex is attributed to CHV.
Adult animals usually go through clinically inapparent infections. CHV-1 leads to a latent infection; after a primary cell-lytic infection, the viruses retreat into the trigeminal and lumbosacral ganglion cells. In stressful situations (e.g. birth or incipient lactation), viruses may be reactivated and then shed in saliva as well as nasal and ocular secretion. Female dogs can transmit the virus in utero to the foetuses; abortions and stillbirths are rare. In adult immunocompromised animals, a peracute course of the disease with fatal outcome is possible. A diagnosis of breeding animals is recommended.

An infection with suid herpesvirus 1 causes **Aujeszky's disease (pseudorabies)**.
For more information see Herpesviruses pig, p. 145.

Herpesviruses cat

The main signs of feline herpesvirus 1 **(FHV-1)** are respiratory symptoms such as rhinitis and sinusitis with ocular and nasal discharge. Conjunctivitis, corneal ulcers, dyspnoea and anorexia may occur. Co-infections, for example with feline caliciviruses and bacteria, are possible. After the primary infection, a lifelong latent infection develops which may be reactivated under stress at any time and thus lead to recurrent symptoms. In kittens, apart from very high fever and general weakness, there may also be deaths (fading kitten syndrome).

Herpesviruses birds

There are many different herpesviruses that are found in birds, including commercial poultry, ornamental, wild and zoo birds. New viruses are also regularly found in these animal groups. Several herpesviruses have been described in parrots, too. The best-known and perhaps clinically most relevant one is psittacid herpesvirus 1 (PsHV-1).
PsHV-1 is responsible for **Pacheco's disease** in parrots and is therefore also called **Pacheco's virus.** The clinical course depends on the genotype or serotype and the affected psittacine species. For budgerigars and cockatiels, mild to subclinical courses with virus shedding are reported. In large parrots, such as macaws, amazon parrots, cockatoos or grey parrots, an infection often leads to death. If symptoms occur, they are usually non-specific and consist of anorexia, apathy and poorly developed feathers. Changes in faeces and an increase in uric acid excretion may occur, too. Occasionally, CNS symptoms are also observed. The disease particularly breaks out in stressful situations, e.g. capture and quarantine of imported birds, change of owner, hospitalisation, beginning of breeding or the onset of sexual maturity. Therefore, a suitable preliminary examination of birds that are to be integrated into the flock is recommended in order to avoid posing a threat to the other birds.
An examination for herpesviruses may also be appropriate for other animals with systemic diseases, diseases of the respiratory system, the liver or with skin lesions or lesions of the mucous membrane at the cloaca or around the beak.
In amazon parrots and cockatoos, psittacid herpesviruses can also be detected in papillomas in the throat and the cloaca.

Herpesviruses reptiles

Herpesvirus infections are most common in a variety of chelonians, including tortoises, terrapins and sea turtles. In the veterinary practice, herpesviruses of **tortoises** of the genus Testudo play an important role. As this is a highly contagious virus infection, animals should be routinely examined for infection before being introduced into a population.
Clinical signs include nasal and ocular discharge, regurgitation, anorexia and lethargy. Necrotic plaques in the oral cavity and on the tongue are also typical.

So far, 4 different types of herpesvirus, **testudinid herpesviruses (TeHV)** 1 – 4, are known in tortoises. In Europe, especially TeHV-1 and TeHV-3 are found. TeHV-3 has a broad host range among tortoises and infections are usually associated with very high morbidity and mortality rates. TeHV-1 can mostly be detected in Russian tortoises (Testudo horsfieldii). These are often diseases of individual animals, since TeHV-1 has a considerably lower tendency than TeHV-3 to spread in the population. Individual cases of TeHV-2 (especially in desert tortoises) and TeHV-4 (in African tortoises) have been detected in Europe in recent years.
In **turtles,** herpesvirus infections are mainly associated with hepatic inflammation. In live animals, dry pharyngeal and cloacal swabs, and in dead animals, liver samples can be examined by PCR.
In **sea turtles**, herpesviruses cause fibropapillomatosis and other diseases. Virus detection by PCR is possible from altered tissue.
In **lizards,** herpesviruses are mainly seen in connection with oral lesions.

Herpesviruses horse

EHV-1 and EHV-4

In horses, donkeys, mules and zebras, infections with EHV-1 as well as with EHV-4 are caused by droplet infection or direct contact. The severity of the clinical symptoms depends on the age and immune status of the infected animal. Particularly infections with EHV-1 are able to spread beyond the respiratory mucosa and cause severe manifestations of the disease: abortions, perinatal foal death, neurological diseases.
In case of foals infected with EHV-4, morbidity rates of up to 100% are possible, especially during the weaning period. More than 80% of the isolates come from animals with rhinopneumonitis.
Once horses are infected with herpesviruses, they remain carriers of the virus throughout their lives, and the virus can be reactivated endogenously under unfavourable conditions (stress, etc.). Lymph organs, the leukocyte fraction and trigeminal ganglion cells are the main latency organs. If the vaccinated horses are also taken into account, seroprevalence in the horse population is high.
In recent years, EHV-1-associated neurological diseases, for which a "neurotropic" strain of EHV-1 is held responsible, have been reported with increasing frequency and severity of the clinical disease. This much-feared clinical picture is referred to as **EHM (equine herpesvirus myeloencephalopathy)**.
Two different variants of EHV-1 have been described in horses (DNA_{pol} D_{752} vs. DNA_{pol} N_{752}). Each is associated with a different level of neuropathogenicity. The D752 variant is associated with most outbreaks of neurological disease and is considered neuropathogenic. However, only a fraction of the horses infected with this virus will develop neurological signs. The N752 variant is most commonly isolated in conjunction with abortions, but also in a smaller number of neurological diseases. The differentiation is particularly interesting from an epidemiological point of view.

EHV-2 and EHV-5
The involvement of EHV-2 and/or EHV-5 in keratoconjunctivitis has long been suspected and these viruses are indeed regularly detected in conjunctival swabs. In recent years, it has increasingly been shown that EHV-2 and 5 are precursors of other viral and bacterial infections of the respiratory tract. Especially in young animals, EHV-2 and/or EHV-5 were detected in treatment-resistant, partly catarrhal-purulent, partly necrotising or abscessing bronchopneumonia. EHV-5 was recently presented as aetiological agent of **"equine multinodular pulmonary fibrosis" (EMPF)**.

EHV-3
Coital exanthema caused by equine herpesvirus type 3 (EHV-3), which only sporadically occurs in Germany, is a mildly progressing breeding infection in horses. Clinically, blisters, pustules and erosions appear on the mucous membrane of the vestibulum, penis or prepuce as well as on adjacent skin areas. Healing takes place spontaneously after approximately 2 – 3 weeks, but can be complicated by secondary infections. Transmission mainly occurs through mating, but is also possible through close contact as well as rectal and vaginal examinations. Infected animals remain carriers of the virus for life.

Herpesviruses cattle
Bovine herpesvirus 1 **(BHV-1)** is the causative agent of infectious bovine rhinotracheitis (IBR), which – depending on where the disease occurs in the individual organ systems – is also known as infectious pustular vulvovaginitis (IPV) and infectious balanoposthitis (IBP). In Germany, it is an **epizootic disease** that is **notifiable upon suspicion!**

Herpesviruses pig
Suid herpesvirus 1 causes **Aujeszky's disease (pseudorabies)** and is also called Aujeszky's disease virus (ADV) or pseudorabies virus (PrV). Pigs are the natural host; they develop different clinical signs depending on age and can survive the infection, while the infection is fatal in other animals. In domestic pigs, Germany has been free of Aujeszky's disease since 2003, but the virus occurs in the wild boar population and can mainly infect hunting dogs – also via meat waste of healthy, but latently infected wild boars. In dogs, an infection causes central nervous disorders, mostly itching and death after 1 – 3 days.
In Germany, Aujeszky's disease is **notifiable upon suspicion** in domestic cattle and domestic pigs.

Herpesviruses koi
Koi herpesvirus **(KHV)** is a highly infectious virus that has caused epidemic disease in carps (koi and common carps) in recent years, depending on the water temperature. Morbidity and mortality rates can be as high as 100% within 1 – 2 weeks after the pathogen has been introduced. The incubation period ranges from a few weeks to several months. It depends on various external and internal factors such as stress and condition of the fish. Fish of all age groups are affected at water temperatures between 18 – 29 °C.

Clinically, the main signs are gill necrosis, increased mucus production, haemorrhages of the skin, liver, spleen and kidneys. Surviving fish probably remain latent carriers of the virus for years and represent a potential hazard in the trade with live fish in pond management and hobby animal keeping. Immunisation by means of live attenuated vaccine is currently rejected from a scientific point of view.
In Germany, it is an **epizootic disease** that is **notifiable upon suspicion!**

Herpesvirus – Pathogen Detection
BHV-1 (cattle)*

Material

Dog: abortion material, tissue of dead puppies (lung, liver, kidney), swab without medium (nose, pharynx, eye, genital tract), EB (viraemia)

Cat: swab without medium (eye, nose, pharynx, genital tract), EB (viraemia!), abortion material, tissue (e.g. kidney, liver)

Birds: 2 – 3 plucked feather shafts, blood (EB or 1 – 2 drops on a filter paper), swab without medium (triple swab: eye + pharynx + cloaca), faeces, tissue (e.g. liver, kidney, spleen)

Tortoise: swab without medium (tongue + pharynx), tissue (liver, intestine, possibly brain)

Turtle: swab without medium (pharynx + cloaca), tissue (liver)

Sea turtle: altered tissue

Lizard: swab without medium (lesions, pharynx), tissue (liver)

Horse: EHV-1: swab without medium (nose or pharynx), bronchoalveolar lavage, abortion material incl. placenta, EB (upon request, the detection from buffy coat is also possible, in this case, at least 5 ml EB is required), CSF, aqueous humour. According to recent studies, it is recommended to also examine EB in parallel with the swabs/organ material.
EHV-2: swab without medium (eye), cornea, aqueous humour; foals with respiratory symptoms: swab without medium (nose or pharynx), lavage (BAL)
EHV-3: swab without medium (lesions on vestibule, penis, prepuce or surrounding skin), tissue (lesions)
EHV-4: swab without medium (nose or pharynx), lavage (BAL), EB (buffy coat, examination of EB + organs: see EHV-1), CSF, abortion material, aqueous humour
EHV-5: swab without medium (eye); foals with respiratory symptoms: swab (nose or pharynx), lavage (BAL), EB, cornea, aqueous humour

Cattle: BHV-1*: swab without medium (eye, nose or genital tract), tracheal lavage, abortion material, tissue (e.g. brain or tonsil)

Koi: KHV: tissue (e.g. gills, brain, liver, spleen, skin or intestine), swab without medium (gills or skin)

Method	Realtime PCR/PCR (birds, reptiles)
Species	Dog, cat, birds, turtle, tortoise, lizard, horse, cattle, koi
Duration	1 – 3 days 2 – 4 days (birds, reptiles) 7 – 14 days (cattle)
Note	Herpesviruses usually produce only short-term viraemia, thus detection in EB is limited to the early acute phase. **Tortoise:** In case of a positive result, differentiation of the virus strain may be of clinical relevance because of different tendencies to spread in the population and for the prognosis of an infection. Differentiation is possible on request. **Horse:** Blood tests are only useful in the febrile phase. Recently, the submission of organ/swab material plus EB has been recommended. The samples are pooled to increase the chance of detection. PCR for EHV-1 includes differentiation of the neuropathogenic variant. Testing for EHV-1 and/or EHV-4 or EHV-2 and EHV-5 is also part of several profiles (see Chapter 13.5.3, p. 246).

Herpesvirus – Antibody Detection
Equine Herpesvirus 1/4 – Antibody Detection

Material	S, HP 0.5 ml Tortoise: S, HP 0.4 ml
Method	Dog, cat: IFAT Horse: ELISA Tortoise: VNT
Species	Dog, cat, tortoise, horse
Duration	1 day Tortoise: 7 – 14 days Horse: 2 – 3 days
Note	Vaccine and infection titres can only be differentiated by testing serum pairs. PCR detection should therefore be preferred if an acute infection is suspected. **Tortoise:** The test detects antibodies against TeHV-1 and TeHV-3. In Hermann's tortoises, often only low antibody titres are observed. **Horse:** Testing of paired serum at an interval of 10 – 14 days. A clear increase in titre would prove an acute EHV infection. However, in acute cases we recommend direct pathogen detection by PCR (from a nasal swab without medium plus EB) to verify excretion. Vaccine titres cannot be distinguished from infection titres.

Aujeszky's Disease Virus (Pseudorabies) – Antibody Detection

Material	S 1 ml
Method	VNT
Species	Dog, wild boar
Duration	3 days

BHV-1 – Antibody Detection*
gB – Antibody Detection*
gE – Antibody Detection*

Material	(1) BHV antibodies: S or milk 1 ml (2) gB/gE antibodies: S 1 ml
Method	ELISA
Species	Cattle
Duration	5 days
Note	In cattle, vaccination and infection titres can be differentiated by determining the gE glycoprotein. Glycoprotein B (gB) has both vaccine strains and field strains in the virion. There is a deletion of the gE gene in the vaccine virus and therefore no glycoprotein E (gE) in the virion, while the field virus has gE in the virion. Antibodies against gE can therefore only be detected in field virus infections, but not after vaccination alone.

Pacheco's Virus – Antibody Detection*

Material	S 0.2 ml
Method	VNT
Species	Birds
Duration	7 – 10 days

Infectious Anaemia ➢ **see Equine Infectious Anaemia Virus, p. 138**
Infectious Viral Arteritis ➢ **see Equine Arteritis Virus, p. 137**

13.1.26 Influenza Virus

Influenza A viruses belong to the family Orthomyxoviridae and are mostly found in humans, pig, poultry and horses, but also in many others such as birds or dogs.

Horse

Equine influenza is caused by influenza A equi 2, European and American lineage. In susceptible Equidae, an infection causes fever and a rough, dry cough. In unvaccinated populations, the virus spreads quickly. Secondary bacterial infections with mucopurulent nasal discharge are frequent and mask the clinical picture, especially in partially immune populations.

Pig

Pigs may not only become infected with porcine, but also with human and avian influenza viruses and thus contribute to the creation of reassortant influenza viruses. The influenza pandemics in humans in 1918/19 and in 2009 were caused by porcine influenza viruses. In pigs, primary infections are usually linked to livestock transport. The infection spreads explosively in the population.

Dog

For a long time, dogs were thought to be immune to influenza as there were no infections in the dog population. After major outbreaks in the USA and South Korea, two canine influenza A subtypes have now been described: CIV H3N8 and CIV H3N2. In dogs, infections with canine influenza A viruses usually cause mild clinical signs such as coughing and sneezing or are even subclinical. Severe courses of the disease with high fever, dyspnoea and pneumonia are rare. Progression of the disease is often aggravated by secondary bacterial infections or infections with other viruses.

Ferret

Ferrets are susceptible to numerous influenza A viruses – susceptibility to human influenza A viruses is important, which is why they are often used as animal models for infection experiments. The risk of zoonosis is particularly important here! Symptoms are similar to those of humans: inappetence, apathy, fever and respiratory signs such as sneezing and nasal discharge, neurological signs have been described as well. Young animals usually have a more severe course of the disease than adult animals and here, too, secondary bacterial infections aggravate the clinical course.

Influenza A Virus – Pathogen Detection	
Material	Swab without medium (respiratory tract), lavage (BAL), TBS
Method	Realtime PCR
Species	Dog, ferret, horse, pig, others (**not** birds)
Duration	1 – 3 days

Influenza A Virus – Antibody Detection*	
Material	S 0.5 ml
Method	HAH
Species	Horse
Duration	5 days
Note	▪ Testing is done for A equi 2 (American, Florida Clade 1) and A equi 2 (European, Newmarket 2/93). A significant increase in titre within 2 weeks is usually associated with acute disease. ▪ Differentiation between vaccine and infection titre is not possible.

13.1.27 Iridovirus

Iridovirus see also ➢ *Ranaviruses, p. 164*

Invertebrate iridoviruses (IIV) particularly occur in insects. In addition, they are regularly found in lizards, where they might cause skin lesions. The detection of iridovirus may be of interest if the mortality rate in the population of feeder animals or lizards is increased.

Iridovirus – Pathogen Detection	
Material	Lizard: tissue (e.g. skin or liver), swab without medium (skin) Feeder animals (whole insects)
Method	Realtime PCR
Species	Reptiles (lizards) and their feeder insects (e.g. crickets)
Duration	1 – 3 days
Note	As these viruses are frequently found in feeder insects, virus detection in pharyngeal or cloacal samples or in the intestine needs to be interpreted very carefully.

13.1.28 Lymphocytic Choriomeningitis Virus (LCMV)

The main reservoir of LCMV, which belongs to the arenaviruses, is the house mouse. Cells infected with LCMV express antigens and are recognised by cytotoxic T lymphocytes. This lymphocyte activity also makes the blood-brain barrier permeable resulting in meninges and neurons being damaged.
Infection of adult **mice** leads to choriomeningitis. In contrast, an intrauterine or neonatal infection generally causes an asymptomatic chronic carrier state in mice, with such animals forming immune complexes in the course of their lifetime that lead to glomerulonephritis. In **guinea pigs** and **hamsters,** LCMV infections often progress subclinically, however, conjunctivitis, blepharitis, respiratory symptoms, tremor, seizures and paralysis have been described. LCMV is transmitted diaplacentally and with all secretions and excretions.
In humans, LCMV rarely leads to choriomeningitis; the infection is usually asymptomatic or shows mild, flu-like symptoms. An infection in the second part of pregnancy can cause severe foetal damage.

Lymphocytic Choriomeningitis Virus (LCMV) – Antibody Detection*	
Material	S, HP 0.5 ml
Method	IFAT
Species	Guinea pig, mouse, hamster
Duration	3 – 5 days
Note	Zooanthroponosis! – Be careful when collecting the sample!

13.1.29 Maedi/Visna Virus

Maedi and visna are two different diseases in sheep that are caused by a **lentivirus** of the retrovirus family and belong to the so-called "slow virus diseases".
Maedi (meaning dyspnoea) disease is characterised by shortness of breath and cough, which are caused by chronic progressive interstitial pneumonia.
Visna (meaning decay) is a slightly contagious but progressive disease of the central nervous system. The animals show paralysis because of a demyelination of the CNS as well as increasing decay.
In Germany, the disease is **notifiable upon diagnosis**.

Maedi/Visna Virus – Antibody Detection	
Material	S 0.5 ml
Method	ELISA
Species	Sheep
Duration	3 days
Note	Rehabilitation of affected flocks is carried out by doing serological tests every six months and culling of reactants. In farms that are approved as unsuspicious, monitoring takes place by serological tests at yearly intervals. In goats and sheep, the ELISA test detects antibodies against lentiviruses, which can cause CAE in goats and Maedi/Visna in sheep.

13.1.30 Myxoma Virus

Myxoma virus is the causative agent of **myxomatosis** in rabbits. It is a large, enveloped DNA virus and belongs to the genus Leporipoxvirus (family: Poxviridae). Despite its envelope, poxviruses are relatively stable in the outside world. However, inactivation can easily be achieved with ordinary disinfectants.
The virus is very host-specific: The European rabbit and domestic rabbit breeds descending from it are most susceptible, but American rabbit species and European hare species can be infected as well. The virus is mainly transmitted through insects (gnats, fleas – mechanical transmission), thus, the disease primarily occurs between the end of July and October. Transmission by direct contact is usually only important in cases of high population density.
After a primary virus replication in the mucous membranes of the head, the regional lymph nodes become infected. Subsequently, there is a cell-associated viraemia (lymphocytes) and the virus spreads to nearly all organs.
After an incubation time of 4 – 10 days, an infection with myxoma virus causes an acute systemic disease with severe conjunctivitis and hypodermal oedema (especially in the facial and the anogenital region). Nodular tumours in the skin and subcutaneous tissue may also occur. Respiratory problems and dysphagia result in inappetence and anorexia.

The mortality rate is between 25 and 90%. Chances of full recovery are generally very low. Seriously affected animals should be euthanised.
Due to the high mortality rate caused by the disease, the virus was introduced into rabbit populations in Europe, Chile and Australia around 1950 for population control. It has since been endemic in these countries. However, co-evolution of the virus and the rabbits has led to weakened virus strains and virus-resistant rabbits. Thus, the severity of clinical symptoms strongly depends on the virulence of the present virus strain and the susceptibility of the host.
Vaccines are available for prophylaxis.

Myxoma Virus – Pathogen Detection	
Material	Swab without medium (conjunctiva, nose or pharynx), tissue (e.g. conjunctiva, lung or kidney)
Method	Realtime PCR
Species	Rabbit
Duration	1 – 3 days

Myxoma Virus – Antibody Detection*	
Material	S 0.5 ml
Method	IFAT
Species	Rabbit
Duration	3 – 5 days

Newcastle Disease Virus ➢ see Paramyxoviruses, p. 156

13.1.31 Nidoviruses

Viruses of the order Nidovirales are large, enveloped, single-stranded RNA viruses. Among others, this order includes the families Arteriviridae and Coronaviridae. The nidoviruses detected in **snakes** are most closely related to the family Coronaviridae, subfamily Torovirinae. They are found in pythons and boas, and have most commonly been detected in ball pythons and green tree pythons so far. They are associated with pneumonia and stomatitis and seem to be important pathogens in different python species.
Nidoviruses have also been detected in **shingleback lizards** and other **Tiliqua spp.** However, these are clearly different from the nidoviruses described in snakes and are called **shingleback nidovirus 1** (genus Tiruvirus). Infection is associated with respiratory disease.

Nidoviruses – Pathogen Detection	
Material	Swab without medium (pharynx or trachea), tracheal lavage, tissue (e.g. lung or trachea)
Method	PCR

Species	Snake (python, boa)
Duration	1 – 3 days

Nidovirus (Shingleback Nidovirus) – Pathogen Detection

Material	Swab without medium (pharynx), tracheal lavage
Method	Realtime PCR
Species	Tiliqua spp. (skink)
Duration	1 – 3 days

13.1.32 Orthopoxviruses

Poxvirus (Avipoxvirus) see ➢ Avipoxvirus, p. 123

The genus Orthopoxvirus belongs to the family Poxviridae. Due to their structure and their viral enzymes, these viruses have a special position within the viruses. Poxviruses are able to mature into infectious viruses in the cytoplasm of the host cell without the cell nucleus being involved. Poxviruses have a relatively large genome with a double-stranded linear DNA.
Orthopoxviruses have a broad host spectrum and can therefore be called cowpox, catpox, elephantpox or ratpox. Cattle, carnivores, rodents and humans are particularly susceptible.
In Germany, the **authorities must be notified.**

Cat

An infection with cowpox virus can cause catpox in both cats and humans. Cats are usually infected by their prey animals such as mice and rats. The virus penetrates the skin through bite or scratch injuries, which are usually located on the head, neck or forelimbs. To some extent, necrotising, extremely itchy smallpox appears at these sites. In most cases, self-healing occurs after a few weeks, but in immunocompromised people and cats (e.g. FIV infection), a systemic infection with severe to fatal pneumonia can develop.
The vaccination against human pox administered until the 1970s does not provide any protection against an infection, but seroconversion with the vaccinia virus used for vaccination can probably lead to an attenuated clinical picture. These vaccinations were discontinued in the mid-1970s and a more frequent occurrence of this infection becomes more likely.
A PCR analysis of skin crust material can provide a quick and reliable diagnosis.
Self-protection during sampling and treatment of an infected cat should not be neglected. In addition, veterinary personnel and, if necessary, the owners should be educated. In most cases, if a person becomes infected with smallpox, it can be diagnostically evaluated whether or not the pet is a carrier.

Rat

The occurrence of Orthopoxvirus bovis infections in pet rats and the resulting transmission to humans has also been described. The rats show necrotising lesions on the limbs and in the head and tail area.

Poxvirus (Orthopoxvirus) – Pathogen Detection	
Material	Scurf
Method	Realtime PCR
Species	Cat, rabbit, guinea pig, rat, mouse, cattle and other susceptible species
Duration	1 – 3 days
Note	Zoonosis – be careful when collecting the sample!

Pacheco's Virus ➢ see Herpesviruses, p. 142

13.1.33 Papillomaviruses

Dog/Cat

Papillomatosis is a rare viral disease in dogs and cats characterised by numerous benign warts (papillomata) in the head area. Although papillomaviruses occur in many animal species and in humans, they are strictly host-specific, so they do not pose a risk to humans or other animals. PCR detects canine and feline papillomaviruses. Papillomata are mainly observed in the oral cavity and are less frequent on the conjunctiva, the cornea and the eyelids. Warts are benign and usually heal without treatment within one to five months. If feed intake is severely affected by them, surgical excision might be indicated. A study has attested a good effectiveness to the administration of azithromycin.

Papillomavirus – Pathogen Detection	
Material	Tissue (skin)
Method	PCR
Species	Dog, cat
Duration	1 – 3 days

Horse

Equine sarcoid is one of the most common skin tumours in horses (about 2 – 12% of all horses are affected). The causative agent is bovine papillomavirus – especially type 1, more rarely type 2. The tumour cells are modified fibroblasts; the skin and subcutaneous tissue are affected. Equine sarcoids are considered semi-malignant tumours, i.e. they do not metastasise, but have a strong tendency to recur if surgical removal is incomplete. It is presumed that transmission mainly occurs through direct contact as well as flies and horseflies, but also indirectly through wound sites, saddles, blankets and cleaning utensils. The entire skin surface as well as certain blood cells are infected; moreover, the infection remains throughout life. The initial diagnosis is made at the age of 3 – 12 years.

BPV (Bovine Papillomavirus 1 and 2, Equine Sarcoid) – Pathogen Detection	
Material	Scurfs, hairs (with root), tissue (tumour)
Method	Realtime PCR
Species	Horse
Duration	1 – 3 days
Note	Positive PCR results confirm the suspected clinical diagnosis. Gold standard for the diagnosis of equine sarcoid is the examination by histopathology.

13.1.34 Parainfluenza Viruses

Dog

Canine parainfluenza virus 2 (CPiV-2) plays a crucial role in acute infections of the upper respiratory tract in dogs, which are referred to as kennel cough. In kennels or similar facilities, antibodies can be detected in up to 70% of all animals.
Infections solely with CPiV-2 usually only lead to a mild or clinically inapparent course of the disease. Only if secondary infections with other viruses (mainly canine adenovirus 2/ canine herpesvirus 1), bacteria (Bordetella bronchiseptica, streptococci, staphylococci, etc.) or mycoplasma occur and if husbandry and/or hygiene conditions are poor, the known severe courses of the disease develop.

Parainfluenza Virus (CPiV) – Pathogen Detection	
Material	Swab without medium (nose, pharynx), lavage (BAL)
Method	Realtime PCR
Species	Dog
Duration	1 – 3 days

Cattle

Bovine parainfluenza virus 3 (PI-3, BPIV-3) plays an important role in acute respiratory tract diseases in cattle, especially in the development of the multifactorial disorder **enzootic bronchopneumonia**. Monoinfections cause only mild symptoms or are clinically inapparent. Only secondary infections with other viruses (e.g. bovine adenovirus), bacteria (pasteurella, mycoplasma) and factors that reduce resistance (cold weather, stress, poor stable hygiene) lead to the development of severe symptoms in the form of endemic bronchopneumonia. The virus is shed with the nasal secretion and the transmission is airborne. The clinical picture is characterised by fever, breathing difficulties and salivation. About 5% of the animals die within 3 – 4 days. Various vaccines are available, but reinfections can occur after a few months.

BPIV-3 – Pathogen Detection	
Material	Swab without medium (nose or pharynx), lavage sample, tissue (e.g. trachea or lung)
Method	Realtime PCR
Species	Cattle
Duration	1 – 3 days
Note	This test can be ordered individually and it is also part of the PCR test Bovine Respiratory Profile 1 (see Chapter 13.5.4, p. 249).

BPIV-3 – Antibody Detection	
Material	S 1 ml
Method	ELISA
Species	Cattle
Duration	3 – 5 days
Note	This test is part of the serological Bovine Respiratory Profile (see Chapter 13.5.4, p. 249).

13.1.35 Paramyxoviruses

Paramyxoviruses see also
- *BRSV, p. 126*
- *Distemper Virus, p. 136*
- *Parainfluenza Viruses, p. 155*
- *Sunshine Virus, p. 168*

Paramyxoviruses are enveloped, single-stranded RNA viruses. They mainly cause respiratory disorders in humans and many animal species, but are also the causative agents of severe systemic diseases.

Birds

Avian Paramyxovirus 1 (aPMV-1, Newcastle Disease Virus)

Newcastle disease virus is an avian paramyxovirus which can infect many different avian species. In fowl, Newcastle disease is also called atypical fowl pest. There are different pathogenic strains which produce clinical signs of varying severity, from subclinical to peracute diseases. Most notably, affected animals can develop respiratory and CNS symptoms; loss of performance, diarrhoea and sudden deaths are also possible. Newcastle disease virus is zoonotic and can cause conjunctivitis, fever, headache and aching limbs in humans.
aPMV-1 is considered the cause of Newcastle disease once it exceeds a certain pathogenicity index. In Germany, Newcastle disease is **notifiable upon suspicion.**
In Germany, poultry must be vaccinated.

Paramyxovirus (aPMV-1) – Pathogen Detection*	
Material	Swab without medium (cloaca, trachea), tissue (trachea, lung, brain, liver, spleen)
Method	Realtime PCR
Species	Birds
Duration	4 – 8 days

Paramyxovirus (aPMV-1) – Antibody Detection*	
Material	S, EB 0.2 ml
Method	HAH
Species	Birds
Duration	7 – 10 days

Reptiles

Paramyxoviruses/Ferlaviruses

Ferlavirus infections most notably occur in snakes. These infections are rarely found in lizards and chelonians. Vipers, elapids, colubrids, boas and pythons are particularly affected. Signs of the disease include nasal discharge, breathing with open mouth and breath sounds. In addition to respiratory changes, CNS signs are often observed. They include poor muscle tone, compulsive movements, head tremor and opisthotonus. Transmission can occur horizontally from one animal to another, by aerosols or through faeces.

In live animals, the virus can best be detected by obtaining a tracheal wash sample or through a combined pharyngeal and cloacal swab. The most suitable organ samples are lung, followed by brain, pancreas as well as liver, intestine and kidney.

Paramyxoviruses/Ferlaviruses – Pathogen Detection	
Material	Swab without medium (pharynx, cloaca), tracheal lavage, tissue (e.g. brain, lung, liver, kidney, pancreas, intestine)
Method	PCR
Species	Reptiles (especially snakes, but also lizards and chelonians)
Duration	1 – 3 days

Paramyxovirus/Ferlavirus – Antibody Detection*	
Material	S, HP 0.2 ml
Method	HAH
Species	Reptiles
Duration	Approx. 1 week

13.1.36 Parvoviruses

Parvovirus is a very small non-enveloped DNA virus with extreme environmental stability. It can persist in the environment for up to a year and is also very temperature-resistant. Animals become infected oronasally with parvoviruses. First, virus replication occurs in the mucous membranes, then followed by viraemia. The lymphatic system and organs become infected.

Dog

In dogs, **parvovirus infection** usually progresses as a cyclic systemic disease with a manifestation in the intestinal epithelium and the resulting clinical picture of anorexia, fever, vomiting and persistent bloody diarrhoea. The disease is most severe in puppies. Different clinical forms of parvovirus infection can develop. Particularly in puppies, a peracute cardiac form with myocarditis may develop and sudden death can occur. The acute form, however, is characterised by severe symptoms. High fever, severe bloody diarrhoea and vomiting occur. Due to the high affinity of the virus to tissues with high mitotic activity, severe leukopenia occurs simultaneously. If the leucocyte count falls below 2000 cells/µl,
prognosis must be made carefully. Subclinically infected animals represent the pathogen reservoir as they shed the virus via the faeces.

Cat

Feline parvovirus infection – **panleukopenia** – is a highly contagious systemic disease of felids. The mortality rate among unvaccinated animals is over 80%.
Clinically, the disease is characterised by fever, diarrhoea, vomiting and dehydration. The blood count shows extreme leukopenia. A special case is the intrauterine infection. The mother cat is infected without showing any symptoms, but it leads to the abortion or death of the kittens. If kittens are born alive, there is often a cerebellar hypoplasia, which leads to ataxia and tremor, usually without any impairment of consciousness.

Ferret

Aleutian mink disease is caused by Carnivore amdoparvovirus 1, a highly contagious parvovirus of the genus Amdoparvovirus. This single-stranded DNA virus is non-enveloped and therefore, like canine and feline parvoviruses, extremely resistant. Minks, but also ferrets, skunks, otters, raccoons, foxes, etc. can be affected by this disease.
The virus triggers an immune complex-mediated disease which is mainly characterised by hypergammaglobulinaemia.
The signs vary: Young animals tend to develop pneumonia, adult animals develop glomerulonephritis, arteritis, and/or meningoencephalitis. Bloody diarrhoea, hind leg paresis and fertility disorders have further been described. The outcome is often lethal.
As there is currently no vaccine available, many ferrets are vaccinated with dog vaccines; it is unlikely that this will provide protection against an infection with the Aleutian mink disease virus.
Transmission can be both direct and indirect.

Horse

Equine serum hepatitis, formerly referred to as **Theiler's disease**, is caused by infection with **equine parvovirus-hepatitis virus (EqPV-H)**. EqPV-H is a hepatotropic single-stranded DNA virus that can cause hepatitis in infected horses. Asymptomatic infection is common. Approximately 2% of infected horses develop clinical hepatic disease, ranging from mild disease to acute fulminant liver failure. Clinical signs may include one or more of the following: lethargy, anorexia, jaundice, neurological signs associated with hyperammonaemic encephalopathy, death usually within 72 hours. EqPV-H should be suspected in horses with signs of illness and/or liver disease. Horses between 3 – 6 years of age have a seroprevalence of about 14%, for the age group of 11 – 15 years even a value of about 43% has been reported. EqPV-H-positive horses have often received a blood product 4 – 8 weeks before.

Pig

Porcine parvovirus (PPV) can be detected in almost all pig populations worldwide. In Germany, a prevalence of 60 – 80% can be assumed.
In an infection with PPV, fertility disorders and embryonic infections with subsequent fetal death (**SMEDI:** stillbirth, mummification, embryonic death, infertility) are the main clinical symptoms. The sows usually show no clinical signs.

Parvovirus – Pathogen Detection	
Material	**Dog:** qualitative PCR: faeces, EB, tissue (e.g. intestine or heart) quantitative PCR: faeces **Cat:** faeces, EB **Ferret:** rectal swab without medium, EB (viraemia), tissue (e.g. spleen, lymph node or bone marrow), (faeces – lower sensitivity than rectal swab) **Horse:** EB, serum, tissue (liver) **Pig:** swab without medium (genital tract), EB, tissue (e.g. abortion material)
Method	Realtime PCR PCR (ferret)
Species	Dog, cat, ferret, horse, pig
Duration	1 – 3 days
Note	▪ PCR can be positive up to four weeks after vaccination with live vaccine. ▪ In **dogs**, differentiation between vaccine strain (CPV-2) and field strains (CPV-2a, CPV-2b, CPV-2c) is possible on request. Please note that when using parvovirus vaccines containing CPV-2b as vaccine antigen (e.g. Zoetis Versican Plus, Virbagen Puppy 2b) we cannot differentiate between vaccine strain and field strain. ▪ If vaccination was carried out using a vaccine with field strains or if the vaccine or vaccination status of the dog is unknown and vaccination was carried out shortly (less than 4 weeks) before the

onset of the symptoms, quantitative PCR is recommended and can be requested following qualitative PCR. A very high pathogen load indicates an acute infection. If the infection has subsided, it is not possible to differentiate between the field strain and the vaccine strain even by qPCR; in both cases, only a low pathogen load is detectable.
- Direct detection of parvoviruses in the blood is possible approx. 1 – 5 days after infection.

Parvovirus – Antigen Detection	
Material	Faeces
Method	EIA
Species	Dog, cat
Duration	1 – 2 days
Note	A faecal sample of the size of a pea is required. False positive reactions may occur up to 5 – 12 days post vaccination with live vaccine!

Parvovirus – Antibody Detection	
Material	**Dog, cat:** S, EP, HP 0.5 ml **Pig:** S 1 ml
Method	**Dog, cat:** IFAT **Pig:** ELISA
Species	Dog, cat, pig*
Duration	1 day Pig: 5 days
Note	Seroconversion occurs 4 – 7 days after infection; vaccine and infection titres can only be differentiated by testing serum pairs.

PBFD ➢ see Circoviruses, p. 130

13.1.37 Picornaviruses

Picornaviruses see also ➢ Sacbrood Virus, p. 166

Picornaviruses are non-enveloped RNA viruses and in **tortoises** also known as **virus "X"**. They are detected regularly in tortoises, and found associated with other infectious pathogens, particularly with herpesviruses and mycoplasma.
Clinically, picornavirus in young animals is associated with a softening of the carapace. In adult tortoises, infections are manifested as rhinitis, stomatitis, ascites and sudden death. Picornaviruses can best be detected by PCR in pharyngeal swabs. Suitable organ samples include intestine, tongue, kidney, liver and other organs.

Picornavirus (Virus "X") – Pathogen Detection	
Material	Swab without medium (pharynx), tissue (e.g. intestine, tongue, kidney, liver)
Method	PCR
Species	Tortoise
Duration	1 – 3 days

Picornavirus (Virus "X") – Antibody Detection	
Material	S, HP 0.2 ml
Method	VNT
Species	Tortoise
Duration	1 – 2 weeks

13.1.38 Polyomaviruses

Polyomaviruses are non-enveloped DNA viruses with a diameter of 45 nm and an icosahedral capsid (similar to papillomaviruses). Polyomaviruses are latently present in mammalian cells and mostly cause persistent infections there. They usually form typical intranuclear inclusions in infected cells and after infection of heterologous cells lead to their transformation. They are therefore regarded as oncogenic. Polyomaviruses have a circular double-stranded DNA.

The highly contagious **budgerigar fledgling disease virus (BFDV)** is considered the first **avian polyomavirus (APV).** BFDV causes an infection that may be fatal for psittacine nestlings; in adult birds, septicaemia and hepatitis are observed. In chronic cases, feather malformation and inability to fly occur; affected animals usually hop or run around. Particularly budgerigars are affected. The disease is also called **French moult.**

Polyomavirus – Pathogen Detection	
Material	2 – 3 recently plucked feather shafts, blood (EB or 1 – 2 drops on a filter paper), faeces, swab without medium (cloaca)
Method	Realtime PCR
Species	Birds (Psittacidae)
Duration	1 – 3 days

13.1.39 Porcine Respiratory and Reproductive Syndrome Virus (PRRSV)

Today, PRRS – also called swine infertility and respiratory syndrome (SIRS), porcine epidemic abortion and respiratory syndrome (PEARS), mystery swine disease (MSD), or blue ear disease – is among the world's most important diseases in pig production. In Germany, the disease first occurred in the winter of 1990/91.
The virus can spread very quickly through droplet and airborne infection. The disease is characterised by late abortions around the 110th day of gestation. Dead or weak piglets can be born. In addition, there may be respiratory tract infections.

PRRSV – Pathogen Detection	
Material	Swab without medium (nose or pharynx), EB, tissue (e.g. abortion material, lung, trachea or lymph node), lavage (BAL), sperm
Method	Realtime PCR
Species	Pig
Duration	1 – 3 days
Note	Detection by PCR allows for a reliable diagnosis and the differentiation between EU and US strains (NA/HP-NA).

PRRSV – Antibody Detection*	
Material	S 1 ml
Method	ELISA
Species	Pig
Duration	5 days

13.1.40 Rabbit Haemorrhagic Disease Virus (RHDV)

Rabbit haemorrhagic disease (RHD), also known as **rabbit calicivirus disease** or **viral haemorrhagic disease**, is a highly contagious disease of European rabbits (Oryctolagus cuniculus). It occurs in both wild and domestic rabbits and causes peracute, acute or subacute diseases.
RHD is caused by caliciviruses, small, non-enveloped, single-stranded RNA viruses. Rabbit haemorrhagic disease virus (RHDV) is closely related to the European brown hare syndrome virus, which causes a similar disease in hares (Lepus spp.). There are several genetically and serologically different variants of RHDV. Until 2010, six different genotypes were known which cross-react serologically. These are called "classic" RHDV or RHDV-1. A new serotype, called RHDV-2 or RHDV-b, was first detected in France in 2010 and has since spread throughout Europe and other parts of the world. The disease caused by RHDV-2 is similar to that of classic RHDV strains but is associated with a slightly lower (but extremely variable) mortality rate. RHDV-2 can also infect some hare species and, unlike RHDV-1, also infects very young rabbits.

RHDV/RHDV-1 and RHDV-2 are mainly transmitted orally. Contaminated herbage can play a role here. Insects also act as mechanical vectors.

RHDV infections often progress peracutely; affected animals die suddenly or within a few days. Clinically, general signs are seen such as anorexia and lethargy, but also neurological symptoms such as opisthotonus, excitement, ataxia or paralysis. Conjunctivitis and respiratory symptoms such as dyspnoea and nasal discharge (possibly bloody) are also frequently observed. In some cases, an increased tendency to bleed can be seen. The chronic form of RHD only occurs in a small number of animals which then develop jaundice.
Hepatomegaly and splenomegaly are the most common pathologies. Histologically, acute necrotising hepatitis can be detected in affected animals. Bleeding and blood stasis in various organs are frequently observed.

In addition to the clinical examination and histopathology, RHD is mainly diagnosed by virus detection using realtime PCR. Due to the genetic differences between the RHDV strains, both RHDV/RHDV-1 and RHDV-2-specific methods must be used.

Treatment is not possible. A prophylactic vaccination is recommended. Several vaccines are available. It must be noted that vaccination should take place against both RHDV/RHDV-1 and RHDV-2. Currently, it is mainly RHDV-2 cases that are observed in Germany, but classic RHDV strains still occur.

RHDV 1 + 2 – Pathogen Detection	
Material	Swab without medium (conjunctiva), urine, faeces, EB, bone marrow, tissue (e.g. liver)
Method	Realtime PCR
Species	Rabbit
Duration	1 – 3 days

13.1.41 Rabies Virus

Rabies virus **(RABV)** belongs to the genus Lyssavirus of the family Rhabdoviridae and is globally distributed. In Germany, rabies is an **epizootic disease** that is **notifiable upon suspicion**. After intensive control measures, Germany has been considered free of classical rabies (RABV) since 2008.
When travelling, some countries demand proof of the antibody titre.

Rabies Virus – Antibody Detection*	
Material	S 1 ml
Method	FAVN
Species	Dog, cat

Duration	1 – 2 weeks
Note	▪ Only for **control of vaccine titres**, for export, too, **not** for suspected infection ▪ Please request an **extra submission form** if the test result is required for export. ▪ To issue a rabies vaccination certificate for export, the time between vaccination and blood sampling must be at least 30 days.

13.1.42 Ranaviruses

Ranaviruses are enveloped double-stranded DNA viruses and belong to the family Iridoviridae. They are found worldwide and have a very wide host range infecting different animal species and even classes. Transmission is by direct contact, environmental contamination or cannibalism (or eating infected animals).
In **amphibians,** ranaviruses are increasingly detected and can cause systemic disease and mass mortality in these animals. A distinction is made between the haemorrhagic and the cutaneous form. Clinically, erythema, especially on abdomen and upper legs, ulceration on the toes, and increased tendency to bleed are seen. Some animals die without having appeared ill, while others can be inapparent carriers.
In **reptiles,** ranaviruses occur especially in chelonians, where they are associated with stomatitis, rhinitis, pneumonia and liver disease. In lizards, ranaviruses seem to have a role in skin lesions, stomatitis, granulomatous changes and mass mortality. In snakes, changes in the mouth and liver have been described.
Ranavirus is also found in **fish.** In fish, the infection can extend from clinically inapparent to systemic disease with mass mortality.

Ranaviruses – Pathogen Detection	
Material	**Chelonians:** swab without medium (pharynx, cloaca), tissue (liver, tongue, kidney, intestine, possibly skin), possibly EB in box turtles **Lizard:** swab without medium (pharynx, cloaca), tissue (above all skin, liver) **Snake:** swab without medium (pharynx), tissue (above all liver) **Amphibians:** biopsy (toe clips, tail clips), EB or drops of blood on filter paper, tissue (above all liver, kidney), perhaps swab without medium (skin) **Fish:** biopsy (gills), blood, tissue (above all liver, kidney), perhaps swab without medium (skin)
Method	PCR
Species	Reptiles, amphibians, fish
Duration	1 – 3 days

13.1.43 Reoviruses

Birds

Reoviruses are non-enveloped, double-stranded RNA viruses that are regularly found in various bird species. They can cause inapparent infections but are also associated with various clinical changes. Liver and intestine are often affected. Respiratory infection also occurs. Especially in Old World parrots, lethal infections can be seen.

Reptiles

Reoviruses are often found in snakes and lizards, but occasionally also in chelonians. In snakes and lizards, they are associated with respiratory symptoms, particularly pneumonia. In lizards, they are also involved in skin lesions (papillomatous changes) and enteritis. In turtles, reoviruses are associated with respiratory symptoms and stomatitis.

Reoviruses – Pathogen Detection		
Material	**Birds:**	swab without medium (cloaca), faeces, tissue (intestine, liver, heart, kidney, lung)
	Reptiles:	swab without medium (pharynx, cloaca), lung lavage, tissue (lung, intestine; in chelonians also tongue)
Method	PCR	
Species	Birds, reptiles	
Duration	2 – 4 days	

13.1.44 Rotaviruses

Group A rotaviruses are one of the most important pathogens of nosocomial gastroenteritis in veterinary and human medicine. In Germany, human rotavirus infections are among the most common gastrointestinal diarrhoeal diseases and are a notifiable infection. Rotaviruses are non-enveloped and therefore very environmentally stable viruses. Rotaviruses are transmitted both via the faecal-oral route and airborne. The destruction of enterocytes and electrolyte imbalances lead to diarrhoea and dehydration.
Detection is done from faeces; the virus antigen is detected by ELISA.

Rotavirus – Antigen Detection	
Material	Faeces
Method	ELISA
Species	Dog, cat, horse, ruminants, New World camels
Duration	1 – 2 days
Note	A faecal sample of at least the size of a pea is required.

13.1.45 Rustrela Virus (RusV)

In a recent publication (Matiasek et al., 2023), Rustrela virus (RusV) is associated with staggering disease in cats, a non-purulent, lymphohistiocytic meningoencephalomyelitis. Symptoms include hind-leg ataxia with generally increased muscle tone as well as other neurological abnormalities: abnormal posture, stiff gait, weakness of the hind legs, tetraparesis, tremor, seizures, etc. In some cases, fever, salivation, hyperaesthesia, behavioural changes, opisthotonos and reduced spinal reflexes are also observed. The disease is progressive and most cats have to be euthanised within 2 months of the onset of clinical signs. Mice probably play a role as pathogen reservoir. Infected cats do not seem to shed the virus. So far, the virus has only been detected in the CNS (and in peripheral nerve fibres in a few cases).

Rustrela Virus (RusV) – Pathogen Detection	
Material	Preferably brain tissue (fresh, frozen, FFPE material), possibly CSF
Method	Realtime PCR
Species	Cat
Duration	1 – 3 days

13.1.46 Sacbrood Virus

Sacbrood virus is an RNA virus of the picornavirus family. This virus only affects bee brood; infected adult animals do not show any symptoms. Transmission occurs through the bees that take up the virus when removing dead larvae and afterwards excrete it again through the hypopharyngeal glands when feeding. The virus can survive winter dormancy in the salivary glands.
Infected larvae die shortly before pupation and become small, fluid-filled "sacs" which later dry out and become scab. The brood pattern shows sunken caps. Sacbrood is considered a so-called secondary infection, since the disease usually only takes on a severe course if the colony has been weakened by a primary infection, such as varroosis. For the therapy of the swarm, affected combs can be removed and melted. Transmission occurs through the bees themselves or through the beekeeper.

Sacbrood Virus – Pathogen Detection	
Material	Bee larvae
Method	PCR
Species	Bees
Duration	1 – 3 days

13.1.47 SARS-CoV-2

Respiratory coronavirus, first detected in 2019 and then temporarily referred to as "2019-nCoV", is now better known as **SARS-CoV-2** (severe acute respiratory syndrome coronavirus 2) or **"COVID-19 virus"**. According to current knowledge, all mammals can be infected with this virus, and cats, lagomorphs, hamsters and ferrets are particularly susceptible to infection with SARS-CoV-2 and have a higher probability of developing clinical signs.
Signs of SARS-CoV-2 infection can range from nasal discharge to sneezing, extensive inflammation of the respiratory tract up to diarrhoea. However, non-specific signs such as lethargy or weight loss have also been described. In Germany, there is an **obligation to notify the authorities!**

SARS-CoV-2 – Pathogen Detection	
Material	Swab without medium (deep nasal/pharyngeal swab), BAL faeces (only great apes)
Method	Realtime PCR
Species	All species, particularly cat, ferret, hamster
Duration	1 – 3 days
Note	for animal samples only

13.1.48 Sendai Virus

Sendai virus, also known as **murine parainfluenza virus 1,** causes infections in rabbits, guinea pigs, hamsters, rats and mice as well as in humans. Detection is particularly relevant in laboratory animals. An introduction into a population leads to severe respiratory symptoms (focally ulcerative/necrotising rhinitis/tracheitis, pneumonia and pleuritis) and mortality rates of up to 100%, especially in mice. If the infection persists in a population, the course of infection is milder or subclinical. Once the infection is overcome, antibodies are detectable throughout life.

Sendai Virus – Antibody Detection*	
Material	S 0.5 ml
Method	IFAT
Species	Rabbit, guinea pig, rat, mouse, hamster
Duration	3 – 5 days

13.1.49 Sunshine Virus

Sunshine virus is a novel paramyxovirus (PMV), which was first detected in pythons in 2012 in Australia. Sunshine virus is only distantly related to Ferlavirus (formerly known as reptile PMV or snake PMV). It has been found in animals with respiratory and/or neurological symptoms, but can occasionally be detected even in clinically healthy animals. Initial studies show that this virus may also be present in European pythons.

Sunshine Virus – Pathogen Detection	
Material	Swab without medium (pharynx, cloaca), tissue (lung, brain)
Method	PCR
Species	Python
Duration	1 – 3 days

13.1.50 Tick-borne Encephalitis Virus (TBEV)

Tick-borne encephalitis (TBE) is caused by an arbovirus. Arboviruses are an inhomogeneous group of viruses whose common feature is the transmission by blood-sucking arthropods. Like the West Nile virus, the TBE virus (TBEV) belongs to the genus Flavivirus and is transmitted by ticks.
In **dogs**, the disease was first described in 1972. Seroepidemiological studies conducted since then have shown that dogs have relatively frequent contact with TBEV (up to 30% in certain areas) without contracting the disease. If the disease is contracted, the symptoms in dogs are a multifocal occurrence involving the cerebrum, brain stem and sometimes also the spinal cord. The disease usually begins acutely to peracutely with a highly elevated body temperature (up to over 41 °C) and a further rapidly progressive course. Changes in behaviour, from being apathetic to overexcited or aggressive, gait disorders up to tetraparesis/tetraplegia and seizures can occur. Various brain nerve deficits are observed, e.g. facioplegia, strabismus, nystagmus, miosis, missing menace reflex. Hyperalgesia in the head and neck area as well as a generally increased painfulness are characteristic. A large part of the disorders ends lethally or by euthanasia within one week. Recently, there have been more and more literature reports on dogs with a chronic course of the disease that have survived. Sometimes slight neurological signs remained, sometimes the dogs were fully recovered.
Diagnosis should be confirmed serologically by antibody detection using ELISA. However, it must be taken into account that the antibodies could be the result of a previous subclinical infection. Antibodies may also appear in the CSF within the first week after infection and can be detected by ELISA.
In the peracute form, PCR can be used to try to detect the virus in the CSF. Due to the very rapid virus elimination from the brain, however, this is only possible in the early phase of infection. **Virus detection** by PCR from a collected **tick** is possible and especially useful if a person is affected by a tick.
TBE is also increasingly detected in neurologically affected **horses**. The clinical picture is similar to the disease caused by the West Nile virus.

Tick-borne Encephalitis Virus – Pathogen Detection	
Material	CSF, S, tick
Method	Realtime PCR
Species	Dog, horse, others on request
Duration	1 – 3 days
Note	Detection from serum (before seroconversion) or cerebrospinal fluid is only possible in the early phase of the infection.

Tick-borne Encephalitis Virus – Antibody Detection	
Material	S, HP 0.5 ml, CSF 0.2 ml
Method	ELISA
Species	Dog, cat, horse
Test frequency	2 x per week
Note	▪ Three different tests are offered: detection of IgM in serum or detection of IgG in serum or detection of IgG in CSF. ▪ Performing the analysis is advisable if animals have been to endemic areas and show neurological signs.

13.1.51 West Nile Virus

West Nile virus **(WNV)** is an RNA virus of the family Flaviviridae, which is endemic in various, mainly tropical regions of the world. Yet, through migratory birds, WNV also regularly occurs in non-tropical areas further north and has been detected in Germany since 2018.
Transmission primarily takes places through mosquitoes (mostly species of Culex) between wild birds. However, the mosquitoes can also transmit WNV to people, horses and other mammals. Due to the low viral load, horses and humans are dead-end hosts and do not represent a source of the virus for mosquitoes.
The incubation period for WNV encephalitis in horses is 3 – 15 days. Most infections are subclinical, only a small percentage of horses develops neurological signs, such as stumbling, hind-leg paralysis, ataxia, tremor or weakness up to recumbency of the animals.
In birds, infections vary from asymptomatic to lethal, depending on the species. Passerine birds, birds of prey and owl species are most susceptible to the disease. They may develop severe epidemics with central nervous signs (e.g. vertigo, tremor, inability to fly) and death rates may increase.
In Germany, the disease is **notifiable upon suspicion** in birds and horses.

West Nile Virus – Pathogen Detection	
Material	Birds: swab without medium (oropharynx, cloaca), EB, serum, tissue (e.g. brain, heart, kidney) Horse: CSF, EB, serum, tissue (e.g. brain, spleen, tonsils)

Method	Realtime PCR
Species	Birds, horse
Duration	1 – 3 days
Note	The very short viraemia phase (1 – 3 days) ends shortly after or before the onset of clinical signs.

West Nile Virus – Antibody Detection	
Material	Birds: S 0.5 ml; horse: S 1 ml
Method	ELISA
Species	Birds, horse
Duration	Birds: 5 days Horse: 2 – 3 days
Note	▪ Birds: Detection of IgG ▪ Horse: Detection of IgM and IgG ▪ In Germany, a positive WNV IgM titre is notifiable upon suspicion.

13.2 Bacteria

Please note: If the detection of a bacterial pathogen is exclusively done by **PCR**, it is **not possible to create an antibiogram**.

13.2.1 Actinobacillus pleuropneumoniae (APP)

Actinobacillus pleuropneumoniae is a gram-negative bacillus. It produces exotoxins that can destroy erythrocytes and lung macrophages. The clinical picture of APP infection is characterised by severe respiratory symptoms and significant impairment of the general condition (body temperature may rise up to 42 °C). In intensive pig farming, pleuropneumonia caused by A. pleuropneumoniae is one of the most important infectious diseases. In peracute courses of the disease, it can lead to the death of the animals within 24 hours.

APP – Pathogen Detection	
Material	(1) Swab with medium, tissue (lung, tonsils) (2) Swab without medium (nose), nasal flush, tissue (lung, tonsils)
Method	(1) Bacterial culture (MALDI-TOF) (2) PCR*
Species	Pig
Duration	(1) 2 – 3 days (2) 7 – 14 days

APP – Antibody Detection*	
Material	S, HP 0.5 ml
Method	ELISA
Species	Pig
Duration	5 days

Actinomyces ➢ see Chapter 14.4, p. 257

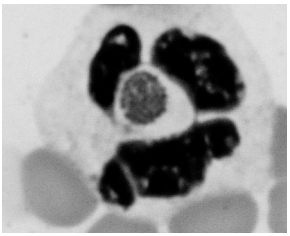
13.2.2 Anaplasma

Based on genetic analyses, the former species Ehrlichia phagocytophila, Ehrlichia equi and the causative agent of human granulocytic ehrlichiosis (HGE) were unified in the new species Anaplasma phagocytophilum. In addition, infection with Anaplasma platys, the causative agent of infectious canine cyclic thrombocytopenia, plays an increasingly important role in Europe, too.

Anaplasma phagocytophilum

Anaplasma phagocytophilum is a gram-negative, obligate intracellular bacterium, which particularly infects neutrophil granulocytes and forms, when multiplying within the granulocytes, typical inclusion bodies, so-called morulae. In Europe, the main vector is Ixodes ricinus. Deer, mice and other rodents are reservoir hosts.
The clinical signs are similar to those of ehrlichiosis, but thrombocytopenia can be observed more often, mainly because of the formation of anti-thrombocyte antibodies. Anaplasma infections can be asymptomatic, can cause non-specific symptoms (fever, inappetence, apathy) or severe symptoms (CNS disorders). In dogs, orthopaedic problems (myositis, joint swellings, lameness) are often associated with Anaplasma infections.

In **horses,** fever, apathy, limb oedema and reluctance to move are initially dominant. Horses older than 4 years show more obvious signs than younger animals. Once the infection is overcome, a resilient immunity is acquired for about 2 years.
In **ruminants,** Anaplasma phagocytophilum can cause **tick-bite fever.** Most infections progress subclinically, but fever and productivity loss or abortions are also possible. Severe cases occur when non-immune animals are introduced into endemically contaminated areas.



Neutrophil granulocyte with Anaplasma phagocytophilum (morula) in the middle of the segmented nuclei (Diff-Quik, 1000x magnification)

Anaplasma phagocytophilum – Pathogen Detection	
Material	EB, bone marrow, synovia, CSF, tick
Method	Realtime PCR
Species	Dog, cat, horse, ruminants, New World camels, others on request
Duration	1 – 3 days
Note	PCR is positive in blood smears 6 to 8 days before and 3 days after the formation of morulae. Similar to an infection with Ehrlichia canis, persistent infections in the bone marrow, spleen and liver are considered for Anaplasma phagocytophilum. Thus, a negative PCR result does not completely rule out an infection.

Anaplasma phagocytophilum – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT; dog: ELISA (IFAT only on specific request)
Species	Dog, cat, horse, cattle
Duration	1 – 2 days

Anaplasma platys

Anaplasma platys (formerly Ehrlichia platys) is an obligate intracellular, gram-negative bacterium in dogs which multiplies in platelets and leads to cyclic thrombocytopenia and bacteraemia with intervals of approximately 14 days. The disease is called **infectious canine cyclic thrombocytopenia.** Descriptions of this species of Anaplasma come from overseas, but the pathogen is also detectable in the Southern Mediterranean (North Africa, southern Portugal, Andalusia, Sicily, southern Italy, southern Greece). It is transmitted through ticks (Rhipicephalus sanguineus). After the initial infection, there is a decrease in the platelet count within 7 days p.i.; the lowest values are reached between days 14 and 24 p.i.
Basophil inclusions (morulae) in the platelets can particularly be detected 7 – 10 days p.i. The phase of bacteraemia extends approximately over a period of 4 – 14 days p.i., followed by a phase in which the pathogen cannot be detected in the peripheral blood. Subsequently, these phases alternate cyclically depending on the platelet count. In the bacteraemic phase, the pathogen can be detected in blood samples by means of PCR.

Anaplasma platys – Pathogen Detection	
Material	EB, tick
Method	Realtime PCR
Species	Dog
Duration	1 – 3 days

Anaplasma ovis

Anaplasma ovis is a haematogenous bacterium in small ruminants. It is a gram-negative, obligate intracellular, coccoid or pleomorphic bacterium from the order Rickettsiales, which infects erythrocytes. Morphologically, it cannot be distinguished from the closely related Anaplasma marginale. Anaplasma ovis infection is a vector-borne disease; the pathogen is probably transmitted by ticks of the genus Dermacentor, Rhipicephalus and Hyalomma. Clinical signs include anaemia, anorexia and weight loss.

Anaplasma ovis – Pathogen Detection	
Material	EB
Method	Realtime PCR
Species	Sheep, goat
Duration	1 – 3 days
Note	Detection of Anaplasma ovis is only available in combination with PCR detection of Mycoplasma ovis (see p. 198).

13.2.3 Bartonella henselae

Bartonella are gram-negative, facultative intracellular bacteria which are transmitted by fleas and ticks. Bartonella henselae is mostly known as the causative agent of **"cat scratch disease"** in humans. Infections in cats are predominantly subclinical. Fever, muscular pain, local lymphadenopathy and, rarely, also neurological symptoms can occur, which usually disappear again after a few days. Recently, the involvement of Bartonella henselae in gingivitis and stomatitis in cats has been discussed more frequently. Pathogen detection and antibody detection often do not match and a definitive diagnosis is linked to the detection of the pathogen. A negative PCR result does not exclude an infection with B. henselae and should be repeated in case of clinical suspicion.
Dogs, too, can occasionally be affected by Bartonella infection. The disease can cause endocarditis, recurrent granulomatous lymphadenitis, systemic granulomatous processes and meningitis.

Bartonella henselae – Pathogen Detection	
Material	EB, CSF, flea
Method	Realtime PCR
Species	Dog, cat
Duration	1 – 3 days

Bartonella henselae – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, cat
Duration	1 – 2 days

Note	Antibodies can usually be detected from the second week p.i. onwards. Seroprevalence is particularly high in cats with flea infestation and is not indicative of a clinical condition. The direct detection of the pathogen by PCR is preferable.

13.2.4 Bordetella bronchiseptica

Bordetella are small gram-negative bacilli which can move by means of flagella. B. bronchiseptica usually only survives for a rather short period of time outside the respiratory tract. Transmission takes place by direct contact or via aerosols.
Because of its toxins, B. bronchiseptica particularly damages the cilia-bearing cells of the respiratory mucosa and it can persist in the respiratory tract for up to three months. The pathogen is not host-specific and can be transmitted from one animal species (e.g. dog) to another (e.g. cat) and also to humans (zoonosis!).
In dogs, Bordetella are known as a component of kennel cough and they are also responsible for respiratory tract diseases in cats, although coughing is not a characteristic symptom in cats. Typical signs are fever, sneezing, nasal discharge, swelling of the submandibular lymph nodes and intensified breath sounds. Usually, only mild symptoms occur which disappear again after about 10 days. However, life-threatening bronchopneumonia can develop in young kittens.

Bordetella bronchiseptica – Pathogen Detection	
Material	(1) Swab must be with medium (Amies) (nose, pharynx) or bronchial secretion (2) Swab without medium (nose, pharynx), bronchial secretion, BAL
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR
Species	Dog, cat, rabbit, ruminants, pig, others on request
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	When requesting a culture test, please clearly indicate on the submission form that Bordetella bronchiseptica should be tested, as special culture media are required.

13.2.5 Borrelia

Borrelia are bacteria which belong to the spirochaete family. Spirochaetes are characterised by contractile axial filaments which are located under a multi-layered outer membrane and that give the spirochaetes their typical spiral shape as well as their motility. Borrelia species which are discussed in connection with Lyme borreliosis in dogs are included in the group Borrelia burgdorferi sensu lato, which currently comprises more than 20 different Borrelia species.

Borrelia are transmitted by vectors (ticks or lice) and except for B. recurrens and B. dutonii they all have a reservoir among wild animals.
The main mode of transmission is a bite of the tick Ixodes ricinus (European castor bean tick). The bacteria are located in the intestine of the tick, are activated by the blood meal and migrate to the salivary glands. It then takes up to 24 hours until transmission via the saliva takes place. If the tick is properly removed within this period, the risk of infection can be greatly reduced.
In contrast to humans, the clinical signs of Lyme borreliosis (**Lyme disease**) in dogs are rather non-specific and can easily be overlooked. In dogs, there is rarely an erythema migrans. Fatigue, loss of performance, possibly fever and, after a symptom-free phase of several weeks, reluctance to move, alternating lameness, emaciation, vomiting and oedema occur. Occasionally, neurological deficits are also observed.
A serious complication is the development of glomerulonephritis with subsequent kidney failure due to the deposition of immune complexes.
The main vector, Ixodes ricinus, occurs throughout Germany but can be found more frequently in certain areas. In such areas, it is therefore recommended to regularly check for any infestation of the dog with ticks and to have a Lyme disease test carried out if the symptoms mentioned above occur.

Infections and diseases in **cats** and cattle are reported more and more often. Furthermore, Lyme disease is classified as an emerging bacterial zoonosis.
Grazing animals are often used for blood meals by borrelia-infected ticks. There are both clinical diseases as well as seropositive animals without any clinical signs, with the evaluation often being difficult.
In **horses,** a variety of signs are associated with borrelia: reduced performance, lameness, changes in the skin, eyes or heart up to neurological deficits and abortions. However, there is still controversy as to whether the infection in horses leads to any clinical signs at all.
Lyme disease in **cattle** is associated with lameness, weight loss and abortion. Pathogen isolation from clinical material is sometimes successful (Borrelia burgdorferi sensu stricto, Borrelia afzelii). Seroconversions have been shown as well as the response to tetracycline therapy.

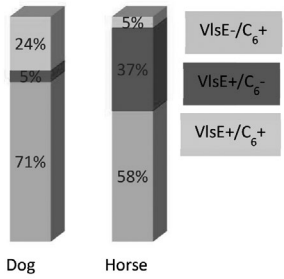
Borrelia – Pathogen Detection	
Material	Tick, biopsy (skin), synovia, CSF
Method	Realtime PCR
Species	Dog, cat, horse, ruminants, New World camels, others on request
Duration	1 – 3 days
Note	The diagnostic value of a PCR is limited by the selection of the appropriate material and the concentration of pathogens. During a chronic infection, pathogen spread can be suspected in many sites, but the concentration of pathogen DNA can be very low and therefore the PCR produces a negative result. While a positive PCR is proof of infection, a negative PCR does not exclude an infection.

Borrelia – Antibody Detection

Material	S, EP, HP 0.5 ml
Method	IFAT; dog: ELISA
Species	Dog, cat, horse, cattle
Duration	1 – 2 days
Note	▪ Simultaneous determination of IgG and IgM in dogs, cats and horses; cattle: IgG determination. ▪ Positive IgG antibody titres are found in dogs after about 3 – 6 weeks, positive IgM antibodies 3 – 4 days after pathogen contact. ▪ The distinction between IgM and IgG is used to distinguish an acute infection from a pathogen contact that occurred a long time ago. ▪ After consultation, detection in dogs can also be done using IFAT.

Borrelia – Blot

Material	S, HP 0.5 ml
Method	Line Immunoassay/western blot (IgG antibody detection)
Species	Dog, horse
Duration	3 days
Note	The Borrelia blot is used to clarify questionable antibody concentrations and to distinguish between vaccine and infection antibodies. The blot also detects antibodies against the VlsE protein and C6 peptide. VlsE (variable major protein-like sequence, expressed) and its subunit C6 are highly immunogenic surface antigens that express Borrelia during active reproduction. There is no recombination of the VslE molecule in vitro or in the Borrelia residing in the tick, the detection of antibodies against the VslE molecule therefore indicates an infection that has previously occurred. The blot can be carried out at the earliest from the 3rd week after infection onwards.



VlsE and C_6 antibodies in dogs and horses
(C_6- and/or VlsE-positive animals)
➔ No antibody detects all infections.

13.2.6 Brachyspira

Brachyspira are gram-negative anaerobic bacteria which, however, have a certain tolerance to oxygen. Reproduction takes place in the goblet cells of the large intestine where Brachyspira can persist after surviving infection (intermittent shedding!). **Pig dysentery,** which is caused by B. hyodysenteriae, is a highly contagious multifactorial diarrhoeal disorder that leads to high economic losses in pig production worldwide. The main sources of infection are infected pigs without clinical signs and rodents as reservoir hosts. B. pilosicoli causes a milder disease, **spirochete diarrhoea** in pigs, which usually occurs directly after weaning.

Brachyspira hyodysenteriae/pilosicoli – Pathogen Detection	
Material	Faeces, tissue (large intestine)
Method	Realtime PCR
Species	Pig
Duration	1 – 3 days
Note	Differentiation between B. hyodysenteriae and B. pilosicoli is done by PCR.

13.2.7 Brucella

The causative agent of brucellosis are gram-negative, aerobic bacilli of the genus Brucella. In Germany, brucellosis in cattle, pigs, sheep and goats is **notifiable upon suspicion**. The disease occurs in both animals and humans. Several Brucella species are known, including B. canis (canine brucellosis), B. abortus (bovine brucellosis), B. melitensis (ovine and caprine brucellosis), B. ovis (brucellosis in rams, infectious epididymitis, also notifiable upon suspicion) and B. suis (porcine brucellosis). Host-specificity of Brucella species is only limited.
Brucella canis is transmitted genitally or via the oral route by latently infected animals. After 2 to 4 weeks, bacteraemia develops. In pregnant female dogs, there may be abortions in the last trimester of gestation or weak puppies are born. Male dogs suffer from inflammation of the testicles and epididymis and can become infertile. A rare sign of Brucella canis infection is discospondylitis, so if there is pain in the spine and lameness, especially in dogs from Southeastern Europe, this infection may be an important differential diagnosis. The main signs of brucellosis in ruminants are abortions, birth of weak animals, inflammation of the testicles and epididymis, and infertility. In humans, the infection leads to fever, fatigue, night sweats, headaches and feelings of cold. The occurrence of cases in humans is always related to the disease being present in domestic or wild animals. Apart from direct animal contact, routes of infection also include the consumption of insufficiently heated food (e.g. raw milk or raw milk cheese) obtained from infected animals.

Brucella canis – Pathogen Detection

Material	Swab without medium (cervix, prepuce), EB, sperm, urine, (faeces, milk), tissue (abortion material)
Method	Realtime PCR
Species	Dog
Duration	1 – 3 days

Brucella canis – Antibody Detection

Material	S 1 ml
Method	(1) IFAT (2) Agglutination Test
Species	Dog
Duration	1 – 2 days
Note	Agglutination tests are often required for entry into non-European countries. When detecting antibodies, cross-reactions with other gram-negative bacteria, e.g. Yersinia enterocolitica, can lead to false positive results.

Brucella abortus and Brucella mellitensis – Antibody Detection*

Material	S, HP 1 ml
Method	ELISA
Species	Cattle, sheep, goat
Duration	5 days

Brucella ovis – Antibody Detection*

Material	S 1 ml
Method	CFT
Species	Sheep, goat, others on request
Duration	5 days

Brucella spp. – Antibody Detection*

Material	S 1 ml
Method	RBT
Species	Small ruminants, New World camels, others on request
Duration	5 days

Brucella suis – Antibody Detection*

Material	S, HP 1 ml
Method	ELISA
Species	Pig
Duration	5 days

13.2.8 Burkholderia mallei

Glanders is a disease of Equidae caused by Burkholderia mallei, which also has zoonotic potential: Apart from humans, wildcats (zoos!), camels, bears, wolves and dogs are susceptible as well. Cattle, sheep and pig are resistant. The course of the disease is either acute (especially in donkeys and mules) with high fever and respiratory symptoms and death after a few days. Or it is rather chronic, particularly in horses, with nodules and ulcerations on the skin, the mucous membrane and the inner organs. Chronically and subclinically infected animals represent a dangerous source of infection. All secretions of the respiratory tract and the skin are infectious; the incubation period ranges from a few days to many months.
In Europe, glanders is considered eradicated, but it does occur in different Asian, African and South American countries (export-relevant test).
In Germany, there is an **obligation to notify the authorities**!

Burkholderia mallei (Glanders) – Antibody Detection*	
Material	S 1 ml
Method	CFT
Species	Equidae
Duration	5 days

13.2.9 Campylobacter

Several Campylobacter species could be detected in mammals, birds and also in humans. Some species are part of the normal gastrointestinal microbiota or their pathogenicity is still unclear.
In **cattle**, C. fetus subsp. veneralis causes epidemic abortions and fertility disorders (bovine genital campylobacteriosis, also called vibriosis in cattle; in Germany, **notifiable upon suspicion**). C. jejuni can lead to diarrhoea or mastitis. In **sheep**, C. fetus subsp. fetus is known as pathogen of the enzootic campylobacter abortion; occasional abortions caused by C. jejuni have also been described. The importance of campylobacter infections in **birds** lies in the contamination of carcasses and the risk of food poisoning associated with it. Most frequently, birds are infected with C. jejuni. Diarrhoea or hepatitis are rare.
In **dogs and cats**, C. jejuni can often be isolated from healthy animals, but can cause diarrhoea especially in young animals. This diarrhoea is often self-limiting. Feeding a barf diet presents a risk of infection.
In **humans**, campylobacter (especially C. jejuni) is one of the most common causes auf bacterial diarrhoea and is usually food-associated (particularly insufficiently heated poultry meat, but also unpasteurised milk and raw minced meat). Rare complications which can occur are Guillain-Barré syndrome (polyradiculitis) and reactive arthritis. Campylobacter of the species C. jejuni, C. coli, C. lani and C. upsalensis are collectively called thermophilic campylobacter. In Germany, campylobacteriosis (thermophilic campylobacter) is **notifiable upon diagnosis** in dogs, cats, ruminants and poultry.

Campylobacter – Pathogen Detection	
Material	(1) Faeces, swab with medium (intestine, cloaca) (2) Faeces, swab without medium (intestine, cloaca)
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR (only detection of **Campylobacter jejuni**)
Species	No limitations known
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	▪ Culture: please send in a faecal sample with a diameter of at least the size of a cherry, otherwise use swab with medium. ▪ A combined detection by culture of Campylobacter and Yersinia is also available. ▪ Resistances are common; treatment should therefore only be carried out after an antibiogram has been performed. Preparation of an antibiogram is only possible after a culture test.

13.2.10 Chlamydia

Chlamydia are obligate intracellular, gram-negative pathogens. Extracellularly, chlamydia do not have their own metabolism and depend on the enzyme activity in the host cell. Chlamydia relevant in veterinary medicine belong to the family Chlamydiaceae. Some years ago, this family was split into the two genera Chlamydia and Chlamydophila. However, based on recent genetic analyses, this classification is no longer considered justified. Because of this, the single term Chlamydia is used here.

Dog

In the literature, only little data is available on chlamydia infections in dogs. Yet in general, its occurrence must be expected in Europe. Respiratory signs up to bronchopneumonia seem to be dominating here. At the onset of the disease, only progressive loss of condition may appear. High fever can develop. When the disease progresses, central nervous disorders are possible. Other manifestations of chlamydiosis in dogs are conjunctivitis and keratitis.

Cat

Originally identified as the causative agent of "feline pneumonitis", C. felis is rather associated with conjunctivitis in cats nowadays. The cardinal symptom is serous conjunctivitis which begins unilaterally and then spreads to the other eye after some days. Especially when there is a secondary bacterial infection, the discharge can become mucopurulent. Chemosis and blepharospasm may also be present. In severe cases, follicular hyperplasia develops or even keratoconjunctivitis with corneal ulcerations. Conjunctivitis can last for 8 weeks or more. Other acute symptoms include slight rhinitis and fever. Animals between 5 weeks and 9 months of age are most

affected, though conjunctivitis neonatalis has also been described. In that case, kittens already suffer a severe conjunctivitis when opening their eyes, often due to a chlamydia infection acquired intrapartum. Transmission occurs directly through conjunctival secretions. Persistent infections are possible, and in some animals also respiratory symptoms may last for several weeks. When the immune system is weakened, the infection can be reactivated.

Birds

In our birds, infections with chlamydia are of particular significance. Infection rates of 10 to 40% may be prevalent in aviculture. As many birds have a carrier status, the disease can "suddenly" become clinically apparent under stress. Symptoms in birds are manifold and extremely non-specific. Ruffled feathers, apathy and lack of appetite must be mentioned. Basically, every "sick bird" could have a chlamydia infection. Respiratory symptoms with or without conjunctivitis are often seen, but central nervous disorders are also possible. The extent of clinical signs largely depends on the animals' condition; the type of symptoms also varies from one bird species to another. Sudden death without prior illness might happen. It is therefore not possible to make a diagnosis based on clinical signs. To make a reliable diagnosis, the identification of the pathogen is always necessary. C. psittaci is a zoonotic agent. Infections in humans are normally airborne, resulting in a flu-like disease. In Germany, the **authorities must be notified** of the direct detection of the pathogen.

Reptiles and amphibians

Various species of chlamydia are regularly detected in reptiles and amphibians. In reptiles, they have been associated with granulomatous changes in different tissues as well as with pneumonia, enteritis, hepatitis and myocarditis. In amphibians, they were found in cases of systemic disease.

Farm animals

In Germany, chlamydiosis in cattle, sheep and goat, as well as in poultry (see above) is a **notifiable** disease.

Chlamydia – Pathogen Detection	
Material	**Dog, cat and others:** swab without medium (eye, pharynx, cervix, prepuce), abortion material **Birds:** triple swab without medium (eye + pharynx + cloaca), tissue (liver, spleen, lung), possibly faeces **Reptiles:** swab without medium (pharynx), lung lavage, tissue (lesions, lung, liver, spleen, intestine, heart) **Farm animals:** swab without medium (eye, nose, cervix), tracheal lavage, milk, faeces, tissue (lung, liver), abortion material **Amphibians:** swab without medium (pharynx), tissue (lesions, lung, liver, spleen, intestine, heart)
Method	Realtime PCR

Species	All
Duration	1 – 3 days
Note	Pathogen detection identifies all chlamydia of the family Chlamydiaceae. In case of a positive result in birds, a PCR specific to C. psittaci is automatically performed.

Chlamydia – Antibody Detection

Material	S, EP, HP 0.2 ml
Method	IFAT
Species	Dog, cat, birds, horse, ruminants, New World camels, pig
Duration	1 – 2 days
Note	Serology can determine whether an infection has occurred. However, evidence of active shedding can only be provided by pathogen detection.

13.2.11 Clostridia

Clostridia are obligate anaerobic, gram-positive, spore-forming bacilli.
Pathogenic Clostridia cause infectious and intoxication diseases; the latter through enterotoxins and neurotoxins. Clostridioides difficile, formerly classified as Clostridia and named Clostridium difficile, was assigned to the genus Clostridioides.

Clostridium botulinum Neurotoxin – Antibody Detection*

Material	S 1 ml
Method	ELISA
Species	Horse, cattle, other farm animals on request
Duration	10 days
Note	Botulism is regarded as pure intoxication, in which only the toxin is absorbed, reabsorbed via the intestine and spread haematogenously. If, in exceptional cases, botulism progresses as a toxin infection, the toxins are formed in the intestine (visceral botulism) or in wounds (wound botulism). The absorption of botulinum toxin leads to paralysis of the motor nerves.

Clostridioides difficile Toxin A and B

Material	Faeces
Method	ELISA
Species	No limitations known
Duration	1 – 2 days
Note	Determination is particularly indicated in case of colitis.

Clostridium perfringens Enterotoxin	
Material	Faeces
Method	ELISA
Species	No limitations known
Duration	1 – 2 days
Note	Determination is particularly indicated in case of colitis. In **carnivores**, Clostridium perfringens enterotoxin can cause diarrhoea and vomiting of varying severity; enterotoxaemia is rare. Toxin formation is induced by antibiotic administration, stress, co-infections or especially by an unbalanced diet rich in proteins and connective tissue. It plays an increasing role in **farm animals**, especially causing serious disease in calves, lambs (lamb dysentery) or suckling piglets (necrotising enteritis). Older animals are affected by clostridiosis (cattle), pulpy kidney disease (sheep), struck (sheep) or sporadic catarrhal and haemorrhagic enteritis (pig).

Clostridium tetani Neurotoxin – Antibody Detection	
Material	S 2 ml
Method	ICA
Species	Dog*, horse
Duration	Dog: 7 days Horse: 1 – 2 days
Note	For semi-quantitative determination whether a **horse has been sufficiently vaccinated.**

Detection of further Clostridia on request.

13.2.12 Corynebacterium pseudotuberculosis

Corynebacterium pseudotuberculosis is a gram-positive bacterium that belongs to the group of actinomycetes. It is the causative agent of pseudotuberculosis in sheep and goats, which is associated with abscessed lymph nodes and which is widely distributed. Pseudotuberculosis is becoming more and more clinically relevant in llamas and alpacas and can also be transmitted to other animal species (wild ruminants, cattle, horses, pigs) and to humans.

Corynebacterium pseudotuberculosis – Pathogen Detection	
Material	Swab with medium
Method	Bacterial culture (MALDI-TOF)
Species	Sheep, goat, New World camels, others
Duration	4 – 6 days

Note	For this test, please order the service "Bacteriology". Please indicate your suspicion on the submission form, as special culture conditions (incubation in a CO2 atmosphere) accelerate the growth of the pathogen.

Corynebacterium pseudotuberculosis – Antibody Detection*	
Material	EB, S 1 ml
Method	ELISA
Species	Sheep, goat, New World camels
Duration	5 days

13.2.13 Coxiella burnetii

Coxiella burnetii is an obligate intracellular, gram-negative bacterium and the pathogen that causes **Q fever.** It is highly infectious, even a small amount of pathogens is sufficient to establish an infection.
Coxiella burnetii is spread worldwide and has a large host range, e.g. ruminants, dogs, cats, rodents and birds as well as humans (zoonosis!). An infection in humans is often subclinical but clinically non-specific severe influenza-like symptoms can occur. Furthermore, chronic forms with endocarditis, hepatitis or CNS involvement have been sdescribed. Especially persons who are in contact with ruminants (e.g. vets, farmers, butchers) are affected.
In ruminants, Coxiella burnetii replicates in the female genital tract and in the utter. Excretion is intermittent or persistent via uterine secretions, amniotic fluid and abortion material, but also in urine, faeces and milk. During replication, small spore-like permanent forms are produced, which can survive in the environment for a very long time. Transmission occurs mostly by inhalation of pathogenic dust, but also by direct contact with infected animals. Ticks have also been found to be vectors of Coxiella burnetii, with tick faeces being particularly infectious.
If clinical signs are seen in animals, they include post-natal complications, metritis, foetal death, late abortions, stillbirths with subsequent infertility or birth of weak calves. In Germany, it is a **notifiable disease** in cattle, sheep, goats and other ruminants!

Coxiella burnetii – Pathogen Detection	
Material	Swab without medium (reproductive tract), abortion material, milk, faeces, urine
Method	Realtime PCR
Species	Mainly ruminants, but also other species
Duration	1 – 3 days
Note	As this is a zoonotic disease, the education of the animal owner and the practice staff on the zoonotic risk is advisable.

Coxiella burnetii – Antibody Detection	
Material	S, HP 0.5 ml
Method	ELISA
Species	Dog, cat, horse, ruminants, New World camels, others on request
Test frequency	1 x per week

13.2.14 Dermatophilus congolensis

Dermatophilus congolensis is the causative agent of dermatophilosis, also known as rain scald or rain rot. It is a gram-positive, facultatively anaerobic bacterium of the class Actinomycetia.
Clinically, papules appear first, later pustules and serous exudate, which causes the hair to stick together and creates a tufted, brush-like appearance. Scabs form with underlying exudate. It is easy to pull whole tufts of hair from the affected areas. The lesions are usually not itchy, but often painful.
It is a multifactorial disease: There are more clinical cases during prolonged periods of rain. The excessive moisture leads to a softening of the epidermis and thus causes the skin to become damaged, which is a prerequisite for the bacteria to penetrate. Skin damage caused by injuries or stinging or biting insects is also a predisposing factor. Transmission usually occurs through direct contact with infected animals, but also indirectly through arthropods and inanimate vectors such as brushes.

Dermatophilus congolensis – Pathogen Detection	
Material	Scab, scales, skin scrapings, skin biopsy
Method	Realtime PCR
Species	Mainly horse, but also ruminants, New World camels
Duration	2 – 4 days
Note	Hair alone is not sufficient as sample material.

13.2.15 Devriesea agamarum

The gram-positive bacterium Devriesea agamarum can cause dermatitis and cheilitis as well as septicaemia in lizards, predominantly in Uromastyx species, although other lizard species can also become infected. In the popular bearded dragons (Pogona vitticeps), asymptomatic courses are common, as Devriesea agamarum may be part of the oral microbiome in these animals. The potential transmission to susceptible animals should be taken into account when creating groups. Clinically, the disease often presents with yellow, scabby lesions in affected animals. Outbreaks with high mortality have been described, especially if septicaemia develops. The bacterium has been detected in both wild lizards as well as lizards in captivity.

Devriesea agamarum – Pathogen Detection	
Material	(1) Scab, scales, skin scrapings, swab without medium (skin, oral cavity), tissue (skin biopsy, cheilitis material, subcutaneous granulomas, organs if septicaemia is suspected), suspicious pure culture of lizard skin (2) Swab with medium (skin, oral cavity), scab, scales, tissue (skin biopsy, cheilitis material, subcutaneous granulomas, organs if septicaemia is suspected)
Method	(1) Realtime PCR (2) Bacterial culture
Species	lizard, mainly Uromastyx as well as Pogona species
Duration	1 – 3 days

E. coli, eae/enteropathogenic ➢ see Chapter 16.1.2, p. 272

13.2.16 Ehrlichia

Infections with ehrlichia occur worldwide. Ehrlichia are gram-negative, obligate intracellular bacteria belonging to the order Rickettsiales and are transmitted by ticks. Depending on the region, the tick species differ and thus also the species of **ehrlichia**. Whereas in Mediterranean countries and tropical as well as warmer areas, Rhipicephalus sanguineus, the main carrier of E. canis, is prevalent, Ixodes ricinus is found in Central and Northern Europe. However, if R. sanguineus is introduced into Germany, it can survive in heated rooms. Infection with Ehrlichia canis still rather presents a "typical" travel-related disease or can mainly be found in imported animals. An infection with E. canis leads to an infection of the monocytes and thus to **canine monocytic ehrlichiosis (CME).** The incubation period is about 8 – 20 days, which then changes into an acute phase of 2 – 4 weeks. Clinical signs are mostly non-specific: fever, anorexia, dyspnoea, anaemia, lymphadenopathy. In rare cases, CNS disorders may occur. In the first 10 – 20 days, thrombocytopenia can be seen, although there is rarely spontaneous bleeding. Subsequently, if untreated, a subclinical stage develops, which lasts for months or years, or chronic infections arise, which are often accompanied by hypergammaglobulinaemia. E. canis can also infect cats!

Ehrlichia canis – Pathogen Detection	
Material	EB, bone marrow, tick
Method	Realtime PCR
Species	Dog, cat
Duration	1 – 3 days

Ehrlichia canis – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	ELISA (dog), IFAT (cat)
Species	Dog, cat
Duration	1 – 2 days
Note	In dogs, detection by IFAT is possible on request.

ESBL ➢ see Chapter 14.4, p. 258

13.2.17 Francisella tularensis

Francisella (F.) tularensis is a gram-negative, pleomorphic, non-motile, aerobically growing bacillus that is very resistant especially in lower environmental temperatures. This pathogen is the causative agent of the so-called **tularaemia (rabbit fever)**, which is a zoonosis.
Four subspecies have been classified. Two subspecies are of particular clinical relevance: F. tularensis ssp. tularensis and F. tularensis ssp. holarctica, with F. tularensis ssp. tularensis naturally occurring in North America only and being responsible for a more aggressive course of the disease. In contrast, F. tularensis ssp. holarctica can be found in the entire northern hemisphere.

It is predominantly hares, rabbits and rodents (mice) that are affected, but also numerous other animal species, including birds, are susceptible to this pathogen. In dogs, cats and sheep, sporadic cases of illness are known. Cats suffer from the disease more often than dogs, but overall, the disease is rarely contracted.
Signs of an acute disease are apathy, fever, tachypnoea and swelling of the lymph nodes; most animals die of septicaemia within 2 weeks. Furthermore, in a chronic course, emaciation and skin ulcerations occur; in dogs and cats in addition to splenomegaly, hepatomegaly, ulcers on the tongue and icterus. Here, too, a lethal outcome is possible after 2 – 6 weeks.
The modes of transmission include blood-sucking insects like fleas, midges, lice, ticks, etc., consumption of infected carcass/meat or contaminated water. The infectious dose is very low, only a few bacteria are sufficient (exception: infections through the gastrointestinal tract).
Humans become infected when frequently exposed to hares, rabbits or wild animals. In Germany, there is an **obligation to notify the authorities** when F. tularensis ssp. is detected in hares and rabbits!

Francisella tularensis – Pathogen Detection	
Material	Tissue (mainly spleen, liver, lung, kidney), lymph node aspirates, swab without medium (pharynx, tonsils)
Method	Realtime PCR
Species	(Dog, cat), rabbit, hare, mouse, others

Duration	1 – 3 days
Note	The PCR detects F. tularensis ssp. holarctica.

13.2.18 Helicobacter

Helicobacter (H.) spp. are helical or curved, gram-negative bacteria. At least 35 species are known; some of them colonise the gastric mucosa, while others colonise the intestine and liver of humans or animals. Transmission occurs via the oral-oral or possibly also the anal-oral route. In humans, H. pylori is correlated with gastritis and stomach ulcers and can also be transmitted to animals. However, it is not pathognomonic in dogs.
Pathogenicity of Helicobacter spp. in animals has not yet completely been clarified. Infections do not always cause a disease; prevalence is very high in both healthy as well as infected animals. H. mustelae was detected in ferrets with gastritis and stomach ulcers, H. heilmanii was found in pigs with stomach ulcers. They are also associated with gastritis, vomiting and inappetence in dogs, cats and ferrets. In cats, Helicobacter spp. are associated with progressive lymphocytic cholangitis. In Muridae, helicobacter infection is often seen in association with typhlitis or rectal prolapse. In hamsters, the infection is often subclinical. In some cases, gastritis similar to that in humans may occur.
Gastric Helicobacter spp. include H. heilmannii, H. felis, H. bizzozeronii, H. salomonis and others; the intestinal ones comprise, for example, H. canis, H. bilis, H. cinaedi as well as Flexispira rappini. Flexispira rappini, which is also assigned to the genus Helicobacter, is associated with abortions in sheep. Aborted lambs show multifocal hepatic necroses – similar to campylobacter infections.

Helicobacter – Pathogen Detection	
Material	Vomitus, gastric lavage, gastric biopsy, sheep: abortion material
Method	PCR
Species	Dog, cat, hamster, mouse, ferret, sheep
Duration	1 – 3 days
Note	Positive PCR results from faecal samples do not necessarily indicate involvement of the stomach (gastritis, stomach ulcer, etc.), as PCR also detects intestinal Helicobacter spp. For this diagnostic task, stomach biopsies or vomitus are recommended as sample material.

13.2.19 Histophilus somni

Histophilus somni (formerly Haemophilus somnus) is a gram-negative bacillus of the family Pasteurellaceae. While some strains of H. somni are commensals of the mucosa of the upper respiratory and reproductive tract in cattle, sheep and other ruminants,

pathogenic strains spread systemically and can cause severe diseases such as pneumonia, thrombotic meningoencephalitis, myocarditis, septicaemia, arthritis and abortions or, together with Mannheimia haemolytica, the multifactorial disease enzootic bronchopneumonia.

Histophilus somni – Pathogen Detection	
Material	(1) Swab with medium (indicate site, special culture medium required), BAL, tissue (2) Swab without medium, nasal lavage, BAL, tissue
Method	(1) Bacterial culture (differentiation MALDI-TOF) (2) Realtime PCR
Species	Cattle, sheep and other ruminants
Duration	(1) 3 – 4 days (2) 1 – 3 days
Note	**Culture**: Take a deep swab; request detection by culture via the service Bacteriology. **PCR detection** is also part of the Bovine Respiratory Profile 2.

13.2.20 Lawsonia intracellularis

Horse

Especially in older foals, Lawsonia intracellularis causes **proliferative enteropathy**, which is accompanied by significant hypoproteinaemia. The animals also show abdominal pain, reduced general condition and anorexia. Secondarily, oedema and a pear-shaped abdomen may occur.

Pig

Porcine proliferative enteropathy (PPE) is caused by an infection with the obligate intracellular, gram-negative bacterium Lawsonia intracellularis. It is widespread in pig herds, especially among weaners, store pigs and fattening pigs. Infected animals suffer from growth disorders and diarrhoea. Infection occurs via the oral route, the spread mainly through the purchase of infected animals. Often, the infection is subclinical. PPE occurs in four clinically apparent forms: as acute and, if untreated, often fatal porcine haemorrhagic enteropathy (PHE) and as porcine intestinal adenomatosis (PIA), or less often as necrotic enteritis (NE) and as terminal regional ileitis (RI) with thickened and stiff ileum. While PHE mainly affects older fattening pigs and younger breeding pigs, the chronic forms PIA, NE and RI mainly occur in weaners and store pigs.

Small mammals

Infection with Lawsonia intracellularis presents with different clinical courses in small mammals. Ileitis is the typical manifestation. Haemorrhagic diarrhoea is a sign of acute disease, in the subacute form, there are reduced growth and diarrhoea as well. There may be no clinical signs in chronic Lawsonia infection. Young animals are often affected

and contract the disease from their subclinically infected parents. A high population density, changes in food and other stress factors facilitate infections or worsen the clinical picture. L. intracellularis infections have primarily been described in hamsters, rabbits, ferrets and rats. It is important to be aware of the zoonotic potential.

Lawsonia intracellularis – Pathogen Detection	
Material	Faeces, tissue (intestine)
Method	Realtime PCR
Species	Horse (mainly foal), pig, small mammals
Duration	1 – 3 days

13.2.21 Leptospira

Leptospira are gram-negative bacteria and zoonotic agents which belong to the spirochete group. They are very thin, flexible, spiral bacteria with a hook-shaped end. Leptospira can actively move by twisting. Within the genus Leptospira interrogans sensu lato, there are various pathogenic and saprophytic species which cannot be differentiated morphologically, but only serologically or genetically. Since 1989, more than 250 serovars have been described that are currently classified in 24 serogroups. Transmission of pathogens occurs directly through the urine or blood of infected animals or indirectly through inanimate vectors such as contaminated water, feed and sleeping places or living vectors like rodents. Leptospira best survive in a humid environment at temperatures of 0 – 25 °C.

Dog

Clinically, leptospirosis in dogs is initially manifested by anorexia, vomiting, dehydration and fever. Later, animals are apathetic and often show difficulty breathing. The mucous membranes are icteric, anaemia with haemoglobinuria appears and, in some cases, as a complication, disseminated intravascular coagulation (DIC). Toxic degradation products lead to haemorrhagic diathesis and necroses. This frequently results in acute nephritis with azotemia. In some cases, hepatitis may also occur, which often has a highly acute course. Leptospira are fetotrophic.

According to our own research, there has been a shift in the types of serovars over the past years. In dogs, analysed serovars include L. Bratislava, L. Australis, L. Autumnalis, L. Icterohaemorrhagiae, L. Pomona, L. Canicola, L. Saxkoebing, L. Grippotyphosa, L. Copenhageni and L. Sejroe.

Cat

Cats seem to show a natural resistance. However, here too, the number of cases with clinical manifestation is increasing. The predominant serovars are L. Grippotyphosa and L. Bratislava, followed by L. Icterohaemorrhagiae, L. Sejroe, L. Autumnalis, L. Australis and L. Javanica.

Reptiles
In reptiles, leptospira antibodies can be detected quite often.

Horse
Leptospira infections, which are spread through the urine of rodents, are usually clinically inapparent in horses. Thus, seroprevalence in healthy horses is high (up to approx. 75%). The pathogen is ingested with feed or water and leads to rather non-specific symptoms in horses, like fever (often intermittent), icterus, inappetence and productivity loss. Abortions have been described as well. Transmission of the pathogen between horses does practically not occur.

Equine recurrent uveitis (ERU) – It is likely that intraocular persistent leptospiral infection contributes to the aetiology of ERU, however, it is not the only possible aetiology. Autoimmune reactions lead to a progressive deterioration of the inner structures of the eye and may even lead to blindness.
Detection of antibodies (= most sensitive test) or pathogen detection using PCR can be carried out from aqueous humour or tissue of the vitreous body.

Ruminants
Leptospirosis in ruminants can cause economic losses and is, in Germany, a **notifiable animal disease in sheep**. It is predominantly cattle kept under extensive grazing conditions that get infected. In cattle, fever, anorexia, icteric mucous membranes, anaemia with haemoglobinuria and a decline in productivity are dominant. Diarrhoea and mastitis can also occur. Leptospira can cause abortions and fertility disorders in cattle and small ruminants.
Predominant serovars in our own research are L. Icterohaemorrhagiae, L. Saxkoebing and L. Bratislava. The recently emerged serovar L. Hardjo was not detected in any of the samples we examined.

Pig
Gravid pigs are especially susceptible to leptospira. The cardinal signs are birth of weak piglets or abortions. Aborted litters normally show different sizes and degrees of decay of the foetuses as the course of the disease is usually protracted.
When testing for antibodies in pigs, we look for serovars specific to this species: L. Canicola, L. Grippotyphosa, L. Saxkoebing, L. Bratislava, L. Sejroe, L. Pomona, L. Copenhageni and L. Tarrasovi.
In Germany, it is **notifiable upon diagnosis** in pigs.

Leptospira – Pathogen Detection	
Material	Urine + EB (bacteraemia only at the beginning of the infection!), tissue (kidney, abortion material) also: **farm animals:** milk, sperm **horse:** aqueous humour, vitreous body

Method	Realtime PCR
Species List	Dog, (cat), small mammals, horse, ruminants, pig
Duration	1 – 3 days

Leptospira – Antibody Detection	
Material	S, EP, HP 0.5 ml, horse: also aqueous humour/vitreous body (if ERU signs are present)
Method	MAT
Species	Dog, cat, reptiles, horse, ruminants, pig, others on request
Duration	1 – 2 days
Note	Initially, antibody titres only confirm pathogen contact. Many animals are seropositive without showing any clinical signs. Generally, titres > 1:400 or a three- to fourfold titre increase in a paired serum sample at an interval of 14 days are considered positive. Peracutely infected animals only show low or even negative antibody titres. Furthermore, if animals have already been treated with antibiotics at a very early stage, the titre often does not increase as expected. For acutely affected animals, direct detection from urine and blood is recommended. **Horse:** Serum antibody titres have no relevance with regard to ERU.

13.2.22 Listeria

Listeriosis can affect many animal species as well as humans.
Listeria are relatively small gram-positive rods with a tendency to grow in chains. Within the genus, Listeria monocytogenes has the greatest significance. Listeria ivanovii has low virulence, but is pathogenic to humans and sheep. The pathogen has also been isolated from monkeys suffering from meningitis.
Listeriosis is predominantly a disease in sheep that contract the disease through the ingestion of spoiled silage. Cattle, chickens, pigs, rabbits and goats are much less prone to the disease. Individual cases have been described in horses, dogs and cats.
In more than 80% of the cases of ovine listeriosis, the brain is affected and the characteristic clinical picture of this disease develops – the animals run in circles and show further signs up to recumbency due to a usually unilateral dysfunction of cranial nerves.
Other forms are septic listeriosis of newborn or young animals, organ listeriosis (e.g. mastitis) or gestation listeriosis with abortions.
Listeriosis (L. monocytogenes) is a **notifiable disease** in Germany.

Listeria – Pathogen Detection	
Material	(1) Faeces, swab with medium, CSF, abortion material, etc. (2) EB (ruminants only), abortion material, (faeces)

Method	(1) Bacterial culture (Listeria spp.) (2) Realtime PCR (specific to Listeria monocytogenes)
Species	(1) Dog, cat, horse, cattle, sheep, goat (2) Ruminants, (horse)
Duration	(1) 3 – 4 days (2) 1 – 3 days
Note	▪ For bacterial culture, please clearly indicate on the submission form that listeriosis is suspected, as special culture media are required. ▪ If pathogenic species are detected, an antibiogram will be performed additionally (subject to a charge). ▪ Detection of listeria is also part of the BARF Faecal Profile, p. 267. ▪ The PCR test is specific to L. monocytogenes.

Listeria – Antibody Detection

Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, cat, horse, cattle, sheep, goat
Duration	1 – 2 days
Note	▪ Antibodies against serovars 1 and 4b are detected. ▪ Low titres may be non-specific (< 1:80), as there is an antigenic relatedness of L. monocytogenes with staphylococci and streptococci.

13.2.23 Mannheimia haemolytica

Mannheimia haemolytica is a gram-negative, facultative anaerobic bacillus of the genus Mannheimia and the family Pasteurellaceae. It is considered the primary causative agent of enzootic bronchopneumonia in cattle and sheep and, moreover, the pathogen of severe mastitis as well as septicaemia in sheep and goats. In ruminants, however, some of the serotypes described for M. haemolytica are part of the natural microflora of the upper respiratory tract.

Mannheimia haemolytica – Pathogen Detection

Material	(1) Swab with medium, tissue (2) Swab without medium, nasal lavage, tissue
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR
Species	Ruminants
Duration	(1) 2 – 3 days (2) 1 – 3 days

Note **Culture**: Take a deep swab; request detection by culture via the service Bacteriology.
PCR detection is also part of the Bovine Respiratory Profile 2 (see Chapter 13.5.4, p. 249).

13.2.24 Melissococcus plutonius

The gram-positive bacterium Melissococcus plutonius is the primary pathogen of **European foulbrood (EFB)** in bees. It mainly affects so-called coiled larvae, which then die at 4 – 5 days of age. The larvae are infected through the food and the pathogen multiplies in the gut. Infected brood changes colour and becomes a semi-liquid mass, which later on dries out to loose scales. Due to the partly sour smell, it is also referred to as sourbrood. After capping, the caps are sunken and perforated. The signs are very similar to those of American foulbrood, a disease which is notifiable upon suspicion in Germany, thus, a precise diagnosis is of great importance. Transmission can either occur through the bees themselves (drifting, robbing) or by the beekeeper. By forming an artificial swarm, the brood can be separated from the healthy bees and then killed.

Melissococcus plutonius – Pathogen Detection	
Material	Bee larvae, bees
Method	PCR
Species	Bees
Duration	1 – 3 days

13.2.25 Methicillin-resistant Staphylococci: MRSA/MRSP

In human medicine, diseases caused by methicillin-resistant Staphylococcus aureus **(MRSA)** are known and feared as so-called "nosocomial infections". These are infections with pathogens that have developed resistance to common antibiotics. The pathogens can enter the environment through hospital visitors, personnel, equipment, etc. As most of these infections in humans are zoonoses, pathogens can also be transmitted to animals as well as vice versa, because of the close contact between humans and animals. This probably also leads to an increase in MRSA cases in veterinary medicine.
MRSA is often detected in farm animals. In 2016, only about every fourth pig in Germany was MRSA-free. Approximately every fourth horse was an MRSA carrier (zoonoses monitoring 2019). In agricultural **livestock,** MRSA of a certain line are predominant, so that the term livestock-associated or laMRSA is used. laMRSA mostly belong to the clonality CC398 and were responsible for 8% of MRSA cases in humans in 2017 and for 5% in 2018. In regions with high livestock density, laMRSA cause increasing numbers of human MRSA cases. People with close animal contact, including veterinarians, are particularly at risk.
In small animals, we detect MRSP, methicillin-resistant Staphylococcus pseudintermedius, far more frequently than MRSA.

MRSA/MRSP	
Material	Swab with medium (skin, eye, pharynx, nose, etc.)
Method	Bacterial culture (on standard and special culture media)
Species	Dog, cat, horse, farm animal, others
Duration	3 – 4 days
Note	Detection of methicillin resistance in Staphylococcus aureus is also possible by PCR after growing a culture (detection of the resistance gene MecA or MecC). The test for MRSA is also part of the service "Analysis of Multidrug-resistant Bacteria" (see Chapter 14.4, p. 258).

13.2.26 Mycobacterium avium ssp. paratuberculosis

Mycobacteria see ➢ Chapter 16.1.2, p. 273

Mycobacterium avium subsp. paratuberculosis (MAP) is the causative agent of **paratuberculosis,** also called **Johne's disease,** a chronic granulomatous enteritis in ruminants. The disease is globally distributed. In addition to domesticated ruminants (cattle, sheep, goat), also wild ruminants and camelids can be affected. MAP could also be isolated from other animal species, e.g. rabbits, mice, foxes and ferrets. The pathogen is very stable and can remain infectious in the environment for up to one year.
Normally, an infection already occurs orofaecally in calves through contact with faeces of infected animals, but it can also spread through the colostrum and milk, and intrauterine infections are possible as well.
The incubation period varies greatly and can take several years. The first clinical signs often tend to occur when the animals are already older than 2 years. Primary signs are continuous, profound, uncontrollable diarrhoea and progressive weight loss with regular appetite. Paratuberculosis is always fatal. Already prior to the onset of these signs, decreased milk production, reduced fertility, etc. lead to high economic losses. Not all infected animals develop clinical signs, subclinically infected carriers also (intermittently) excrete the pathogen. Animals suspected of being infected should be isolated and, in case of a positive result, should soon be eliminated from the population or slaughtered. Test results vary depending on the phase of infection, therefore, the use of repeated sampling is recommended if an infection is suspected!
In Germany, it is a **notifiable disease** in cattle, sheep and goats!

Mycobacterium avium ssp. paratuberculosis – Pathogen Detection	
Material	Faeces, tissue (intestine, lymph node), milk
Method	Realtime PCR
Species	Cattle, sheep, goat, New World camels
Duration	1 – 3 days

Mycobacterium avium ssp. paratuberculosis – Antibody Detection	
Material	S, HP, milk 1 ml
Method	ELISA
Species	Cattle
Duration	3 days

13.2.27 Mycoplasma

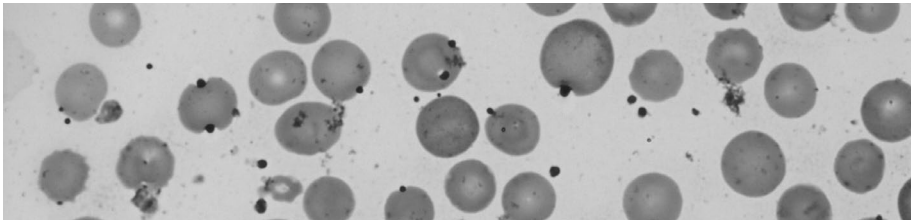
Mycoplasmas are gram-negative bacteria of the family Mycoplasmataceae that are divided into haemotropic and non-haemotropic mycoplasma. Outside the organism, mycoplasmas are very unstable.

13.2.27.1 Haemotropic Mycoplasma

Haemotropic mycoplasmas (formerly haemobartonella and eperythrozoon) are globally spread. They attach to the surface membrane of erythrocytes and can cause anaemia.

Dog

So far, **Mycoplasma haemocanis** and **Candidatus Mycoplasma haematoparvum** have been described in dogs. Both strains are found in Europe, especially in the Mediterranean area. Clinically, the course of the disease is often just chronic and asymptomatic. In contrast, acute infections with fever, anorexia, weight loss and lethargy are mainly seen in immunocompromised dogs, dogs that had splenectomy or those simultaneously infected with other pathogens. Deaths are also possible. Natural infection probably occurs through vectors, particularly the brown dog tick (Rhipicephalus sanguineus) is being discussed. Vertical transmission through the placenta and milk is also possible, and blood transfusions present a risk of infection as well.



Erythrocytes with mycoplasma on the membrane (dog, Diff-Quik, 1000x magnification).

Cat

Currently, three different types of haemotropic mycoplasmas with different pathogenicity have been described in cats. In addition to the strain **Mycoplasma haemofelis**, which is known as Ohio isolate, and the most commonly found California isolate, **Candidatus Mycoplasma haemominutum**, another strain, **Candidatus Mycoplasma turicensis**, has been known for some years. The latter was first detected in cats in Switzerland,

but seems to occur relatively rarely in Germany. While Mycoplasma haemofelis can cause serious illness even in immunocompetent animals, an infection with Candidatus Mycoplasma haemominutum usually progresses subclinically in healthy animals. Co-infections are possible with clinical signs typically being more distinct than in mono-infections.
Natural infection probably occurs through vectors; particularly fleas, but also ticks and stinging insects are being discussed. Vertical transmission through the placenta and milk is also possible. Blood transfusions present a risk of infection, too, as well as direct transmission between animals through bite wounds.
Clinical signs in the acute phase are anaemia (haemolytic anaemia as cardinal symptom), fever, splenomegaly, general weakness and possibly polypnoea, tachycardia and icterus. The cause of haemolytic anaemia is damage of the erythrocyte membrane by haemotropic mycoplasmas. Because of the change in the erythrocyte surface, a secondary immune haemolytic anaemia can develop later on; in this case, the direct Coombs test will be positive. The main signs of a chronic infection include weight loss and intermittent fever. Studies have shown that a high percentage of the dog and cat population is infected without the animals showing any clinically relevant signs. These carriers present a particular risk for breeding and blood transfusions.

Camelids
In its acute phase, an infection with **Mycoplasma haemolamae** can cause haemolytic anaemia in affected animals. However, infections can also primarily progress silently and lead to a chronic carrier state. The disease may fully break out in these animals in situations linked to stress and/or immunosuppression.

Pig
Porcine infectious anaemia (synonym: porcine eperythrozoonosis) is an infectious disease caused by **Mycoplasma suis** (formerly Eperythrozoon suis). The pathogens attach to the erythrocytes (adhesion, invasion) and provoke damage to and lysis of the erythrocytes due to the formation of autoantibodies. Below the normal body temperature ("cold antibodies"), they agglutinate the blood cells and result in anaemia. Once infected animals go through episodes of anaemia time and again. The disease becomes chronic. Older pigs are only latently infected and only suffer from another relapse when they are very weak. The pathogen remains in the body throughout life.

Small ruminants
Mycoplasma ovis is a haemotropic bacterium in small ruminants. Mycoplasma ovis lacks a cell wall and is a pleomorphic bacterium from the class Mollicutes, which attaches to the erythrocytes.
Infection with Mycoplasma ovis is a "vector-borne disease", the vectors are blood-sucking insects such as mosquitoes, lice and autumn flies as well as ticks of the genus Rhipicephalus. Clinical signs include anaemia and weight loss. Anaemia can be so severe that it may lead to cardiovascular failure and death. Signs particularly manifest when there is also an infestation with gastrointestinal parasites.

Mycoplasma (haemotropic) – Pathogen Detection	
Material	EB, tissue (spleen)
Method	Realtime PCR
Species	Dog, cat
Duration	1 – 3 days
Note	PCR detection should be preferred over microscopic detection as the sensitivity of the microscopic detection is low (around 30%). Species differentiation is included in the detection of haemotropic mycoplasma (dog: Mycoplasma haemocanis, Candidatus Mycoplasma haematoparvum; cat: Mycoplasma haemofelis, Candidatus Mycoplasma haemominutum, Candidatus Mycoplasma turicensis).

Mycoplasma haemolamae – Pathogen Detection	
Material	EB
Method	Realtime PCR
Species	Llama, alpaca
Duration	1 – 3 days

Mycoplasma (Eperythrozoon) suis – Pathogen Detection	
Material	EB, tissue (spleen)
Method	Realtime PCR
Species	Pig
Duration	1 – 3 days

Mycoplasma ovis – Pathogen Detection	
Material	EB
Method	Realtime PCR
Species	Sheep, goat
Duration	1 – 3 days
Note	Detection of Mycoplasma ovis is only available in combination with PCR detection of Anaplasma ovis (see p. 173).

13.2.27.2 Non-haemotropic Mycoplasma

Non-haemotropic mycoplasmas can be found on the mucous membranes of the respiratory and the urogenital tract **(mucosa-associated mycoplasmas)**, where they can escape from the immune response of the infected animal for a very long time. Conjunctivitis and rhinitis are clinically apparent, disorders of the upper respiratory tract occur less frequently. Mycoplasmas can also be primarily pathogenic.

Dog

Mycoplasmas often occur in dog populations and are sometimes considered as commensals in the literature. Yet, they are also associated with diseases of the urogenital region and with infertility. Clinically, an infection with canine mycoplasma can cause prostatitis and/or orchitis in male dogs, and can, amongst others, lead to endometritis in female dogs. However, mycoplasmas may also play a role in canine respiratory diseases. As it is difficult to cultivate mycoplasma, PCR detection is the method of choice.

Cat

In the cat common cold complex, not only viral components (FHV, FCV) play a role, but also **Mycoplasma felis**. Clinically, an infection is usually manifested by conjunctivitis and rhinitis. **Mycoplasma gatae** and **Mycoplasma feliminutum** are sometimes isolated from cats, nevertheless, their clinical relevance is questionable.

Rat and mouse

Mycoplasma pulmonis is the causative agent of "murine respiratory mycoplasmosis" in rats and mice, a slowly progressing infection of the respiratory tracts associated with the formation of thick mucus. Clinical signs of infected animals are sneezing, mucopurulent nasal discharge, stertorous breathing sounds and dyspnoea. The infection can spread to the middle ear and lead to otitis media and head tilt.
In addition, especially in older female rats, Mycoplasma pulmonis can cause genital infection which leads to infertility or a small litter size. In rare cases, metritis or pyometra are also seen.
Latent infections without any clinical signs are common.
Transmission occurs through aerosols in close direct contact. Sexual or intrauterine transmission is also possible.

Reptiles

Several Mycoplasma spp. exist in tortoises. An infection with a virulent **Mycoplasma agassizii** strain causes the so-called upper respiratory tract disease (URTD), a disease clinically characterised by serous, mucous and purulent nasal discharge as well as ocular discharge, conjunctivitis and eyelid oedema. Furthermore, it can cause lethargy, dehydration, anorexia and fatal cachexia. An essential trait of mycoplasma infections is the fact that they can persist in the organism without triggering any symptoms. Often, the disease only breaks out if there are other microorganisms and environmental factors involved, combined with the genetic properties and immune reactions of the host. Mycoplasmas are also detected in turtles and other reptiles, especially pythons, but little is known about their clinical relevance.

Cattle

In the first weeks of the life of a calf, **Mycoplasma bovis** can cause mostly enzootic pneumonia and arthritis, and in cows it leads to severe mastitis.
Affected calves typically suffer from otitis with hanging earlobes and head tilt. As mastitis pathogen, Mycoplasma bovis is highly infectious. Typically, the mammary gland increases in size and hardens, and within a few weeks, the inflammation spreads to the neighbouring udder quarters.

The pathogen is also often detected in connection with chronic diseases of the respiratory tract. Reservoirs of M. bovis are the respiratory tract of clinically healthy calves and young cattle as well as the udder of cows with subclinical mastitis. **Mycoplasma mycoides subsp. mycoides** is the causative agent of contagious bovine pleuropneumonia (**notifiable upon suspicion** in Germany).

Pig

Mycoplasma hyopneumoniae is the primary causative agent of enzootic porcine pneumonia (EPP). EPP is one of the most significant causes of respiratory infectious diseases in pigs. The disease is globally distributed. However, the pathogen only causes high economic losses in pig production when combined with poor environmental conditions and secondary bacterial and/or viral infections.

Poultry

Infections with **Mycoplasma gallisepticum** cause the so-called chronic respiratory disease (CRD) in chickens and infectious sinusitis in turkeys. Infection occurs both horizontally through the air and direct contact as well as vertically through hatching eggs. The main symptoms include chronic inflammation of the upper respiratory tracts and air sacs, accompanied by disorders of the joints, tendon sheaths and the genital tract. Central nervous disorders can also arise. In addition, laying performance and hatching rates decrease significantly. Mixed infections with viral pathogens, such as Newcastle disease virus (NDV) or infectious bronchitis virus (IBV) are not unusual and can severely aggravate the clinical picture (also as vaccine viruses).

In chickens and turkeys, **Mycoplasma synoviae** causes infectious synovitis and arthritis, which is clinically manifested by joint swellings and lameness. Inflammation of the air sacs, myocardium and pericardium also occurs. Especially after mixed infections, respiratory symptoms can be seen as well. Stunted growth, reduced laying performance and greenish diarrhoea are also due to the infection. Besides game birds, geese, too, are susceptible to this pathogen.

Mycoplasma – Pathogen Detection		
Material	**Dog:**	swab without medium (eye, nose, pharynx, genital tract), BAL, abortion material
	Cat:	swab without medium (eye, nose, pharynx, genital tract), BAL, abortion material
	Rat, mouse:	swab without medium (nose, pharynx), tissue (lung)
	Chelonians, snake:	swab without medium (conjunctiva, mouth), nasal lavage
	Cattle:	swab without medium (nose, pharynx), nasal lavage, BAL, milk, synovia, sperm, tissue (lung)
	Pig:	swab without medium (trachea, nose), BAL, tissue (lung)
	Poultry:	swab without medium (pharynx, cloaca), faeces, tissue (lung)

Method	PCR/realtime PCR
Species	Dog, cat, rat, mouse, tortoise/turtle, snake, cattle, pig, poultry
Duration	1 – 3 days
Note	▪ Mycoplasma PCR in **dogs** detects at least the following species: M. arginii, M. gateae, M. spumans, M. cynos, M. molare, M. canis, M. edwardii, M. bovigenitalum, M. maculosum, M. opalescens, M. feliminutum. ▪ Mycoplasma PCR in **cats** detects M. felis.

Mycoplasma bovis – Antibody Detection

Material	S 1 ml
Method	ELISA
Species	Cattle
Duration	5 days
Note	This test can only be requested as part of the serological Bovine Respiratory Profile (see Chapter 13.5.4, p. 249).

Mycoplasma hyopneumoniae – Antibody Detection*

Material	S 1 ml
Method	ELISA
Species	Pig
Duration	5 days
Note	This test can be ordered individually and is also part of the serological Porcine Respiratory Profile (see Chapter 13.5.4, p. 250).

Nocardia ➢ **see Chapter 14.4, p. 259**

Paenibacillus larvae ➢ **see Chapter 14.4, p. 259**

13.2.28 Neoehrlichia mikurensis

Officially named in 2004, Neoehrlichia mikurensis is an obligate intracellular, gram-negative bacterium. The pathogen is characterised by endotheliotropism but has not been cultivated in vitro so far and thus could not be completely described yet.
N. mikurensis was first found in common rats on the Japanese island of Mikura. It is assumed that small mammals, such as mice and rats, serve as reservoir; transmission most likely occurs through ticks. In recent years, N. mikurensis has been detected in about 2 to 25% of Ixodes ricinus ticks in Germany.
Since 2007, this pathogen has been associated with diseases in humans. Especially the elderly and immunocompromised people have been affected by neoehrlichiosis, including two patients from Germany. The symptoms are non-specific, with high fever and headaches as well as muscle and joint pain being the most common signs. The

occurrence of vascular complications, like deep vein thromboses, pulmonary embolism and arterial aneurysms, was most noticeable. Laboratory findings particularly indicate an increased level of C-reactive protein, leukocytosis with neutrophilia and anaemia. In dogs, so far only one single case has been reported in which this bacterium could be isolated. It was an eight-year old female Irish Setter after ovariohysterectomy and mastectomy. Postoperatively, she was lethargic and developed profuse subcutaneous bleeding (Diniz et al. 2011).

Neoehrlichia mikurensis – Pathogen Detection	
Material	EB, tick, tissue (e.g. spleen, kidney, liver)
Method	Realtime PCR
Species	Dog, tick
Duration	1 – 3 days

13.2.29 Pasteurella multocida

Pasteurella multocida is a gram-negative bacillus. Pasteurella are commensals of the mucous membrane of the upper respiratory tract. Factors that reduce resistance, such as overpopulation or a bad stable environment, provide a predisposition to infections with toxigenic strains. Co-infections with Bordetella bronchiseptica are common and lead to particularly severe symptoms.
Pasteurella multocida, either as a mono-infection or together with Bordetella bronchiseptica and other bacteria, leads to **"snuffles"** in **rabbits.** Normally, this disease is a stock problem and is often recurrent.
In **pigs,** Pasteurella multocida toxin is the aetiological agent that causes progressive **atrophic rhinitis,** with especially the toxigenic pasteurella types A and D being involved. The cytotoxic toxin (PMT) inhibits the osteoblasts. With the activity of the osteoclasts being maintained, it leads to atrophy of the nasal conchae and deformation of the nasal septum. The importance of the toxin in pneumonia in cattle and pigs has not yet been clarified.

Pasteurella multocida (toxin producing) – Pathogen Detection	
Material	Swab without medium (nose, pharynx), BAL, NSP, tissue (lung)
Method	Realtime PCR
Species	Rabbit, pig, others on request
Duration	1 – 3 days
Note	▪ The serogroups/types (A – F)/serotypes cannot be differentiated by PCR, as there is no correlation between the serotype and genotype characteristics. ▪ Detection by culture of solely P. multocida is also possible; please indicate on the submission form that pasteurella is suspected. A possible toxin formation cannot be detected by culture.

13.2.30 Rhodococcus hoagii (formerly Rhodococcus equi)

Rhodococcus hoagii is a facultative pathogenic organism in soil or horse faeces. R. hoagii is the most frequent causative agent of severe pneumonia with high fatility rates in foals aged 3 weeks to 6 months. Entry and predilection site is the lung (abscessation!), from where haematogenous spread to other organs and, through swallowing, a dissemination into the gastrointestinal tract (ulcera, diarrhoea, source of infection!) are possible. Umbilical infections occur as well. Moreover, R. hoagii shows an affinity for bones and joints.

Rhodococcus hoagii (formerly Rhodococcus equi) – Pathogen Detection	
Material	(1) Swab with medium (nose, navel), BAL, tracheal lavage (preferred), faeces (2) Swab without medium (nose, navel), BAL, tracheal lavage, faeces
Method	(1) Culture (2) Realtime PCR
Species	Horse
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	▪ Because of the sensitivity of PCR, it is possible to also identify clinically healthy carriers. ▪ If PCR detection is positive, the virulence factor gene VapA will be automatically detected at no additional cost.

13.2.31 Rickettsia

Rickettsia are obligate intracellular coccoid, rod-shaped or pleomorphic gram-negative bacteria that parasitise in reticuloendothelial cells or erythrocytes. They are usually transmitted by arthropods.
Rickettsia are divided into the categories "spotted fever group", thyphus group and "others", which includes Coxiella burnetii.
In the USA, Rickettsia rickettsii, the causative agent of **Rocky Mountain spotted fever**, and in the Mediterranean area, Rickettsia conorii, the causative agent of **Mediterranean spotted fever**, are of central importance in animal infections. Infected dogs may remain asymptomatic or show symptoms ranging from lymphadenopathies, fever, hyperesthesia, peripheral oedema up to lameness.

Rickettsia spp. – Pathogen Detection	
Material	Tick, EB, tissue (skin)
Method	Realtime PCR
Species	Dog, cat, others
Duration	1 – 3 days

Rickettsia conorii – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, cat
Duration	1 – 2 days
Note	R. conorii is found in the Mediterranean, Africa, South West Asia and India. Serological studies suggest a high prevalence in asymptomatic dogs.

Rickettsia rickettsii – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog
Duration	1 – 2 days
Note	Rickettsia ricketsii infection causes Rocky Mountain spotted fever. It is found in North and South America.

13.2.32 Salmonella

Salmonella belong to the family Enterobacteriaceae and are found in the intestines of animals and humans. In most cases, infection occurs faecal-orally or by feeding raw meat.
Salmonella infections affect almost all animal species. Compared to herbivorous pets, dogs and cats are more resistant to salmonella infections. Under favourable conditions, salmonellosis causes diarrhoea with vomiting and fever; in young animals, the disease can also become septicaemic.
In reptiles and amphibians, salmonella can be part of the normal intestinal flora. In these animals, clinically relevant salmonellosis is associated with immune deficiency.
According to the Robert Koch Institute (RKI), about 10% of all human salmonella infections, which cause diarrhoea, are related to direct contact with excreting dogs, cats and particularly reptiles.
For some time now, ESBL producers have also been detected among salmonella, especially in livestock. Because of the **ESBL problem, creating an antibiogram** is essential. In Germany, it is an **epizootic disease** in cattle that is **notifiable upon suspicion**. In other species, it is **notifiable upon diagnosis**. For commercial poultry in Germany, there is also an obligation to notify and inform the authorities, but this is strictly monitored and can result in official measures being taken in the flock.

Salmonella – Pathogen Detection	
Material	(1) Faeces, swab with medium (intestinal or cloacal swab) (2) Faeces; in birds also swab without medium (cloaca), eggs, tissue

Method	(1) Bacterial culture with enrichment, MALDI-TOF (2) Realtime PCR
Species	All
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	Culture with enrichment is the most sensitive test method. After successful culture growth, a serological pathogen differentiation is carried out (subject to a charge).

Salmonella Abortusequi – Antibody Detection*

Material	S 1 ml
Method	Slow agglutination
Species	Horse
Duration	5 days
Note	▪ Export-relevant test. ▪ In the host-adapted serotype Abortusequi, pathogen transmission occurs orally; rarely through mating. With regard to miscarriages, this pathogen does not currently play a role in Germany anymore.

13.2.33 Staphylococcus

Staphylococci are gram-positive and extremely resistant bacteria. They normally reside on the skin and the mucous membranes, where they are part of the physiological microbial flora.
Inflammation caused by staphylococci is usually locally limited. Only in cases of decreased resistance, septicaemia and pyaemia can occur. In ruminants, staphylococci are of major importance as causative agents of mastitis.
Nowadays, special attention should be paid to whether methicillin-resistant strains of Staphylococcus aureus (MRSA) or, in the small animal practice, of Staphylococcus pseudintermedius (MRSP) are present (see Chapter 13.2.24, p. 194). In case of repeated wound healing problems in patients visiting the practice, which are caused by MRSA or MRSP, it should be considered testing the staff of the practice, too, whether they carry this type of pathogen on their nasal mucosa.
Detection can be done through culture examination of clinical samples, e.g. swabs of pustules, mucosal swabs and other body secretions and excretions.

Staphylococcus – Pathogen Detection

Material	Swab with medium, milk (ruminants)
Method	Culture with enrichment
Species	All
Duration	2 – 3 days
Note	Further differentiation can be made if MRSA is suspected.

Staphylococcus – Antibody Detection	
Material	S 0.5 ml
Method	MAT (IgG)
Species	Dog, cat
Duration	1 – 2 days
Note	To recognise animals sensitive to Staphylococcus in cases of pyoderma.

13.2.34 Streptococcus equi

The globally spread and highly infectious equine disease **strangles** is caused by an infection with **Streptococcus equi subsp. equi** and is characterised by purulent lymphadenitis and pharyngitis. It used to be a typical disease in young animals which induces long-lasting immunity. Over the past years, however, an increasing number of affected adult horses has been described, with the disease showing a rather atypical progression (mainly fever, respiratory disorders).
Compared to culture, PCR has the advantage of delivering faster results while at the same time offering a comparably higher sensitivity and specificity. This way, the identification of clinically healthy carriers, which play a major role in pathogen epidemiology, is also more reliable.
As PCR does not differentiate between dead or living organisms, a positive pathogen detection should always be formulated as a suspected diagnosis and be confirmed by culture examination.
Clinically, an infection with Streptococcus equi subsp. equi cannot always be distinguished from an infection with **Streptococcus equi subsp. zooepidemicus.** Streptococcus equi subsp. zooepidemicus can be found in all domestic animals and in humans. In horses, it is a facultative pathogenic commensal; infections can cause, amongst others, respiratory disorders and purulent bronchopneumonia. As with strangles, especially foals and young horses are affected.

Streptococcus equi – Pathogen Detection	
Material	(1) Swab with medium (nose, abscess, lymph node), lavage sample (guttural pouch, pharynx, BAL), TBS (2) Swab without medium (nose), lavage sample (guttural pouch, BAL), TBS, tissue (lymph node)
Method	(1) Culture (2) Realtime PCR
Species	Horse
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	▪ In culture, both subspecies (Streptococcus equi equi and Streptococcus equi zooepidemicus) are determined and differentiated by MALDI-TOF.

- If detection is to be done by means of PCR, it can be chosen between the single detection of Streptococcus equi equi or the detection of both subspecies mentioned above.

Streptococcus equi – Antibody Detection	
Material	S 0.5 ml
Method	ELISA (quantitative)
Species	Horse
Duration	1 – 3 days
Note	▪ Generally, this test determines both Streptococcus equi equi and Streptococcus equi zooepidemicus. However, the detected surface antigen SeM is considered a virulence factor which mainly occurs in Streptococcus equi equi. ▪ In case of a positive result, antibodies will always be quantified. Knowing the titre level can be particularly helpful if purpura haemorrhagica or metastasising abscesses are suspected; these animals have high titres. ▪ The level of the titre does not give any information on the immunisation or the carrier status of a horse.

13.2.35 Taylorella

Taylorella asinigenitalis

Taylorella (T.) asinigenitalis is closely related to T. equigenitalis, the causative agent of contagious equine metritis (CEM). The bacterium was first described in the USA, but in recent years it has also been detected in several European countries (e.g. Italy, France, Croatia, Spain, UK). Most of the time, T. asinigenitalis has mainly been detected on the genital mucosa of male donkeys, less frequently in horses. It is generally classified as apathogenic. However, in infection trials with the bacterium, it was possible to cause transient metritis and cervicitis, although the clinical picture was milder than that of an infection with T. equigenitalis. Another more pathogenic strain has also been described which led to severe, purulent endometritis after intrauterine application in mares. Remarkably, female donkeys remained asymptomatic after infection with this strain. Apart from PCR for T. equigenitalis, an additional PCR screening for T. asinigenitalis is recommended for a comprehensive breeding soundness examination to be able to identify future outbreaks of pathogenic strains of T. asinigenitalis at an early stage.

Taylorella asinigenitalis – Pathogen Detection	
Material	Swab without medium (stallion: penile sheath, urethra, fossa glandis; mare: fossa clitoridis, sinus clitoridis, cervix), sperm
Method	Realtime PCR

Species	Horse, donkey
Duration	1 – 3 days

Taylorella equigenitalis

Contagious equine metritis (CEM) is caused by the gram-negative bacillus Taylorella equigenitalis. Transmission particularly occurs during mating; stallions latently carry the pathogen on the mucous membrane of the penis, especially in the Fossa urethralis and in the smegma of the prepuce. Transmission from infected mares to stallions is also possible. In mares, an infection leads to endometritis/cervicitis with mucopurulent vaginal discharge and to reduced fertility. Stallions show no clinical signs of the disease. For exports, a bacteriological examination is required; within the EU, however, detection by PCR is now also recognised as a suitable test method. In Germany, there is an **obligation to notify the authorities**, if Taylorella equigenitalis is detected.

Taylorella equigenitalis/CEM – Pathogen Detection	
Material	(1) Swab with medium (Amies with charcoal, not older than 48 hours) (2) Swab with medium with charcoal (not older than 48 hours), e.g. Amies, sperm Stallion: penile sheath, urethra, fossa glandis Mare: fossa clitoridis, sinus clitoridis, cervix
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR
Species	Horse
Duration	(1) Culture: 1 week Export to the USA: 1 week Export to Canada: 2 weeks (2) PCR: 1 – 3 days
Note	▪ Detection by PCR is offered as an individual service for one sample or as a CEM profile for the examination of several sites (see Chapter 13.5, p. 240). The CEM Profiles stallion 1 and mare 1 are suitable as PCR detection before export to another EU country. ▪ Even after successful bacterial cultivation, it is not possible to create an antibiogram for Taylorella equigenitalis.

13.2.36 Treponema paraluiscuniculi

Rabbit syphilis (Spirochaetosis cuniculi) is caused by the highly contagious bacterium Treponema paraluiscuniculi. Only rabbits and hares are susceptible, human infections are not possible. Transmission occurs directly, usually during mating. However, the animals can also become infected through other mucosal contacts as well as bedding and feed. Rabbit syphilis typically occurs as a chronic disease, but latent infections are

possible, too. The incubation period is weeks to months. First clinical signs can be seen as oedematous swellings and formation of nodules on the external genital organs. In the further course of the disease, these nodules erode into ulcers and become purulent and encrusted. By licking the affected anogenital region, other skin areas, such as lips, eyelids or the edge of the ears often become infected as well.

Treponema paraluiscuniculi – Pathogen Detection	
Material	Tissue (mainly skin lesions/scurfs; possibly regional lymph nodes), swab without medium (vagina, prepuce)
Method	Realtime PCR
Species	Rabbit, hare
Duration	1 – 3 days

Treponema paraluiscuniculi – Antibody Detection*	
Material	S 0.5 ml
Method	Treponema pallidum haemagglutination test
Species	Rabbit
Duration	3 – 5 days

13.2.37 Yersinia

Yersinia belong to the order Enterobacterales. Yersinia (Y.) pseudotuberculosis is the causative agent of **pseudotuberculosis/rodentiosis**, an infectious disease many mammalian and bird species can contract. For instance, rodents and cats are predisposed. Cats, however, rarely show any clinical signs, but if so, they are often non-specific. The pathogen has a high tenacity. In the soil, the pathogen remains infectious for months.
Y. enterocolitica causes enterocolitis in humans and animals. Immunopathological reactions can lead to arthritis, arthrosis and skin diseases. Animals, especially pigs, sheep and poultry, often act as pathogen reservoir. Dogs rarely become ill, if at all, puppies are mainly affected. The infection manifests itself as enteritis, resulting in mucous to bloody diarrhoea. Especially in Y. pseudotuberculosis infections, abscesses can occur in various organs. Y. pseudotuberculosis can also play a role in wild ruminants (game enclosures!).
Just like Y. enterocolitica, Y. pseudotuberculosis is a **zoonotic agent**!

Yersinia – Pathogen Detection	
Material	Faeces
Method	(1) Bacterial culture (MALDI-TOF) with cold enrichment (2) Realtime PCR (Y. enterocolitica only)
Species	All

Duration	(1) Up to 4 weeks (2) 1 – 3 days
Note	▪ A faecal sample of at least the size of a cherry is required. ▪ In exceptional cases, a swab with transport medium can also be used for culture. ▪ Detection by culture is offered as a combined service together with the detection of Campylobacter. ▪ After successful culture growth, a serological pathogen differentiation is carried out (subject to a charge).

13.3 Fungi

13.3.1 Aspergillus

Aspergillus is a genus of moulds with approximately 200 species worldwide. In the environment, Aspergillus is particularly found in soil, organic waste, but also in animal feed. Parrots often get infected through unpeeled peanuts.
Aspergillosis is often caused by the species Aspergillus fumigatus and preferably affects the skin, nose, paranasal sinuses and the lung. Aspergillosis frequently occurs in birds, especially if the animal is predisposed by improper keeping, the administration of antibiotics or stress. This very often results in severe respiratory disorders. Other organs (e.g. CNS) can also be affected.

Aspergillus – Pathogen Detection	
Material	Swab with medium, BAL, nasal lavage, tracheal lavage, faeces
Method	Culture
Species	All
Duration	Up to 7 days
Note	Order via the Mycology service.

Aspergillus-Galactomannan – Antigen Detection*	
Material	S 0.5 ml
Method	ELISA
Species	Birds
Duration	5 days
Note	Galactomannan is a polysaccharide found in the cell wall of Aspergillus spp. In animals affected by aspergillosis, it can be detected in the blood. For birds that only develop low antibody titres against Aspergillus (often in parrots), the detection of galactomannan in the blood can help to diagnose aspergillosis. However, galactomannan is only released during active infection, i.e. during growth and spread of

the fungus. In inactive older granulomas, the polysaccharide cannot be detected in the blood.
Animals that display high antibody titres against Aspergillus normally do not have detectable galactomannan in the blood, so that antibody and antigen detection in combination can complement each other when making a diagnosis.

Aspergillus spp. – Antibody Detection	
Material	S 0.5 ml
Method	MAT
Species	Dog, cat, birds, cattle, others on request
Duration	1 – 2 days
Note	Culture detection of Aspergillus is often very difficult due to the site of infection. Antibody detection may be used to support the diagnosis.

13.3.2 Batrachochytrium

Batrachochytrium spp. are fungi which are being held responsible for large losses in **amphibians**.

Batrachochytrium dendrobatidis

The chytrid fungus Batrachochytrium (B.) dendrobatidis was first identified in Australia in 1998 and named in 1999. This fungus causes chytridiomycosis in anurans and salamanders and is thought to be partly responsible for the population decline and the global extinction of > 200 amphibian species.
Infections with B. dendrobatidis are often associated with very high mortality rates (in lab up to 100%), but the fungus is not necessarily lethal. Other factors such as stress or co-infections with other pathogens also seem to play a role.
B. dendrobatidis multiplies in keratinised tissue and therefore affects primarily the outer skin of adult animals (stratum corneum to stratum granulosum). In larvae, the keratinised mouthparts are affected. During metamorphosis, the infections can lead to dramatically high mortality rates. The clinical signs are often non-specific and may affect the skin (often appears macroscopically unchanged or "dull" or depigmented; hyperkeratosis and excessive episodes of skin shedding; mixed infections with severe erosions of the skin) as well as the behaviour (atypical behaviour, such as prolonged stay in the water, ataxia and CNS problems). Spontaneous deaths without previous clinical manifestation are also observed.

Batrachochytrium dendrobatidis – Pathogen Detection	
Material	Swab without medium: skin swabs of the ventral body surface (adult animals) or of the keratinized skin at the mouth (tadpoles), tissue (sloughed skin of infected animals)

Method	Realtime PCR
Species	Amphibians
Duration	1 – 3 days

Batrachochytrium salamandrivorans

Batrachochytrium salamandrivorans is a recently described highly-contagious and deadly chytrid fungus that has massively infested and killed fire salamanders especially in North-West Europe. Infected animals show anorexia, apathy and ataxia as well as skin lesions with superficial erosions and deep ulcerations all over the body. Batrachochytrium salamandrivorans can also infect other salamanders, but has not yet been detected in anurans.

Batrachochytrium salamandrivorans – Pathogen Detection	
Material	Swab without medium and tissue (also ventral body surface and lesions)
Method	Realtime PCR
Species	Amphibians (mainly salamander)
Duration	1 – 3 days

13.3.3 Cryptococcus

Cryptococcus is a yeast and mainly found in bird faeces and contaminated soil and dust. Cryptococci are potential causative agents of systemic infections in humans, domestic and wild animals. Direct transmission from vertebrates to humans has not yet been observed. Clinical disease occurs more frequently in cats than in dogs. It is possible to differentiate between nasal, central nervous, cutaneous or systemic forms of the disease. In dogs, nasal or cutaneous infection is less common; instead, systemic or central nervous signs are more frequently seen. In both species, the lungs can be affected as well. As Cryptococcus neoformans infection can lead to serious diseases, early detection is important.

Cryptococcus – Pathogen Detection (Antigen)	
Material	(1) S 0.5 ml (2) Faeces, swab with medium
Method	(1) Agglutination (2) Culture, mycology
Species	Dog, cat, others on request
Duration	(1) 1 – 2 days (2) 2 – 7 days

13.3.4 Dermatophytes

Dermatophytes are filamentous fungi that can cause skin lesions in humans and animals. The disease is called dermatophytosis. The fungi use keratin as a carbon source and colonise keratinised tissue, such as hair, skin or claws.
Dermatophytes are highly contagious. Infection is direct or indirect. Favourable factors are, for example, immunosuppression, reduced immune response (e.g. high age) or previous damage of the skin (e.g. by ectoparasites). Moreover, spores as form of propagation can remain infectious in the environment for years.
The clinical signs are diverse and dependent on the virulence of the fungal strain, the infection period and the immune status of the host. Typical patchy alopecia may appear on the face, ears and front legs. Pruritus may be missing or may range from mild to severe. In case of skin diseases, dermatophytosis must always be considered in the differential diagnosis.
Especially guinea pigs from pet shops are (asymptomatic) carriers of Trichophyton benhamiae in 90% of the cases. Most zoonotically transmitted dermatophytoses in humans are now caused by this pathogen. Before introducing guinea pigs into a household, particularly if there are children or immunocompromised persons, the animals should be examined for dermatophytes.

Dermatophytes – Pathogen Detection	
Material	Hair with roots, deep skin scraping, scales, scabs, claws
Method	(1) Culture (2) Realtime PCR
Species	Dog, cat, rabbit, guinea pig, horse, cattle (and other species)
Duration	(1) 3 days to 3 weeks (2) 2 – 4 days
Note	▪ Zoonosis! ▪ Culture also detects Malassezia; a false negative result is possible with previous treatment. ▪ PCR is validated for the detection of the following dermatophyte species: Microsporum canis, Nannizzia gypsea (formerly: Microsporum gypseum), Nannizzia persicolor (formerly: Microsporum persicolor), Trichophyton (T.) mentagrophytes, T. benhamiae, T. equinum, T. verrucosum, T. erinacei. Further types of skin fungus might also be detected by the PCR. Differentiation of the most common dermatophyte species can be conducted on request. ▪ PCR is not suited for therapy monitoring (dead dermatophytes are detected as well).

13.3.5 Macrorhabdus ornithogaster

Macrorhabdus ornithogaster is a yeast which is found in many different **avian** species, especially in budgerigars. Macrorhabdiosis is also called **megabacteriosis** or **going light syndrome.** Infected animals may develop maldigestion and lose weight even though there is no change in appetite. Undigested seeds can be excreted in the faeces, sometimes there is also blood in the faeces. Choking and vomiting as well as a general weakness can also be found in macrorhabdiosis. Inapparent carriers are frequent. Transmission presumably occurs through billing and feeding as well as through contaminated feed and water.

Macrorhabdus ornithogaster – Pathogen Detection	
Material	Faeces, crop lavage, proventriculus, smear on slide
Method	Stain, microscopy
Species	Birds
Duration	1 – 2 days

13.3.6 Nosema

Nosemosis is the most common disease of adult honey bees. The genus Nosema belongs to the microsporidia, which are parasitic fungi. It is spread through spores that are viable for several years. Two species can be differentiated: Nosema apis and Nosema ceranae, which can only be distinguished by PCR, but differ in pathogenicity. The pathogens infect the midgut cells and thus lead to yellowish diarrhoea. Affected animals are often unable to fly and the abdomen is bloated. Many times, signs are rather non-specific, the bees are weak. Nosemosis is a multifactorial disorder, which means outbreaks of the disease only occur when there are other adverse conditions involved, such as cold, other illnesses, etc. Hence, nosemosis is potentially curable by resolving the other factors. Due to the resistance of the spores, it is often difficult to completely eliminate the pathogens. As with many bee diseases, transmission occurs through the bees themselves (drifting or robbing) or through the beekeeper.

Nosema – Pathogen Detection	
Material	30 – 40 dead bees
Method	(1) Microscopy (2) PCR (differentiation) – only possible after positive microscopy
Species	Bees
Duration	(1) 1 – 2 days (2) 1 – 3 days
Note	If the result of the microscopic examination is positive, we recommend PCR differentiation between Nosema apis and Nosema ceranae.

13.3.7 Ophidiomyces ophidiicola

Ophidiomyces (formerly Nannizziopsis) ophiodiicola is a dermatophyte found in snakes. Infections with O. ophidiicola are associated with skin lesions, pustules, nodules and swelling of the skin. Lesions primarily occur on the head, but can also spread to the whole body.

Ophidiomyces ophidiicola – Pathogen Detection	
Material	(1) Swab without medium (skin), tissue (skin) (2) Swab with medium (skin), skin scraping
Method	(1) Realtime PCR (2) Culture, mycology
Species	Snake
Duration	(1) 1 – 3 days (2) 3 days to 3 weeks

13.4 Parasites

13.4.1 Aelurostrongylus abstrusus

The adults, which are 0.5 to 1.5 cm in size, live in the bronchioles and alveoli of cats and wild felids. They release eggs into the alveoli and terminal bronchioles. The larvae hatch there, enter the pharynx through coughing, are swallowed and excreted in the faeces. Various snails and slugs serve as intermediate hosts in which the development into infective L3 larvae takes place. Transport hosts such as mice and rats, but also birds, amphibians and reptiles play an important epidemiological role. In cats, the L3 larvae reach the lungs through the lymphatic system and the bloodstream when the intermediate or transport host is eaten.
Egg or larvae production usually lasts for 5 – 6 months, after that the infection is self-limiting and the cat remains immune to further infections with L3. Therefore, mainly young animals or immunocompromised cats are affected.
Lungworm infections can be asymptomatic, detection of lungworm larvae is often an incidental finding during routine coproscopic examinations. Mild to severe respiratory symptoms are also possible, including coughing, nasal discharge, tachypnoea and dyspnoea. Young animals are more frequently affected and usually suffer more severely.

Aelurostrongylus abstrusus – Pathogen Detection	
Material	(1) Faeces (fresh faecal sample) (2) Faeces, BAL, tracheal lavage, lung tissue
Method	(1) Baermann technique (2) PCR
Species	Cat
Duration	1 – 3 days

Note

- False negative results cannot be excluded due to prepatency, intermittent shedding and limited sensitivity of the test methods. Tests should therefore be repeated if there is a clinical suspicion.
- It is difficult to differentiate the L1 larvae microscopically from the L1 larvae of Troglostrongylus brevior.
- PCR detection of Aelurostrongylus abstrusus is included in the Lungworm Profile Cat (see Chapter 13.5.1, p. 241).

13.4.2 Angiostrongylus vasorum

Angiostrongylus vasorum is a globally distributed nematode that parasitises the pulmonary arteries and, less frequently, the right heart of dogs and wild canids. Infections with A. vasorum occur more often in Germany than normally expected (a prevalence of 7.4% according to Barutzki and Schaper, 2009). Thus, an infection with this lungworm should always be considered in differential diagnosis if respiratory and/or cardiovascular symptoms are present.

Dogs as definitive hosts get infected by ingesting L3 larvae when eating infected snails or slugs (intermediate hosts). L3 invade the lymphatic and blood system through the wall of the small intestine of the dog and enter the pulmonary arteries. Six to eight weeks p.i., the females begin to lay eggs. Via the blood, the eggs reach the fine pulmonary capillaries where they develop into L1 larvae and enter the pulmonary alveoli. From here, they are carried up by the ciliated epithelium or are coughed up, swallowed again and finally excreted in the faeces. L1 are taken up with the faeces by intermediate hosts and the infectious L3 then develop within them.

Especially young dogs between the age of one and two years are affected by canine angiostrongylosis. Besides clinically inapparent infections, the course of the disease may be mild to life-threatening. Clinical signs are highly variable, however, the main symptoms include cardiopulmonary signs such as dyspnoea and cough. The second most typical symptoms are coagulopathy with epistaxis, haemoptysis, haematoma and anaemia. Subsequently, DIC, circulatory insufficiency and death can occur. Vomiting or neurological symptoms like muscle tremor, ataxia, dizziness and epileptiform seizures are also possible.

Angiostrongylus vasorum – Pathogen Detection	
Material	(1) Faeces (3-day pooled sample) (2) EB, BAL, faeces (3-day pooled sample), tissue (lung, brain)
Method	(1) Baermann technique (2) Realtime PCR
Species	Dog
Duration	(1) 2 days (2) 1 – 3 days

Note
- If blood should be examined, a combination of PCR and ICA is recommended as it increases sensitivity.
- False negative results cannot be excluded due to prepatency, intermittent shedding and limited sensitivity of the test methods. Tests should therefore be repeated if there is a clinical suspicion.
- PCR detection of Angiostrongylus vasorum is included in the Lungworm Profile Dog (see Chapter 13.5.1, p. 241).

Angiostrongylus vasorum – Antigen Detection	
Material	S 0.5 ml
Method	ICA
Species	Dog
Duration	1 – 2 days

13.4.3 Anoplocephala

Anoplocephala perfoliata is the most common type of tapeworm in horses. It is globally distributed; in Germany, focal prevalences of up to 30% have been described. The moss mite acts as intermediate host; mites infected with tapeworm larvae are ingested by the horse while grazing. Within 6 – 10 weeks, the larvae develop into adult tapeworms. The adult worms colonise the mucosa of the small and large intestine, mainly the ileocecal valve, and cause local erosion and ulceration. Colic-like symptoms may occur.

Anoplocephala perfoliata – Antibody Detection	
Material	S 0.5 ml
Method	ELISA
Species	Horse
Test frequency	1 x per week

Note
- The test is suitable for stock screening and a targeted therapy.
- As Anoplocephala only releases eggs at intervals of several weeks, antibody detection is superior to pathogen detection from faeces (flotation/SAFC, microscopic detection of eggs) because of the higher sensitivity and specificity.

13.4.4 Babesia (Piroplasms)

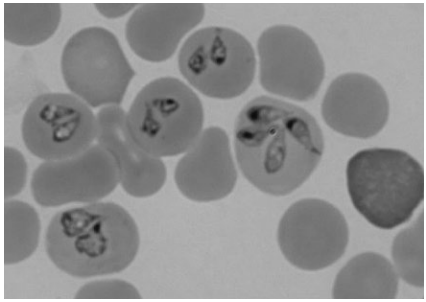
Babesiosis in mammals has become one of the most important parasitic diseases. The pathogens, which belong to the order Piroplasmida, are transmitted by ticks.
In *peracute or acute* infections, non-specific clinical signs such as fever, apathy and loss of appetite appear between the 5th and 28th day p.i. Anaemia, icterus and massive haemoglobinuria occur. A *chronic* infection, especially with B. vulpes (= B. microti-like

= B. annae), is characterised by fatigue and emaciation of the animals over months, anaemia and intermittent periods of fever.
Without treatment, dogs can also develop a *subclinical form,* especially when infected with B. canis and B. vogeli, with the blood count being normal again. Many dogs imported from Eastern Europe are subclinically infected with B. canis and thus pose a risk of infection for other dogs. In addition, the infection can be reactivated in these dogs by various factors. Cattle and horses can also remain carriers of Babesia for many years.

Dog

Babesia canis

B. canis is transmitted by Dermacentor reticulatus (ornate dog tick) and is more virulent than B. vogeli. A distinction is made between the French and the Hungarian strain.
French strain:
Distribution: north and east Mediterranean area, locally in Holland (The Hague, Arnhem) and England, focuses in western Germany (Saarland, Rhineland-Palatinate, Baden-Württemberg).
What is often noticed about the French strain is its low antibody production.
Hungarian strain:
Distribution: Hungary, Ukraine, Russia (beyond the north of Moscow), Romania, eastern Germany.
What is often noticed about the Hungarian strain is its high antibody production. In 80% of the animals, new infections with the Hungarian strain lead to death if untreated.



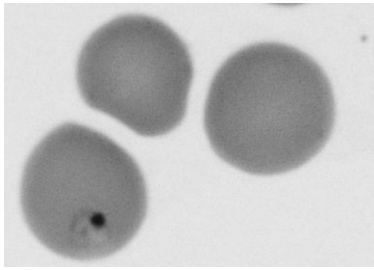
Erythrocytes with 2 – 4 Babesia (B. canis) (dog, Diff-Quik, 1000x magnification)

Babesia vogeli

Distribution: North Africa, the whole Mediterranean area, Portugal.
B. vogeli is transmitted by Rhipicephalus sanguineus (brown dog tick) and often only leads to low antibody titres.

Babesia gibsoni

Distribution: Asia, USA, Europe (imported)
Transmitted by Rhipicephalus sanguineus; distribution in Europe is considered questionable.
The cases of Babesia gibsoni described for Portugal and Spain were corrected later, partly into the pathogen Theileria annae (now: B. vulpes).



Erythrocytes with small Babesia (B. gibsoni) (dog, Diff-Quik, 1000x magnification)

Babesia vulpes (formerly Babesia microti-like, B. annae)
Distribution: north west Spain, Central Europa including England.
Vector unknown, assumed are: Ixodes hexagonus (hedgehog tick), I. ricinus (European castor bean tick), I. canisuga (dog tick) und Dermacentor reticulatus (ornate dog tick).

Cat

Babesia canis
Distribution: Thailand, Brazil, France, Poland, Germany
Very rare, only known in combination with other chronic underlying disease.

Babesia felis
Distribution: in parts of Africa

Babesia cati
Distribution: India

Cytauxzoon
Taxonomically, Cytauxzoon belongs to the family Theileriidae. This family differs from Babesiidae in the fact that reproduction does not only take place in erythrocytes but also in other tissues. In Cytauxzoon, the erythrocytic stages are preceded by meronts in lymphoid cells. Transmission occurs through the bite of different species of soft ticks. While feline babesiosis is a very rare but well-known disease in Europe, cytauxzoonosis in felids is one of the "emerging diseases". Cytauxzoon spp. found here differ genetically and pathogenetically from the species Cytauxzoon felis found in America. In recent years, there have been case reports in domestic cats from Italy, France, Spain, Switzerland, Germany and other countries.
In our own analysis of over 600 blood samples from anaemic cats from Germany, no piroplasms were detected by PCR. They therefore seem to play a minor role as causative agent of anaemia in Germany. Morphologically, Babesia and Cytauxzoon cannot be differentiated in blood smears.

Horse

Babesia caballi and Theileria equi (formerly Babesia equi)
Distribution: from the tropics and subtropics to the temperate zones. Ticks are vectors. Equine babesiosis (piroplasmosis) is also expected to occur in Germany.

Cattle

Babesia divergens
Distribution: in Europe from Finland down to the Mediterranean. Vectors are Ixodes ricinus (European castor bean tick) and Ixodes persulcatus (taiga tick). Babesia divergens is also pathogenic to humans.

Babesia major
Distribution: Central Europe in small endemic areas. In Germany, only on the North Sea islands Amrum, Norderney and Juist. Haemaphysalis punctata (red sheep tick) is the vector.

Babesia bigemina
Distribution: tropics and subtropics; in Europe: the Balkans, coastal areas in the Mediterranean, Portugal.

Babesia (Piroplasms) – Pathogen Detection	
Material	(1) EB 1 ml + blood smear (2) EB 0.2 ml, tick
Method	(1) Microscopy (2) Realtime PCR
Species	Dog, cat, horse, cattle
Duration	(1) 1 day (2) 1 – 3 days
Note	(1) Microscopic detection is possible from the 5th day p.i. onwards.It is preferable to collect capillary blood (edge of the ear) and spread it onto a glass slide. The detection from capillary blood significantly increases sensitivity! (2) PCR detects Babesia spp., Cytauxzoon spp. (cat) and Theileria (horse). Species differentiation is done automatically and free of charge after a positive PCR result. PCR detection is far more sensitive than the detection from a blood smear. In case of a chronic infection, it can be assumed that pathogens have spread to many sites. However, the concentration of pathogen DNA in the blood may be very low and thus lead to a negative result in the PCR. While a positive PCR is proof of an infection, a negative PCR never rules out an infection.

Babesia – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	(1) IFAT (cat; horse only when leaving the country) (2) ELISA (dog) (3) cELISA (horse – export to the USA, most sensitive test) (4) CFT (horse – often required for export)*
Species	Dog, cat, horse
Duration	(1 and 2) 1 – 2 days (3) 2 – 3 days (4) 5 days
Note	Seroconversion from the 2nd week p. i., maximum titre after 4 weeks. False negative results can occur in young dogs under 6 months and in the early phase of infection.

13.4.5 Coccidia

Coccidia are unicellular intestinal parasites found in a variety of domestic and farm animals. In many animal species, different species of coccidia occur with varying pathogenicity. They range from apathogenic species to highly pathogenic ones, which can lead to watery and haemorrhagic diarrhoea if there is a heavy infestation. Young animals are particularly affected here. In dogs and cats, especially puppies and kittens at 3 to 4 weeks of age can fall ill.
Coccidia have different predilection sites in the intestine, so that dissection may also provide an indication of coccidiosis and the respective coccidia species. Eimeria species are found in **ungulates, ruminants, poultry and rabbits**. Isospora is a parasite in **dogs and cats**, and in **pigs**, both Eimeria and Isospora occur, with Isospora suis often causing diarrhoea in piglets.

Tortoise intranuclear coccidiosis (TINC) is a severe disease in tortoises with high morbidity and mortality rates. TINC has already been detected in different tortoises and box turtles in North America and Europe. Clinical signs include lethargy, significant weight loss, erosive rhinitis, dyspnoea and occasionally skin lesions. Infections are generally systemic. These coccidia are most frequently detected in the intestine, pancreas, liver and kidney. However, they can also be found in the Eustachian tube, in macrophages of the spleen, in the middle ear, lungs and stomach. In live animals with rhinitis, they can also be detected in nasal lavage samples.

Coccidia – Pathogen Detection	
Material	Faeces
Method	Flotation
Species	All
Note	Testing for coccidia is part of the service "Endoparasites" (see Chapter 15.1, p. 262) and should be ordered via this service.

Intranuclear Coccidians (TINC) – Pathogen Detection	
Material	Swab without medium (nose, possibly cloaca), nasal lavage, tissue (nasal mucosa, intestine, pancreas, kidney, liver)
Method	Realtime PCR
Species	Tortoise, turtle
Duration	1 – 3 days

13.4.6 Crenosoma vulpis

The adult nematodes, which are 0.4 to 1.5 cm in size, are found in the bronchi and trachea of wild canids, occasionally also in dogs. The females lay eggs there, from which the L1 larvae hatch. These L1 larvae are coughed up, swallowed and later excreted in the faeces. They then infect various snail and slug species in which they develop into the

infective third-stage larvae (L3). Definitive hosts in turn become infected by ingesting these intermediate hosts or transport hosts (small amphibians and reptiles). After penetrating the intestinal wall, L3 migrate through the portal vein, liver and right heart into the lungs, where they mature into adults.
Lungworm infections can be asymptomatic, detection of lungworm larvae is often an incidental finding during routine coproscopic examinations. Mild to severe respiratory symptoms are also possible, including coughing, nasal discharge, tachypnoea and dyspnoea. Young animals are more frequently affected and usually suffer more severely.

Crenosoma vulpis – Pathogen Detection	
Material	(1) Faeces (fresh faecal sample) (2) Faeces, BAL, EB, tracheal lavage, lung tissue
Method	(1) Baermann technique (2) Realtime PCR
Species	Dog
Duration	1 – 3 days
Note	PCR detection of Crenosoma vulpis is included in the Lungworm Profile Dog (see Chapter 13.5.1, p. 241).

13.4.7 Cryptosporidia

Cryptosporidia are very small, unicellular parasites of the gastrointestinal tract. They are classified as coccidia. Different species are described with very similar morphology. Some of these are host-specific, others (e.g. Cryptosporidium parvum) can infect various animal species and humans (zoonosis).
Infections occur after intake of sporulated oocysts. The infectious dose is very low (approx. 100 oocysts). Subsequently the liberated sporozoites infect the intestinal epithelial cells, followed by a development cycle over trophozoites, meronts, merozoites, gamonts, zygotes and in the end again oocysts are formed. The oocysts excreted in the faeces show a high tenacity, are resistant to many disinfectants and can remain infectious for months. Therefore, e.g. contaminated pens or terrariums are frequent sources of infection.
Schlagwörter???
In **cattle,** cryptosporidiosis is a very common endoparasitosis. A large proportion of calves go through an infection with C. parvum. Clinically apparent courses with enteritis and diarrhoea occur especially in calves up to 3 weeks of life, often related to co-infections. Quite often **lambs, piglets** and **foals** are also affected.
A much lower prevalence is seen in **dogs and cats,** with usually asymptomatic infections. However, oocysts are excreted in the faeces here, too, for about 2 weeks. Manifest infections can be seen in puppies or immunocompromised animals (e.g. FeLV, FIV, distemper, neoplasia, etc.).
In **reptiles,** cryptosporidiosis is a serious disease that can cause severe losses, especially in snake and lizard stocks. C. serpentis is an important parasite in snakes and infects the gastric mucosa. Due to the chronic inflammation, a subsequent swelling and

hardening of the connective tissue in the gastric area can occur. A typical sign is the regurgitation of food days after ingestion. C. saurophilum (also called C. varanii) destroys the lining of the intestinal walls of affected lizards and snakes. Clinically, malabsorption with excretion of undigested food, profound weight and fluid loss are observed. Both pathogens are not pathogenic to humans. Quite often, C. muris and C. parvum are found in reptile faeces as intestinal passengers (origin: infected feeder animals). Therefore, further differentiation is absolutely necessary if the result is positive.

In laboratory diagnostics, several **methods** are available for detection. Already during the microscopic examination after specific enrichment (SAFC) oocysts can be found. As with all parasitological faecal examinations, sensitivity is relatively limited at approximately 60%.
In **cattle,** ELISA testing, which detects C. parvum, is recommended. The immunofluorescence test includes a wider range of Cryptosporidium species and is therefore suitable for **dogs, cats,** but also **small rodents** (guinea pig: C. wrairi).
In case of positive test results in **reptiles**, differentiation between pathogenic agents and intestinal passengers is of interest. For this, PCR with subsequent differentiation is recommended. In addition to PCR, detection by IFAT and microscopy are also available. Yet, these methods do not allow for a differentiation of the individual species. If reptile faeces are examined microscopically, the preparations will be stained additionally (modified Ziehl-Neelsen stain) to increase the detection rate.
It should be noted that a single negative result does not completely rule out a Cryptosporidia infection, as the pathogen can be excreted intermittently. So far, no successful treatment is available. The emphasis in the control of cryptosporidiosis is on symptomatic treatment and hygiene management.

Cryptosporidia – Pathogen Detection	
Material	Faeces; in **snakes** also: regurgitated material, gastric lavage, stomach biopsy
Method	(1) Antigen detection: EIA, reptiles: IFAT (2) PCR (3) Modified Ziehl-Neelsen staining
Species	Dog, cat, small mammals, reptiles, ruminants, New World camels, others on request
Duration	(1) IFAT: 1 day, EIA: 2 days (2) 1 – 3 days (3) 1 day
Note	If the PCR yields positive results in reptiles, it is possible to perform a differentiation of the Cryptosporidium species to distinguish between harmless intestinal passengers (origin: infected feeder animals) and pathogenic agents.

13.4.8 Demodex

Demodex mites are strictly host-specific ectoparasites of numerous mammals and of humans. So far, there have been three species each described in dogs and cats (dogs: particularly Demodex (D.) canis, rarely D. injai and D. cornei; cats: especially D. cati, but also D. gatoi and an unnamed species).
The entire development of demodex mites takes place in the hair follicles, the sebaceous and apocrine glands of the host. They cannot survive very long in the environment. Transmission mainly occurs postpartum while nursing. Demodex mites belong to the physiological skin fauna, but are facultative pathogenic. In dogs, there is often a low number of mites present without any clinical symptoms (prevalence up to 85%), but demodicosis is rare. Nevertheless, it is one of the most frequent dermatoses in dogs (especially young dogs), in cats, however, it is very rare.

In **dogs,** lesions generally start in the face or on the forelegs and spread from there. The *localised form* affects a few well-defined skin areas and most notably occurs in young dogs. The skin areas are often hairless and may also be scaly. Comedones are typical as well. In general, itching only occurs in case of secondary bacterial infections.
If more than four lesions are present, an entire body region or at least two paws are affected and if it continuously worsens without treatment, it is referred to as *generalised demodicosis*. There are usually secondary bacterial infections present and alopecia appears with follicular papules up to furunculosis, focal ulcerations and fistula tracts. Most of the time, there is no itching, but sometimes intense pain. Fever, anorexia, lethargy, lymphadenopathy and sepsis may occur and it might be fatal if not treated. Special forms are *podo-* and *otodemodicosis.*
Favourable factors for mass reproduction of mites include, e.g., endoparasitosis, malnutrition, cortisone treatment, neoplasia, hypothyroidism or hyperadrenocorticism. There is a genetic predisposition in young dogs (juvenile generalised demodicosis). These dogs should be excluded from breeding.
In **cats,** demodicosis particularly occurs if systemic diseases, such as diabetes mellitus, FIV, FeLV or neoplasia, are present, and most notably causes alopecia and crusts on the head and neck. Itching is also possible. **D. gatoi** is a mite that dwells rather on the surface and lives in the stratum corneum (not in the hair follicles). It has a short, broad body. D. gatoi is considered a primarily pathogenic parasite and is highly contagious. D. cati, in contrast, has the elongated morphology characteristic of Demodex mites, lives in the hair follicles and is part of the cutaneous fauna of cats.
It seems that hypersensitivity to the mites can cause severe pruritus even if only a few D. gatoi mites are present (similar to sarcoptic mange in dogs). How intense the itching is varies between cats; asymptomatic carriers have been described as well. The disease is characterised by pruritic lesions, self-induced alopecia, miliary dermatitis, excoriation, erosions and ulceration. Any part of the body may be affected, but the abdomen, inner thighs, flanks and forelegs appear to be the most common sites.
Demodicosis caused by D. gatoi should be included in the differential diagnosis of any cat with pruritus.

Demodex spp., Demodex gatoi – Pathogen Detection	
Material	Dog: deep skin scraping Cat: superficial skin scraping, (hairs)
Method	(1) Microscopy (2) Realtime PCR (Demodex spp., semi-quantitative; Demodex gatoi)
Species	Dog, cat
Duration	(1) 1 day (2) 1 – 3 days
Note	▪ Demodex PCR is used to detect 3 species each in dogs (D. canis, D. injai, D. cornei) and cats (D. cati, D. gatoi, unnamed species). PCR for D. gatoi can also be requested separately as an individual test. ▪ **Cat:** Because the density of infestation of D. gatoi is sometimes low, it is recommended to perform several superficial skin scrapings. ▪ D. gatoi is a mite that dwells rather on the surface and lives in the stratum corneum (not in the hair follicles) of the cat. It is considered a primarily pathogenic parasite and is highly contagious. ▪ Since Demodex mites belong to the normal skin fauna in **dogs** and only an excessive increase leads to demodicosis, a positive PCR result should always be interpreted in connection with clinical and epidemiological data. A negative PCR result cannot completely rule out an infection. ▪ If reduced immunocompetence or immunodeficiency is suspected, examination of the lymphocyte subpopulation by flow cytometry (see Immune Status, Chapter 7, p. 82) may be helpful.

13.4.9 Echinococcus

Echinococcus (E.) multilocularis does not only infect foxes as definitive hosts, but also dogs and cats; it is present in Central Europe (particularly southern Germany, northern Switzerland and western Austria), West and East Europe and focally in Scandinavia. Definitive hosts of E. granulosus are dogs and other canids. E. granulosus is mainly detected in the Baltic States, East and South Europe, including the Mediterranean, and is very rare in other places.
For the definitive hosts, echinococci are harmless intestinal parasites, whereas in intermediate hosts (herbivores and omnivores), metacestode cysts are mainly formed in the liver and lungs, even in humans as accidental hosts. In cystic echinococcosis caused by E. granulosus, encapsulated lesions are formed. In alveolar echinococcosis caused by E. multilocularis, in contrast, cysts show invasive growth with metastasis, so that the disease will lead to death if untreated.
There is a higher risk of echinococcus infestation and excretion of tapeworm eggs in dogs that eat rodents or that are used for fox hunting in dens. In Germany, echinococcosis is a **notifiable disease**.

Echinococci – Pathogen Detection	
Material	Faeces, tissue
Method	Realtime PCR
Species	Dog, cat, fox
Duration	1 – 3 days
Note	PCR can detect infections with E. granulosus and E. multilocularis, while microscopy after enrichment often only allows for the detection of non-differentiable Taenia eggs.

Echinococcus – Antibody Detection	
Material	S, HP 0.5 ml
Methode	ELISA
Species	Dog
Duration	5 days
Note	Antibodies against E. multilocularis are detected.

13.4.10 Encephalitozoon

Encephalitozoon cuniculi

The pathogen Encephalitozoon cuniculi causes **encephalitozoonosis** (also called **torticollis, wry neck, head tilt**) in rabbits. Approximately 80% of healthy rabbits carry the pathogen without showing any clinical signs. Mature infectious spores are mainly excreted intermittently in the urine, so that transmission takes place orally and nasally by eating infected food or sniffing at food and litter. However, infected pregnant female hares can also transmit the pathogen to their young in the womb. Faecal excretion of pathogens was detected but seems to be of little importance.
The pathogen has also been found in many other animal species such as dogs, foxes, rodents and some bird species and even in humans. Especially in immunocompromised persons, infection can be relevant.
Apart from head tilt, the clinical picture in rabbits is mainly characterised by ataxia, nystagmus, seizures or cramps. As the disease can also take a milder course, it is recommended to test for E. cuniculi in case of any neurological signs.

Encephalitozoon cuniculi – Pathogen Detection	
Material	Urine, CSF 0.2 ml, (faeces), tissue (e.g. kidney, brain or eye/lens)
Method	PCR
Species	Rabbit, guinea pig and others
Duration	1 – 3 days

Encephalitozoon cuniculi – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT
Species	Dog, cat, rabbit, guinea pig, others on request
Duration	1 – 2 days
Note	Positive titres can be expected from day 14 p.i. onwards. Subclinical infections are possible. IgG are detected. On request, there is an additional test available for the detection of IgM and IgG in rabbits and possibly in other animal species.

Encephalitozoon pogonae

Encephalitozoon pogonae has been described in bearded dragons (Pogona spp.; Agamidae) and belongs to the microsporidia. Microsporidia are unicellular, intracellular, spore-forming fungi reclassified from the group of protozoa. Due to similar morphology and genetic similarities, the pathogen was first identified as Encephalitozoon cuniculi. In 2016, it was then classified as an independent species.
Infections can be associated with non-specific signs such as lethargy, anorexia, weight loss and polydipsia. Multiplication takes place in macrophages of different organs, especially the kidneys, but also the gastrointestinal tract, liver, ovaries, spleen, lungs, the vascular endothelium and ventricular ependymal cells of the brain are affected, and granulomas are formed. Co-infections with agamid adenovirus 1 and coccidia have been described and may lead to a more severe clinical picture.
Faecal excretion can occur and transmission is likely via the faecal-oral route. Diagnosis is made by PCR and/or histopathology of the affected tissue or by PCR from a cloacal swab or faeces.

Encephalitozoon pogonae – Pathogen Detection	
Material	Swab without medium (cloaca), faeces, tissue
Method	PCR
Species	Bearded dragon
Duration	1 – 3 days

13.4.11 Entamoeba

Entamoeba are protozoan parasites and go through a direct life cycle. In reptiles, species of this genus can cause non-specific signs like diarrhoea, anorexia and lethargy. Organs such as the liver and the intestine are primarily affected, but other organs may also be involved. Infection can lead to severe inflammation with necrosis and abscesses. Acute death has been described as well. Entamoeba invadens is a pathogenic species in

reptiles that mainly affects captive animals. Symptomatic courses have mainly been described in snakes and carnivorous lizards, but also occur in different chelonian species. There may also be asymptomatic carriers, especially in herbivorous turtles and tortoises. However, these animals can also develop clinical amoebiasis. E. invadens should therefore be considered pathogenic for all reptiles.
This protozoan is transmitted by the faecal-oral route, through the ingestion of infectious cysts. Diagnostic testing can be done by PCR and/or histology of affected tissue or faeces, or by microscopic examination of faeces.

Entamoeba invadens – Pathogen Detection	
Material	(1) Faeces, tissue (2) Faeces
Method	(1) PCR (2) Microscopy after enrichment by SAFC method
Species	Snake
Duration	(1) 1 – 3 days (2) 1 day
Note	▪ It could be necessary to repeat testing as the amount excreted may vary or be low. ▪ Differentiation of the apathogenic species Entamoeba coli from the pathogenic species Entamoeba histolytica in warm-blooded animals and Entamoeba invadens in snakes can be done microscopically based on the number of nucleoli.

Entamoeba spp. – Pathogen Detection	
Material	(1) Faeces, tissue (2) Faeces
Method	(1) PCR (2) Microscopy after enrichment by SAFC method
Species	Reptiles
Duration	(1) 1 – 3 days (2) 1 day
Note	It could be necessary to repeat testing as the amount excreted may vary or be low.

Fasciola ➢ **see Chapter 15.2, p. 265**

13.4.12 Filaria

In Europe alone, five different filarial species are known to cause filariasis in dogs: Dirofilaria immitis, Dirofilaria repens as well as Acanthocheilonema (Dipetalonema) reconditum, Acanthocheilonema (Dipetalonema) dracunculoides and Cercopithifilaria grassi. Dirofilaria immitis causes cardiovascular dirofilariasis (heartworm disease), Dirofilaria repens causes cutaneous dirofilariasis. Both types of dirofilariasis are zoonoses and are transmitted by mosquitoes, including the common house mosquito (Culex pipiens) which is very common in Germany. The mosquito genera Aedes and Anopheles are also competent intermediate hosts and vectors in Europe.

Dirofilaria immitis – Pathogen Detection (Dirofilaria Antigen)

Material	S, EP, HP 0.5 ml
Method	ELISA
Species	Dog, cat, ferret, others on request
Duration	1 – 2 days
Note	▪ The serological examination is the most sensitive detection method for Dirofilaria immitis and detects the surface proteins of female, parturient filariae (macrofilariae), which are parasites in the heart or in larger vessels. ▪ The earliest time for a positive result is half a year p.i., but it can be delayed up to nine months if infected dogs receive heartworm prevention. Examination of puppies under the age of six months is therefore not appropriate. If in doubt, it is recommended to test for microfilariae or to take the test at a later point in time. Therapy monitoring should be done at the earliest 4 – 5 months after completing therapy. For the detection of microfilariae see below. ▪ Dirofilaria **Antigen Detection – Heat Pre-treatment** can be requested as a separate service.

Microfilaria – Pathogen Detection

Material	EB 0.5 ml
Method	Microscopy, Knott test, filtration test Realtime PCR; quantitative PCR (dog)
Species	Dog, cat Ferret (PCR)
Duration	1 – 3 days
Note	▪ Accumulation of the microfilariae of Dirofilaria immitis in the peripheral blood takes place in the evenings (adaptation to the piercing behaviour of vector mosquitoes). This behaviour has not yet been documented for other filarial species, but it is advisable to possibly take the blood sample in the evening hours.

- Before departing to South Africa, it is mandatory to do a filtration test.
- In case of a positive PCR result, differentiation of the filarial species can be done on request and is recommended in order to initiate treatment adapted to the type of filaria.
- Dog: Quantitative PCR is used for dose adjustment (in case of high pathogen loads, reduction of dose to reduce the risk of thromboembolism) and, as therapy monitoring, to exclude resistances. Quantitative PCR can be requested directly or following qualitative PCR.

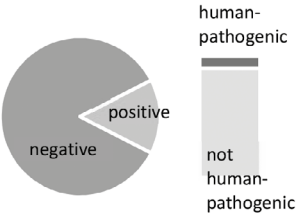
13.4.13 Giardia

Giardia is a flagellate that can be found in the intestine of mammals, birds, reptiles, amphibians and humans. There are some well-differentiated species, such as G. intestinalis (lamblia, duodenalis). Giardia is ingested orally (food, water) or through smear infection as cysts, excystates in the intestine and attaches as trophozoites to the intestinal wall where it replicates. Damage to and detachment of the intestinal epithelium cause chronic intermittent catarrhal to mucous-bloody diarrhoea. The cysts that are excreted in the faeces remain infectious for many months in cold water and a humid environment.
Except for Giardia in birds and amphibians, Giardia is partially of zoonotic nature. Seven variants have been identified through genetic characterisation of which variants (assemblages) A and B mainly occur in humans, variants C and D are primarily detected in dogs and variant F can mostly be found in cats. Across species, however, isolates of different subtypes of A as well as those of B can be detected in different animal species, so that a transmission from humans to animals and from animals to humans cannot be excluded. In dogs and cats, Giardia is the predominant type of intestinal parasites. In our own examinations, Giardia infections were detected in 15% of cats; 3.5% of these animals contained the human-pathogenic assemblage A.

Giardia – Pathogen Detection	
Material	Faeces
Method	(1) Microscopy after enrichment by SAFC method (2) EIA (antigen detection) (3) IFAT (detection of cysts) (4) Realtime PCR
Species	Dog, cat, small mammals, reptiles, large animals
Duration	(1, 2 and 3) 1 – 2 days (4) 1 – 3 days

Note

- Giardia infections lead to a decrease in vitamin B 12.
- If treatment of Giardia fails in cats, Tritrichomonas foetus should also be considered.
- In case of a positive PCR result, testing for the presence of humanpathogenic assemblages A and B can subsequently be conducted.



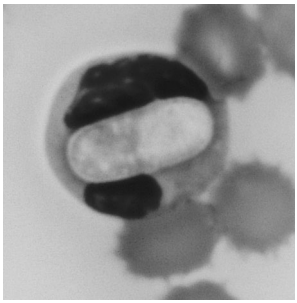
Giardia in cats:
15% of the animals are positive. 3.5% of the carriers are infected with human-pathogenic assemblage A.

13.4.14 Haemosporidia (avian)

Haemosporidia are common blood parasites in European songbirds and birds of prey (prevalence in blackbirds, for example, is close to 100%). The most important genera of these parasites include Plasmodium and Haemoproteus, which both produce malarial pigment and therefore belong to the malaria parasites, and Leucocytozoon. These 3 genera can be detected by our PCR test.
These parasites are globally distributed and very diverse, with well over 200 species currently described. Depending on the parasite species, the host spectrum ranges from highly specific (only one bird species affected) to generalised (various bird species from different, unrelated orders can be affected). Mixed infections are widespread in native songbirds.
The course of the disease ranges from peracute in susceptible bird species (e.g. penguins) to subclinical (e.g. blackbirds). The severity of the disease depends on the parasite species, the bird species as well as the age and the immune status of the host. Signs vary from reduced general condition, fatigue and anorexia to dyspnoea, anaemia, hepatomegaly, splenomegaly and pulmonary oedema. In penguins, sudden death is possible. Birds that survive the acute phase of infection may remain chronically infected for years. In these animals, the symptomatic phase of the disease can recur at any time if the animal is stressed or infected by another pathogen.

Avian Haemosporidia – Pathogen Detection	
Material	EB, tissue (spleen, liver, lung)
Method	Realtime PCR
Species	Birds (mainly songbirds and birds of prey (e.g. snowy owl), penguinst
Duration	1 – 3 days

13.4.15 Hepatozoon



Neutrophil granulocyte with **Hepatozoon canis** (acidophilic capsule) (Diff-Quik, 1000x magnification)

Hepatozoon canis belongs to the protozoa and goes through a typical coccidial life cycle with the dog as intermediate host. Asexual reproduction, schizogony, takes place in several generations in the endothelial cells of the spleen, liver and bone marrow. The merozoites formed here penetrate the leukocytes and differentiate into gamonts.
The definitive host, the tick, ingests the gamonts during the blood meal. Gamogony and sporogony take place in the tick and oocysts with 16 infectious sporozoites each are formed.
Infection with H. canis occurs by biting or swallowing an infected tick, primarily the brown dog tick (R. sanguineus), which is found in warm countries (mainly Southern Europe, South America, Africa and Asia). By now, the pathogen has also become endemic in several regions of Germany. Vertical intrauterine transmission is possible as well.
Acute infections are characterised by fever, lymphadenitis, anorexia, apathy, myositis and epileptiform seizures (bleeding in meninges). Massive lesions up to necrosis occur in the affected organs (spleen, liver, lung, brain). Chronic infections cause intermittent fever, lymphadenopathy, anaemia, diarrhoea and vomiting. Hyperaesthesia and muscular pain with stiffening of the neck muscles and the trunk muscles occur. Periosteal bone proliferation can be seen and epileptiform seizures may also occur in chronic diseases. In case of low parasitaemia, the infection may be clinically inapparent or may only have mild clinical signs.

Hepatozoon – Pathogen Detection	
Material	EB 0.2 ml, tissue (liver), tick
Method	(1) Microscopic buffy coat smear (semi-quantitative) (2) Realtime PCR (Hepatozoon canis/felis)
Species	Dog, cat
Duration	1 – 3 days
Note	Occurrence of the disease is mainly linked to the presence of the vector (preferably subtropical and tropical countries), but can also take place in animal shelters, where Rhipicephalus is often able to survive the winter.

13.4.16 Leishmania

Leishmaniosis is an infectious disease transmitted by insects. The vectors of Leishmania are sand flies (Phlebotominae). Leishmania is taken up during the blood-sucking process. The promastigote stages, which are infectious 6 – 12 days after the blood-sucking process, multiply in the sand fly. In Europe, the pathogen is Leishmania infantum. South of the Bosporus and especially in North Africa, Leishmania tropica occurs additionally. Other species of Leishmania have been described worldwide. The main infection areas in Europe are Spain, Portugal, Italy and Greece. Foxes and possibly also small rodents are considered to be pathogen reservoirs.
In Germany, naturally occurring sand flies (mainly Phlebotomus mascittii; no transmission of Leishmania is known so far) have been found along the Rhine rift in Baden-Württemberg, in Rhineland-Palatinate in the Kaiserslautern region, and in Saarbrücken in Saarland.
Infected animals can be asymptomatic for up to 7 years. The beginning of the disease is mostly characterised by lymphadenopathy, anaemia; in the cutaneous form of leishmaniosis, skin changes at the edges of the ears, the rhinarium and periorbital lesions are visible.
In chronic infections, the animals show reduced resilience, weight loss, lymphadenopathy, scaly, non-itchy skin change and eye changes.

Leishmania – Pathogen Detection	
Material	Qualitative PCR: swab without medium (conjunctiva), bone marrow, tissue (skin, lymph node, spleen), possibly EB Quantitative PCR (dog): EB or bone marrow
Method	Realtime PCR, cytology, histology
Species	Dog, others on request
Duration	1 – 3 days
Note	▪ PCR detection is much more sensitive than microscopic detection. ▪ Quantitative PCR in dogs has a high predictive value and is recommended in combination with serology, especially if titres are low or questionable. Quantitative PCR is also suitable for monitoring the course of infection and the treatment (mostly if titres are high); as such, the same sample material needs to be used und tested by the same laboratory to ensure that the results are comparable. ▪ PCR sensitivity is much higher in bone marrow than in EB.

Leishmania – Antibody Detection	
Material	S 0.5 ml; IFAT also EP, HP 0.5 ml
Method	IFAT, ELISA (only dog)
Species	Dog, cat, others on request
Duration	1 – 2 days

Note	Positive antibody titres appear at the earliest 2 – 3 weeks p.i. In asymptomatic dogs, ELISA is significantly more sensitive (approx. 90%) than IFAT (approx. 50 – 70%). Antibody detection is not suitable for therapy monitoring. Instead, serum protein electrophoresis and determination of C-reactive protein are recommended.

13.4.17 Neospora caninum

A neurological disease in dogs whose pathogens were similar to toxoplasma but could not be classified was first described in Norway in 1984. In 1988, a similar pathogen was found in dogs in the USA and was named Neospora caninum. It was later determined that Neospora caninum was identical to the Norwegian pathogen. Neosporosis has already been detected in many countries, it must therefore be assumed that it is spread worldwide. Natural infections have been found in dogs, cattle, horses, sheep, goats, red deer and cats. Numerous other animals can be experimentally infected.
Clinically, dogs and cattle are particularly severely affected. In the latter, at every stage of gestation, the clinical picture is determined by abortions. In dogs, neurological signs are prominent: ascending paralysis of the hind legs with hyperextension are a typical finding, but all limbs might be affected as well (tetraplegia). Other possible findings are dysphagia, paralysis of the jaw, head tilt, muscle weakness, cardiac insufficiency and pneumonia. Young, congenitally infected dogs show more severe signs, sometimes with sudden deaths. Older dogs often show signs of disseminated infection with polyradiculitis, polymyositis and possibly multiple organ involvement. Thus, in older dogs with neurological signs, neosporosis should always be included in the differential diagnosis. However, due to the often high antibody prevalence in certain regions, it is assumed that only a small percentage of infected dogs actually develops a clinical disease.

Neospora caninum – Pathogen Detection	
Material	**Dog:** faeces, CSF **Cattle:** abortion material, foetal tissue (brain, lung, liver, kidney)
Method	Realtime PCR
Species	Dog, cattle
Duration	1 – 3 days

Neospora caninum – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	IFAT, ELISA (cattle)
Species	Dog, cat, horse, cattle
Duration	1 day, cattle: 3 days

Ostertagia ➢ see Chapter 15.2, p. 266

13.4.18 Sarcoptes

Sarcoptes scabiei is the only species of the genus Sarcoptes. The Sarcoptes mites that are found in the different hosts are considered varieties of S. scabiei. The varieties are mostly host-specific, yet these itch mites are able to spread to other hosts, but usually do not settle there permanently.
Sarcoptes scabiei varietas canis causes sarcoptic mange in dogs. Red foxes are considered reservoir animals. Occasionally, the mite is also transmitted to ferrets, rabbits, guinea pigs, cats and humans.
Transmission occurs by direct contact between animals, but also indirectly via the contaminated environment. In dogs, indirect transmission seems to be gaining more and more importance. The whole developmental cycle of itch mites takes place on the host animal. In abraded skin material, the mites can survive up to 3 weeks, if the environment is damp and cool.
The mites burrow their tunnels into the horny layer of the skin. They prefer skin areas that are only sparsely haired, so they are often found on ears, elbows, lower abdomen and ankles. If the disease spreads, larger areas of the body may be colonised. The main clinical sign is massive pruritus, which is often intensified by heat.
In pigs, the mites spread beginning from the inside of the pinna. Bovine sarcoptic mange especially affects the head and neck, but can also spread to the udder. Mange causes loss of performance.

Sarcoptes – Pathogen Detection	
Material	Skin scraping (superficial, large-scale)
Method	(1) Microscopy (2) Realtime PCR (Sarcoptes scabei var. canis)
Species	(1) Dog, cat, farm animal, others (2) Dog, (cat, rabbit, ferret, other canids and mustelidae)
Duration	(1) 1 day (2) 1 – 3 days
Note	▪ Often, the infestation in dogs cannot be diagnosed by performing a skin scraping. In this case, the diagnosis can only be made by antibody detection. ▪ In cats, localised infections are found in the head and neck area. ▪ Zoonosis (pseudoscabies) ▪ Microscopic detection can be ordered via the service Ectoparasites. This also detects, for example, Notoedres.

Sarcoptes – Antibody Detection	
Material	S 0.5 ml
Method	ELISA
Species	Dog
Duration	1 – 2 days

Note	Seroconversion only begins after 2 – 3 weeks p.i. and persists for weeks or months after successful treatment.

13.4.19 Toxoplasma

Toxoplasma gondii is an obligate intracellular parasite which belongs to the class Coccidia. It is ubiquitous and causes clinical signs in all warm-blooded animals, including humans.
More than 1 billion people worldwide have antibodies against toxoplasma. In addition to fever and cold-like symptoms, congenital infection during pregnancy is feared. The intrauterine infection of the foetus occurs approximately 3 – 4 weeks after the first infection of a seronegative mother, when the placental barrier is crossed and placentitis occurs. Miscarriages and severe neurological or ophthalmological diseases can occur in the newborn. The cat as the definitive host excretes oocysts for approx. 3 weeks, which sporulate and become infectious after approx. 2 – 4 days, depending on temperature (daily cleaning of the cat litter box!).
Another source of infection is meat contaminated with tissue cysts that has not been sufficiently cooked before consumption. However, the main source of infection is gardening, where oocysts may be absorbed via contaminated soil (aerosols).
Cats can also be intermediate hosts at the same time; they rarely fall ill, but the clinical signs depend on where the tissue cysts are located. For example, hepatitis, cholangitis, dyspnoea may occur, and in case of CNS involvement, there may be ataxia, motor deficits and epileptic seizures. Additionally, uveitis and chorioretinitis can occur. The same signs can also be seen in dogs.
In sheep and goats, about 10% of the abortions worldwide are attributed to T. gondii.

In Germany, the **authorities must be notified** if Toxoplasma gondii is detected in cats, hares, rabbits, equids, ruminants, pigs and other mammals, especially those supplying food.

Toxoplasma gondii – Pathogen Detection	
Material	**Cat:** faeces (detection of excretion), CSF **Dog, rabbit, guinea pig:** CSF, tissue (e.g. brain) **Farm animals:** abortion material, tissue (brain, heart, lung and others)
Method	Realtime PCR
Species	Dog, cat, rabbit, guinea pig, farm animal, others on request
Duration	1 – 3 days
Note	Detection by parasitological examination is possible, but much less sensitive than PCR.

Toxoplasma – Antibody Detection	
Material	S, EP, HP 0.5 ml
Method	ELISA

Species	Dog, cat, rabbit, guinea pig, ruminants, New World camels, pig, others on request
Duration	1 – 2 days
Note	Detection of IgG (all species) and IgM (all species except for goats) **Cat:** Increased titres of IgM may indicate the excretion of oocysts. IgG antibodies are indicative of exposure and may also indicate clinical symptoms in cats.

13.4.20 Trichomonads

Trichomoniasis in birds (also called **canker** or **frounce**) is a disease of the gastrointestinal tract, especially of the crop, which is caused by protozoa of the order Trichomonadida. In particular, the flagellates are transmitted through the crop milk or through contaminated drinking water. It is most notably pigeons and finches, but also budgerigars, cockatiels and sometimes other parrots and canary birds that become infected. In pigeons, older animals are often persistently infected, clinically inapparent carriers. Trichomonas gallinae is a pear-shaped flagellate of 5 to 18 µm in size that uses small lesions in the mucous membrane to penetrate into the tissue and triggers the characteristic focal, yellowish tumours there. Occurrence of the disease is often associated with stress, vitamin deficiency or other illnesses and in some cases it can lead to the colonisation of inner organs such as the liver and the heart. Clinical signs often include regurgitation of undigested food, but diarrhoea can be an indicator, too. In case of a longer duration of the disease, the animals lose weight and become apathetic. In young birds, the mortality rate can be up to 40%.

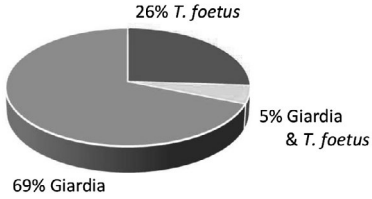
Trichomonas spp, – Pathogen Detection	
Material	(1) Swab with medium (crop), lavage sample (crop) (2) Swab without medium (crop), lavage sample (crop)
Method	(1) Microscopy (2) PCR
Species	Birds
Duration	(1) 1 day (2) 1 – 3 days

13.4.21 Tritrichomonas foetus

Tritrichomonas foetus is a protozoan of the order Trichomonadida. The trophozoite is characterised by three anterior flagella and one posterior flagellum. However, similar to Giardia, these are only microscopically visible in fresh faecal samples.
Transmission between cats occurs by faecal-oral route. Transmission between cattle or pig to cat is not documented.

Affected animals show typical large intestinal diarrhoea with frequent defaecation in small portions; admixtures of mucus and blood may occur. Tenesmus and uncontrolled defaecation are frequently observed. The general condition usually remains unaffected, increases in temperature are rare. T. foetus should always be considered as differential diagnosis in cats suffering from chronic, intermittent diarrhoea.
In cattle, Tritrichomonas foetus causes bovine trichomoniasis, which is characterised by inflammation of the reproductive tract in cows leading to repeat breeding and abortion. Bulls transmit the disease but display no clinical signs. In Germany, **bovine trichomoniasis is notifiable upon suspicion**.

Tritrichomonas foetus – Pathogen Detection	
Material	**Cat:** faeces **Cattle:** swab without medium (cervix), preputial wash
Method	Realtime PCR
Species	Cat, cattle, others on request
Duration	1 – 3 days
Note	▪ Especially in cases of faecal incontinence in cats, an infection with Tritrichomonas foetus should be considered. If anamnesis includes the following information "patient responded to therapy against Giardia, afterwards immediate recurrence", it indicates Tritrichomonas foetus. ▪ PCR is considered the most sensitive and specific method for the detection of Tritrichomonas foetus. As T. foetus is excreted intermittently, it is recommended to send a pooled faecal sample (collected over a period of 3 days) for analysis.



Tritrichomonas foetus and Giardia: mono an co-infections in infected cats

13.4.22 Troglostrongylus brevior

Troglostrongylus brevior has been detected in cats in Italy, Bulgaria, Spain and Greece. This parasite is 0.6 to 1.7 cm in size and mainly infects wild felids such as lynx and wildcats, but also domestic cats. It has a life cycle similar to that of Aelurostrongylus abstrusus: The adults parasitise in the bronchi and bronchioles of the definitive hosts. There, females lay eggs from which the L1 larvae hatch. After they are coughed up, swallowed and excreted in the faeces, snails and slugs act as intermediate hosts. It is very likely that paratenic hosts are also involved in the transmission of the infective L3 larvae to cats.

Lungworm infections can be asymptomatic, detection of lungworm larvae is often an incidental finding during routine coproscopic examinations. Mild to severe respiratory symptoms are also possible, including coughing, nasal discharge, tachypnoea and dyspnoea. Young animals are more frequently affected and usually suffer more severely.

Troglostrongylus brevior – Pathogen Detection	
Material	(1) Faeces (fresh faecal sample) (2) Faeces, BAL, tracheal lavage, lung tissue
Method	(1) Baermann technique (2) PCR
Species	Cat
Duration	1 – 3 days
Note	▪ False negative results cannot be excluded due to prepatency, intermittent shedding and limited sensitivity of the test methods. Tests should therefore be repeated if there is a clinical suspicion. ▪ It is difficult to differentiate the L1 larvae microscopically from the L1 larvae of Aelurostrongylus abstrusus. ▪ PCR detection of Troglostrongylus brevior is included in the Lungworm Profile Cat (see Chapter 13.5.1, p. 241).

13.4.23 Trypanosoma

Trypanosoma equiperdum

Infection with Trypanosoma equiperdum, also known as **dourine**, is a chronic or acute infectious disease in equids, which is transmitted directly between animals during mating. Infected equids are the only natural reservoir; the pathogens are present in the genital secretions of both mares and stallions. Incubation period, severity and duration of the disease vary considerably. Subclinical infections are possible; donkeys and mules are more resistant to the pathogen. Clinically, affected animals show inflammation of the outer genitals with depigmentation of the mucosa up to peripheral-neurological disorders/paralysis. Particularly in Asia and Africa, Trypanosoma is still widespread; Central Europe is currently considered free from Trypanosoma equiperdum. Export-relevant test.

Trypanosma equiperdum (dourine) – Antibody Detection*	
Material	S 1 ml
Method	CFT
Species	Horse
Duration	5 days
Note	In Germany, dourine is an epizootic disease that is **notifiable upon suspicion**.

Trypanosoma evansi

Trypansoma evansi is present in North Africa, the Middle East, Latin America and Asia. Transmission mainly occurs mechanically through blood-sucking insects. Infections have been described in various mammals, but especially in camels, cattle and horses. However, dogs can also be infected. In contrast to camels, clinical signs in dogs are often mild.

Trypanosoma evansi – Pathogen Detection (Antigen)	
Material	EB 1 ml
Method	Microscopy
Species	Dog
Duration	1 day
Note	If requested for travelling abroad, please order via the comment field or use service ID 8888 when ordering online.

Trypanosoma evansi – Antibody Detection	
Material	S 0.5 ml
Method	CATT (card agglutination test for T. evansi)
Species	Dog, horse, others on request
Duration	1 – 2 days

13.5 Pathogen Detection Profiles (PCR)

An overview of all profiles, particularly those not listed in this chapter with a combination of clinical-chemical parameter and/or serological testing for pathogens with direct pathogen detection by PCR, can be found in the current catalogue Prices and Services or on the Laboklin website in a separate section under the tab "Products".

13.5.1 PCR Profiles Dog/Cat

Anaemia Small (dog)	
Material	EB
Parameter	Anaplasma phagocytophilum, babesia (incl. species differentiation)

Anaemia Vector-borne (dog)	
Material	EB
Parameter	Haemotropic mycoplasma (incl. species differentiation), babesia (incl. species differentiation), Ehrlichia canis, Anaplasma phagocytophilum

BAL Profile ➢ **see Cytology (Chapter 18.3, p. 283)**

Diarrhoea Pathogens Cat

Material	Faeces
Parameter	Coronavirus, Tritrichomonas foetus, giardia, parvovirus, cryptosporidia

Diarrhoea Pathogens Dog

Material	Faeces
Parameter	Coronavirus, parvovirus, circovirus, giardia, cryptosporidia

Diarrhoea, Human Pathogenic Causes

Material	Faeces
Parameter	Salmonella, Yersinia enterocolitica, Campylobacter jejuni

Dysbiosis Profile ➢ **see Chapter 16.1.1. Faecal Profiles, p. 267**

Eye (cat)

Material	Swab without medium (eye)
Parameter	FHV, chlamydia, Mycoplasma felis

Eye (dog)

Material	Swab without medium (eye)
Parameter	CHV, chlamydia, mycoplasma

Flea (cat)

Material	Flea, EB
Parameter	Haemotropic mycoplasma (incl. species differentiation), Bartonella henselae, rickettsia

Lungworms (cat)

Material	Faeces, BAL
Parameter	Aelurostrongylus abstrusus, Troglostrongylus brevior

Lungworms (dog)

Material	Faeces, EB, BAL
Parameter	Angiostrongylus vasorum, Crenosoma vulpis

Neurology (cat)

Material	CSF 0.2 ml
Parameter	Coronavirus, Toxoplasma gondii, Bartonella henselae, bornavirus

Neurology (dog) ➢ **see catalogue Prices and Services**

Reproduction (cat)

Material	Swab without medium (vagina, prepuce), abortion material
Parameter	FHV, chlamydia, Mycoplasma felis

Reproduction (dog)

Material	Swab without medium (vagina, prepuce), abortion material
Parameter	CHV, chlamydia, mycoplasma, Brucella canis

Respiratory I (cat)

Material	Swab without medium (pharynx, nose, eye), BAL
Parameter	FCV, FHV, chlamydia, Mycoplasma felis, Bordetella bronchiseptica

Respiratory II (cat)

Material	Swab without medium (pharynx, nose, eye), BAL
Parameter	FCV, FHV, chlamydia, Mycoplasma felis

Respiratory III (cat)

Material	Swab without medium (pharynx, nose, eye)
Parameter	FCV, FHV, chlamydia

Respiratory IV (cat)

Material	Swab without medium (pharynx, nose, eye), BAL
Parameter	FCV, FHV

Respiratory I (dog)

Material	Swab without medium (pharynx, nose, eye), BAL
Parameter	CHV, CAV-2, CPiV, CRCoV, distemper virus, influenza A virus, Bordetella bronchiseptica, mycoplasma

Respiratory II (dog)

Material	Swab without medium (pharynx, nose, eye), BAL
Parameter	CAV-2, CPiV, CRCoV, Bordetella bronchiseptica, mycoplasma

Respiratory III (dog)

Material	Swab without medium (pharynx, nose, eye), BAL
Parameter	CPiV, CRCoV, mycoplasma

Travel Profiles Dog and Cat**/Thrombocytopenia Profile** Dog**/Tick-borne Diseases**
➢ **see catalogue Prices and Services**

Tick I – PCR	
Material	Tick
Parameter	Borrelia, TBE virus

Tick II – PCR	
Material	Tick
Parameter	Anaplasma phagocytophilum, piroplasms (babesia, cytauxzoon, theileria; incl. species differentiation), borrelia, TBE virus

Tick III – PCR	
Material	Tick
Parameter	Anaplasma phagocytophilum, Anaplasma platys, piroplasms (babesia, cytauxzoon, theileria; incl. species differentiation), borrelia, Ehrlichia canis, Hepatozoon

Tick IV – PCR	
Material	Tick
Parameter	Anaplasma phagocytophilum, piroplasms (babesia, cytauxzoon, theileria; incl. species differentiation), borrelia, TBE virus, rickettsia

13.5.2 PCR Profiles Small Mammals, Birds, Reptiles and Fish

Small Mammals

Ferret: Respiratory Profile	
Material	Swab without medium (pharynx, nose, eye), BAL, tissue
Parameter	Distemper virus, Influenza A virus, SARS-CoV-2

Rabbit: Respiratory Profile	
Material	Swab without medium (pharynx, nose, eye), nasal lavage, tissue
Parameter	Bordetella bronchiseptica, toxigenic Pasteurella multocida, chlamydia

Rat/Mouse: Respiratory Profile	
Material	Swab without medium (pharynx, nose, eye), BAL, tissue
Parameter	Mycoplasma pulmonis, chlamydia, Bordetella bronchiseptica

Birds

Avian Profile I	
Material	EB, feather
Parameter	PBFD, sex determination

Avian Profile II	
Material	EB, feather
Parameter	PBFD, polyomavirus

Avian Profile III	
Material	EB, feather
Parameter	PBFD, polyomavirus, sex determination

Avian Profile IV	
Material	EB, feather
Parameter	PBFD, polyomavirus, sex determination, herpesviruses (e.g. Pacheco's virus)

Avian Profile V	
Material	EB, feather + swab without medium (eye, pharynx, cloaca; preferably 1 swab from all 3 sites)
Parameter	PBFD, polyomavirus, herpesviruses (e.g. Pacheco's virus), chlamydia, bornavirus

Avian Profile VI	
Material	EB, feather + swab without medium (eye, pharynx, cloaca; preferably 1 swab from all 3 sites)
Parameter	PBFD, polyomavirus, chlamydia

Reptiles/Amphibians

Amphibian Profile	
Material	Swab without medium (skin), tissue (skin, organs)
Parameter	Batrachochytrium dendrobatidis, Batrachochytrium salamandrivorans, ranaviruses

Brumation Check (tortoise) ➢ **see catalogue Prices and Services**

Quarantine (aquatic turtle)

Material	Swab without medium (pharynx, cloaca; preferably 1 swab from both sites), nasal lavage
Parameter	Herpesviruses, mycoplasma, ranaviruses

Quarantine (boa/python)

Material	Swab without medium (pharynx, cloaca; preferably 1 swab from both sites), tracheal lavage + EB
Parameter	Adenoviruses, arenaviruses, paramyxoviruses/ferlaviruses, reoviruses, nidoviruses

Quarantine (colubrid/viper)

Material	Swab without medium (pharynx, cloaca; preferably 1 swab from both sites), tracheal lavage + skin (swab without medium or tissue)
Parameter	Adenoviruses, paramyxoviruses/ferlaviruses, reoviruses, Ophidiomyces ophidiicola
Note	For pharynx + cloaca, 1 swab can be used. Please take a separate swab for the skin.

Quarantine (lizard)

Material	Swab without medium (pharynx, cloaca; preferably 1 swab from both sites)
Parameter	Adenoviruses, ranaviruses, reoviruses

Quarantine (tortoise) ➢ **see catalogue Prices and Services**

Respiratory/Neurology (boa)

Material	Swab without medium, tracheal lavage + EB
Parameter	Adenoviruses, arenaviruses, paramyxoviruses/ferlaviruses, reoviruses

Respiratory/Neurology (pythons)

Material	Swab without medium (pharynx, cloaca; preferably 1 swab from both sites), tracheal lavage + EB
Parameter	Adenoviruses, arenaviruses, nidoviruses, paramyxoviruses/ferlaviruses, reoviruses, mycoplasma

Respiratory Profile Large (tortoise)

Material	Swab without medium (pharynx), nasal lavage
Parameter	Herpesviruses, mycoplasma, picornavirus

Respiratory Profile Small (tortoise, turtle)

Material	Swab without medium (pharynx), nasal lavage
Parameter	Herpesviruses, mycoplasma

Skin Profile (lizard)

Material	Skin + swab without medium (skin)
Parameter	Mycology Adenoviruses, Devriesea agamarum, ranaviruses

Small Mammals

Koi Carp Profile

Material	Tissue (gills)
Parameter	Koi herpesvirus, carp edema virus

13.5.3 PCR Profiles Horse

Abortion Profile (horse)

Material	Swab without medium (vagina, uterus), abortion material
Parameter	EHV-1, EHV-4, EVA, leptospira

Anaemia Small (horse)

Material	EB
Parameter	Anaplasma phagocytophilum, piroplasms (babesia, cytauxzoon, theileria; incl. species differentiation)

CEM Profile Mare 1

Material	2 swabs with medium with charcoal, e.g. Amies (fossa clitoridis, sinus clitoridis)
Parameter	Taylorella equigentialis from the 2 sites listed above
Note	▪ The sites meet the requirements of the EU Council Directive 92/65/EEC (cf. Chapter 13.2.33, p. 205). ▪ Samples must be analysed within 48 hours after collection.

CEM Profile Mare 2

Material	3 swabs with medium with charcoal, e.g. Amies (fossa clitoridis, sinus clitoridis, cervix)
Parameter	Taylorella equigenitalis from the 3 sites listed above

CEM Profile Stallion 1

Material	3 swabs with medium with charcoal, e.g. Amies (penile shaft, urethra, fossa glandis)
Parameter	Taylorella equigenitalis from the 3 sites listed above
Note	▪ The sites meet the requirements of the EU Council Directive 92/65/EEC (cf. Chapter 13.2.33, p. 205). ▪ Samples must be analysed within 48 hours after collection.

CEM Profile Stallion 2

Material	3 swabs with medium with charcoal, e.g. Amies (penile shaft, urethra, fossa glandis) + sperm
Parameter	Taylorella equigenitalis from the 3 sites listed above and in sperm

Eye Profile (horse)

Material	Swab without medium (eye)
Parameter	EHV-2, EHV-5

Foal Diarrhoea Pathogens

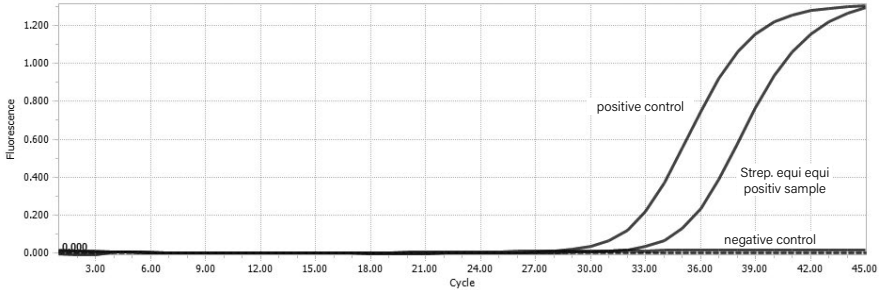
Material	Faeces
Parameter	Coronavirus, Lawsonia intracellularis, Rhodococcus hoagii (formerly Rhodococcus equi) (incl. vapA)

Respiratory Profile (foal)

Material	Swab without medium (nose), BAL, TBS
Parameter	EHV-1, EHV-4, Influenza A virus, Rhodococcus hoagii (formerly Rhodococcus equi) (incl. vapA)

Respiratory I (horse)

Material	Swab without medium (nose), BAL
Parameter	EHV-1, EHV-4, influenza A virus, Streptococcus equi equi/zooepidemicus



A **realtime PCR** curve, here using the example of Streptococcus equi equi. In contrast to classic gel electrophoresis, realtime PCR not only uses a specific primer pair, but also a probe which is labelled with a fluorescent dye. In positive samples, this label is cleaved and a fluorescence signal proportional to the amount of cleaved fragments is generated – this signal is measured and can be displayed in a curve in real time. Each PCR is accompanied by a positive and a negative control, which is the only way to analyse the PCR.

Respiratory II (horse)

Material	Swab without medium (nose), BAL + faeces
Parameter	EHV-1, EHV-4, Influenza A virus, Streptococcus equi equi, equine coronavirus

Respiratory III (horse)

Material	Swab without medium (nose), BAL, TBS
Parameter	EHV-1, EHV-4, Influenza A virus

Respiratory IV (horse)

Material	Swab without medium (nose or pharynx), BAL, EB 0.2 ml (viraemia) (detection from buffy coat is possible on request; we need at least 5 ml EB for this)
Parameter	EHV-1, EHV-4
Note	Herpesviruses usually have only a short viraemic phase. Detection from EB is therefore often only useful at the beginning of the disease.

Uveitis Profile ➢ **see catalogue Prices and Services**

13.5.4 PCR Profiles Ruminants (Infectious Disease Profiles)

Bovine Abortion Profile	
Material	Abortion material, swab without medium + swab with medium (vagina, uterus)
Parameter	Bacteriology PCR: Neospora caninum, Coxiella burnetii, chlamydia, BVDV

Bovine Respiratory Profile 1	
Material	Nasal lavage, swab without medium + swab with medium (nose, pharynx)
Parameter	Bacteriology PCR: BRSV, BPIV-3, Mycoplasma bovis

Bovine Respiratory Profile 2	
Material	Swab without medium (nose, pharynx), nasal lavage
Parameter	PCR: Mannheimia haemolytica, Histophilus somni, Mycoplasma bovis, Pasteurella multocida (toxigenic)

Camelid Abortion Profile	
Material	Abortion material, swab without medium (vagina, uterus)
Parameter	Leptospira, Toxoplasma gondii, chlamydia

Mastitis PCR Profile*	
Material	Milk
Parameter	PCR test of 16 mastitis pathogens (incl. mycoplasma, yeasts, Prototheca sp.) and β-lactamase gene (no antibiogram)

Small Ruminant Abortion Profile	
Material	Abortion material, swab without medium + swab with medium (vagina, uterus)
Parameter	Bacteriology PCR: chlamydia, Coxiella burnetii

13.5.5 PCR Profiles Pig (Infectious Disease Profiles)

Porcine Reproduction Profile	
Material	Abortion material, swab without medium (vagina, uterus)
Parameter	PPV, PRRSV, PCV-2, leptospira, chlamydia

Porcine Respiratory Profile	
Material	Nasal lavage, swab without medium + swab with medium (nose, pharynx)
Parameter	Bacteriology PCR: Mycoplasma hyopneumoniae, APP*, PRRSV, Influenza A, Pasteurella multocida (toxigenic)

14 Bacteriology/Mycology

14.1 Smears/Aspirates/Milk/Faeces/Blood

Below, the most frequent requirements for general microbiology are listed. If indicated, special tests can be ordered separately (see Chapters 13.2, p. 170; 13.3, p. 210; 14.3, p. 256; 14.4, p. 257 and 16.1, p. 267).

In Chapter 1.2, p. 20, we have summarised the pre-analytical requirements for the sample material and sample collection as well as the necessary information about the sample that needs to be provided on the submission forms.

The bacteriological examination detects **aerobic** pathogens. **Anaerobic** pathogens are not detected in aerobic bacteriology; their examination can either be requested as an individual service or as a combined service Bacteriology (aerobic and anaerobic).

Because of the increase in multidrug-resistant pathogens such as MRSA (methicillin-resistant Staphylococcus aureus) or MRSP (methicillin-resistant Staphylococcus pseudintermedius) as well as in Enterobacteriaceae of the ESBL strains (extended spectrum of beta-lactamases), a cultural examination and a subsequent antibiogram are almost indispensable in case of bacterial infections.

Mycology can be ordered as an individual test or in combination with the bacteriological examination for aerobic pathogens.

Abscess Material	
Parameter	Pathogenic agents, aerobic or anaerobic
Method	Bacterial culture (MALDI-TOF) and mycological culture
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	Aerobic: 2 – 3 days Anaerobic: approx. 1 week If mycology is included: up to 1 week
Note	Split the abscess cavity and swab the inside of the abscess membrane; requesting an anaerobic bacteriological examination is recommended, too.

Aspirates (from primarily sterile body cavities)	
Parameter	Pathogenic agents, aerobic or anaerobic
Method	Bacterial culture (MALDI-TOF) and mycological culture
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	Aerobic: 2 – 3 days Anaerobic: approx. 1 week If mycology is included: up to 1 week

Note
- For aspirates from primarily sterile body cavities, the use of a Peds Plus™ blood culture bottle is recommended; the sample material should not be cooled.
- If testing for actinomycetes and Nocardia is required, it needs to be requested separately.

Blood Culture

Parameter	Pathogenic agents
Method	Bacterial culture (MALDI-TOF) aerobic and anaerobic
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	7 – 10 days

Note
- Please order blood culture bottle(s) in advance (subject to a charge).
- Different blood culture bottles are available (see Chapter 1.9, p. 26). If there is a single bottle, analysis of aerobic and anaerobic pathogens is carried out from this bottle. The set contains a separate bottle for the blood sample for anaerobic testing with a transport medium optimised for these pathogens. The set should be preferred if sufficient blood can be obtained from the patient.
- Inoculation is done with 1 – 3 ml of blood for the single bottle; in the set, each bottle must be inoculated with 5 – 10 ml of blood.
- Blood should be collected during a fever episode.
- It is recommended to send in 2 – 3 (sets of) blood culture bottles (blood collection at different times, intervals of at least 1 hour).
- Storage and transport are uncooled.
- Full blood in normal blood tubes (e.g. EDTA tubes) or swabs do not lead to reliable results, so we recommend always using a blood culture bottle.
- Bacteraemia may occur physiologically in reptiles.

Bronchial Lavage, Bronchial Secretion, Tracheal Secretion

Parameter	Pathogenic agents, aerobic
Method	Bacterial culture (MALDI-TOF) and mycological culture
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	Aerobic: 2 – 3 days If mycology is included: up to 1 week
Note	For microbiological examination, lavage fluid should be sent in using a swab with transport medium.

Cerebrospinal Fluid

Parameter	Pathogenic agents, aerobic or anaerobic
Method	Bacterial culture (MALDI-TOF) and mycological culture

Species	Dog, cat, small mammals, large animals
Duration	Aerobic: 2 – 3 days Anaerobic: 1 week If mycology is included: up to 1 week

Ear Smear

Parameter	Pathogenic agents, aerobic
Method	(1) Bacterial culture (MALDI-TOF) and mycological culture (2) Parasitology
Species	Dog, cat, small mammals, large animals
Duration	(1) 2 – 3, mycology up to 7 days (2) 1 day
Note	▪ Please send in a swab with medium for culture examination. If a parasitological examination is also requested, a swab without medium must be sent in additionally. ▪ An antimycogram for Malassezia spp. is only performed on special request.

Faeces

Parameter	Aerobic facultative and obligate pathogenic bacteria incl. salmonella, fungi
Method	Bacterial culture (MALDI-TOF) and mycological culture
Species	Dog, cat, small mammals, birds, large animals
Duration	2 – 3 days
Note	Diagnostic findings and significance of bacteriological faecal examination see Chapter 16.1, p. 267.

Milk

Parameter	Pathogenic agents, aerobic, including bacterial count
Method	Bacterial culture (MALDI-TOF)
Species	Cow, sheep, goat (others: see note)
Duration	2 – 3 days
Note	▪ Cow: Examination of either 1/4 or 4/4 milk samples is possible. ▪ Sheep and goat: examination of 2/2 milk sample ▪ Bacteriological examination of milk samples of other mammalian species can be requested via the standard service Bacteriology. ▪ Determination of the cell count in 10 ml of cow's milk can be requested as a separate service. The cell count is determined by flow cytometry (duration: 1 day).

Swabs (nose, pharynx, urethra, vagina, etc.)	
Parameter	Pathogenic agents, aerobic or anaerobic
Method	Bacterial culture (MALDI-TOF) and mycological culture
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	Aerobic: 2 – 3 days Anaerobic: 1 week If mycology is included: up to 1 week
Note	For detection by culture, a swab with medium is required. A detection by culture from purulent material is often difficult as the bacteria are pre-damaged and therefore difficult to breed.

Urine, Uricult	
Material	Pathogenic agents, aerobic, including bacterial count
Method	Bacterial culture (MALDI-TOF)
Species	Dog, cat, small mammals, large animals
Duration	2 – 3 days Uricult: 1 – 3 days
Note	▪ It is best to submit urine (ideally cystocentesis or catheter urine or clean-catch midstream urine) and a urine swab (swab with medium). ▪ The urine culture test is also offered in combination with the urinalysis/sediment test (see Chapter 5, p. 68). In this case, at least 6 ml of urine or 5 ml of urine + swab with medium or 5 ml of urine + Uricult are required for the test.

Wound Swab	
Parameter	Pathogenic agents, aerobic or anaerobic
Method	Bacterial culture (MALDI-TOF) and mycological culture
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	Aerobic: 2 – 3 days Anaerobic: approx. 1 week If mycology is included: up to 1 week

14.2 Skin/Hair/Feathers

Skin Swabs	
Parameter	(1) Pathogenic agents, aerobic (2) Dermatophytes, yeasts
Method	(1) Bacterial culture (MALDI-TOF) (2) Mycological culture

Species	Dog, cat, small mammals, birds, reptiles, large animals, fish
Duration	(1) 2 – 3 days (2) Up to 3 weeks
Note	▪ Testing for pathogenic agents (bacteriology) can be ordered in combination with the mycological examination (skin) and, if required, with the parasitological examination for ectoparasites as well. For these combined services, it is necessary to submit a swab with medium and skin or skin scales or scab or hairs/feathers and, if parasitology is requested (see Chapter 15.3, p. 266), an additional skin scraping or tape test. ▪ For fish, we also offer this test in combination with the test for fish tuberculosis (Ziehl-Neelsen staining).

Skin, Danders, Hairs, Feathers

Parameter	(1) Pathogenic agents, aerobic (2) Dermatophytes, yeasts (3) Parasites (4) Pathogenic agents (aerobic), dermatophytes, yeasts, ectoparasites
Method	(1) Bacterial culture (MALDI-TOF) (2) Mycological culture + paraffin oil preparation (3) Parasitology: paraffin oil preparation (4) Bacterial culture (MALDI-TOF), mycological culture, paraffin oil preparation
Species	Dog, cat, small mammals, birds, reptiles, large animals
Duration	(1) 2 – 3 days (2, 4) Up to 3 weeks (3) 1 day
Note	▪ Testing for pathogenic agents (bacteriology) can be ordered in combination with the mycological examination (skin) and, if required, with the parasitological examination for ectoparasites as well. For these combined services, it is necessary to submit a swab with medium and skin or skin scales or scab or hairs/feathers and, if parasitology is requested (see Chapter 15.3, p. 266), an additional skin scraping or tape test. ▪ For pathogenic yeasts, an antimycogram can be performed on special request. ▪ It is absolutely necessary to collect samples from the edge of the skin lesions.

Trichogram/Pennogram

Parameter	Current condition of coat/plumage
Method	Microscopy
Species	Dog, cat, small mammals, birds, large animals

Duration	1 – 2 days
Note	In skin patients, a trichogram serves as an additional method for diagnostic assessment. It cannot replace histology, bacteriological, mycological and parasitological examinations, cytology and other tests, such as the determination of clinical-chemical parameters or hormone assays, but it can provide very valuable information. Trichograms are particularly suitable in the diagnosis of cats with hair loss that have no apparent itching and for which alopecia sine causa is already clinically suspected. A trichogram can also provide valuable diagnostic information in case of colour mutant alopecia.

14.3 Bacteriological Examination Horse

BAL Profile ➢ **see Chapter 18.3, p. 283**

Reproductive Fitness

Material	Swab with medium **Mare:** cervical swab **Stallion:** shaft swab, urethral swab or glans penis swab
Parameter	Pathogenic agents, aerobic
Method	Bacterial culture (MALDI-TOF) and possibly mycological culture
Species	Horse
Duration	2 – 3 days, mycology: 7 days
Note	▪ This test can be ordered with or without mycological examination. ▪ Culture examination for reproductive fitness is also offered in combination with CEM detection (culture). In this case, please send in an additional swab with Amies medium with charcoal. ▪ Furthermore, we offer a combination of Bacterial and mycological culture as well as pathological examination of 1 – 3 endometrial biopsies for mares.

Streptococcus equi

Material	(1) Swab with medium (nose, abscess, lymph node), lavage sample (guttural pouch, pharynx, BAL), TBS (2) Swab without medium (nose), lavage sample (guttural pouch, BAL), TBS, lymph node pus, tissue (lymph node)
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR
Species	Horse
Duration	(1) 2 – 3 days (2) 1 – 3 days

Note
- In culture, both subspecies (Streptococcus equi equi and Streptococcus equi zooepidemicus) are determined and differentiated by MALDI-TOF.
- If detection is to be done by means of PCR, it can be chosen between the single detection of Streptococcus equi equi or the detection of both subspecies mentioned above.

Taylorella equigenitalis (CEM)

Material	**Mare:** cervical or clitoral swab **Stallion:** shaft swab, urethral swab or glans penis swab (1) Swab with medium (Amies with charcoal, not older than 48 hours) (2) Swab with medium (Amies with charcoal), sperm
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR
Species	Horse
Duration	(1) 7 days, for export up to 14 days (2) 1 – 3 days

Note
- Culture: For exports to Canada, the incubation period is 14 days, otherwise 7 days.
- Even after successful bacteriological cultivation, it is not possible to create an antibiogram for CEM.
- Detection by PCR is offered as an individual service for one sample or as CEM profile for the examination of several sites (see Chapter 13.5, p. 246). The CEM Profiles stallion 1 and mare 1 are suitable as PCR detection before export to another EU country.
- In Germany, there is an **obligation to notify the authorities**.

14.4 Specific Pathogen Detection

Actinomyces, microaerophilic

Material	Aspirates, swab with medium, etc.
Method	Bacterial culture
Species	Dog, cat, small mammals, large animals
Duration	Approx. 8 days
Note	This examination is offered as service "Nocardia/Actinomyces".

Bordetella bronchiseptica (aerobic)

Material	(1) Swab with medium (Amies) (nose, pharynx), bronchial secretion (2) Swab without medium, bronchial secretion, BAL
Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR

Species	Dog, cat, rabbit, cattle, sheep, goat, pig, others
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	When requesting a bacteriological examination, please indicate clearly on the submission form that Bordetella bronchiseptica should be tested, as special culture media are required.

ESBL – Pathogen Detection

Material	Swab with medium, faeces
Method	Culture
Species	Dog, cat, horse, cattle, others
Duration	3 – 4 days
Note	▪ Extended-spectrum β-lactamase (ESBL)-producing bacteria of the order Enterobacterales such as E. coli, Klebsiella spp. and Proteus spp. are called ESBL. Due to the specific β-lactamase with extended spectrum of activity, the bacteria are resistant to β-lactam antibiotics, both to penicillins as well as cephalosporins (also to 3rd and 4th generation cephalosporins). The property of ESBL formation is encoded on easily transferable genetic segments and, during reproduction, can be transferred from one bacterial generation to the next (vertical transfer) or exchanged between bacteria (horizontal transfer). ▪ This test is performed in additon to the bacteriological examination. ▪ Testing for ESBL is also part of the service "Analysis of Multidrug-resistant Bacteria" (see below).

Analysis of **Multidrug-resistant Bacteria (MRSA, VRE, ESBL, Carbapenemase producer)**

Material	4 swabs with medium ▪ Swab 1: nasal-buccal ▪ Swab 2: skin (armpit or groin) or conjunctiva ▪ Swab 3: pooled swab from the animal's environment (dog basket + food bowl + floor) ▪ Swab 4: rectal swab
Method	Culture, microdilution
Duration	3 – 4 days
Note	▪ Phenotypic detection of resistance ▪ This profile is used to specifically screen for bacteria that are resistant to critically important antibiotics in order to identify asymptomatic carriers (e.g. therapy dogs in hospitals and care facilities). Particularly critical resistances occur in methicillin-resistant staphylococci (mainly Staphylococcus aureus and S. pseudintermedius

in dogs), vancomycin-resistant enterococci (mainly Enterococcus faecium and E. faecalis) and enterobacteria resistant to 3rd and 4th generation cephalosporins and to carbapenem antibiotics.
- Swabs 1 – 3 are used to detect MRSA; swab 4 is used to detect vancomycin-resistant enterococci and multidrug-resistant gram-negative bacteria.
- The sampling sites are recommendations. If other sites are prescribed by the hospital or the respective facility, please follow these recommendations.
- The profile provides phenotypic detection of resistance of selected bacterial isolates. It does not test for resistance genes by molecular biology.
- The test result reflects the current colonisation of the animal, so it needs to be considered whether regular screenings should be carried out.

Nocardia	
Material	Aspirates, swab with medium, etc.
Method	Bacteriological culture
Species	Dog, cat, small mammals, large animals
Duration	Approx. 8 days
Note	This examination includes the detection of Actinomyces.

Paenibacillus larvae (aerobic)	
Material	Honey and wax sample
Method	Bacterial culture (MALDI-TOF)
Species	Bees
Duration	At least 7 days
Note	- Two tablespoons of feed honey from the honey dome should be scratched from a central brood comb, packed into a freezer bag and sent in. - In Germany, **American (malignant) foulbrood** is an **epizootic disease** that is **notifiable upon suspicion**.

14.5 Susceptibility Testing

All antibiograms are performed by microdilution method according to CLSI standard.

Antibiogram (aerobes)

There are species-specific standard programs (see note). An antibiogram is invoiced as a fixed price per bacterial culture, even if several antibiograms need to be performed.

Duration 2 – 3 days

Note The antibiograms include the following number of antibiotics (at the time of printing)
- small animals: 31
- rabbits and rodents: 29
- birds: 25
- reptiles and amphibians: 19
- large animals: 34
- fish: 19

Antibiogram (anaerobes)

We can also perform an antibiogram if anaerobes are detected. Only antibiotics with potential efficacy against anaerobes are tested.

Duration 5 – 7 days

Note If the antibiogram is already ordered together with the test for anaerobes, the duration mentioned above only applies from the time of pathogen identification (the time at which you receive the findings on the anaerobes detected).

Antimycogram

We can perform an antimycogram if yeasts incl. Malassezia have been cultured. This needs to be requested, though. We store the cultivated yeasts incl. Malassezia for one week.

Duration 2 – 5 days

Analysis of **Multidrug-resistant Bacteria** ➢ **see Chapter 14.4, p. 258**

14.6 Additional Susceptibility Testing

Aromatogram Bacteria or Yeasts

The aromatogram is an in vitro test for testing the sensitivity of bacteria or yeasts/ Malassezia to various essential oils. The procedure is based on the principle of the agar diffusion test (disk diffusion test) or the microdilution method.

The in vitro efficacy of essential oils is classified into 4 categories: from ineffective to slightly, moderately and highly effective.

Duration Bacteria: 2 days
Yeasts: up to 7 days

15 Parasitology

15.1 Parasitological Examination – Faeces

Below, the most frequent requirements for parasitological faecal examination are listed. For the enrichment by flotation or SAFC method (sodium acetate-acetid acid-formalin concentration) we need a cherry-sized amount of faeces, if possible a 3-day pooled faecal sample. For serological detection by EIA, a pea-sized amount is usually sufficient.

Digital Endoparasites/Protozoa - Image Analysis

The image upload in "MyLab" allows you to quickly get a veterinary diagnosis of digital images with unclear findings from your practice. You can upload up to 4 images of a microscopic preparation with your diagnostic task via the **image analysis "Digital Parasitology"** in the password-protected area of our "MyLab" website. You will receive the laboratory findings by e-mail, usually on the same day.

Egg Count: Modified McMaster Method

Counting of worm eggs is done using a counting chamber after enrichment by flotation. This method is primarily used in horses, small ruminants and New World camels to carry out targeted deworming to reduce the development of resistance to strongyles. In targeted or selective deworming, individual deworming is only carried out if there are > 200 eggs per gram of faeces.
If all animals of a population that have a worm infestation are dewormed, only resistant worms survive. However, if only animals that have a more severe worm infestation are dewormed, an untreated worm population is also found in the animal population, which reduces the selective advantage of resistant worms and thus counteracts the further increase in resistance.

Duration 1 – 2 days

Egg Count Reduction Test

The egg count reduction test is used to check whether there is resistance to anthelmintics. To do so, the number of worm eggs in the faeces is counted before and after deworming. The number of eggs per gram of faeces is determined with the **modified McMaster method.** Within the concept of selective deworming, these results are used to carry out a targeted deworming of only those animals that have > 200 eggs per gram of faeces. 10 – 14 days after treatment, further individual samples are tested using the modified McMaster method. If high egg counts are still present, anthelmintic resistance should be considered. This method is mainly used in the large animal practice in ruminants, horses and pigs.

Even if deworming does not take place selectively at the level of the individual animal but, for example, of groups of animals, regular monitoring of the effectiveness of anthelmintics by means of an egg count reduction test is recommended.

Duration 1 – 2 days

Endoparasites (Protozoa and Worms)

Material	Faeces
Method	Microscopy after enrichment by flotation and SAFC method
Species	All
Duration	1 – 2 days
Note	▪ As parasite eggs or protozoa are only shed intermittently, the test needs to be repeated if there is any suspicion (it is best to send in 3 consecutive samples). ▪ Each sample is tested by flotation and SAFC method. ▪ Horse: From the eggs, differentiation of large and small strongyles is not possible; a larval culture would be required here, which can be requested separately.

Lungworm Larvae (Baermann Test)

Material	Faeces
Method	Baermann technique
Species	Dog, cat, small mammals, large animals
Duration	2 days
Note	▪ A Baermann test is indicated in cases of chronic cough and dyspnoea because of possible lungworm larvae infections. ▪ Lungworms **Angiostrongylus vasorum**, **Crenosoma vulpis**, **Aelurostrongylus abstrusus** and **Troglostrongylus brevior** cannot only be detected by Baermann technique but also by PCR in blood and, if necessary, BAL as individual test (see Chapter 13.4, p. 215 ff.) as well as in the Lungworm Profile Dog and the Lungworm Profile Cat (see Chapter 13.5.1, p. 241). ▪ In **horses**, BAL can also be tested.

Endoparasite Profiles

Endoparasite Profile

Material	Faeces
Method	Flotation, EIA
Species	Dog, cat
Duration	1 – 2 days
Note	▪ Analysis is done for endoparasites and Giardia sp. antigen (EIA). ▪ For other animal species, the parameters can be ordered individually.

Endoparasites (Reptiles)

Material	Faeces
Method	Microscopy after enrichment by flotation and SAFC method, Ziehl-Neelsen staining, fresh specimen
Species	Reptiles
Duration	1 – 2 days
Note	As parasite eggs or protozoa are only shed intermittently, the test needs to be repeated if there is any suspicion.

Endoparasites + IFAT

Material	Faeces (3-day pooled faecal sample)
Method	Flotation and IFAT
Species	Dog, cat
Duration	1 – 2 days
Note	The profile Endoparasites and IFAT includes the microscopic detection of helminths and protozoa by means of flotation and the detection of giardia and cryptosporidia by means of IFAT.

Equine Endoparasite Profile

Material	Faeces
Method	Flotation, SAFC method and modified McMaster method
Species	Horse
Duration	1 day

Large **Feline Endoparasite Profile**

Material	Faeces
Method	Flotation, EIA, realtime PCR
Species	Cat
Duration	1 – 3 days
Note	▪ Test for endoparasites, Giardia sp. antigen (EIA) and Tritrichomonas foetus (PCR). ▪ For other animal species, the parameters can be ordered individually.

Ferret and Chinchilla Parasite Profile

Material	Faeces
Method	Flotation, EIA
Species	Chinchilla, ferret
Duration	1 – 2 days
Note	Analysis is done for endoparasites and Giardia sp antigen (EIA).

Hedgehog Parasite Profile	
Material	Faeces
Method	Flotation, SAFC method and Baermann test
Species	Hedgehog
Duration	1 day
Note	Analysis is done for endoparasites and lungworm larvae.

Ruminant Endoparasites	
Material	Faeces
Method	Flotation, SAFC method and Baermann technique
Species	Cattle, sheep, goat
Duration	1 day

15.2 Testing for Specific Parasitic or Protozoa Infections

Cryptosporidia – Pathogen Detection	
Material	Faeces, in snakes also: regurgitated material, gastric lavage, stomach biopsy
Method	(1) Antigen detection: EIA, IFAT (reptiles) (2) Modified Ziehl-Neelsen staining (3) PCR
Species	Dog, cat, small mammals, reptiles, ruminants, New World camels, others on request
Duration	(1) IFAT: 1 day, EIA: 2 days (2) 1 day (3) 1 – 3 days
Note	If the PCR yields positive results in reptiles, differentiation of the Cryptosporidium species is possible on request. This is done to distinguish between harmless intestinal passengers (origin: infected feeder animals) and pathogenic Cryptosporidia.

Echinococci – Pathogen Detection	
Material	Faeces, tissue
Method	Realtime PCR
Species	Dog, cat, fox
Duration	1 – 3 days

Note	Detection by PCR can reveal infections with E. granulosus and E. multilocularis, while microscopy after enrichment is often only able to detect non-differentiable Taenia eggs. Echinococcosis is a **notifiable disease** in Germany.

Echinococcus – Antibody Detection

Material	S, HP 0.5 ml
Method	ELISA
Species	Dog
Duration	5 days
Note	Antibodies against E. multilocularis are detected. **Notifiable disease** in Germany, see above.

Fasciola hepatica (Liver Fluke) – Antibody Detection

Material	S, HP, milk, tank milk 0.5 ml
Method	EIA
Species	Cattle
Duration	3 days

Giardia – Pathogen Detection

Material	Faeces
Method	(1) Microscopy after enrichment (2) EIA (antigen detection) (3) IFAT (detection of cysts) (4) Realtime PCR
Species	Dog, cat, small mammals, reptiles, large animals
Duration	(1, 2 and 3) 1 – 2 days (4) 1 – 3 days
Note	If examination should also clarify whether human-pathogenic assemblages A and B are present, PCR is available as an alternative detection method (see Chapter 13.4.9, p. 230).

Nosema – Pathogen Detection

Material	30 – 40 dead bees
Method	(1) Microscopy (2) PCR (differentiation)
Species	Bees
Duration	(1) 1 – 2 days (2) 1 – 3 days
Note	If the result of the microscopic examination is positive, PCR can differentiate between Nosema apis and Nosema ceranae.

Ostertagia ostertagi – Antibody Detection	
Material	Milk, tank milk 0.5 ml
Method	EIA
Species	Cattle
Duration	3 days

Toxoplasma gondii ➢ **see Chapter 13.4.19, p. 236**

Tritrichomonas foetus ➢ **see Chapter 13.4.21, p. 237**

15.3 Parasitological Examination – Skin

Digital Ectoparasites - Image Analysis

The image upload in "MyLab" allows you to quickly get a veterinary diagnosis of digital images with unclear findings from your practice. You can upload up to 4 images of a case with your diagnostic task via the **image analysis "Digital Parasitology"** in the password-protected area of our "MyLab" website. You will receive the laboratory findings by e-mail, usually on the same day.

Skin	
Material	Skin scraping, tape test, plucked hairs, feathers
Method	Microscopy
Species	Dog, cat, small mammals, large animals
Duration	1 – 2 days
Note	The detection of ectoparasites is done by examination of skin scrapings, which should possibly be placed into shipping containers before they are sent in. If mites are suspected, the depth of the scraping should be adapted to the habitat of the respective mite. Because of their habitat, some parasites such as Demodex mites can be detected at the roots of plucked hairs. If there are fur mites or predatory mites, it is often possible to find eggs attached to the hair. Ectoparasite detection is also part of the service Bacteriology + Mycology + Ectoparasites.

16 Tests for Indigestion and Diarrhoea

16.1 Bacteriological Examination

The physiological intestinal flora consists of numerous bacterial species that live together with the host in a complex symbiotic ecosystem. Shortly after birth and the suckling phase, the gastrointestinal flora is established and remains largely stable for the rest of the life.
However, within the intestinal tract, there are considerable differences in distribution. While pathogen counts in the duodenum and the jejunum are rather low due to the influence of gastric acid, bile and pancreatic enzymes as well as the present mucosal defence systems, they massively increase in the ileocecal area and reach their highest concentration in the large intestine. The number of anaerobes and facultative anaerobic pathogens is 1,000 to 10,000 times higher than the number of aerobic microflora. The highest concentrations are reached by Bacteroides spp., lactobacilli and bifidobacteria as well as Enterobacteriaceae.

16.1.1 Faecal Profiles

If possible, please submit a faeces tube that is ¾ full. When doing a culture test, an aerobic bacteriological and possibly mycological examination, including enrichment for salmonella, is performed. **Pathogen differentiation** is done by **MALDI-TOF**. Unless otherwise stated, the test duration is 2 – 3 days.
If required, **serological pathogen differentiation** (e.g. salmonella) and an **antibiogram**, which are subject to a charge, will be performed additionally.

Dog and Cat

Combined Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, gas producers, endoparasites as well as Giardia sp. antigen EIA and Cryptosporidia antigen EIA

BARF Faecal Profile

Salmonella including enrichment, yersinia including enrichment, campylobacter, listeria, endoparasites

Duration 3 days; yersinia: 28 days

Faecal Profile Pathogenic Bacteria

Salmonella including enrichment, yersinia including enrichment, campylobacter, enteropathogenic E. coli incl. virulence factors (STa, STb, LTb, stx1, stx2, eae)

Duration 2 – 3 days; yersinia: 28 days

Faecal Profile Puppy/Kitten

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, gas producers, parvovirus, endoparasites, Giardia sp. antigen EIA

Large Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, Clostridium perfringens enterotoxin, Clostridioides difficile toxin A and B, gas producers, endoparasites, Giardia sp. antigen EIA

Small Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, gas producers

Dog and Cat – Faecal Profiles PCR

Diarrhoea, Human Pathogenic Causes

Salmonella, Yersinia enterocolitica, Campylobacter jejuni

Diarrhoea Pathogens Cat

Coronavirus, Tritrichomonas foetus, giardia, parvovirus, cryptosporidia

Diarrhoea Pathogens Dog

Coronavirus, parvovirus, circovirus, giardia, cryptosporidia

Dysbiosis Profile

Key bacteria intestinal microbiome quantitative, mycology, calprotectin, α-1 antitrypsin, secretory IgA (sIgA), pancreatic elastase (dog) and microscopic nutritive digestion (cat), endoparasites

Note For information on microbiome analysis, see Chapter 16.5, p. 278

Small Mammals, Birds and Reptiles

Avian Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, endoparasites

Note This profile is also available without the detection of endoparasites.

Ferret Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, endoparasites, Giardia sp. antigen EIA

Pigeon Faecal Profile

Salmonella incl. enrichment, endoparasites (incl. coccidia)

Reptile Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella

Rodent and Rabbit Faecal Profile

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, endoparasites

Horse

Dysbiosis Analysis ➢ **see Chapter 16.5, p. 278**

Faecal Profile Foal

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, gas producers, rotavirus, Clostridium perfringens enterotoxin, endoparasites incl. protozoa, strongyloides

Large **Faecal Profile (horse)**

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, Clostridium perfringens enterotoxin, Clostridioides difficile toxin A and B, gas producers, endoparasites, equine coronavirus (PCR)

Small **Faecal Profile (horse)**

Bacteriology (aerobic) and mycology, obligate and facultative pathogenic bacteria including enrichment for salmonella, endoparasites

Camelids

Camelid Faecal Profile

This profile includes the general aerobic bacteriological and mycological examination, including salmonella, testing for gas producers, endoparasites, coccidia, cryptosporidia as well as the virological examination for rotavirus and coronavirus.

Ruminants

Bovine Faecal Profile

In addition to an aerobic bacteriological, mycological examination and the test for obligate and facultative pathogenic bacteria, including enrichment for salmonella, as well as testing for endoparasites, this Bovine Faecal Profile also includes the detection of Mycobacterium avium ssp. paratuberculosis by means of PCR.

Calf Faecal Profile – Large

The Calf Faecal Profile Large includes the general aerobic bacteriological and mycological examination, including enrichment for salmonella and, if E. coli is present, its serological typing (K99). Furthermore, this profile includes testing for endoparasites, cryptosporidia and coccidia as well as the virological examination for rotavirus and coronavirus.
If salmonella are detected, they will be serologically typed as an additional service (subject to a charge).

Calf Faecal Profile (EIA)

The Calf Faecal Profile includes testing for rotavirus and coronavirus, E. coli K99 and cryptosporidia. The advantage of ELISA testing is the short test duration (1 day, max. 2 days).

Pig

Piglet Faecal Profile

The Piglet Faecal Profile includes the general aerobic bacteriological and mycological examination, including salmonella, testing for endoparasites, the virological examination for rotavirus and coronavirus as well as the test for Clostridium perfringens enterotoxin. If salmonella or E. coli (K88) are detected, they will be serologically typed as an additional service (subject to a charge).

Porcine Faecal Profile

The Porcine Faecal Profile includes the general aerobic bacteriological and mycological examination, including salmonella, as well as the detection of Lawsonia intracellularis by means of PCR.

16.1.2 Single Determinations

Campylobacter

Material (1) Faeces, swab with medium (intestine, cloaca)
(2) Faeces, swab without medium (intestine, cloaca)

Method	(1) Bacterial culture (MALDI-TOF) (2) Realtime PCR (only detection of Campylobacter jejuni)
Species	No limitations known
Duration	(1) 2 – 3 days (2) 1 – 3 days

Note
- A combined detection of campylobacter and yersinia by culture is also available.
- Resistances are common; treatment should therefore only be carried out after an antibiogram has been performed. Preparation of an antibiogram is only possible after performing a culture test.
- In dogs, feeding a barf diet is a source of infection for C. jejuni.
- Campylobacter of the species C. jejuni, C. coli, C. lari and C. upsaliensis are classified as thermophilic campylobacter.
- In Germany, campylobacteriosis (thermophilic campylobacter) is a **notifiable disease** in dogs, cats, ruminants and poultry.
- For genital infection cattle, sheep, see Chapter 13.2.9, p. 179.

Clostridioides difficile Toxin A and B

Material	Faeces
Method	ELISA
Species	No limitations known
Duration	1 – 2 days

Note
- Determination is specifically indicated if colitis-like symptoms occur.
- A faecal sample at least the size of a cherry is required.

Clostridium perfringens Enterotoxin

Material	Faeces
Method	ELISA
Species	No limitations known
Duration	1 – 2 days

Note
- Determination is specifically indicated if colitis-like symptoms occur.
- A faecal sample at least the size of a cherry is required.
- In carnivores, Clostridium perfringens enterotoxin can cause diarrhoea and vomiting of varying severity; enterotoxaemia is rare. Toxin formation is induced by antibiotic administration, stress, co-infections or especially by an unbalanced diet rich in proteins and connective tissue.
- Clostridium perfringens enterotoxin is gaining importance in **farm animals**. It mainly causes serious diseases in young animals like calves, lambs (lamb dysentery) or suckling piglets (necrotising enteritis). Older animals are affected by clostridiosis (cattle), pulpy kidney disease (sheep), struck (sheep) or sporadic catarrhal and haemorrhagic enteritis (pigs).

E. coli, eae Gene (Intimin)

Material	Faeces
Method	PCR after prior detection of E. coli by culture PCR detection of the eae gene, which encodes the production of intimin in calves
Species	Calf, piglet
Duration	3 – 4 days
Note	▪ The eae gene is a virulence factor of E. coli. The eae gene (E. coli attaching and effacing) encodes the production of intimin, which permits E. coli to attach itself to the intestinal cells. ▪ Detection of the eae gene is also part of the Faecal Profile Pathogenic Bacteria.

E. coli, enteropathogenic (STa, STb, LTb, stx1, stx2, eae)

Material	Faeces
Method	PCR after prior detection of E. coli by culture
Species	Calf, piglet
Duration	3 – 4 days
Note	E. coli which carry genes for the synthesis of enterotoxins or Shiga toxins (EPEC, STEC) and/or the virulence factor intimin (EPEC) can cause intestinal complaints such as diarrhoea, especially in young animals. Adult animals may shed enteropathogenic E. coli in faeces without showing any clinical signs.

Helicobacter spp.

Material	Vomitus, gastric lavage, gastric biopsy
Method	PCR
Species	Dog, cat, hamster, mouse, ferret
Duration	1 – 3 days
Note	▪ Positive PCR results from faecal samples do not necessarily indicate involvement of the stomach (gastritis, stomach ulcer, etc.), as PCR also detects intestinal Helicobacter spp. For this diagnostic task, stomach biopsies or vomitus are recommended. ▪ In Muridae, helicobacter can cause typhlitis and rectal prolapse, in sheep, however, it can cause abortions (see Chapter 13.2.18, p. 188)

Macrorhabdus ornithogaster

Material	Faeces, smear on slide, crop lavage, proventriculus
Method	Stain, microscopy
Species	Birds
Duration	1 – 2 days
Note	A faecal sample possibly the size of a pea is required.

Mycobacteria (Microscopic Detection of Acid-fast Rods)	
Material	Faeces, smear on slide
Method	Ziehl-Neelsen staining, microscopy
Species	No limitations known
Duration	1 – 2 days
Note	A faecal sample with a diameter of at least 2 cm is required. For fish, we also offer this test in combination with the bacteriological examination (service Bacteriology Fish + Fish Tuberculosis, material: tissue or swab without medium

Salmonella	
Material	(1) Faeces, (intestinal swab or cloacal swab) (2) Faeces; in birds also swab without medium (cloaca), eggs, tissue
Method	(1) Bacterial culture including enrichment, MALDI-TOF (2) Realtime PCR
Species	No limitations known
Duration	(1) 2 – 3 days (2) 1 – 3 days
Note	Culture with enrichment is the most sensitive test method. After successful culture cultivation, a serological pathogen differentiation follows (subject to a charge).

Yersinia	
Material	Faeces
Method	(1) Culture (MALDI-TOF) with cold enrichment (2) Realtime PCR (only Yersinia enterocolitica)
Species	No limitations known
Duration	(1) 4 weeks (2) 1 – 3 days
Note	▪ A faecal sample at least the size of a cherry is required. In exceptional cases, a swab with transport medium can also be used for culture. ▪ After successful culture cultivation, a serological pathogen differentiation follows (subject to a charge). ▪ A combined detection of campylobacter and yersinia by culture is also available.

16.2 Virological Examination

16.2.1 Faecal Profiles – Virology

Diarrhoea Profiles (dog/cat) ➢ **see Chapter 13.5.1, p. 241**

Virological Faecal Profile (dog, cat)

Parvovirus, rotavirus, coronavirus (EIA)

16.2.2 Single Determinations

Coronavirus – Pathogen Detection

Material	Faeces, in pigs also tissue (intestine)
Method	Realtime PCR Ferret: PCR Quantitative PCR (cat): droplet digital PCR
Species	Dog, cat, ferret, horse, ruminants, New World camels, pig
Duration	1 – 3 days
Note	▪ In small animals, a pooled faecal sample is recommended as it increases sensitivity. ▪ **Cat: Quantitative PCR** (from a 3-day pooled faecal sample) is available to evaluate the pathogen excretion, e.g. during rehabilitation of the cat population. For more information see Chapter 13.1.14, p. 134. ▪ Pathogen detection by means of an antigen test is part of the Virological Faecal Profile (EIA) or the Calf Faecal Profiles. ▪ Bovine coronaviruses also cause respiratory diseases (see Chapter 13.1.14, p. 132). ▪ For SARS-CoV-2 see Chapter 13.1.47, p. 167.

Parvovirus – Pathogen Detection

Material	**Dog:** qualitative PCR: faeces, EB, tissue (e.g. intestine or heart) quantitative PCR: faeces **Cat**: faeces, EB **Ferret:** rectal swab without medium, EB (viraemia), tissue (e.g. spleen, lymph nodes or bone marrow), (faeces – lower sensitivity than rectal swab) **Horse:** EB, serum, tissue (liver) **Pig:** swab without medium (genital tract), EB, tissue (e.g. abortion material)

Method	Realtime PCR / Ferret: PCR
Species	Dog, cat, ferret, horse, pig
Duration	1 – 3 days
Note	▪ PCR can be positive up to four weeks after vaccination with live vaccine. ▪ In **dogs**, differentiation between vaccine strain and field strains is possible on request (see Chapter 13.1.35, p. 159). ▪ In dogs, quantitative PCR is also possible from faeces (see Chapter 13.1.36, p. 159). ▪ Direct detection of parvovirus in the blood is possible approx. 1 – 5 days after infection. ▪ Porcine parvovirus causes fertility disorders (SMEDI, see Chapter 13.1.36, p. 159).

Parvovirus – Antigen Detection

Material	Faeces
Method	EIA
Species	Dog, cat
Duration	1 – 2 days
Note	A faecal sample at least the size of a cherry is required. The test may yield positive results 5 – 12 days after vaccination with live vaccine.

Rotavirus – Antigen Detection

Material	Faeces
Method	ELISA
Species	Dog, cat, horse, cattle, ruminants, New World camels
Duration	1 – 2 days
Note	A faecal sample at least the size of a cherry is required.

16.3 Tests for Maldigestion/Malabsorption

A faecal sample the size of a cherry is required.

Bile Acids

Material	Faeces
Method	ELISA
Species	Dog, cat
Test frequency	1 x per week
Note	Bacterial overgrowth of the small intestine or a shortened intestinal passage after surgery can lead to diarrhoea which causes a loss of bile acids. The symptoms are aqueous diarrhoea or steatorrhoea.

Microscopic Nutritive Digestion

Material	Faeces
Method	Microscopy
Species	Dog, cat
Duration	1 – 2 days
Note	This is a semi-quantitative detection of undigested food components, which depends on the type and composition of the diet. Increased excretion of starch, neutral fats, fatty acids and muscle fibres can therefore only indicate a reduced digestive and absorptive capacity (maldigestion or malabsorption). Microscopic Nutritive Digestion is also part of the Dysbiosis Profile for cats (see Chapter 16.1.1, p. 268).

Pancreatic Elastase E1

Material	Faeces
Method	EIA
Species	Dog
Duration	2 – 3 days
Note	This is a functional test for the diagnosis of exocrine pancreatic insufficiency in dogs. Elastase is pancreas-specific, stable in the intestine, and the test results are not altered by a substitution therapy. Pancreatic Elastase is also part of the Dysbiosis Profile (see Chapter 16.1.1, p. 268).

Particle Size

Material	Faeces
Method	Measurement
Species	Horse
Duration	1 – 2 days
Note	The particle size provides information about insufficient chewing of the feed components. Dental examination should follow. Furthermore, the ration should be checked with regard to the amount of components that are difficult to digest (e.g. excessive feeding of straw) and to structure (e.g. sufficient fibre length).

16.4 Determination of an Inflammatory Exudative Process

For these tests, a faecal sample approximately the size of a cherry is required.

α-1-Antitrypsin

Material	Faeces
Method	ELISA
Species	Dog
Test frequency	1 x per week
Note	▪ To detect protein loss syndrome ▪ α-1-antitrypsin is also part of the Dysbiosis Profile (see Chapter 16.1.1, p. 268).

Calprotectin

Material	Faeces
Method	Photometry
Species	Dog, cat
Duration	1 – 2 days
Note	▪ Biomarker used to diagnose an acute or chronic inflammatory intestinal disease, for the non-invasive detection of suspected IBD. ▪ Calprotectin is also part of the Dysbiosis Profile (see 16.1.1, p. 268).

Chemical Detection of Blood

Material	Faeces
Method	Chemical (modified Guajak test)
Species	No limitations known
Duration	1 – 2 days
Note	To avoid false-positive results, carnivores should not be fed any meat for 3 – 4 days.

Secretory Immunoglobulin A (sIgA)

Material	Faeces
Method	ELISA
Species	Dog, cat
Test frequency	2 x per week
Note	▪ As part of the adaptive and mucosa-associated immune system, sIgA protects against infections. In chronic inflammatory bowel disease, recurrent infections and atopy, sIgA levels may be reduced. Elevated levels indicate an increased immune response, e.g. to defend against enteropathogens or food allergens.

- Testing for sIgA is also part of the Dysbiosis Profile (see Chapter 16.1.1, p. 268).

16.5 Microbiome Analysis

The microbiota is the total of all microorganisms that colonise the body surfaces and the inside of an animal. Most of them are located in the colon (10^{11} – 10^{12} bacteria/g of faeces). 99.9% of the bacteria that grow under these conditions are anaerobes. The main function of these organisms is the nutrition and protection of the mucous membrane. If there are bacterial imbalances, these tasks can only be fulfilled insufficiently. As a result, colonisation resistance is reduced and increased colonisation with obligatory or facultative pathogens takes place. Due to the reduced barrier function of the mucosa, antigens, endotoxins and histamine, amongst others, can pass from the intestinal lumen into the bloodstream and thus initiate or aggravate pathomechanisms.
As bacterial markers, some bacteria and groups of bacteria indicate a dysbiotic state of the gut. This can be used to diagnose dysbiosis and to fully analyse the gut microbiome (all genetic information collected from the commensal gut bacteria).

Dysbiosis Analysis	
Material	Faeces
Method	PCR (quantitative)
Species	Dog, cat, horse
Duration	3 – 5 days
Note	▪ Key bacteria intestinal microbiome quantitative (incl. anaerobes) ▪ Indications for the examination of the microbiome: – chronic diarrhoea, flatulence, constipation – exocrine pancreatic insufficiency, deficiency symptoms – disorders of the immune system (immune deficiency, feed allergies, atopic dermatitis) – inflammatory intestinal diseases (also for therapy monitoring) – leaky gut – loss of performance – diagnosis of microflora dysfunction after antibiotic therapy ▪ It is also possible to perform this test during treatment with synbiotics or probiotics! ▪ For dogs and cats, microbiome analysis is also part of the **Dysbiosis Profile** (see Chapter 16.1.1, p. 268) ▪ Possible treatment option autovaccines: see Chapter 17, p. 279.

17 Autogenous Vaccine (Autovaccine)

For chronic recurrent bacterial infections, treatment with an autogenous vaccine (autovaccine) is an alternative and promising option. Such treatment also helps to counteract the development of resistance, as it can often reduce or avoid the administration of antibiotics.
Autogenous vaccines are individually produced for each animal from their own aerobic pathogens which are relevant for the infection – a previous culture test with pathogen isolation is required. It is also possible to produce an autovaccine for several animals that show the same signs. The aim of the treatment with autovaccines is to sensitise the immune system to the isolated pathogen(s) and to stimulate the formation of specific antibodies.
Pathogen concentration, application method (see Chapters 17.1 and 17.2) as well as application quantity, intervals and duration depend on the sampling site, clinical history and species. It should be noted that an autovaccine can only reach its full potential if underlying diseases have been excluded in advance through extensive diagnostics.

Preparation of an autovaccine

Order	Must be done in writing. We need a **prescription** from your veterinary practice/clinic for the preparation of this product!
Species	We prepare autovaccines for the following species: Dog, cat, Rabbit, rodents, ferret, Parrot, budgerigar, mynah, hawk, pigeon, ostrich, Snake, Horse, Llama, alpaca, Gibbon, orang-utan, gorilla, marmosets, giant panda, lion, tiger, elephant, tapir, elk, giraffe, Bactrian camel, kangaroo (Applies only to non-food producing animals.)
Method	An aerobic microbiological examination is performed of a sample of the affected organ system and the relevant pathogens are isolated. They are multiplied in pure culture, then inactivated and subsequently used to produce the vaccine.
Duration	3 weeks
Delivery	Exclusively to the veterinary pharmacy

17.1 Autovaccine

Injection Vaccine	
Material	Swab with medium, hairs, etc.
Note	▪ Indications: chronic skin/ear infections (e.g. Staphylococcus pseudintermedius), respiratory infections ▪ For ordering, species, method and duration, see introduction.

Oral Vaccine	
Material	Faeces (possibly also faecal swab with medium)
Note	▪ Indications: chronic diarrhoea, faecal water syndrome horse ▪ For ordering, species, method and duration, see introduction. ▪ Chronic diarrhoea is one of the indications for microbiome analysis (see Dysbiosis Analysis/Profile in Chapter 16.5, p. 278). For the subsequent preparation of an autovaccine, a previous culture test with pathogen isolation is required.

Vaccine for Inhalation	
Material	Swab with medium (respiratory tract), BAL, tracheal lavage
Note	▪ Indications: chronic respiratory infections (nasopharyngeal area) ▪ For ordering, species, method and duration, see introduction.

17.2 Combination Vaccine

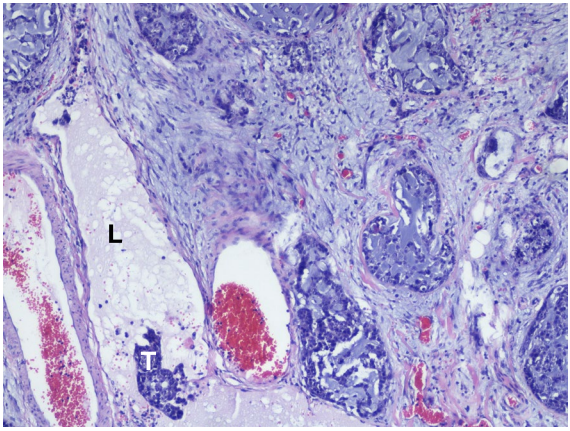
Combination Vaccine (Oral and Injection Vaccine)	
Material	Swab with medium (e.g. vagina), urine
Note	▪ Indications: chronic urogenital infections ▪ For ordering, species, method and duration, see introduction.

18 Pathology

18.1 Histopathology

Endometrial Biopsy (mare)	
Material	1 – 3 tissue samples approx. 1.0 x 1.0 x 0.5 cm (1 x corpus, 2 x cornua uteri), formalin-fixed (4% neutral buffered formaldehyde ≙ 10% formalin; if there is a risk of freezing, please add a maximum of 10 vol% abs. of alcohol to prevent the sample from freezing)
Method	Microscopy (standard und special stainings)
Duration	3 – 7 days
Note	▪ For the following clinical issues: breeding suitability test, barren mare, abortion, etc. ▪ Histological diagnosis of endometritis, endometrosis, angiopathies, (pathological) inactivity, lymphatic lacunae, false differentiations, etc. ▪ Fertility prognosis (categorisation according to Kenney & Doig 1986, mod. according to Schoon et al. 1992) ▪ Endometrial biopsy can also be requested via the standard service Pathology and as a combined service together with reproductive fitness and mycological examination. In this case, a swab with medium must be submitted in addition to the formalin-fixed sample.

Histopathology	
Material	▪ Formalin-fixed tissue samples (fixation in 4% neutral buffered formaldehyde ≙ 10% formalin; if there is a risk of freezing, please add a maximum of 10 vol% abs. of alcohol to prevent the sample from freezing) ▪ For dermatologic issues use skin punches (≥ 0.6 cm).
Method	Microscopy (standard und special stainings)
Duration	3 – 7 days
Note	▪ Fill in the submission form Pathology. ▪ Depending on the sample material, histopathology must be requested separately on the submission forms, based on the effort required: - Examples of histopathology at a basic price (per diagnostic task): tumours (up to 2 sites), skin biopsies, uterine biopsies, organ biopsies up to 3 organs - Examples of histopathology with higher costs: toe, whole organs (e.g. spleen, testicles), 3 – 5 mammary complexes, biopsies of 4 – 6 organs, tumour margins/tumour bed biopsies extensive



Histopathology: Malignant mammary tumour in a dog, invasion of tumour cells (T) into a lymph vessel (L). Haematoxylin-eosin staining, 100x magnification.

18.2 Immunohistology

Immunohistology	
Material	Formalin-fixed and/or paraffin-embedded tissue samples
Method	Microscopy (labelling with specific antibodies)
Duration	5 – 7 days
Note	**Tumour diagnosis:** ▪ CD3/CD20 (if required CD79a/Pax-5) in lymphoma diagnosis ▪ c-KIT expression pattern in mast cell tumours ▪ Ki-67 antigen as proliferation marker ▪ Cox-2, prostaglandin synthesis enzyme, in tumours possibly an indicator of the effectiveness of inhibitors (NSAIDs) ▪ Cytokeratin, vimentin, CD18, melan-A to differentiate between epithelial/spindle cell/round cell/melanocytic tumours **Infection diagnosis:** ▪ e.g. FIP virus

18.3 Cytology

Cytology	
Material	Aspirate, air-dried smears on slides (SLD) after puncture, impression smears or fine needle aspiration (stained or unstained on slides **without** cover glass)
Method	Microscopy (standard and special stainings)
Duration	2 – 4 days
Note	▪ Please send **liquids** (puncture fluids, excretions, secretions) for further clinical chemical examinations native in neutral tubes (also suitable for bacteriology) and additionally in an EDTA tube (superior cell morphology). ▪ Depending on the sample material, cytology must be requested separately on the submission forms, based on the effort required: - Examples of cytology at a basic price: 1 site: up to 4 SLD, 1x liquid/lavage plus 2 SLD - Examples of cytology with higher costs: 1 site: 5 – 6 SLD, 2 sites up to 4 SLD per site, liquid/lavage plus more than 2 SLD or several liquids - Quick **analysis of digital images** via image upload in **"MyLab"**: To get a veterinary diagnosis, you can upload up to 4 images of a cytological preparation from your practice with your diagnostic task via the image analysis **"Digital Cytology"** in the password-protected area of our "MyLab" website. You will receive the laboratory findings by e-mail, usually on the same day.

BAL Profile	
Material	Bronchoalveolar lavage (1 ml), native smear, swab with medium
Method	Cytology, Culture (bacteriology, mycology), Molecular biology: PCR (dog), realtime PCR (cat)
Species	Dog, cat, horse
Duration	2 – 7 days
Note	The profile includes cytology, bacteriology and mycology, as well as analysis for mucous membrane-associated mycoplasma in dogs and Mycoplasma felis in cats.

CSF Profile	
Material	Liquid (0.7 ml) (+ cytocentrifugation, if possible)
Method	Cytology, photometry, flow cytometry
Species	Dog, cat, horse
Duration	2 – 4 days

Note	The profile includes cytology, total protein, cell count, glucose. Please send puncture fluid for clinical chemical examinations native in a neutral tube (also suitable for bacteriology) and additionally in an EDTA tube (superior cell morphology).

Synovia Profile

Material	Synovial fluid (1 ml), native smear
Method	Cytology, photometry, flow cytometry
Species	Dog, cat, horse
Duration	2 – 4 days
Note	The profile includes cytology, total protein, cell count. Please send puncture fluid for clinical chemical examinations native in a neutral tube (also suitable for bacteriology) and additionally in an EDTA tube (superior cell morphology).

Thoracic/Abdominal Cavity Profile

Material	Liquid (2 ml) + native smear + sediment smear
Method	Cytology, photometry, flow cytometry, Rivalta test (cat)
Species	Dog, cat, horse
Duration	2 – 4 days
Note	The profile includes cytology, total protein, albumin/globulin, cell count, cholesterol, triglycerides, LDH, glucose, Rivalta test (cat). Please send puncture fluid for clinical chemical examinations native in a neutral tube (also suitable for bacteriology) and additionally in an EDTA tube (superior cell morphology).

Bone Marrow Cytology ➢ see Chapter 3, p. 37

Differentiation Exudate/Transudate

Parameter	Low-protein transudate	Exsudate	High-protein (modified) transudate
Colour	colourless/light yellow	bloody/yellowish/ brownish	variable
Transparency	transparent	mostly opaque	cloudy
Total protein	< 25 g/l	> 30 g/l	25 – 75 g/l
Cell count	< 1000/µl	> 5000/µl	1000 – 7000/µl

18.4 Lymphocyte Clonality by PARR

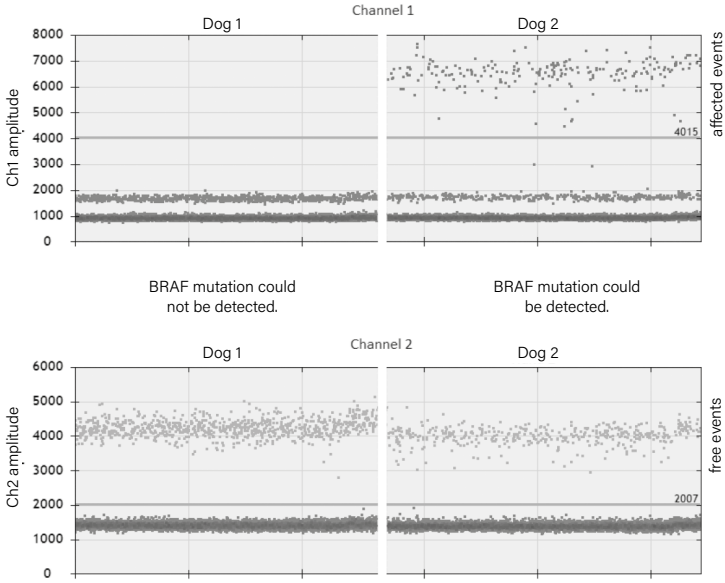
Lymphocyte Clonality (PARR)	
Material	Tissue, air-dried stained or unstained cytological smears on slides **without** cover glass, paraffin material, lymphoid material
Method	PCR for antigen receptor rearrangements (PARR)
Species	Dog, cat
Duration	4 – 6 days
Note	This test provides the possibility 1) to confirm a suspected diagnosis (lymphoma/lymphatic leukaemia vs. reactive hyperplasia) and 2) if lymphoma/lymphatic leukaemia is present, to differentiate between T- or B-cell origin. As only a cytological or a histological examination can reliably determine the presence of a lymphocyte population, the respective examinations are highly recommended. With regard to interpretation and limitations, please refer to the literature (e.g. Vet Clin Small Anim 43 (2013) 1331 – 1347). Furthermore, the results of all pre-examinations as well as the clinical picture should be included in the overall diagnosis (summary probability diagnosis). The examination can be performed on all materials containing a sufficient number of lymphocytes (fixed and unfixed cell material/ tissue/smears/EDTA blood). Cell material can also be obtained directly from the cytological smear (without cover glass) or the histological paraffin block.

18.5 Tumour-genetic Tests

BRAF Mutation Test	
Material	<u>If urinary bladder/urothelial carcinoma (transitional cell carcinoma) is suspected:</u> Urinary sediment (especially early morning urine; fluid + smear) Aspiration cytology (smears) OR Formalin-fixed, paraffin-embedded tissue (from previous histological examination) <u>If prostate carcinoma is suspected:</u> Smears rich in cells or formalin-fixed, paraffin-embedded tissue (from previous histological examination)
Method	Droplet digital PCR
Species	Dog
Duration	3 – 5 days

Note

- Detection of BRAF variant V595E.
- Indications:
  - It was not possible to get a reliable histological/cytological diagnosis.
  - Screening for urothelial carcinoma (transitional cell carcinoma) in certain predisposed terrier breeds (e.g. Scottish Terrier, Fox Terrier, Jack Russell Terrier, West Highland White Terrier)
  - Difficult patient



BRAF diagnosis by droplet digital PCR
("Affected events": Detection of cells with BRAF mutation;
"free events": Detection of cells without BRAF mutation)

- Only a positive result is conclusive.
- Reasons for negative results:
  - The urothelial (transitional cell)/prostate carcinoma is not caused by BRAF mutation (approx. 30 – 50% of these carcinomas – depending on the breed).
  - There were no mutated cells present in the sample.
  - It is not a urothelial (transitional cell)/prostate carcinoma.
- The test cannot be used for cats.

c-kit Mutation

Material	Formalin-fixed tissue, slide
Method	Sequencing
Species	Dog
Duration	14 days
Note	▪ Sequencing is performed on exons 8, 9 and 11. ▪ It is tested whether there is a mutation in the c-kit gene. ▪ The higher the histological grade of a cutaneous mast cell tumour (according to Patnaik et al. 1984 or Kiupel et al. 2011), the more likely it is that there is a mutation in the c-kit gene in exon 8, 9 or 11. Detecting the c-kit gene mutation helps to improve prognostic assessment and allows to design an individual treatment plan.

18.6 Publication on the Subject of Pathology

Book "Diagnostic Colour Atlas of Bee Pathology"

With this bilingual book (German/English), **PD Dr. Heike Aupperle** and **Prof. Dr. Elke Genersch** have created a new standard work for all those interested in bees, bee diseases and the (functional) anatomy of bees. The atlas with more than 350 full-colour images is a reference work for pathologists, scientists, students and interested bee-keepers when it comes to diagnosing diseases of all developmental stages of bees. The book was published by Laboklin in 2016.

19 Sex Determination in Birds

The method we use to determine the gender is based on the principle of polymerase chain reaction (PCR). It allows for quick and reliable determination of the sex of the bird using small quantities of genome-containing samples. The test is based on the replication of two highly conserved target genes, which makes it possible to examine many different species.
The method carried out by us provides double safety: During PCR, one probe specifically binds to the "female" sequence, while the other one binds to the "male" sequence, if these are present. This way, there will be one sex confirmed and the other sex excluded.

Which sample material is appropriate?

Sex determination can be done by using either blood or quills. One to three drops of whole blood (preferably EB) are sufficient. They can be collected in suitable micro capillary tubes or applied dropwise to a filter card. Filter cards/blood cards should be completely dry before shipment.
Alternatively, 2 – 3 quills are required from feathers freshly plucked under anaesthesia (breast feathers, no wing or tail feathers). Lost feathers and down feathers are not suitable for the test.

To ensure a correct analysis, the sample must not be contaminated with foreign DNA. For this purpose, please wear gloves when sampling or wash your hands after each sample you take. Please pack feathers separately for each bird. For "dry" feathers, it is sufficient to use an envelope or a small paper bag, "wet" feathers can, for example, be packed in blood or urine tubes or in standard freezer bags. Additionally, we offer so-called SampleKits for submitting feather samples or blood cards. You can request them free of charge. It is important to label the samples in such a way that the animals can be clearly identified. If available, please mark the samples with the ring or chip number of the bird.

Which bird species can be tested?

We have performed sex determination tests for several years and thus have already tested many different bird species. Only after we tested a female and a male bird of a species, we give clearance for routine diagnostics. In some species, PCR differentiation is not possible. We will be pleased to provide you with information on which bird species we test.
It is **essential to specify the exact bird species** when submitting the samples.

20 Hereditary Diseases/Phenotype/ Breed Characteristics

Individual Tests and Packages

In addition to the individual tests, we also offer various breed-specific packages covering hereditary diseases and coat traits in dogs, cats and horses. These packages provide excellent value for money and can be used to request several diseases and genetic traits in a compact format. The package combinations are continuously adapted to new findings. You will always find the latest and most suitable packages on our website laboklin.com in the section Services/Genetics.

LABOGenetics XXL cat ➢ **see Chapter 20.3.3, p. 379**

20.1 Heredities

Autosomal recessive inheritance
Carriers (N/mut) do not fall ill themselves, but each of them passes on the defective gene to their offspring with a probability of 50%. If two carriers are mated, there is a probability of 25% that one of the offspring will be affected (mut/mut; carriers 50%, free (N/N) 25%). Recessively inherited diseases can spread within the population without clinical manifestation.

X-linked recessive inheritance
The defective gene is located on a sex chromosome. Heterozygous female animals (X_n/X_{mut}) are carriers, male carriers (X_{mut}/Y) express the disease.

Autosomal dominant inheritance with incomplete penetrance
Heterozygous carriers also show signs of the disease, although the degree of severity varies.

Autosomal dominant inheritance
Heterozygous carriers also show signs of the disease.

20.2 Dog

20.2.1 Hereditary Diseases

Acatalasaemia	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Beagle
Inheritance	Probably autosomal recessive
Duration	3 – 5 days
Note	Acatalasaemia is caused by the absence of the enzyme catalase which is important for cellular defence in oxidative stress. Affected dogs suffer from tissue necrosis in the mouth.

Achromatopsia/Day Blindness (ACHM)	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Shepherd, Labrador Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Achromatopsia ACHM is a disease in which the cone cells of the retina, which are responsible for colour and daylight vision, are not developed properly. Initial symptoms of day blindness are noticeable in affected dogs from 8 – 10 weeks of age. In low light conditions, their visual function is comparable to healthy dogs.

Acral Mutilation Syndrome (AMS)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	German Short-Haired Pointing Dog, English Cocker Spaniel, English Pointer, English Springer Spaniel, French Spaniel
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	AMS is characterised by a sensory neuropathy of the peripheral parts of the body. Affected puppies show an insensitivity to pain in their distal extremities and begin to lick, bite or injure themselves on the paws and toes at around 4 months of age. Proprioception, motor skills and spinal reflexes remain intact.

Acute Respiratory Distress Syndrome (ARDS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dalmatian
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In Dalmatians, a familial juvenile respiratory disease similar to ARDS in humans was found. The clinical signs are tachypnoea, dyspnoea and pulmonary lesions. Some affected puppies also showed renal aplasia and hydrocephalus. The first signs of the disease typically appear at 5 – 10 months; these puppies usually have to be euthanised 1 – 6 weeks later.

Afibrinogenaemia (AFG)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dachshund
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A genetic variant of the fibrinogen alpha chain gene (FGA) is associated with afibrinogenaemia. If the coagulation factor I (fibrinogen) is absent, it can result in delayed blood clotting, bleeding of the mucous membranes or in joints as well as in haematomas. Severe haemorrhage may occur after surgery, injuries or even spontaneously. Affected dogs have extremely delayed coagulation in various coagulation tests (PT, PTT, TT); however, the activity of factors II, V, VII and X and the platelet count are normal.

Alaskan Husky Encephalopathy (AHE)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Husky
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	AHE is a disease that is already fatal in puppies. Affected dogs mainly show behavioural disorders and central nervous deficits such as dysphagia, lack of responsiveness and analgesia, blindness, movement and coordination disorders as well as ataxia and paralysis.

Alaskan Malamute Polyneuropathy (AMPN)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Alaskan Malamute
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	AMPN is a neurological disease which leads to progressive muscle weakness and exercise intolerance as well as signs of paralysis and respiratory problems at a later stage.

Alexander Disease (AxD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Labrador Retriever
Inheritance	Autosomal dominant
Duration	1 – 2 weeks
Note	In Labrador Retrievers, Alexander disease causes progressively worsening tetraparesis with a spastic posture of the thoracic limbs and a flattened chest. Later on, myoclonic jerks at the head and the cervical region, absent patellar reflexes, weakness of the four limbs and mild generalised muscle atrophy may become apparent.

Amelogenesis Imperfecta/Familial Enamel Hypoplasia (AI/FEH)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Akita, American Akita) Sequencing (Italian Sighthound, Parson Russell Terrier, Samoyed)
Breed	Akita, American Akita, Italian Sighthound, Parson Russell Terrier and Samoyed
Inheritance	Autosomal recessive
Duration	3 – 5 days (Akita, American Akita) 1 – 2 weeks (Italian Sighthound, Parson Russell Terrier, Samoyed)
Note	AI is a hereditary enamel hypoplasia. Affected animals have small, pointed teeth with brown, thin enamel. Despite this change, the teeth do not seem to be more susceptible to caries.

Behaviour Propensity

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Belgian Shepherd (only Malinois)
Inheritance	See note
Duration	1 – 2 weeks

Note	The Malinois is a variety of the Belgian Shepherd. In addition to the provoked form of aggression ("targeted aggression") aimed at in their training, unpredictable, episodic aggression is reported. This undesired aggression happens for no apparent reason and is completely unpredictably; these dogs no longer react to any external influences and cannot be controlled. A correlation was found between undesirable aggression and the dopamine transporter gene SLC6A3: allele A22 occurs more frequently. According to their owners, Malinois with the genotypes A0/A22 or A10/A22 more often show undesired aggression. Genotype A22/A22 was found to be particularly common in extreme behavioural problems.

Brachyuria (stumpy tail)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Australian Shepherd, Australian Stumpy Tail Cattle Dog, Austrian Pinscher, Bourbonnais Pointing Dog, Bouvier des Ardennes, Brazilian Terrier, Brittany Spaniel, Croatian Sheepdog (Hrvatski Ovcar), Danish-Swedish Farmdog, Jack Russell Terrier, Karelian Bear Dog, Miniature American Shepherd, Mudi, Polish Lowland Sheepdog (PON), Pyrenean Sheepdog, Savoy Sheepdog, Schipperke, Spanish Water Dog, Swedish Vallhund (Västgötaspets), Welsh Corgi Cardigan, Welsh Corgi Pembroke
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	Particularly the tail length gives many dog breeds their characteristic look. In most countries, docking a dog's tail is forbidden. Exhibiting and participating in events where these dogs are compared, tested or judged is also no longer permitted under the Animal Welfare Dog Ordinance in some countries. DNA analysis now allows to confirm whether the stumpy tail is of natural origin.

C3 Deficiency (C3)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Brittany Spaniel
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The third component of the complement system (C3) plays an important role in the body's immune defence against microorganisms such as bacteria, fungi or parasites. The causative mutation in the C3 gene prevents the complete formation of C3 and interrupts the defence cascade. Affected dogs exhibit higher susceptibility to bacterial infections, e.g. glomerulonephritis.

Canine Leucocyte Adhesion Deficiency (CLAD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Irish Red and White Setter, Irish Red Setter
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	CLAD is a hereditary immune deficiency that is usually fatal. Symptoms include various inflammatory processes and unsteady gait.

Canine Multi-focal Retinopathy (CMR1/2/3)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Coton de Tuléar) Sequencing (all the other breeds listed below)
Breed	American Bulldog, Australian Shepherd, Boerboel, Bullmastiff, Coton de Tuléar, Dogue de Bordeaux, English Bulldog, Finnish Lapphund, French Bulldog, Italian Cane Corso, Lapponian Herder, Mastiff, Miniature American Shepherd, Presa Canario, Pyrenean Mountain Dog, Swedish Lapphund
Inheritance	Autosomal recessive
Duration	3 – 5 days (Coton de Tuléar) 1 – 2 weeks (all the other breeds mentioned above)
Note	CMR is an inherited disease which causes multiple lesions of the retina. First symptoms can typically be found at the age of four months. In some cases, lesions disappear for some time and occur again at a later point in time. Impaired vision or sight disorders are not described in affected dogs.

Canine Multiple System Degeneration (CMSD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Chinese Crested Dog, Kerry Blue Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Animals affected by CMSD show normal development up to an age of 3 – 6 months. After that, symptoms such as cerebellar ataxia and movement disorders become apparent. Most dogs must be euthanised at 1 – 2 years of age.

Cardiomyopathy with Juvenile Mortality (CJM)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Belgian Shepherd (all varieties: Groenendael, Laekenois, Malinois, Tervueren)
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	In the Belgian Shepherd, a genetic variant in the tyrosyl-tRNA synthetase gene (YARS2) correlates with a form of mortality in puppies. CJM manifests itself through non-specific signs (vomiting, movement disorders, respiratory problems) at the latest at the age of 6 – 8 weeks. The animals usually die of heart failure within a few days. Carriers should only be mated with dogs that do not carry this variant.

Centronuclear Myopathy (CNM)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (German Hunting Terrier, Great Dane) FLP (Labrador Retriever)
Breed	German Hunting Terrier, Great Dane, Labrador Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days (German Hunting Terrier, Great Dane) 1 – 2 weeks (Labrador Retriever)
Note	If Labrador Retrievers or Great Danes suffer from CNM, the dog's muscles do not develop properly. Affected dogs lack tendon reflexes and gain less weight than puppies of the same age (at 4 weeks). From an age of approximately 12 to 20 weeks onwards, muscular weakness, abnormal posture, clumsy gait and feeding difficulties appear. In German Hunting Terriers, the disease is also called Exercise Induced Metabolic Myopathy (EIMM). EIMM is caused by a deficiency of acyl-CoA dehydrogenase (VLCAD) and therefore of the fatty acid oxidation (insufficient energy production). During or after exertion, affected dogs suffer from weakness up to collapse, severe muscle pain, muscle cell necroses and myoglobinuria from an age of 7 – 24 months onwards. About 30 – 120 minutes after physical exertion, they can develop tetraparesis or tetraplegia. Increased levels of CK, ALT and the long-chain fatty acid C14:1 can be detected.

Cerebellar Ataxia* (CA)	
Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	Spinone Italiano

Inheritance	Autosomal recessive
Duration	5 – 6 weeks
Note	CA is a progressive disease of the cerebellum caused by a mutation in the ITPR1 gene, which codes for a calcium channel and is involved in synaptic transmission. Typical signs of the disease are hypermetria and hyperextension, uncoordinated movements, impaired balance, tremor of the head as well as nystagmus. Gait disorders normally begin at 4 months of age; on average, affected dogs are no longer able to stand up at the age of one year and have to be euthanised.

Cerebellar Ataxia (CA1)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Belgian Shepherd
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Affected puppies develop a cerebellar dysfunction and show a wide-based stance and ataxic gait, exaggerated gait movements as well as stumbling, unsteadiness and a tremor of the head. There are slight proprioceptive deficits; the vestibulo-ocular reflex is normal to reduced. CSF and blood are normal. The first signs of CA1 appear at around 4 weeks of age.

Cerebellar Degeneration – Myositis Complex (CDMC)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Nova Scotia Duck Tolling Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	CDMC is caused by a mutation in the SLC25A12 gene. In affected dogs, the first signs appear between 10 weeks and 6 months of age. Clinical signs include generalised ataxia, hypermetria, delayed movements and reduced withdrawal reflexes in all four limbs. One affected dog also showed head tremor, others suffered from generalised muscle weakness with episodic collapse, stiff-legged gait and "bunny hopping". MRI findings showed bilateral symmetrical lesions in the cerebellum and multifocal lesions in the masticatory muscles. Biopsies detected lymphohistiocytic myositis and serum CK elevation.

Cerebellar Hypoplasia (CH)

Material	EB 1 ml, buccal swab
Method	Sequencing

Breed	White Swiss Shepherd Dog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the RELN gene which causes cerebellar hypoplasia (CH) was detected in White Swiss Shepherd Dogs. Affected puppies were clinically normal at birth, then they stopped gaining weight and progressive ataxia developed from around 2 weeks of age. They were euthanised at 4 weeks of age. Post-mortem examination revealed anatomical abnormalities in the brain, including severe cerebellar hypoplasia with lissencephaly (congenital lack of brain folds) and moderate internal hydrocephalus with enlarged lateral ventricles and fourth ventricle.

Cerebral Dysfunction (CDFS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Stabijhoun
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	CDFS in the Stabijhoun breed is an inherited disease of the brain. Clinically affected animals exhibit a large variety of neuronal signs such as depressive behaviour, walking circles, obsessive sniffing and running backwards.

Charcot-Marie-Tooth Neuropathy (CMT)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Miniature Schnauzer
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The neuromuscular disease CMT leads to changes in the myelin sheath of the axons of peripheral nerves due to a variant in the SBF2 gene (also called MTMR13 gene). Affected dogs show frequent regurgitation and respiratory difficulties at a young age (< 2 years) caused by megaoesophagus and laryngeal paralysis, and have a relatively long survival of more than 3 years after diagnosis.

Chondrodysplasia (dwarfism)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Chinook, Karelian Bear Dog, Norwegian Elkhound

Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Chondrodysplasia is a genetically determined skeletal dysplasia which leads to malformations in the structure of the long bones and dwarfism. In addition to shortened limbs, clinical signs include a large skull, spine changes and deformations of the legs.

Chondrodysplasia and -dystrophia (IVDD risk) (CDDY & CDPA)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	All, particularly short-legged breeds
Inheritance	CDPA autosomal dominant; semi-dominant for CDDY-related leg length, dominant for IVDD risk
Duration	1 – 2 weeks
Note	Breed-specific short limbs can be caused by chondrodystrophy (CDDY) and/or chondrodysplasia (CDPA). Only CDDY is associated with an increased **risk of a herniated disc** (Hansen's Type I Intervertebral Disc Disease, IVDD). CDDY is semi-dominantly inherited with regard to leg length, i.e. heterozygous dogs have shorter legs than homozygous free dogs, while homozygous affected dogs have even shorter legs than the heterozygous dogs. The IVDD risk is inherited as an autosomal dominant trait, which means that already one copy of the altered chromosome significantly increases the risk.

Cleft Lip/Palate and Syndactyly (CLPS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Nova Scotia Duck Tolling Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	Cleft lip/palate and syndactyly (CLPS) describes a hereditary disease, which so far has only been detected in Nova Scotia Duck Tolling Retrievers. Affected puppies develop a cleft palate, cleft lips as well as syndactyly.

CNS Atrophy with Cerebellar Ataxia (CACA)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Belgian Shepherd
Inheritance	Autosomal recessive

Duration	1 – 2 weeks
Note	CACA is caused by a deletion of the SELENOP gene for selenoprotein P, which is responsible for selenium transport to the brain and tissues. Selenium deficiency in the brain causes uncoordinated movements, intention tremor, spastic fits, increased muscle tone and a reduced swallowing reflex. These neurological signs can be observed in varying intensity from the age of about 2 weeks onwards and either result in early euthanasia or are mild.

Collie Eye Anomaly* (CEA)

Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	Australian Kelpie, Australian Shepherd, Bearded Collie, Border Collie, Boykin Spaniel, Collie (rough/smooth), Hokkaido, Lancashire Heeler, Silken Windsprite (Long-haired Whippet), Miniature American Shepherd, Nova Scotia Duck Tolling Retriever, Shetland Sheepdog (Sheltie), Silken Windhound
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	CEA leads to changes in the retina of the eye and can manifest itself in different degrees of severity. In the most severe form of CEA, blood vessel changes cause retinal haemorrhage, which can lead to retinal detachment and blindness in the dog.

Colour Dilution and Neurological Defects (CDN)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dachshund (Dackel)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In Dachshunds, a variant in the MYO5A gene has been found which causes CDN and resembles human Griscelli syndrome type I. Myosin VA-mediated transport plays an important role in neurons, the cerebellum and in the transport of melanosomes into growing hair shafts. An affected 4-week-old puppy had noticeably pale fur, was unable to hold itself in a prone position and showed rowing movements in the lateral position. It could neither maintain an upright head position nor coordinate head movements. The puppy also hardly reacted to environmental stimuli and was euthanised. The histopathological findings were a multifocal accumulation of melanin and a deposition of clumped keratin in the follicular epithelium of hairy skin.

Cone Degeneration (CD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Shorthaired Pointer
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In CD, a mutation in the CNFB3 gene is responsible for the degeneration of the cone cells of the retina already at puppy age. This results in day blindness. Affected dogs avoid exposure to light, and bright light may even be painful. With increasing age, the degeneration of the cone cells progresses.

Congenital Hypothyroidism (CHG)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Fox Terrier, French Bulldog, Rat Terrier, Spanish Water Dog, Tenterfield Terrier, Toy Fox Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Affected dogs usually die a few days after birth. Administration of hormones can prolong the life span, but the dogs still suffer from dwarfism and goitre formation.

Congenital Ichthyosis

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Great Dane
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	So far, lamellar ichthyosis is only known in Great Danes. In the course of the disease, the skin becomes dry and loses its elasticity, resulting in a generally wrinkled appearance particularly in the head area. In addition, affected puppies may develop severe swelling of the eyelids. The skin changes in the area of the folds enhance the risk of secondary infections.

Congenital Idiopathic Megaoesophagus (CIM)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Shepherd
Inheritance	Unknown
Duration	1 – 2 weeks

Note	Megaoesophagus is characterised not only by dilation of the oesophagus but also by reduced peristalsis. Affected dogs regurgitate food and water so that puppies fail to thrive. German Shepherds have a high risk of CIM; factors that play a role include gender (the risk is twice as high in male dogs) as well as a genetic variant (especially in the homozygous state).

Congenital Myasthenic Syndrome (CMS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Golden Retriever, Jack Russell Terrier, Labrador Retriever, Old Danish Pointing Dog, Parson Russell Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The main sign of CMS is a generalised muscle weakness, especially after stress or excitement. It can already be seen at just two weeks of age. Mobility of all limbs is severely limited, even the ability to carry the own body weight diminishes over time. In all areas of the limbs, reflexes are significantly reduced.

Congenital Stationary Night Blindness (CSNB)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary FLP
Breed	Briard
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for FLP)
Note	In affected dogs, night vision is severely impaired already at a few weeks of age; after a few years, some dogs also suffer from reduced daylight vision.

Copper Storage Disease (CT/COMMD1) in the Bedlington Terrier

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Bedlington Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Copper toxicosis in Bedlington Terriers is caused by a disorder of copper metabolism which leads to an accumulation of copper in the liver and other organs. A genetic variant in the COMMD1 gene causes dysregulation of copper levels in the liver cells, resulting in inflammation, fibrosis and liver cirrhosis. Affected dogs suffer from

reduced appetite, excessive thirst, vomiting, weight loss, jaundice, ascites and neurological abnormalities. The release of copper into the blood can also lead to haemolytic anaemia. Possible therapeutic approaches include: liver diet with reduced copper content, chelation therapy, the intake of zinc or, if necessary, a combination of several treatment approaches.

Copper Storage Disease (CT)* in the Dobermann and Labrador Retriever

Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	Dobermann and Labrador Retriever
Inheritance	See note
Duration	1 – 2 weeks
Note	In Labrador Retriever and Dobermann breeds, a variant in the copper-transporting **ATP7B**-ATPase gene leads to reduced copper excretion resulting in excessive copper storage in the liver and other organs. Usually, symptoms only appear in middle-aged or older dogs. Inheritance is autosomal dominant with incomplete penetrance. Dogs with 2 mutant alleles are normally more severely affected than heterozygous animals, but may also be free of symptoms throughout their lives. In Labrador Retrievers, the risk of contracting the disease may be reduced: A second mutation – in the **ATP7A**-ATPase gene – leads to reduced accumulations of copper. As this second variant is inherited in an X-linked dominant manner with incomplete penetrance, female dogs are more likely to have the disease, since the second mutation often only affects the metabolism if it is homozygous, whereas in male dogs, one copy of this gene variant is sufficient. This second mutation was also identified in Dobermanns, but so far, no correlation with the hepatic copper concentration has been detected.

Craniomandibular Osteopathy (CMO)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Cairn Terrier, Scottish Terrier, West Highland White Terrier
Inheritance	Autosomal dominant with incomplete penetrance
Duration	3 – 5 days
Note	CMO is a painful proliferative disease of the jaw bones affecting dogs in the first year of life. Clinical signs of the disease are recurrent episodes of fever and painful mandibular swelling.

Cystinuria	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Continental Bulldog, English Bulldog, French Bulldog, Landseer, Mastiff, Newfoundland, Olde English Bulldog) Sequencing (Australian Cattle Dog, Labrador Retriever, Miniature Pinscher)
Breed	Australian Cattle Dog, Continental Bulldog, English Bulldog, French Bulldog, Labrador Retriever, Landseer, Mastiff, Miniature Pinscher, Newfoundland, Olde English Bulldog
Inheritance	Autosomal recessive; autosomal dominant in Australian Cattle Dog, Miniature Pinscher
Duration	3 – 5 days (Continental Bulldog, English Bulldog, French Bulldog, Landseer, Mastiff, Newfoundland, Olde English Bulldog) 1 – 2 weeks (Australian Cattle Dog, Labrador Retriever, Miniature Pinscher)
Note	A transport disorder of dibasic amino acids in the kidney leads to the formation of cystine calculi.

Dandy-Walker-like Malformation (DWLM)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Eurasian
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Dogs affected by DWLM suffer from underdevelopment of the cerebellum, which is already noticeable in puppies. Depending on the severity, ataxia, spontaneous falling, and even severe epileptic seizures may occur.

Degenerative Myelopathy (DM) (Exon 1 and 2)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All (exon 2) Bernese Mountain Dog (exon 1+2)
Inheritance	Autosomal recessive with age-dependent incomplete penetrance; a major risk factor (mutation in the SOD1 gene), which is associated with DM, is detected.
Duration	3 – 5 days
Note	The disease is characterised by a degeneration of the axons and the myelin in the thoracic and lumbar part of the spinal cord causing progressive ataxia and paresis. The test detects a mutation which is considered the main risk factor for this disease.

DM exon 2: Laboklin owns the exclusive license to perform this genetic test.

Delayed Postoperative Haemmorhage (DEPOH)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Scottish Deerhound
Inheritance	Autosomal dominant with incomplete penetrance
Duration	1 – 2 weeks
Note	A variant in the SERPINF2 gene in the Scottish Deerhound is associated with an increased risk of delayed postoperative haemorrhage 1 to 4 days after surgery. Signs range from frank bleeding from the wound to severe bruising around the wound and haemoabdomen. Prothrombin time, partial thromboplastin time, von Willebrand antigen as well as the platelet count were normal.

Dental-skeletal-retinal Anomaly (DSRA)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Italian Cane Corso
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	DSRA is the result of a defect in the MIA2 gene and is characterised, among others, by dental problems (discolouration, chips and fractures, smaller teeth than normal), skeletal problems and progressive retinal atrophy (PRA). Further manifestations and pathogenesis are subject of current research.

Dermatomyositis (DMS)

Material	EB 1 ml, buccal swab
Method	2 x TaqMan SNP assay + sequencing
Breed	Collie (rough/smooth), Shetland Sheepdog (Sheltie)
Inheritance	Polygenic
Duration	1 – 2 weeks
Note	DMS is an autoimmune disease that causes skin lesions (hair loss and crusts) in Collies and Shetland Sheepdogs and can be detected histologically (biopsy). Only in Collies, additional muscular dysfunctions (difficulty to swallow, a high and stilted gait with muscular atrophy in the head and neck area) have been described. The complex genetic trait needs an additional external trigger like vaccination or viral infection to cause signs of the disease. Based on genotype combinations of three different loci (A, B, C), the likelihood of developing DMS

can be classified. Breeding puppies with genotypes that have a high risk (especially: AABBCC, AaBBCC, AABbCC, AABBCc) should be avoided wherever possible. Genotypes with moderate risk are AAbbCC, AAbbCc, aaBBCC, AaBBCc, AABbCc; those with low risk are aabbCC, aabbCc, AabbCC, AabbCc, aaBbCC, aaBbCc, AaBbCC, AaBbCc, aaBBCc.

Digital Hyperkeratosis (DH/HFH)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Dogue de Bordeaux, Irish Terrier, Kromfohrländer
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	This disease, which is also called "corny feet", manifests itself a few months after birth as excessive keratin formation on the foot pads, which can lead to skin cracks and subsequently to secondary infections at these sites. Nail growth is also often accelerated.

Dilated Cardiomyopathy (DCM) in the Schnauzer and Giant Schnauzer

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Giant Schnauzer, Schnauzer
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	DCM is caused by different mutations in different breeds. In the Schnauzer, a variant in the RBM20 gene was identified which correlates very well with DCM. In this breed, the first symptoms typically appear at the age of 1 – 3 years. DCM can lead to sudden cardiac death even without any previous clinical signs.

Dilated Cardiomyopathy (DCM) in the Manchester Terrier and the Welsh Springer Spaniel

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Manchester Terrier, Welsh Springer Spaniel
Inheritance	Autosomal recessive (Manchester Terrier) Autosomal dominant with incomplete penetrance (Welsh Springer Spaniel)
Duration	1 – 2 weeks
Note	In the Welsh Springer Spaniel, a genetic variant in the phospholamban gene is associated with DCM. Phospholamban plays an important role in regulating the intracellular calcium

concentration. Typical signs of DCM are enlargement of the left ventricle, poor systolic function, cardiac arrhythmia and sudden cardiac death. In Welsh Springer Spaniels, DCM penetrance is very high, which is why almost all carriers of the variant show signs by the age of 20 months.
In the Manchester Terrier, a genetic variant in the ABCC9 gene, which encodes a cardiac ATP-sensitive potassium channel, has been identified. DCM can lead to sudden death, which occurs before 2 years of age, typically at the age of 6 months. In the acute form, the heart is macroscopically normal. In the chronic form, there is often mild cardiomegaly, enlargement of the left ventricle, thickening of the left ventricular wall and enlargement of the left atrium. The dogs appear to be healthy before death, in some cases previous anaesthesia or extensive exercise before death has been reported.

Dilated Cardiomyopathy (DCM1 and DCM2) in the Dobermann

Material	EB 1 ml, buccal swab
Method	FLP (DCM1), TaqMan SNP assay (DCM2)
Breed	Dobermann
Inheritance	Autosomal dominant with incomplete penetrance
Duration	1 – 2 weeks
Note	DCM is widespread in the Dobermann. Affected dogs suffer from heart failure or sudden cardiac death. So far, two genetic variants have been identified: the DCM1 variant in the PDK4 gene (regulates the energy supply of the heart) and the DCM2 variant located in the titin (TTN) gene (influences heart contraction). Penetrance of DCM is highly variable, so genetically affected dogs might only show very mild or even no signs at all throughout their lives. Apart from the genotype of the two variants, diet, exercise level and other genes also seem to influence a dog's individual risk. Dogs carrying the DCM1 variant (heterozygous or homozygous) have a 10-fold increased risk of developing DCM; 37% of the dogs show signs. Carriers of the DCM2 variant are 21 times more likely to develop DCM, while 50% develop the disease. Dogs with both variants have a 30-fold increased risk of DCM and 60% show relevant signs.

Disproportionate Dwarfism

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dogo Argentino, Magyar Vizsla
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

Note	A variant in the PRKG2 gene causes disproportionate dwarfism in the Dogo Argentino. The PRKG2 gene encodes a protein which has a regulatory function in chondrocyte proliferation and in the differentiation into bone tissue. From about 2 months of age onwards, a smaller body size and length, a disproportionately large head and possibly impaired gait due to carpus valgus can be seen. Radiographs indicate an uneven growth of the ulna and radius and show reduced calcification at the growth plate during bone formation. Adolescent dogs have shortened legs, a shortened body and neck, a relatively broad head, with the nose being slightly turned upwards, as well as a pronounced vertical groove between the eyes. In the Magyar Vizsla, a variant in the PCYT1A gene was found that causes disproportionate dwarfism (SD3). PCYT1A catalyses the biosynthesis of phosphatidylcholine, which is also important in the mineralisation of the endochondral bone tissue. From 3 to 5 weeks of age, changes in the long bones can be noticed, in particular a shortening and deformation of the humerus and femur. Affected animals often have an abnormal elbow position, a thickening of the metaphysis and a wide-based stance in the forelimbs. The hind limbs are less shortened than the forelimbs The severity of the signs varies.

Dry Eye Curly Coat Syndrome (CCS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Cavalier King Charles Spaniel
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Affected puppies have an unusual coat (rough and curly) and show signs of keratoconjunctivitis sicca (conjunctivitis/keratitis due to a lack of lacrimal fluid). Changes of the skin of the foot pads, the foot pads and the nails cause pain and lameness. Teeth and hair are also affected.

Dyserythropoietic Anaemia and Myopathy (DAMS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	English Springer Spaniel, Labrador Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Different mutations in the EHBP1L1 gene cause DAMS in English Springer Spaniels and Labrador Retrievers. Clinical signs in the Labrador Retriever include muscle atrophy, pelvic limb weakness and regurgitation. Blood tests of affected dogs showed marked microcytosis

and changes in the erythrocytes. Myopathy and megaoesophagus were detected at around 5 years of age, while microcytosis and erythrocyte abnormalities were already seen in affected dogs at a younger age.
In the English Springer Spaniel, the disease shows an early onset of anaemia, megaoesophagus, cardiomyopathy and generalised, slowly progressive muscle atrophy. Despite the different clinical signs, both breeds have similar changes in erythrocyte morphology and muscle histopathology.

Dystrophic Epidermolysis Bullosa (DEB)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Central Asian Shepherd Dog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In DEB, blister formation occurs beneath the lamina densa of the cutaneous basement membrane. A severe form of DEB is found in Central Asian Shepherd Dogs. It is caused by a nonsense mutation in the COL7A1 gene, which encodes for type VII collagen. Already at an early age, affected puppies suffer from skin lesions, blisters and ulcers on the paws, ears, muzzle and oral mucosa and must be euthanised due to the unfavourable prognosis.

Ectodermal Dysplasia/Skin Fragility Syndrome (ED/SFS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Chesapeake Bay Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Already at birth, the skin of affected dogs is translucent on the ears, foot pads, nose and mouth. Bleeding or skin detachment occurs in these areas when slight friction is present. Affected dogs have to be euthanised.

Epidermolytic Hyperkeratosis (EHK)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Norfolk Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

Note	Because of a keratin defect, this disease leads to superficial, mild, plantar epidermolytic hyperkeratosis with epidermal fragility. Affected dogs show clinical signs from birth up to old age.

Episodic Falling (EF)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Cavalier King Charles Spaniel
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Episodic falling is a neurological disorder. Episodes are triggered by stress, excitement or exertion and can range from stiffness to collapse. Laboklin owns the exclusive license to perform this genetic test.

Exercise Induced Collapse (EIC)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Boykin Spaniel, Chesapeake Bay Retriever, Clumber Spaniel, Curly Coated Retriever, German Wire-Haired Pointing Dog, Labrador Retriever, Old English Sheepdog, Welsh Corgi Pembroke
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The first signs of EIC are a swaying or stiff gait as if the dog had stiff legs. After only 5 – 15 minutes of exertion, affected dogs develop muscle weakness and collapse. Laboklin owns the exclusive license to perform this genetic test.

Exfoliative Cutaneous Lupus Erythematosus (ECLE)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Short-haired Pointing Dog, Magyar Vizsla
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The autoimmune skin disease ECLE, also known as lupoid dermatitis, is caused by a variant in the UNC93B1 gene, which plays an important role in the immune response. Typical signs of ECLE are excessive scales – local or all over the body, hypopigmentation, erythema, hair loss, crusts, ulcers as well as secondary bacterial skin infections caused by immunodeficiency and, sometimes, short-term lameness. The first signs are seen at a juvenile or early adult age. Due to the severe symptoms and insufficient treatment options, affected dogs are usually euthanised.

Factor VII Deficiency

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Airedale Terrier, Alaskan Klee Kai, Beagle, Deerhound, Finnish Hound, Giant Schnauzer, Papillon, Phalène, Welsh Springer Spaniel,
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Affected dogs show a mild to moderate bleeding tendency but can also remain asymptomatic.

Factor XI Deficiency

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Kerry Blue Terrier
Inheritance	Autosomal recessive with incomplete penetrance
Duration	1 – 2 weeks
Note	A mutation in the F11 gene causes factor XI deficiency. In some cases, severe prolonged bleeding can occur in affected animals 12 – 24 hours after surgical procedures. Other dogs only have a slight tendency to spontaneous bleeding and some animals are asymptomatic.

Familial Nephropathy (FN)

Material	EB 1 ml, buccal swab
Method	Partner laboratory* (English Cocker Spaniel, Welsh Springer Spaniel) Sequencing (English Springer Spaniel, Samoyed)
Breed	English Cocker Spaniel, English Springer Spaniel, Samoyed, Welsh Springer Spaniel
Inheritance	Autosomal recessive (English Cocker Spaniel, English Springer Spaniel, Welsh Springer Spaniel) X-linked recessive in Samoyed
Duration	1 – 2 weeks
Note	Dogs with FN typically develop chronic renal failure between 6 months and 2 years of age, which sometimes leads to a rapid destruction of both kidneys and is ultimately fatal.

Familial Thyroid Carcinoma (FTFC) – Risk Analysis

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Long-haired Pointing Dog
Duration	1 – 2 weeks

Note	Two genetic variants in the TPO gene have been identified in the German Long-haired Pointing Dog that are associated with familial thyroid follicular cell carcinoma (FTFC). The risk of developing FTFC in dogs with two copies of one or both variants is around 16 times higher than in dogs that do not carry these variants. Most of the dogs analysed were older than 10 years at the time of diagnosis.

Fanconi Syndrome

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Basenji
Inheritance	Unknown
Duration	1 – 2 weeks
Note	Fanconi syndrome is a disease in which the kidneys are no longer able to reabsorb electrolytes and nutritive substances from the primary urine. Typical signs are polydipsia and polyuria. Without treatment, the disease leads to death because of muscle weakness and acidosis. In Basenjis, Fanconi syndrome is hereditary and is usually seen between the ages of 4 – 8 years.

Finnish Hound Ataxia (FHA)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Finnish Hound, Norrbottenspitz
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Starting at about 4 weeks of age, this disease can lead to a progressively worsening ataxia in affected animals, which initially manifests itself as slight coordination problems, but later as paralysis up to immobility.

Fucosidosis

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	English Springer Spaniel
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	This storage disease causes deposits in cerebral and peripheral nervous tissue. Affected animals show a disturbed coordination of movements, behavioural abnormalities, blindness, deafness and impaired deglutition. The disease manifests itself between the age of 18 months and 4 years with a progressive course and ultimately fatal outcome.

Gallbladder Mucoceles

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	American Cocker Spaniel, Cairn Terrier, English Cocker Spaniel, Pomeranian, Shetland Sheepdog (Sheltie)
Inheritance	Autosomal dominant with incomplete penetrance
Duration	1 – 2 weeks
Note	Undetected gallbladder mucoceles can lead to cholecystitis and thus increase the risk of a rupture of the gallbladder. Clinical signs occur in older dogs and include vomiting, anorexia, lethargy, icterus and abdominal pain.

Glanzmann Thrombasthenia (GT)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Pyrenean Mountain Dog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	GT is a bleeding disorder that occurs in two different types. They differ in the amount of specific glycoproteins (αIIbβ3) embedded in the cell membrane of platelets (thrombocytes), which are necessary for coagulation. In the more severe form of GT, type I, the level is less than 5% of the normal value. A mutation in the αIIb gene disrupts the production of one main component of these glycoproteins. Symptomatically, bleeding diathesis is usually recognised by continuous gingival bleeding after shedding of deciduous teeth. Persistent epistaxis can also be an indication for this disorder.

Glaucoma and Goniodysgenesis (GG)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Border Collie
Inheritance	Presumably autosomal recessive (still in research)
Duration	3 – 5 days
Note	A mutation in the olfactomedin-like 3 gene (OLFML3) leads to a predisposition for severe goniodysgenesis with narrowing or occlusion of intraocular channels of the iridocorneal angle and glaucoma and blindness as possible consequences. In heterozygous carriers, goniodysgenesis without glaucoma was diagnosed. Furthermore, several dogs did not develop glaucoma despite severe goniodysgenesis for 15 years or more. It is therefore assumed that the development of glaucoma is influenced by a combination of genetic factors as well as environmental and/or random factors.

Globoid Cell Leukodystrophy (Krabbe Disease)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Cairn Terrier, West Highland White Terrier) Sequencing (Irish Red Setter)
Breed	Cairn Terrier, Irish Red Setter, West Highland White Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days (Cairn Terrier, West Highland White Terrier) 1 – 2 weeks (Irish Red Setter)
Note	Krabbe disease is an incurable lipid storage disorder with progressive degeneration of the white matter of the CNS. It is characterised by muscle atrophy and neurological degeneration with the onset of the signs being at 1 – 3 months of age.

Glycogen Storage Disease Type Ia (GSD Ia)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Pinscher, Maltese
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	GSD Ia is caused by a congenital disorder of the glucose metabolism which leads to organ dysfunction of varying severity. In affected puppies, an undersupply of glucose and delayed growth occur very early after birth.

Glycogen Storage Disease Type II (GSD II, Pompe Disease)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Finnish Lapphund, Lapponian Herder, Swedish Lapphund
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Affected dogs suffer from vomiting, progressive muscle weakness, loss of condition and cardiac insufficiency, which leads to death at about 1.5 years of age.

Glycogen Storage Disease Type IIIa (GSD IIIa)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Curly Coated Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

Note	Affected animals often only show few clinical signs in the first years of life. With advancing age, the disease manifests itself more and more frequently as lethargy and episodic hypoglycaemia with collapse.

GM1 Gangliosidosis (GM1)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Shiba Inu) Sequencing (Husky, Portuguese Water Dog)
Breed	Husky, Portuguese Water Dog, Shiba Inu
Inheritance	Autosomal recessive
Duration	3 – 5 days (Shiba Inu) 1 – 2 weeks (Husky, Portuguese Water Dog)
Note	GM1 is a lysosomal storage disease that leads to neurological disorders. Affected dogs suffer from paralysis of the extremities and spasticity of the muscles.

GM2 Gangliosidosis (GM2)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Japanese Chin, Poodle, Shiba Inu
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	GM2 gangliosidosis, also known as Sandhoff's disease, is a progressive neurodegenerative lysosomal storage disease. The first neurological signs appear at 9 to 12 months of age, which rapidly worsen and lead to death at 18 to 23 months. Signs include loss of vision, difficulty walking, loss of balance, tremor and vomiting.

Grey Collie Syndrome (GCS) (Canine Cyclic Neutropenia)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Collie (rough/smooth)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Due to a dysfunction in stem cell formation in the bone marrow, affected dogs are more susceptible to infections and tend to bleed.

Haemophilia A (Factor VIII Deficiency)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (German Shepherd) Sequencing (Boxer, Labrador Retriever, Old English Sheepdog) FLP (Havanese, Rhodesian Ridgeback)

Breed	Boxer, German Shepherd, Havanese, Labrador Retriever, Old English Sheepdog, Rhodesian Ridgeback
Inheritance	X-linked recessive
Duration	3 – 5 days (German Shepherd) 1 – 2 weeks (Boxer, Havanese, Labrador Retriever, Old English Sheepdog, Rhodesian Ridgeback)
Note	Depending on the severity of factor VIII deficiency, there is slight to severe bleeding diathesis.

Haemophilia B (Factor IX Deficiency)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Rhodesian Ridgeback) Sequencing (American Akita, Hovawart, Lhasa Apso)
Breed	American Akita, Hovawart, Lhasa Apso, Rhodesian Ridgeback
Inheritance	X-linked recessive
Duration	3 – 5 days (Rhodesian Ridgeback) 1 – 2 weeks (American Akita, Hovawart, Lhasa Apso)
Note	Haemophilia B is one of the most important hereditary coagulation disorders in the Rhodesian Ridgeback. Depending on the severity of factor IX deficiency, there is a slight to severe bleeding diathesis. Other genetic causes of haemophilia B have been found in the American Akita, Hovawart and Lhasa Apso.

Haemorrhagic Diathesis (Scott Syndrome)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Shepherd
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	This bleeding diathesis is caused by impaired coagulation activity; activated platelets can be detected which are incapable of presenting anionic phospholipids, especially phosphatidylserine, and to release procoagulant microparticles. Other coagulation parameters remain unchanged, except for a reduced prothrombin consumption during the coagulation of whole blood.

Hereditary Ataxia (HA)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Gordon Setter, Old English Sheepdog) Sequencing (Australian Shepherd, Norwegian Buhund, Norwegian Elkhound)

Breed	Australian Shepherd, Gordon Setter, Norwegian Buhund, Norwegian Elkhound, Old English Sheepdog
Inheritance	Autosomal recessive
Duration	3 – 5 days (Gordon Setter, Old English Sheepdog) 1 – 2 weeks (Australian Shepherd, Norwegian Buhund, Norwegian Elkhound)
Note	HA is a progressive disease of the musculoskeletal system characterised by hypermetria, uncoordinated gait, tremor and spasticity up to severe gait disturbances and loss of balance. In the Old English Sheepdog and the Gordon Setter, first signs appear at the age of 5 months to 4 years. A variant in the RAB24 gene has been identified as the causative mutation in these breeds. A mutation in the KCNIP4 gene causes HA in the Norwegian Buhund, while a mutation in the HACE1 gene causes HA in Norwegian Elkhounds. Affected puppies of both breeds show clinical signs between 4 and 20 weeks of age and have a drooping tail atypical for the breed. In the Australian Shepherd and the Miniature American Shepherd, first signs such as hypermetria, "bunny hopping" and a wobbly and stiff-legged gait of the hind legs can be seen between 4 and 19 months of age. It may lead to an inability to walk at the age of 30 to 44 months. Histological findings revealed diffuse demyelination in the brain. A mutation in the PNPLA8 gene was found to cause HA in these breeds.

Hereditary Cataract (HSF4)

Material	EB 1 ml, buccal swab
Method	Partner laboratory* (Boston Terrier, French Bulldog, Staffordshire Bull Terrier) Sequencing (Australian Shepherd, Miniature American Shepherd, Wäller, Wirehaired Pointing Griffon (Korthals Griffon))
Breed	Australian Shepherd, Boston Terrier, French Bulldog, Miniature American Shepherd, Staffordshire Bull Terrier, Wäller, Wirehaired Pointing Griffon (Korthals Griffon)
Inheritance	Autosomal recessive (Boston Terrier, French Bulldog, Staffordshire Bull Terrier, Wirehaired Pointing Griffon (Korthals Griffon)) Unclear (Australian Shepherd, Miniature American Shepherd, Wäller)
Duration	1 – 2 weeks
Note	Cataract is one of the most frequent causes for blindness in dogs. In the Boston Terrier, French Bulldog and Staffordshire Bull Terrier, hereditary cataract is caused by a different mutation in the HSF4 gene (heat-shock factor 4 gene) than in the Australian Shepherd, Miniature American Shepherd and Wäller.

In the latter breeds, homozygosity results in nuclear cataract, but heterozygosity only causes posterior subcapsular cataract, which rarely impairs vision. An autosomal recessive mode of inheritance is also suspected in these breeds, but it is influenced by at least one other genetic factor. In the Wirehaired Pointing Griffon (Korthals Griffon), the causative variant was detected in the FYCO1 gene.

Hereditary Deafness (EOAD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Beauceron, Dobermann, Rhodesian Ridgeback, Rottweiler
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the PTPRQ gene causes congenital deafness and disorders of the vestibular system in the Dobermann. Affected puppies are already deaf 3 weeks after birth and suffer from balance disorders. Pathologically, progressive cochlear degeneration with loss of auditory sensory cells in the inner ear has been reported. In addition, ear crystals (otoconia) may be missing or malformed. In the Rottweiler, a variant in the LOXHD1 gene, which is thought to be involved in the function of the hair cells in the cochlea, leads to early hearing loss. It has not yet been conclusively clarified whether the puppies are born deaf or if they are initially hard of hearing and then become completely deaf within a few weeks. In the Beauceron, a mutation in the CDH23 gene also causes hereditary bilateral deafness. In the Rhodesian Ridgeback, a deletion in the EPS8L2 gene causes a form of hereditary deafness that leads to hearing loss at the age of 1 – 2 years. This form is called early-onset adult deafness (EOAD).

Hereditary Nasal Parakeratosis (HNPK)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Labrador Retriever) Sequencing (Greyhound)
Breed	Greyhound, Labrador Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days (Labrador Retriever) 1 – 2 weeks (Greyhound)
Note	Affected dogs suffer from crust formation on the nose. Treatment can only be symptomatic. Laboklin owns the exclusive license to perform this genetic test in Labrador Retrievers.

Hereditary Neuropathy (GHN)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Greyhound
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Signs particularly include progressive amyosthenia, exercise intolerance, loss of reflexes and ataxia of all limbs, and later, loss of the ability to stand as well as breathing problems.

Hyperuricosuria (HUU/SLC)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Hyperuricosuria is a metabolic disorder that leads to an increased excretion of uric acid instead of allantoin, which is why the disease is also called "hyperuricosuria and hyperuricaemia". To prevent the formation of calculi, affected dogs should get a low purine diet. Additionally, adequate hydration is vital.

Hypomyelination/Shaking Puppy Syndrome (SPS)

Material	EB 1 ml, buccal swab
Method	Sequencing (English Springer Spaniel) TaqMan SNP assay (Weimaraner)
Breed	English Springer Spaniel, Weimaraner
Inheritance	Autosomal recessive
Duration	3 – 5 days (Weimaraner) 1 – 2 weeks (English Springer Spaniel)
Note	This disease is caused by abnormal formation of the myelin sheath of the spinal cord. At the age of 12 – 14 days, affected dogs show generalised tremor, whose severity varies greatly. The dogs are able to walk, but have a hopping gait in the hind legs. Tremor is not present when the dogs are at rest or asleep and decreases considerably from the age of 3 – 4 months onwards and may even disappear completely.

Hypophosphatasia (HPP)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Karelian Bear Dog

Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	HPP has been described in Karelian Bear Dogs and in humans. Defective variants of the non-tissue-specific alkaline phosphatases are formed. This impairs the release of phosphate from inorganic compounds and leads to insufficient mineralisation of the skeleton. At the age of 2 – 10 weeks, dogs show growth retardation, movement disorders as well as muscle weakness and seizures. In the serum of affected puppies, total protein, albumin and urea levels may be elevated, and more PEA (phosphatase substrate phosphoethanolamine) is excreted in the urine. Affected animals usually die after a few weeks or are euthanised.

Ichthyosis in Great Danes ➢ see Congenital Ichthyosis p. 300

Ichthyosis (American Bulldog)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	American Bulldog
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Ichthyosis is a congenital disorder of the normal desquamation of the skin caused by a change in keratinisation. In addition, the skin may also appear differently pigmented. The first signs of the disease appear after only a few weeks of life.

Ichthyosis* (Golden Retriever)

Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	Golden Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	See Ichthyosis in American Bulldogs.

Ichthyosis Type 2 (Golden Retriever)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Golden Retriever
Inheritance	Autosomal recessive
Duration	1 – 2 Wochen

Note	In addition to the PNPLA1 variant, which has been known since 2012, another variant in the ABHD5 gene was now found in the Golden Retriever, which can also cause the typical signs of ichthyosis (called type 2 here). So far, the type 2 variant has mostly been identified in American breeding lines.

Imerslund-Gräsbeck Syndrome (IGS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Beagle, Border Collie) Sequencing (Komondor)
Breed	Beagle, Border Collie, Komondor
Inheritance	Autosomal recessive
Duration	3 – 5 days (Beagle, Border Collie) 1 – 2 weeks (Komondor)
Note	Malabsorption of vitamin B12 leads to neurological signs and irreversible damage of the brain and nervous system.

Inflammatory Myopathy (IM)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dutch Shepherd
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Inflammatory myopathy (IM) is the result of homozygous inheritance of a variant in the SLC25A12 gene. The genetic defect causes a decreased activity of the mitochondrial aspartate-glutamate transporter and a resulting proinflammatory milieu as well as oxidative stress in the muscles. Beginning at 3 – 9 months of age, affected dogs show progressive muscle weakness up to the inability to walk. Serum CK is permanently elevated. Affected animals were euthanised at about 2 years of age.

Inflammatory Pulmonary Disease (IPD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Collie (rough and smooth)
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Just a few days after birth, IPD causes coughing, shallow breathing, heavy breathing sounds, foamy vomiting and fever. The dogs respond well to treatment with antibiotics and secretolytics but tend to relapse without antibiotic treatment.

Junctional Epidermolysis Bullosa (JEB)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	German Short-Haired Pointing Dog
Inheritance	Autosomal recessive; the genetic test detects a mutation that is inherited together with the causative mutation.
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	Due to a defect in the cutaneous basement membrane, erosions and encrustations occur in the area of the foot pads, at pressure points on the limbs, on the inside of the auricles, and in areas of the gums, tongue and lips.

Juvenile Brain Disease (JBD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Jack Russell Terrier, Parson Russell Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	JBD is a disorder with an early onset at the age of 6 – 12 weeks which leads to epileptic seizures. The disease progresses rapidly and causes irreversible brain damage leading to death.

Juvenile Epilepsy (JE)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Lagotto Romagnolo
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Between the 5th and 12th week of life, affected dogs suffer from episodes of slight trembling, unsteady gait or inability to walk and spastic paralysis.

Juvenile Laryngeal Paralysis and Polyneuropathy (JLPP)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Black Russian Terrier, Rottweiler
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	JLPP is a hereditary disease that leads to breathing difficulties when excited or physically stressed already at the age of three months. As

	the disease progresses, weakness and coordination problems in the hind limbs develop, which eventually extend to the front limbs, and swallowing difficulties appear. This disease cannot be cured and is fatal within a few months after the onset of the symptoms.

Juvenile Myoclonic Epilepsy (JME)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Rhodesian Ridgeback
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	For Rhodesian Ridgebacks, JME is a typical form of epilepsy with frequent myoclonic twitches. The dogs suffer from involuntary, sudden muscle jerks which especially occur at rest. First symptoms appear at the age of about 6 months. In more than 85% of the cases, seizures occur daily. In the course of the disease, 40% of the dogs develop generalised tonic-clonic seizures.

L-2-hydroxyglutaric Aciduria (L-2-HGA)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Staffordshire Bull Terrier) Sequencing (Yorkshire Terrier)
Breed	Staffordshire Bull Terrier, Yorkshire Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days (Staffordshire Bull Terrier) 1 – 2 weeks (Yorkshire Terrier)
Note	L-2-HGA produces a variety of neurological deficits, including psychomotor retardation, seizures and ataxia. Signs are “wobbly” gait, muscle stiffness as a result of exercise or excitement, and altered behaviour.

Lafora Disease	
Material	EB 1 ml (EDTA blood only)
Method	Special FLP
Breed	Basset Hound, Beagle, Chihuahua, Dachshund (Dackel), French Bulldog, Newfoundland, Welsh Corgi Cardigan, Welsh Corgi Pembroke
Inheritance	Autosomal recessive
Duration	2 – 3 weeks
Note	Lafora disease is a glycogen metabolism disorder that causes progressive myoclonic epilepsy. Soluble glycogen is transformed to insoluble polyglucosan that aggregates to form Lafora bodies and

accumulates in the neuronal somatodendritic compartments of the brain as well as in muscles, heart, skin and liver. The signs of this disease are: poor vision/blindness, generalised tonic-clonic seizures, myoclonic jerks, panic attacks, dementia, aggression and, in later stages, faecal and urinary incontinence. The first signs usually appear from 7 years of age onwards.

Lagotto Storage Disease (LSD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Lagotto Romagnolo
Inheritance	Autosomal recessive with incomplete penetrance
Duration	3 – 5 days
Note	Lagotto storage disease (LSD) is a storage disease with neurodegenerative symptoms, which leads to cerebellar damage in affected animals. These are the cause of movement control and balance disorders. In some affected dogs, nystagmus as well as behavioural changes like aggression and restlessness can be detected. The first signs appear at an age of four months to four years.

Laryngeal Paralysis (LP)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Bull Terrier, Miniature Bull Terrier
Inheritance	Autosomal recessive with incomplete penetrance
Duration	1 – 2 weeks
Note	In Bull Terrier and Miniature Bull Terrier breeds, a genetic variant was identified to be a major genetic risk factor for an early form of laryngeal paralysis. Homozygous dogs have a ten to twenty times higher risk of developing laryngeal paralysis. Because of the high clinical relevance of LP (voice impairment, stridor, limited exercise tolerance, dyspnoea, collapse), mating should be done with at least one of the parent animals tested as homozygous-clear to avoid homozygous-affected puppies.

Laryngeal Paralysis with Polyneuropathy Type 3 (LPPN3)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Labrador Retriever, Leonberger, St. Bernard
Inheritance	Autosomal recessive
Duration	3 – 5 days

Note	Dogs suffering from LPPN3 often show respiratory problems that can lead to laryngeal paralysis. Other typical signs of polyneuropathy such as gait disorders may also occur. In addition to this mutation, there are other causative mutations that lead to LPN1 or LPN2, which are similar diseases in the Leonberger.

Late Onset Ataxia (LOA)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Jack Russell Terrier, Parson Russell Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The disease leads to progressive restrictions of the musculoskeletal system and loss of balance. In affected animals, symptoms usually appear between 6 and 12 months of age. SCA can also cause this clinical picture, but usually has an earlier onset.

Leonberger Polyneuropathy (LPN1 and LPN2)

Material	EB 1 ml, buccal swab
Method	FLP (LPN1) Sequencing (LPN2)
Breed	Leonberger
Inheritance	Autosomal recessive (LPN1) Autosomal dominant with incomplete penetrance (LPN2)
Duration	1 – 2 weeks
Note	LPN types 1 and 2 are characterised by increasing exercise intolerance and uncoordinated gait, especially in the hind legs. Eventually, the animals can hardly carry their own weight. Furthermore, there are distinct breathing sounds, altered barking and dysphagia. The onset of LPN1 is at about 2 – 4 years of age and it shows a severe progression. The LPN1 mutation causes around 11% of all cases of polyneuropathy in Leonbergers. The average onset of LPN2 is around 6 years of age. LPN2 causes around 21% of all cases of polyneuropathy in Leonbergers. In addition to these two mutations, there are other unknown causative mutations.

Lethal Acrodermatitis (LAD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Bull Terrier, Miniature Bull Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days

Note	Already in the first weeks of life, LAD is characterised by typical skin lesions, especially on the paws, growth retardation and immunodeficiency. Initially, the skin lesions resemble a zinc deficiency, later on, severe infections (malassezia, candida) as well as hyperkeratosis of the foot pads and deformation of the nails occur. Additionally, diarrhoea and pneumonia occur. LAD usually leads to death in 1 – 2 years.

Lethal Lung Disease (LAMP3)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Airedale Terrier
Inheritance	Autosomal recessive with incomplete penetrance
Duration	1 – 2 weeks
Note	In Airedale Terriers, a variant in the LAMP3 gene was found which encodes for a membrane protein of the lamellar bodies. Since lamellar bodies are involved in surfactant formation in the pulmonary alveoli, synthesis of the surfactant is severely impaired. Homozygous affected puppies are already lethargic at birth, refuse to suckle and develop dyspnoea/tachypnoea and severe oxygen deficiency within the first days or weeks; they are usually euthanised. It is suggested that there might be an unknown protective variant which causes incomplete penetrance of LAMP3.

Leukocyte Adhesion Deficiency III (LAD3)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Shepherd
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	LAD3 is an inherited immunodeficiency disease. It is caused by a recessive mutation affecting the cell-to-cell contact. Thereby, granulocytes are unable to migrate to the site of the infection. Animals suffering from LAD3 can neither form pus nor develop neutrophilia. Affected dogs develop severe, often life-threatening infections at a very early stage, which cannot be treated even with high doses of antibiotics.

Leukoencephalomyelopathy (LEMP)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Leonberger) Sequencing (Great Dane, Rottweiler)

Breed	Great Dane, Leonberger, Rottweiler
Inheritance	Autosomal recessive with incomplete penetrance
Duration	3 – 5 days (Leonberger) 1 – 2 weeks (Great Dane, Rottweiler)
Note	LEMP is a neurodegenerative disease of the white matter of the CNS, in which lesions of the myelin sheath lead to coordination and movement disorders. The first signs appear at the age of 1 – 3 years; only a few months after the onset of the first signs, the affected dogs will not be able to stand up or walk anymore. Since about 1% of the examined dogs without symptoms are tested as homozygous affected, it is assumed that the penetrance is incomplete and an influence of modifier genes or factors is expected.

Leukoencephalopathy (LEP)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Schnauzer
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In LEP, there are defects in myelin proteins and/or metabolic defects of the oligodendrocytes with insufficient formation/maintenance of the myelin sheath. Signs include dysphagia, tetraparesis and ataxia, walking circles, distemper, head tilt, strabismus and tonic-clonic seizures or sudden death. Brains of affected dogs showed lesions of the cerebellar white matter, a reduced distinction between grey and white matter and mild hydrocephalus. Affected puppies are usually euthanised a few days after birth.

Limb Girdle Muscular Dystrophy (LGMD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dachshund
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the gene of the sarcoglycan alpha subunit (SGCA) causes LGMD, a dystrophy of the shoulder and pelvic girdle muscles. Affected dogs suffer from exercise intolerance, stiff-legged gait, progressive weakness, myoglobinuria, dysphagia and pneumonia. Markedly elevated serum creatine kinase levels can continuously be measured. The onset of signs was at around 7 – 17 months of age. Muscle biopsies were dystrophic. Immunostaining and Western blot analysis of α, β and γ-sarcoglycans indicated sarcoglycanopathy, a form of limb girdle muscular dystrophy.

Lundehund Syndrome (LHS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Norwegian Lundehund
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The typical signs of LHS are similar to those of protein-losing enteropathy (PLE). They include gastritis, protein loss, chronic inflammation, lymphangiectasia and malabsorption. In addition, poor general condition, frequent vomiting and oedema can be observed in affected animals.

Macrothrombocytopenia (MTC)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bichon Frisé, Boxer, Cairn Terrier, Cavalier King Charles Spaniel, Chihuahua, Cocker Spaniel, Havanese, Jack Russell Terrier, Labrador Retriever, Maltese, Norfolk Terrier, Parson Russell Terrier, Poodle, Shih Tzu
Inheritance	Autosomal dominant (intermediate) (Bichon Frisé, Boxer, Cavalier King Charles Spaniel, Chihuahua, Cocker Spaniel, Havanese, Jack Russell Terrier, Labrador Retriever, Maltese, Parson Russell Terrier, Poodle, Shih Tzu) Autosomal recessive (Cairn Terrier, Jack Russell Terrier, Norfolk Terrier, Parson Russell Terrier)
Duration	1 – 2 weeks
Note	MTC is a hereditary disorder affecting platelet production. Two mutations have been identified in the β1-tubulin gene, one of which is recessive, while the other one is dominant. Congenital MTC leads to thrombocytopenia, with counts ranging between 100.000 and 50.000 per µl or even below. Moreover, many platelets are larger than normal. Heterozygous carriers of the dominant mutation have counts that lie between those of affected and normal dogs. Affected dogs do not have a bleeding diathesis, but as treatment with antibiotics or steroids is contraindicated for congenital MTC, this genetic test should be considered as an important method for differential diagnosis.

Macular Corneal Dystrophy (MCD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Labrador Retriever

Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	MCD is a progressive disease which affects the stroma of the cornea. The disease is caused by a genetic variant in the CHST6 gene, which encodes for an enzyme involved in the synthesis of keratan sulphate. Keratan sulphate is thought to be relevant for corneal hydration. MCD leads to increasing corneal opacity at 4 – 6 years of age and severe visual impairment over time. In some dogs, vascularisation of the corneal epithelium may also occur.

Malignant Hyperthermia (MH)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	This disease is caused by inhalation narcotics and muscle relaxants and is characterised by increased body temperature, hypercapnia, rhabdomyolysis, cardiac arrhythmias and renal failure. Damage to neural, hepatic and renal tissue and death occur if narcotics and muscle relaxants are further administered.

Maxillary Canine Tooth Mesioversion (MCM)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Shetland Sheepdog (Sheltie)
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	A variant in the FTSJ3 gene has been identified that is associated with tooth displacement and reduced body size and weight in Shetland Sheepdogs. Mesioversion of the maxillary canines (MCM) can affect one or both canines and displace them towards the nose, which may cause abnormal occlusion, ulceration of the upper lip and periodontal disease and require extraction or orthodontic treatment.

May-Hegglin Anomaly (MHA)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Pug Dog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

Note	Animals with MHA show persistent thrombocytopenia and greatly enlarged platelets which are variably altered in morphology. In addition, cytoplasmic inclusions can be detected in neutrophil granulocytes. In affected animals, coagulation is delayed.

MCAD Deficiency

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Cavalier King Charles Spaniel
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the ACADM gene causes medium-chain acyl-CoA dehydrogenase (MCAD) deficiency. Affected dogs display focal seizures with prolonged lethargy, reduced responsiveness and proprioceptive ataxia. These conditions occur several times a week and can last from 20 minutes to 24 hours. Urine and blood analyses show an increased level of medium-chain fatty acids. Signs improve with treatment and a low-fat diet, resulting in several months without seizures.

MDR1 Gene Variant (Ivermectin Hypersensitivity)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Australian Shepherd, Border Collie, Collie (rough/smooth), Elo, German Shepherd, Silken Windsprite (Long-haired Whippet), McNab Shepherd, Miniature American Shepherd, Old English Sheepdog, Shetland Sheepdog (Sheltie), Silken Windhound, Wäller, White Swiss Shepherd
Inheritance	Autosomal recessive; hypersensitivity is also to be expected in carriers
Duration	3 – 5 days
Note	Hypersensitivity to the antiparasitic drug ivermectin is caused by a variant in the multi-drug resistance transporter (MDR1). In addition to ivermectin and loperamide, **numerous other pharmaceutical substances** are known which are expected to easily enter the brain tissue if applied in combination with an altered MDR1 transporter.

Methaemoglobinaemia (MetHg)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Pomeranian
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

Note	A variant in the CYB5R3 gene that causes methaemoglobinaemia (MetHg) has been detected in the Pomeranian dog breed. Methaemoglobin causes cyanosis and exercise intolerance. The oral mucosa, tongue and the skin on the lower abdomen of affected dogs show a bluish discolouration. Blood tests performed on affected dogs revealed a significantly lower level of b5R (NADH cytochrome b5 reductase).

Microphthalmia (RBP4)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Irish Soft Coated Wheaten Terrier
Inheritance	Autosomal recessive with maternal influence
Duration	3 – 5 days
Note	Microphthalmia can be caused by a hereditary prenatal vitamin A deficiency. Homozygous affected puppies only show signs if their mother is also homozygous affected and suffers from disturbed vitamin A transport. If the mother is heterozygous for the genetic defect, the puppies will probably not show any signs.

Mitochondrial Fission Encephalopathy (MFE)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bullmastiff
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the MFF gene causes MFE. Homozygous affected dogs suffer from ataxia, uncoordinated gait and behavioural abnormalities; the signs develop at a very young age and are progressive. Other signs of the disease are a wide-based stance and impaired vision. A neurological examination indicates a disease of the cerebral cortex and the vestibulocerebellum; changes in the cerebellum were confirmed by MRI.

Mucopolysaccharidosis Type IIIa (MPS3a)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Dachshund (Dackel), New Zealand Huntaway
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	MPS3a-affected animals suffer from severe degeneration of the central nervous system. First neurological signs usually appear from the age of eighteen months onwards, rapidly worsen, culminating in ataxia, and often lead to the death of the affected dog.

Mucopolysaccharidosis Type IIIb (MPS3b)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Schipperke
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In Schipperkes, MPS3b is a lysosomal storage disease that is also known as "Sanfilippo syndrome type 3b". An enzyme defect prevents the breakdown of heparan sulphate, which accumulates in the lysosomes. Signs include tremor and imbalance, even with falling to either side. The onset of the signs is between 2 – 4 years and they become worse, so that these animals are usually euthanised 1 – 2 years later.

Mucopolysaccharidosis Type VI (MPS6)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Miniature Pinscher
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The genetic variant causing MPS6 appears to be relatively common in the Miniature Pinscher and causes lysosomal storage disease in homozygous cases due to an arylsulphatase B (ARSB) deficiency, so that sulphate cannot be broken down from chondroitin sulphate and dermatan sulphate. In case of MPS6, these sulphate compounds are detectable in the urine (toluidine blue staining strongly positive). There is no serum ARSB enzyme activity. Severe signs (corneal opacity, disproportionate dwarfism, kyphosis, facial dysmorphia) usually lead to the animals being euthanised as puppies or young adult dogs.

Mucopolysaccharidosis Type VII (MPS7)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Brazilian Terrier) Sequencing (German Shepherd)
Breed	Brazilian Terrier, German Shepherd
Inheritance	Autosomal recessive
Duration	3 – 5 days (Brazilian Terrier) 1 – 2 weeks (German Shepherd)
Note	This lysosomal storage disease causes corneal clouding as well as severe skeletal deformities. Dogs cannot walk even at the age of several weeks to months.

Muscular Dystrophy (MD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Landseer) Sequencing (Cavalier King Charles Spaniel, Golden Retriever, Norfolk Terrier)
Breed	Cavalier King Charles Spaniel, Golden Retriever, Landseer, Norfolk Terrier
Inheritance	X-linked recessive (Cavalier King Charles Spaniel, Golden Retriever, Norfolk Terrier) Autosomal recessive (Landseer)
Duration	3 – 5 days (Landseer) 1 – 2 weeks (Cavalier King Charles Spaniel, Golden Retriever, Norfolk Terrier)
Note	Affected dogs show raised creatine kinase levels in serum, muscle atrophy with contractures, fibrosis and cardiomyopathy. Generally, first signs appear at the age of three to six months. Affected dogs usually die between the ages of 4 and 24 months.

Musladin-Lueke Syndrome (MLS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Beagle
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Due to extensive fibrosis of the skin and joints, affected dogs suffer from arthrosis and stiffness, have shortened outer toes and a typical flat head shape.

Mycobacterium avium Complex Sensitivity (MAC)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Miniature Schnauzer
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	In Miniature Schnauzers, a variant in the CARD9 gene leads to immunodeficiency, which is associated with an increased susceptibility to Mycobacterium avium with its subspecies (Mycobacterium avium complex, MAC) and Mycobacterium intracellulare. Starting at the age of 1 – 8 years, this leads to disturbed general condition, nasal discharge, conjunctivitis, diarrhoea and enlarged lymph nodes, liver and spleen. The animals do not respond adequately to treatment and may pose a risk to animal owners with a weakened immune system.

Myostatin Mutation ("Bully" Gene)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Whippet
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In Whippets, a significant correlation between this mutation (in the heterozygous genotype) and racing performance was found. Dogs with two "bully" alleles (homozygous case) appear extremely muscular, but their ability to run is limited.

Myotonia Congenita

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Miniature Schnauzer) Sequencing (Australian Cattle Dog, Border Collie, Labrador Retriever
Breed	Australian Cattle Dog, Border Collie, Labrador Retriever, Miniature Schnauzer
Inheritance	Autosomal recessive
Duration	3 – 5 days (Miniature Schnauzer) 1 – 2 weeks (Australian Cattle Dog, Border Collie, Labrador Retriever)
Note	This disease affects the skeletal muscle ion channels. Clinical signs are mainly stiff-legged gait, dysphagia and excessive salivation. All affected Miniature Schnauzers showed abnormal dentition and overbite, in some cases also abnormal barking.

Myxomatous Mitral Valve Disease (MMVD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Cavalier King Charles Spaniel, Dachshund
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Myxomatous mitral valve disease (MMVD) is characterised by a slowly progressive degenerative change of the mitral valves of the heart leading to mitral valve prolapse and regurgitation (blood flowing back into the left atrium of the heart) and eventually to heart failure due to fluid accumulation in the lungs. The Cavalier King Charles Spaniel and the Dachshund have an early-onset form of this disease and therefore greater cardiac morbidity and mortality compared to other breeds. A variant in the NEBL gene is associated with an increased risk of developing this early-onset form.

Narcolepsy

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Labrador Retriever) Sequencing (Dachshund (Dackel), Dobermann)
Breed	Dachshund, Dobermann, Labrador Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days (Labrador Retriever) 1 – 2 weeks (Dachshund (Dackel), Dobermann)
Note	Narcolepsy is a neurological disease which is characterised by sleep attacks, cataplexy and sleep paralysis.

Necrotizing Meningoencephalitis (NME/PDE)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Pug Dog
Inheritance	Autosomal recessive with incomplete penetrance The test identifies a risk factor which is associated with NME (also called PDE, pug dog encephalitis).
Duration	1 – 2 weeks
Note	Due to the autoimmune inflammation of the central nervous system, disorientation, confusion and seizures occur. The genetic test determines the risk for the development of this disease.

Necrotizing Myelopathy (HNM)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Kooikerhondje
Inheritance	Autosomal recessive
Duration	3 – 5 days, possibly 1 – 2 weeks
Note	A variant in the IBA57 gene causes HNM in the Kooikerhondje breed. The onset of paresis and ataxia in the hind limbs is between 3 and 12 months of age and progresses to tetraparesis before the age of 2 years. There were increased spinal reflexes in the hind limbs. Affected dogs had abnormal MRI findings and were euthanised. Post-mortem examination revealed a symmetric bilateral necrotizing myelopathy with malacia in the ventral and dorsal white matter of the cervical spinal cord.

Nemaline Myopathy (NM)

Material	EB 1 ml, buccal swab
Method	Sequencing

Breed	American Bulldog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	NM in American Bulldogs is characterised by a variety of muscular disorders, such as muscle weakness, muscular hypotonia, hypoventilation and dysphagia.

Neonatal Cortical Cerebellar Abiotrophy (NCCD)

Material	EB 1 ml, buccal swab
Method	FLP (Beagle) Sequencing (Magyar Viszla)
Breed	Beagle, Magyar Vizsla
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Puppies with neonatal (cortical) cerebellar abiotrophy (NCCD) are slower and less coordinated than other puppies their age.

Neonatal Encephalopathy with Seizures (NEWS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Poodle
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	NEWS is a malformation of the cerebellum. Already at birth, affected puppies are relatively small and weak and they often die within the first week of their lives. Those surviving this phase develop ataxia, tremor and seizures. So far, these animals had to be euthanised before they were 8 weeks old.

Neuroaxonal Dystrophy (NAD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Lagotto Romagnolo, Papillon, Rottweiler, Spanish Water Dog
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	NAD is generally characterised by a distinct histology and neurodegenerative pathology of the central and/or peripheral nervous system. As with most neurological disorders, symptoms may vary greatly. Homozygous puppies typically die shortly after birth due to respiratory failure and, histologically, show swollen, spheroid axons throughout the nervous system.

Neuronal Ceroid Lipofuscinosis (NCL)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing (American Bulldog, Australian Shepherd, Border Collie, English Setter, Golden Retriever, Gordon Setter, Miniature American Shepherd, Tibetan Terrier) Sequencing (Chihuahua, Chinese Crested Dog, Dachshund, Italian Cane Corso, Saluki) TaqMan SNP assay and sequencing (Australian Cattle Dog)
Breed	American Bulldog, Australian Cattle Dog, Australian Shepherd, Border Collie, Chihuahua, Chinese Crested Dog, Dachshund, English Setter, Golden Retriever, Gordon Setter, Italian Cane Corso, Miniature American Shepherd, Saluki, Tibetan Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing) (American Bulldog, Australian Shepherd, Border Collie, English Setter, Golden Retriever, Gordon Setter, Miniature American Shepherd, Tibetan Terrier) 1 – 2 weeks (Australian Cattle Dog, Chihuahua, Chinese Crested Dog, Dachshund, Italian Cane Corso, Saluki)
Note	NCL is a progressive neurodegenerative disease caused by lysosomal storage defects. Clinical signs include increasing levels of agitation and aggression. The dogs become hyperactive and ataxic and may suffer from epileptic seizures and impaired vision. The age of the onset of the disease as well as its severity may vary greatly.

Neuronal Ceroid Lipofuscinosis* (NCL) in the American Staffordshire Terrier	
Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	American Staffordshire Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	See Neuronal Ceroid Lipofuscinosis (NCL) above.

Obesity	
Material	EB 1 ml, buccal swab
Method	FLP
Breed	Flat Coated Retriever, Labrador Retriever
Inheritance	Multifactorial
Duration	1 – 2 weeks
Note	In Labrador Retrievers and in Flat Coated Retrievers, a POMC (pro-opiomelanocortin) mutation was found which influences energy

homeostasis. POMC mutation is associated with greater weight, obesity and increased food motivation. The mutation was particularly often detected in assistance and companion dogs.

Osteogenesis Imperfecta (Brittle Bone Disease)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing (Dachshund) Sequencing (Beagle, Golden Retriever)
Breed	Beagle, Dachshund (Dackel), Golden Retriever
Inheritance	Autosomal recessive (Dachshund) Autosomal dominant (Beagle, Golden Retriever)
Duration	3 – 5 days (1 – 2 weeks for sequencing) (Dachshund) 1 – 2 weeks (Beagle, Golden Retriever)
Note	The cause of brittle bone disease (osteogenesis imperfecta) is a defective formation of type 1 collagen resulting in extremely brittle bones and teeth already in puppies.

Paroxysmal Dyskinesia (PxD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Irish Soft Coated Wheaten Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Affected dogs suffer from episodes of involuntary, sudden, irregular and unpredictable movements of the limbs, especially the hind legs, known as hyperkinesia. These attacks last several minutes to hours and occur up to 10 times a day. The first signs typically occur at the age of about two years and worsen with age.

Paroxysmal Exercise-Induced Dyskinesia (PED)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Shetland Sheepdog (Sheltie), Weimaraner
Inheritance	Probably autosomal dominant (still in research) (Shetland Sheepdog) Autosomal recessive (Weimaraner)
Duration	1 – 2 weeks
Note	A variant in the PCK2 gene was found that is associated with PED. Affected dogs show short to long-lasting episodes of generalised ataxia and hypermetria, increased muscular tension in all four limbs, as well as decreased mental activity and mild tremor. Episodes are triggered by stress or excitement. Good stress management,

a specific diet (gluten- and grain-free, seafood-based with high levels of tryptophan) and anti-epileptic treatment can influence the frequency of episodes and reduce signs.

Persistent Müllerian Duct Syndrome (PMDS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Miniature Schnauzer
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Persistent Müllerian duct syndrome (PMDS) is caused by a mutation in the MISRII gene and is associated with an incomplete regression of the Müllerian duct during sex differentiation in male dogs. Normally, the external genitalia are fully developed. In 50% of the affected animals, the testicles do not descend (testicular dystopia), which can lead to infertility and possibly tumour formation.

Phosphofructokinase Deficiency (PFKD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	American Cocker Spaniel, English Springer Spaniel, German Spaniel, Whippet
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Enzyme deficiency causes the destruction of red blood cells, and thus leads to a red colouration of the urine, anaemia and icterus as well as to exercise intolerance and muscle cramps.

Pituitary Dwarfism

Material	EB 1 ml, buccal swab
Method	FLP (Czechoslovakian Wolfdog, German Shepherd, Saarloos Wolfhond, Tibetan Terrier, White Swiss Shepherd Dog) Sequencing (Karelian Bear Dog, Lapponian Herder)
Breed	Czechoslovakian Wolfdog, German Shepherd, Karelian Bear Dog, Lapponian Herder, Saarloos Wolfhond, Tibetan Terrier, White Swiss Shepherd Dog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Dwarfism results from a lack of growth hormone caused by a dysfunction of the pituitary gland. In Shepherds and Wolfhounds, growth stops at 3 – 8 weeks of age. If left untreated, the animals either keep

their puppy fluff or completely lose their coat. Topcoat usually only develops in the head/foot area. Affected Karelian Bear Dogs, Tibetan Terriers and Lapponian Herders gain weight more slowly and keep their puppy coat or suffer from severe hair loss, rather thin skin and skin inflammation at 2 – 3 years of age.

Polycystic Kidney Disease (PKD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bull Terrier
Inheritance	Autosomal dominant
Duration	1 – 2 weeks
Note	PKD leads to the formation of cysts in the liver, pancreas and kidneys. The fluid-filled kidney cysts eventually cause renal failure and lead to death.

Postoperative Haemorrhage (P2Y12 mutation)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Great Swiss Mountain Dog
Inheritance	Autosomal dominant
Duration	1 – 2 weeks
Note	In Great Swiss Mountain Dogs, a mutation in the P2Y12 gene leads to severe coagulation disorders. Affected animals only show severe bleeding, which is often fatal, during major surgery or serious injuries. The genetic test is therefore diagnostically useful as a preventive measure before surgery.

Prekallikrein Deficiency (KLK)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Shih Tzu
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Even though KLK leads to deficiency in prekallikrein, a component of the coagulation cascade, it is not associated with increased bleeding diathesis. Only in combination with other defects in the coagulation cascade (factor VII, VIII and IX deficiencies), an increased tendency to bleed has been described in a few cases.

Primary Ciliary Dyskinesia (PCD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing (Old English Sheepdog) Sequencing (Alaskan Malamute)
Breed	Alaskan Malamute, Old English Sheepdog
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing) (Old English Sheepdog) 1 – 2 weeks (Alaskan Malamute)
Note	This syndrome is characterised by recurrent infections of the respiratory tract as well as reduced male fertility. Approximately 50% of the affected patients develop situs inversus (Kartagener syndrome).

Primary Hyperoxaluria (PH)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Coton de Tuléar
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	PH leads to the accumulation of oxalate and the subsequent formation of calcium oxalate crystals in the urinary organs. The resulting crystals also accumulate in the kidney tissue and can lead to decreased renal function.

Primary Lens Luxation (PLL)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	American Eskimo Dog, American Hairless Terrier, Australian Cattle Dog, Chinese Crested Dog, Danish-Swedish Farmdog, Fox Terrier, German Hunting Terrier, Jack Russell Terrier, Lakeland Terrier, Lancashire Heeler, Lucas Terrier, Miniature Bull Terrier, Norfolk Terrier, Norwich Terrier, Parson Russell Terrier, Patterdale Terrier, Pug Dog, Rat Terrier, Sealyham Terrier, Teddy Roosevelt Terrier, Tenterfield Terrier, Tibetan Terrier, Toy Fox Terrier, Volpino Italiano, Welsh Terrier, Westfalen Terrier, Yorkshire Terrier
Inheritance	Autosomal recessive; it is estimated that about 2 – 20% of the carriers will develop PLL.
Duration	3 – 5 days
Note	Affected dogs may suffer from painful glaucomas and blindness due to a dislocation of the lens.

Primary Open Angle Glaucoma (POAG)

Material	EB 1 ml, buccal swab
Method	Sequencing (Basset Fauve de Bretagne, Basset Hound, Beagle, Norwegian Elkhound) FLP (Petit Basset Griffon Vendeen)
Breed	Basset Fauve de Bretagne, Basset Hound, Beagle, Norwegian Elkhound, Petit Basset Griffon Vendeen
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Without any prior eye disease, there is a rise in pressure in the eyeball which leads to visual field loss and blindness.

Primary Open Angle Glaucoma and Lens Luxation (POAG/PLL)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Shar Pei
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	A genetic dysfunction of the connective tissue in the eye leads to glaucoma (POAG) and often to lens luxation (PLL). POAG can lead to blindness. Usually, affected dogs show first signs at the age of 4 – 6 years.

Progressive Retinal Atrophy (PRA)

Progressive retinal atrophy (PRA) is a disease of the retina which continuously progresses and always leads to blindness. Over time, the photoreceptors of the eye will be destroyed. In most forms, rods are initially affected and cones are affected later, so that night blindness occurs first. Clinical signs usually appear in early youth, but the time of onset varies in different dog breeds. The ophthalmologic signs are similar in all forms (bilateral mydriasis, hyperreflective tapetum lucidum, atrophy of the retinal vessels).
The breed-specific forms of PRA are described below.

Bas-PRA1

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Basenji
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Further forms of PRA are suspected. The form of PRA in Basenjis, which can be detected by genetic testing, has an onset at about 5 years of age.

BBS2-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Shetland Sheepdog (Sheltie)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Besides the already known variant in the CNGA1 gene, a genetic variant in the Bardet-Biedl syndrome 2 (BBS2) gene is associated with PRA in Shetland Sheepdogs. The first signs have been reported from 8 – 10 years of age. Typically, affected dogs initially develop night blindness, followed by a noticeable decline in daylight vision and, in some cases, also a secondary cataract. In addition to PRA, phenotypic characteristics that are atypical for the breed (muzzle curved upwards, unusual wavy coat structure, dental abnormalities) may also be present.

BBS4-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Puli
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Affected dogs have a variant in the BBS4 gene and were diagnosed with PRA at the age of 2 years. Signs were variable: reduced vision due to ophthalmological changes such as reduced myelination of the optic nerve, as well as obesity and infertility.

CNGA1-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Shetland Sheepdog (Sheltie)
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	There seems to be at least one more mutation in the CNGA1 gene. In Shelties, first signs of PRA are usually seen from the age of two. "Slowly progressing retinopathy" (SPR), which also occurs in Shelties, is similar to PRA in the early stages and can only be distinguished in differential diagnosis by means of ERG.

cord1-PRA/crd4-PRA

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Beagle, Bolonka Zwetna, Clumber Spaniel, Curly Coated Retriever, Dachshund (Dackel), English Springer Spaniel

Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In cone-rod dysplasia (cord1), the cone cells degenerate first, approximately from the age of 6 months onwards. In some genetically affected dogs, however, no signs are seen even at a higher age. The connection between this mutation and the occurrence of the disease is still a subject of scientific debate.

crd-PRA

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Dachshund (Dackel)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The early loss of retinal cone cells is characteristic for crd-PRA. The first clinical signs of crd-PRA can occur at the age of six months. After about 1 to 2 years, the full clinical picture (day blindness) becomes apparent.

crd1-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	American Staffordshire Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	See crd-PRA.

crd2-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	American Pitbull Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	See crd-PRA.

crd3-PRA

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Irish Glen of Imaal Terrier
Inheritance	Still unknown
Duration	1 – 2 weeks
Note	A variant in the ADAM9 gene causes crd3. At the age of 12 – 24 months, the cone and later also the rod photoreceptor cells begin to

degenerate. It can take several years until complete blindness sets in. At ophthalmological examinations, crd3 can normally only be detected from 3 – 5 years of age onwards.

Dominant PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bullmastiff, Mastiff
Inheritance	Autosomal dominant
Duration	1 – 2 weeks

Early-onset PRA (eo-PRA)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Portuguese Water Dog, Spanish Water Dog
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Early-onset PRA is caused by a variant in the PDE6B gene. Owners of eo-PRA-affected dogs report initial visual impairment at the age of about 1.5 years and describe the animals as mostly blind by 4.5 years. Early-onset PRA can often only be diagnosed through a clinical ophthalmological examination at a later point in time, after the owners have already noticed the first changes.

Generalised PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Schapendoes
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

GR-PRA1 and GR-PRA2

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Golden Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The onset of the diseases varies within the breed, but diagnosis is often not made until about 5 years of age.

IFT122-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Lapponian Herder

Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	IFT122-PRA is usually diagnosed between 5 – 12 years of age. It is caused by a variant of the intraflagellar transport 122 gene (IFT122 gene) and progresses slowly so that some dogs still have some vision at 13 years of age.

JPH2-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Shih Tzu
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	A genetic variant in the JPH2 (junctophilin) gene causes PRA in the Shih Tzu. First signs were reported by owners of affected dogs from the age of 5 – 9 years.

MERTK-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Swedish Vallhund (Västgötaspets)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the MERTK gene causes PRA in the Swedish Vallhund (Västgötaspets). The age of onset as well as the severity of the signs vary. The age of diagnosis is also highly variable (from 1.1 years to 12.6 years).

NECAP1-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Giant Schnauzer
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In Giant Schnauzers, a variant in the NECAP1 gene was found. This gene encodes for a protein that is involved in clathrin-mediated endocytosis (CME) in the synapses. It is assumed that by inhibiting CME, rhodopsin accumulates in the photoreceptors and leads to retinal degeneration. First signs have been described from about 4 years onwards.

pap-PRA1

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Papillon, Phalène
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	There are further forms of PRA in these breeds.

PRA3

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Tibetan Spaniel Tibetan Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A genetic variant in the FAM161A gene, which encodes a ciliary protein and is expressed in retinal photoreceptors, causes PRA3 in Tibetan Spaniels and Tibetan Terriers. The onset of typical PRA signs is rather late, at around 5 years of age. It is assumed that other currently unknown variants which can cause PRA may occur in Tibetan Terriers in addition to the PRA3 variant and rcd4 PRA variant.

PRA4

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Lhasa Apso
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	PRA4 is caused by a variant in the IMPG2 gene. Clinical signs can appear as early as 2.5 years of age, although the age is very variable. It often takes several years until the owners of affected dogs notice any visual impairment.

prcd-PRA*

Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	All
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

rcd1-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Irish Red and White Setter, Irish Red Setter
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)

rcd1a-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Sloughi
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

rcd2-PRA

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Collie (rough/smooth)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

rcd3-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Chinese Crested Dog, Pomeranian, Welsh Corgi Cardigan
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

rcd4-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Australian Cattle Dog, English Setter, Gordon Setter, Irish Red and White Setter, Irish Red Setter, Old Danish Pointing Dog, Polish Lowland Sheepdog (PON), Poodle, Small Munsterlander, Tatra Shepherd Dog, Tibetan Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks

Type B1-PRA (HIVEP3)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Miniature Schnauzer
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	New research confirms the correlation between a mutation in the HIVEP3 gene and this early form of type B PRA in the Miniature Schnauzer. We recommend testing for the HIVEP3 variant as it has a better correlation than the previously offered test for the PPT1 gene.

XL-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Husky, Samoyed
Inheritance	X-linked recessive
Duration	1 – 2 weeks
Note	XL-PRA is a late form of the disease. The first signs usually occur at the age of three to five years.

Protein Losing Nephropathy (PLN) – Risk Analysis

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Airedale Terrier, Irish Soft Coated Wheaten Terrier
Duration	3 – 5 days
Note	Hereditary PLN manifests itself as hidden proteinuria from middle age onwards. The disease can be stable and mild for years. In some cases, however, severe complications such as kidney failure or thrombosis occur. The genetic test provides a risk assessment for PLN.

Pyruvate Dehydrogenase Phosphatase 1 Deficiency (PDP1)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Clumber Spaniel, Sussex Spaniel
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Even after minimal effort, affected dogs suffer from severe exercise intolerance which may lead to collapse. There may also be neurological symptoms.

Pyruvate Kinase Deficiency (PK)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Basenji, Beagle, Cairn Terrier, Labrador Retriever, Pug Dog, West Highland White Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	The lack of pyruvate kinase causes severe chronic regenerative haemolytic anaemia, reticulocytosis, progressive myelofibrosis and osteosclerosis.

Raine Syndrome

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Border Collie
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Affected dogs show very severe tooth wear and gingivitis, which can lead to the loss of teeth. The excessive wear of the teeth results from a lack of mineralisation and, thus, reduced hardness of the enamel. The bones of these animals are usually less mineralised as well.

Renal Cystadenocarcinoma and Nodular Dermatofibrosis (RCND)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	German Shepherd
Inheritance	Autosomal dominant
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	A mutation in the BHD gene causes multifocal renal cystadenocarcinoma and nodular dermatofibrosis. Heterozygous affected dogs develop bilateral, multifocal renal tumours, uterine leiomyomas and skin nodules consisting of dense collagen fibres. This mutation seems to be embryonically lethal in most homozygous affected dogs.

Renal Dysplasia and Hepatic Fibrosis (RDHN)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Norwich Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	RDHN in Norwich Terriers is a structural/functional defect of primary cilia (ciliopathy). Primary cilia are only passively motile, occur on almost all types of cells and are, for example, important for organogenesis. Affected puppies suffer from diffuse cystic, enlarged kidneys, hepatic fibrosis, subcutaneous oedema, pleural effusion and ascites, underdeveloped lungs, cleft palate, diaphragmatic malformation/hernia and usually die shortly after birth.

Retinal Dysplasia (OSD)

Material	EB 1 ml, buccal swab
Method	Sequencing (Northern Inuit, Tamaskan) Partner laboratory* (Labrador Retriever)

Breed	Labrador Retriever, Northern Inuit, Tamaskan
Inheritance	Autosomal dominant with incomplete penetrance (Labrador Retriever) Autosomal recessive (Northern Inuit, Tamaskan)
Duration	1 – 2 weeks
Note	Retinal dysplasia (RD), also called retinal folds, is a relatively common clinical observation in many dog breeds and is per se not a breeding restriction. However, in the Labrador Retriever breed, retinal dysplasia can be associated with a more severe syndrome, the oculoskeletal dysplasia (OSD). Clinical signs of OSD are skeletal malformations, shortened limbs (dwarfism) as well as blindness at an early age. OSD in the Northern Inuit and the Tamaskan is caused by a different genetic variant (COL9A3 gene, exon 14) and is very similar to that in Labradors, but vision is not always impaired in these two breeds.

Robinow-like Syndrome (DVL2)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	American Bulldog, American Pitbull Terrier, American Staffordshire Terrier, Boston Terrier, Continental Bulldog, Dogue de Bordeaux, English Bulldog, French Bulldog, Olde English Bulldog, Shih Tzu, Staffordshire Bull Terrier
Inheritance	Autosomal dominant with incomplete penetrance
Duration	1 – 2 weeks
Note	Robinow syndrome in humans is characterised by abnormal facial features (prominent forehead, wide-spaced eyes, flat nasal bridge) and shortened limbs. In dogs, the English Bulldog, French Bulldog and Boston Terrier have a breed-typical phenotype with brachycephaly and a small body size. Malformed or missing caudal vertebrae result in a truncated screw tail. This phenotype is associated with a genetic variant in the dishevelled gene DVL2. DVL2, along with other genes (SMCO2 and BMP3), is associated with brachycephaly and does not only correlate with caudal vertebral malformations but also with thoracic vertebral malformations in these breeds. Inheritance seems to be recessive, with incomplete penetrance with regard to thoracic vertebral malformations. The DVL2 variant could also be linked to other health concerns like the brachycephalic obstructive airway syndrome (BOAS) and congenital heart defects, but this is still part of ongoing research. The DVL2 variant has also been found homozygous or heterozygous in the following breeds: American Pitbull Terrier, Staffordshire Bull Terrier, Shih Tzu, American Staffordshire Terrier, Dogue de Bordeaux, Olde English Bulldog and American Bulldog. Here, too, DVL2 seems to

be associated with brachycephaly and caudal vertebral malformations. In these breeds, however, the number of vertebrae is not reduced, the tail is not completely malformed and it does not seem to cause malformations of the thoracic vertebrae, but this could also be because of the incomplete penetrance.

Sensory Neuropathy (SN)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Border Collie
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	SN is caused by a degeneration of sensory and (to a lesser extent) motor neurons. Clinical signs start between 2 and 7 months of age and include progressive proprioceptive ataxia with hyperextension of the limbs and self-mutilation of the limbs. The hind legs are usually more affected. Proprioception and nociception are reduced in all limbs or are no longer present as the disease progresses. Urinary incontinence and vomiting may also occur. Sensory action potentials are reduced or absent, motor nerve conduction velocity is normal or reduced, the EMG of the innervated muscles is normal.

Severe Combined Immunodeficiency (SCID)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Frisian Water Dog, Jack Russell Terrier, Parson Russell Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	SCID is associated with very low immunoglobulin levels and lymphocyte counts, which causes a severe weakening of the cellular and humoral immune response. Affected dogs show increased susceptibility to viruses and bacteria and usually die of opportunistic infections at the age of 8 – 12 weeks.

Shar Pei Autoinflammatory Disease (SPAID)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Shar Pei
Inheritance	Autosomal dominant with incomplete penetrance (marker test)
Duration	3 – 5 days
Note	In addition to the typical fever, SPAID may cause the following symptoms: arthritis, dermatitis, otitis, systemic amyloidosis, erythema in

the area of the skin folds, skin that is stuck together and thickened, eye inflammation and recurrent intestinal inflammation. First clinical signs of the disease usually appear at the age of 1 to 6 years.

Skeletal Dysplasia 2 (Dwarfism) (SD2)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Labrador Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	SD2 causes an early halt in growth of long bones. In contrast to other forms of dwarfism (pituitary dwarfism), the result are "disproportioned" dogs with shortened front limbs and a raising dorsal line, while torso length and depth are not altered.

Spinal Dysraphism (NTD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Weimaraner
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Neural tube defects result from abnormal closure or development of the neuronal tube during embryogenesis. In Weimaraners, spinal dysraphism is characterised by non-progressive ataxia and causes abnormal hair streams along the back, kinked tails, scoliosis in the lumbar spinal region, bunny-like hopping, crouched stance and paraparesis.

Spinocerebellar Ataxia (SCA)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Fox Terrier, Jack Russell Terrier, Parson Russell Terrier, Patterdale Terrier, Tenterfield Terrier, Toy Fox Terrier) Sequencing (Alpine Dachsbracke)
Breed	Alpine Dachsbracke, Fox Terrier, Jack Russell Terrier, Parson Russell Terrier, Patterdale Terrier, Tenterfield Terrier, Toy Fox Terrier
Inheritance	Autosomal recessive
Duration	3 – 5 days (Fox Terrier, Jack Russell Terrier, Parson Russell Terrier, Patterdale Terrier, Tenterfield Terrier, Toy Fox Terrier) 1 – 2 weeks (Alpine Dachsbracke)
Note	The disease leads to a progressive restriction of the musculoskeletal system and loss of balance. The onset of the first signs is usually from the age of 3 months onwards.

Spondylocostal Dysostosis (Comma Defect)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Miniature Schnauzer
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	Comma defect is mainly characterised by segmentation disorders of the spine and ribs. Already as newborns, affected dogs show disproportionate dwarfism as well as spinal shortening and rib defects. The skull has a prominent forehead and a protruding occiput. In addition, there may be malformations of the toes and abdominal wall defects. Malformed ribs lead to a smaller ribcage and respiratory insufficiency.

Spongiform Leukoencephalomyelopathy* (SLEM)

Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	Border Terrier
Inheritance	Autosomal recessive
Duration	5 – 6 weeks
Note	SLEM, also known as shaking puppy syndrome, is a degenerative neurological disease. Changes in the myelin sheath of the nerve fibres in the white matter of the brain result in reduced transmission of nerve impulses. At around 2 weeks of age, there are usually initial tremors in the hind legs, later followed by generalised tremors, lack of coordination, seizures and a lower weight than the littermates. The onset of the first signs and their severity can vary, which is why it is assumed that other genetic variants or environmental factors are involved. The lack of effective treatment options leads to a poor quality of life, so that affected puppies usually have to be euthanised.

Spongy Degeneration with Cerebellar Ataxia (SDCA1 and 2)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (SDCA1) FLP (SDCA2)
Breed	Belgian Shepherd, Dutch Shepherd
Inheritance	Autosomal recessive
Duration	3 – 5 days (SDCA1) 1 – 2 weeks (SDCA2)
Note	SDCA is a neurodegenerative disease in Belgian and Dutch Shepherds. Puppies with SDCA have an early onset of clinical signs at 5 – 8 weeks of age. They show ataxic gait, which is particularly obvious in the hind limbs. Other clinical signs are stumbling, staggering,

intention tremor, muscle spasms, as well as loss of balance and falling. SDCA is a progressive disease, so that affected dogs must usually be euthanised at the age of 12 weeks.

Squamous Cell Carcinoma (SCC) of the Toe – Risk Analysis

Material	EB 1 ml (EDTA blood only)
Method	Droplet digital PCR
Breed	Giant Schnauzer (black), Poodle (black)
Duration	3 – 5 days
Note	Testing for digital SCC helps to assess the individual risk of developing acral squamous cell carcinoma in black Giant Schnauzers and Black Poodles. A structural change, known as copy number variation, in the c-KIT ligand gene (KITLG) is analysed. A higher copy number of the KITLG gene indicates an increased risk of developing SCC.

Stargardt Disease (Retinal Degeneration) (STGD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Labrador Retriever
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	In Labrador Retrievers, a variant in the ABCA4 gene was found which can be associated with STGD and causes clinical signs similar to the human disease. The ABCA4 gene encodes a membrane transporter protein located in the rods and cones. The gene variant leads to an increased accumulation of lipofuscin in the retinal pigment epithelium and to a degeneration of the cones and, later on, the rods. Some vision remains throughout lifetime.

Startle Disease

Material	EB 1 ml, buccal swab
Method	FLP (Irish Wolfhound) Sequencing (Australian Shepherd, Galgo Español, Miniature American Shepherd)
Breed	Australian Shepherd, Galgo Español, Irish Wolfhound, Miniature American Shepherd
Inheritance	Autosomal recessive
Duration	3 – 14 days (Irish Wolfhound) 1 – 2 weeks (Australian Shepherd, Galgo Español, Miniature American Shepherd)

Note	Startle disease or hyperekplexia is a hereditary neurodegenerative disease associated with impaired transport of the neurotransmitter glycine. In the Irish Wolfhound and the Galgo Español, the disease is caused by individual mutations in the SLC6A5 gene, while a variant in the GLRA1 gene was found in Australian Shepherds and Miniature American Shepherds. The first signs appear at a very young age and intensify during movement, for example muscle tremors in response to acoustic or tactile stimuli, exaggerated stiffness of the leg muscles (up to a rigid position of all four limbs and inability to stand and walk). Cyanosis may also occur while suckling. Affected puppies must be euthanised. Laboklin owns the exclusive license to perform this genetic test in the Irish Wolfhound.

Subacute Necrotising Encephalopathy (SNE)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Yorkshire Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	SNE is characterised by ataxia and spasticity as well as central nervous visual and sensory disorders. The first signs appear in the first year of life.

Succinic Semialdehyde Dehydrogenase Deficiency (SSADHD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Saluki
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	SSADH is involved in the degradation of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA). In SSADH deficiency, the degradation of GABA is interrupted after the formation of succinic semialdehyde (SSA), which is then reduced to 4-hydroxybutyric acid (GHB), among others. GHB is a major contributor to the clinical picture. The onset of neurological disorders (mild ataxia), seizures and behavioural changes (vocalisation, lethargy) is at 6 – 10 weeks and usually lead to euthanasia. Further abnormalities include absent reflexes (e.g. menace reflex), SSA in urine, GHB in serum and symmetrical spongiform changes in several areas of the brain (histology).

Thrombopathia

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Basset Hound, Landseer
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Dogs suffering from this hereditary form of thrombopathia have an unusually high number of veins, haematomas and bruises because their platelets do not respond normally to activation signals.

Trapped Neutrophil Syndrome (TNS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Border Collie
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Dogs with TNS can produce neutrophils but cannot release them into the bloodstream. Therefore, affected puppies have a weakened immune system. The onset and severity of the disease vary, but most dogs do not get older than four months.

Upper Airway Syndrome (UAS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Norwich Terrier
Inheritance	Autosomal dominant with incomplete penetrance
Duration	1 – 2 weeks
Note	Although Norwich Terriers are considered a mesocephalic breed, they can suffer from Upper Airway Syndrome (UAS). In this breed, a variant in the ADAMTS3 gene was found which can be associated with UAS. Homozygous affected dogs show an elongated soft palate, malformed cartilage, everted laryngeal saccules and possibly vocal fold oedema. The resulting constriction of the respiratory tract leads – similar to brachycephalic breeds – to respiratory problems, heat and stress intolerance, cyanosis and the animals can collapse.

Van den Ende-Gupta Syndrome (VDEGS)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Fox Terrier, Toy Fox Terrier
Inheritance	Autosomal recessive

Duration	3 – 5 days
Note	All affected dogs exhibit a prominent underbite with short maxilla. Additional symptoms include lack of bone mineralisation, swollen knee joints as well as luxation of elbow or patella.

Ventricular Arrhythmia (IVA)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Rhodesian Ridgeback
Inheritance	Unclear (see note)
Duration	3 – 5 days
Note	IVA is triggered by a variant in the QIL1 gene. This gene encodes a protein involved in the formation and distribution of mitochondrial cristae. Affected dogs show ventricular and/or supraventricular tachycardia and other cardiac arrhythmias, usually between 6 – 18 months of age. In some cases, this leads to sudden cardiac death. This hereditary disease has incomplete penetrance and expression. Only about 60% of dogs carrying the variant have abnormal heart sounds and in some dogs the signs disappear with age.

Vitamin D-dependent Rickets (VDR)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Pomeranian
Inheritance	Unknown
Duration	1 – 2 weeks
Note	The hereditary form of vitamin D-dependent rickets type II is caused by a defect in the vitamin D receptor (VDR) gene. As a consequence, calcium cannot be absorbed intestinally, which results in skeletal malformation and hypomineralisation of bones during growth. Because the VDR gene is also involved in the hair growth cycle, alopecia may occur as well.

Von Willebrand Disease Type 1 (vWD1)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Bernese Mountain Dog, Coton de Tuléar, Dobermann, Drentse Patrijshond, German Pinscher, Irish Red and White Setter, Irish Red Setter, Kerry Blue Terrier, Kromfohrländer, Manchester Terrier, Papillon, Poodle, Stabijhoun, Welsh Corgi Pembroke
Inheritance	Autosomal dominant with incomplete penetrance and expressivity

Duration	3 – 5 days
Note	Clinical signs of vWD are prolonged bleeding time and severe bleeding.

Von Willebrand Disease Type 2 (vWD2)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	German Short-Haired Pointing Dog, German Wire-Haired Pointing Dog
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Clinical signs of vWD are prolonged bleeding time and severe bleeding.

Von Willebrand Disease Type 3 (vWD3)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (Scottish Terrier, Shetland Sheepdog) Sequencing (Kooikerhondje)
Breed	Kooikerhondje, Scottish Terrier, Shetland Sheepdog (Sheltie)
Inheritance	Autosomal recessive
Duration	3 – 5 days (Scottish Terrier, Shetland Sheepdog) 1 – 2 weeks (Kooikerhondje)
Note	Clinical signs of vWD are prolonged bleeding time and severe bleeding.

Xanthinuria Type 2

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Cavalier King Charles Spaniel, Dachshund (Dackel), English Cocker Spaniel, English Toy Terrier, Manchester Terrier
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In xanthinuria type 2, genetic variants in the molybdenum cofactor sulfurase (MOCOS) gene lead to increased excretion of xanthine, a by-product of purine metabolism, in the urine. There is an increased risk of forming xanthine crystals and urinary stones. Signs can already occur at a few weeks of age but also in dogs that are several years old. Low-purine diets and increased water intake can reduce the risk of urinary stone formation.

X-linked Myotubular Myopathy (XL-MTM)

Material	EB 1 ml, buccal swab
Method	Sequencing

Breed	Labrador Retriever, Rottweiler
Inheritance	X-linked recessive
Duration	1 – 2 weeks
Note	XL-MTM affects all skeletal muscles. Clinical signs for this disease can already be seen from birth. Symptoms are severe muscle hypotonia, muscle atrophy and progressive weakening of the hind limbs. Impaired breathing can ultimately lead to death by suffocation.

X-linked Severe Combined Immunodeficiency (X-SCID)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Basset Hound, Welsh Corgi Cardigan, Welsh Corgi Pembroke
Inheritance	X-linked recessive
Duration	1 – 2 weeks
Note	The disease is characterised by developmental disorders, increased susceptibility to pathogens and degeneration of peripheral lymph nodes. Affected dogs usually die as puppies.

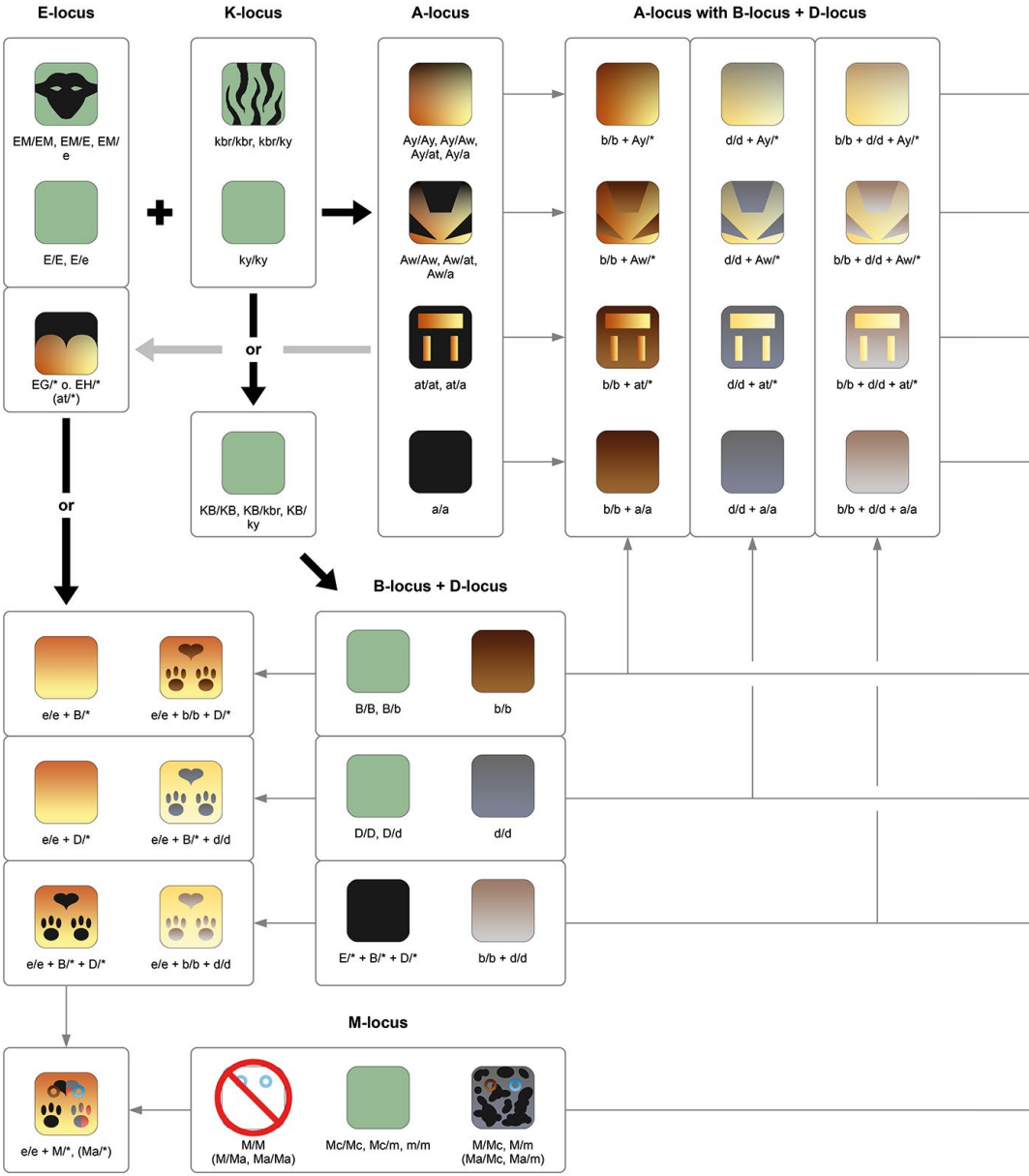
20.2.2 Coat Colour/Coat Structure Dog

The coat colour of dogs is determined by the interaction of several genes that control the formation and distribution of the two main pigments eumelanin (black) and phaeomelanin (red/yellow).

Production is controlled by the gene MC1R (melanocortin-1 receptor), other genes are responsible for colour variants and patterns. The gene for the brown coat colour (TYRP1) modifies the black pigment to brown without the red pigment being involved. Other genes involved in coat colour include Agouti (ASIP), which organises the distribution of black and red pigments, and Dilute (MLPH), which dilutes, among others, black to blue/grey and brown to silver/lilac. There are other genes for the distribution of white patterns and other dilution genes which only play a role in certain breeds. Below, you will find the genetic tests for the inheritance of coat colour in dogs which are carried out at Laboklin.

A-locus: agouti
(fawn, sable, black & tan, tricolor, recessive black)

Material	EB 1 ml, buccal swab
Method	FLP + TaqMan SNP assay
Breed	All
Duration	1 – 2 weeks


E-locus
K-locus
A-locus
A-locus with B-locus + D-locus
EM/EM, EM/E, EM/e
E/E, E/e
kbr/kbr, kbr/ky
ky/ky
Ay/Ay, Ay/Aw, Ay/at, Ay/a
Aw/Aw, Aw/at, Aw/a
at/at, at/a
a/a
b/b + Ay/*
b/b + Aw/*
b/b + at/*
b/b + a/a
d/d + Ay/*
d/d + Aw/*
d/d + at/*
d/d + a/a
b/b + d/d + Ay/*
b/b + d/d + Aw/*
b/b + d/d + at/*
b/b + d/d + a/a
EG/* o. EH/* (at/*)
or
KB/KB, KB/kbr, KB/ky
or
B-locus + D-locus
e/e + B/*
e/e + b/b + D/*
e/e + D/*
e/e + B/* + d/d
e/e + B/* + D/*
e/e + b/b + d/d
B/B, B/b
b/b
D/D, D/d
d/d
E/* + B/* + D/*
b/b + d/d
M-locus
e/e + M/*, (Ma/*)
M/M (M/Ma, Ma/Ma)
Mc/Mc, Mc/m, m/m
M/Mc, M/m (Ma/Mc, Ma/m)


Brindle
EM-locus
S-locus + T-locus
M-locus
kbr/* + Ay/*
EM/* + Ay/*
S/* + Ay/*
? + S/* + Ay/*
M/* + Ay/*
kbr/* + Aw/*
EM/* + Ay/*
S/* + Aw/*
? + S/* + Aw/*
M/* + Aw/*
kbr/* + at/*
EM/*, at/*
S/* + at/*
? + S/* + at/*
M/* + at/*
kbr/* + a/a
EM/* + a/a
S/* + a/a
? + S/* + a/a
M/* + a/a
b/b + kbr/*
b/b + EM/*
b/b + S/*
b/b + ? + S/*
b/b + M/*
d/d + kbr/*
d/d + EM/*
d/d + S/*
d/d + ? + S/*
d/d + M/*
b/b + d/d + kbr/*
b/b + d/d + EM/*
b/b + d/d + S/*
b/b + d/d + ? + S/*
b/b + d/d + M/*
M/*, (Ma/*) + S/*
M/*, (Ma/*) + ? + S/*

B-locus: brown, chocolate, liver (nose)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

B-locus: rare variants (b4, be, bh)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (b4) Sequencing (be, bh)
Breed	b4: Australian Shepherd, Miniature American Shepherd be: Lancashire Heeler bh: Husky
Duration	3 – 5 days (b4) 1 – 2 weeks (be, bh)

C-locus: albino (caL and OCA2)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	French Bulldog, German Spitz, Lhasa Apso, Pekingese, Pomeranian
Duration	3 – 5 days

C-locus: albino (OCA4)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bullmastiff
Duration	1 – 2 weeks

Coat Length I (long or short hair)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Coat Length II (long or short hair)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Afghan Hound, Akita, Alaskan Malamute, Chow Chow, Eurasian, French Bulldog, Husky, Prague Ratter, Samoyed, Shar Pei, Shiba Inu
Duration	1 – 2 weeks

Note	For these breeds, this test should be carried out in addition to the test coat length I listed above.

Cocoa: dark brown, dark chocolate

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	French Bulldog
Duration	3 – 5 days

Curly: curled hair

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, sequencing
Breed	All
Duration	1 – 2 weeks

D-locus: d1 (dilution)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

D-locus: d2, d3 (rare variants)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	d2: Chow Chow, Sloughi, Thai Ridgeback Dog d3: Chihuahua, Italian Sighthound, Pumi and many more
Duration	1 – 2 weeks
Note	For breeds with d2 and d3, testing for d1 + d2 or d1 + d3 is recommended.

E-locus: e1 (yellow, lemon, red, cream, apricot)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days
Note	In Australian Shepherds, Border Collies and other herding dogs, the colour variant "red" is detected by genetic testing of the B-locus.

E-locus: e2 (rare variants)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Australian Cattle Dog
Duration	1 – 2 weeks

E-locus: EG, EH, eA (special colours)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay (eA and EH) Sequencing (EG)
Breed	eA: all ("Husky colouring", similar to domino) EG: Afghan Hound (domino), Barzoi, Saluki (grizzle) EH: American Cocker Spaniel, English Cocker Spaniel (sable)
Duration	3 – 5 days (eA, EH) 1 – 2 weeks (EG)

EM-locus (melanistic mask)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Furnishing (wire hair)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

H-locus (harlequin)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Great Dane
Duration	3 – 5 days
Note	The dominant harlequin allele brightens the merle colour to white and leads to harlequin colouring with black patches on white background. Dogs with genotype H/H are not viable and already die in utero.

Hairlessness (powderpuff)

Material	EB 1 ml, buccal swab
Method	FLP (Chinese Crested Dog, Mexican and Peruvian Hairless Dog) Sequencing (Deerhound)
Breed	Chinese Crested Dog, Deerhound, Mexican Hairless Dog (Xoloitzcuintle), Peruvian Hairless Dog
Duration	1 – 2 weeks
Note	Dogs of the breeds Chinese Crested Dog and Mexican or Peruvian Hairless Dog which carry the heterozygous variant have sparse or no body hair, sometimes abnormal dentition and occasionally malformations of the pinna and the external auditory canal. Dogs without such a variant, on the other hand, have a normal coat and are called powderpuffs. Embryos with a homozygous genetic variant will already die during gestation. In the Deerhound, another variant (in the SGK3 gene) may be associated with juvenile alopecia (loss of coat in the first weeks of life, permanent hairlessness).

I-locus (phaeomelanin intensity)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Improper Coat

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Portuguese Water Dog
Duration	1 – 2 weeks

K-locus: only allele KB

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days
Note	The alleles kbr (brindle) and ky are not covered by this test.

M-locus*: merle alleles (Mh, M, Ma+, Ma, Mc+, Mc, m and mosaics)

Material	EB 1 ml, buccal swab
Method	Partner laboratory
Breed	All

Duration	1 – 2 weeks
Note	Merle (M) is a coat pattern with sections of diluted colour pigments. It is caused by the gene variants M, Mh (harlequin merle) or Ma (atypical merle). Mc (cryptic merle) does not lead to any colour change. The 4 gene variants are inherited in an incomplete dominant manner to the normal form (non-merle, m). The genotype M/M (double-merle) and all combinations of M or Mh with the alleles Mh, M or Ma can lead to severe malformations of the inner ear with hearing loss or deafness as well as to malformations of the eye and are therefore considered as cruel breeding. Such animals often display a very high amount of white or are completely white. The occurrence of merle colouration can be limited to small areas (minimal merle) or may be covered by another colouration (hidden merle). A genetic test is therefore always advisable if merle is present or suspected in a breeding line.

Panda White Spotting

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	German Shepherd
Duration	1 – 2 weeks
Note	This form of white spotting with areas of unpigmented skin is inherited as an autosomal dominant trait; the homozygous mutation is lethal.

S-locus: white spotting, piebald

Material	EB 1 ml, buccal swab
Method	FLP
Breed	All
Duration	1 – 2 weeks
Note	A severe form of spotting is often linked to deafness, which mainly occurs in animals where the white spotting covers the head and ears.

Saddle-tan (A-locus modifier)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Basset Hound, Welsh Corgi Cardigan, Welsh Corgi Pembroke
Duration	1 – 2 weeks

Shedding	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks
Note	Shedding in dogs is influenced by the shedding trait in combination with other coat structural characteristics (furnishing, hair length).

Ticking (roan, mottle, spotted)	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks
Note	Genetic testing for the Tr allele provides information on the inheritance of the ticking trait in unpigmented areas of white spotting, but does not indicate whether it manifests itself as roan, mottle, spots or flecks.

20.3 Cat

20.3.1 Hereditary Diseases

Acrodermatitis Enteropathica (AE)	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Turkish Van
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	AE is caused by a variant in the SLC39A4 gene. This gene encodes an intestinal zinc transporter; a loss of function of this transporter leads to systemic zinc deficiency. Affected kittens show growth retardation and diarrhoea from 6 – 8 weeks of age onwards and suffer from severe, rapidly progressing dermatological signs such as scaling, alopecia, moist dermatitis, severe erosions and lesions on abdomen and limbs. Since there is another intestinal zinc transport pathway, zinc deficiency can be treated by high oral doses of zinc.

Alpha-Mannosidosis (AMD)	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Persian

Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Alpha-mannosidosis (AMD) is a lysosomal storage disease which causes clinical signs like malformation in bone structure as well as severe neurological signs such as ataxia, tremor and limited vision. Cats affected by this rare disease usually die after birth or in the first months of life.

Autoimmune Lymphoproliferative Syndrome (ALPS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	British Shorthair
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	In British Shorthair, ALPS has been found in cats in New Zealand and Australia. Already from 8 weeks of age, the animals display lymphadenopathy and splenomegaly.

Congenital Myasthenic Syndrome (CMS)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Devon Rex, Sphynx
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	CMS in cats leads to generalised amyosthenia in affected animals, especially after stress and agitation. Some animals exhibit a typical "squirrel-like" posture. First signs already appear at three weeks of age. Cats with CMS normally die within two years.

Cystinuria

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Cystinuria is an inherited metabolic disease with defective absorption of certain amino acids in the proximal renal tubule. This results in an increased urinary excretion of the amino acid cystine. Because of the excessive accumulation of cystine in the urine and its poor solubility in water, cystine crystallises and calculi are formed. These uroliths already occur at juvenile age.

Factor XI Deficiency (FXI)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Maine Coon
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Laboklin has identified a genetic defect to be the cause of factor XI deficiency in Maine Coon cats. Diagnostically, factor XI deficiency manifests itself in a prolonged partial thromboplastin time while prothrombin time remains normal, and clinically, there is a tendency for haematoma and minor bleeding after trauma.

Factor XII Deficiency (FXII)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Coagulation factor XII is involved in the intrinsic cascade of blood coagulation. Two different mutations have been described in the factor XII gene that cause FXII deficiency. XII deficiency prolongs the partial thromboplastin time (PTT) in plasma without increasing the bleeding tendency in affected cats.

Gangliosidosis Type GM1, Type GM2

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Balinese, Burmese, Javanese, Korat, Oriental Shorthair (OSH), Peterbald, Seychellois, Siamese, Thai, Tonkinese
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Kittens affected by this lysosomal storage disease have head tremors at the beginning, later followed by impaired coordination of the limbs which eventually lead to paralysis. In GM2 gangliosidosis, clinical signs usually appear earlier (around the age of 2 months) and worsen more quickly. In GM1 gangliosidosis, the onset of neurological signs is a little later (3 months) and they progress more slowly.

Genetic Blood Group

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay

Breed	All, except for European Shorthair
Duration	3 – 5 days
Note	The genetic blood typing test looks for the genetic "b" allele which is necessary for the formation of the serological blood type B. If a female cat has blood type B, the male cat must also have blood type B to avoid neonatal isoerythrolysis in the kittens of the litter. (See also Chapter 3.3, p. 44)

Glycogen Storage Disease Type IV (GSD4)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	Norwegian Forest Cat
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Most affected kittens die at or soon after birth, presumably due to hyperglycaemia. Survivors of the perinatal period appear clinically normal until the onset of progressive neuromuscular degeneration at 5 months of age which eventually leads to death.

Head Defect

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Burmese
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Cats with Burmese head defect have a severe craniofacial deformity and are not viable. One copy of the mutation does not cause any "malformation" but may lead to a shortened facial structure (brachycephaly).

Hypertrophic Cardiomyopathy (HCM1, HCM3, HCM4)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Maine Coon (HCM1, A31P mutation), Ragdoll (HCM3, R820W mutation), Sphynx (HCM4)
Inheritance	Autosomal dominant with incomplete penetrance
Duration	3 – 5 days
Note	HCM is caused by two variants in the MYBPC3 gene (HCM1, HCM3) or one variant in the ALMS1 gene. In HCM1 and HCM3, there is an increased risk of phenotypic expression if the cat is homozygous for the mutation. So far, it is unclear whether the risk of HCM4 is higher in homozygous cats than in heterozygous ones. Furthermore, in the

Sphynx, it is assumed that there is at least one other unknown variant that can cause HCM. Generally, not all genetically affected cats show clinical signs of HCM (incomplete penetrance).

Hypokalaemia

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Australian Mist, Burmese, Cornish Rex, Devon Rex, Singapura, Sphynx, Tonkinese
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Hypokalaemia, also known as familial episodic hypokalaemic polymyopathy, is characterised by episodes of skeletal muscle weakness. Affected cats have problems with walking, jumping and holding their head correctly.

Hypotrichosis and Short Life Expectancy

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Birman (Sacred Cat of Burma)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Affected kittens have a thin downy coat that falls out within a week of birth. Regrowth of a thin coat may occur within the first two months in some animals. Other kittens are born completely bald. In addition, oily and crusty skin in the facial area and anomalies of the claws, tongue and whiskers are other clinical signs. The disease also leads to stillbirths and early death in kittens in the first thirteen weeks of life due to impaired immune response.

MDR1 Gene Variant

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	MDR1 is a drug transporter. It limits the entry of drugs across the blood-brain barrier into the brain and influences intestinal absorption and concentration in bone marrow cells. The MDR1 gene defect correlates with a disturbance in the metabolism of various pharmaceuticals such as antiparasitics (e.g. ivermectin) and possibly also antibiotics, cytostatics as well as analgesics and anaesthetics. There

is an increased absorption of drugs from the intestine with simultaneously reduced excretion in the liver and kidneys. This leads to higher drug levels in the blood and corresponding signs of a toxic effect on the brain, liver, kidneys and the haematopoietic system. In heterozygous animals, too, it must be assumed that drug metabolism is impaired and tolerance is reduced.

Mucopolysaccharidosis Type VI (MPS6)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Balinese, Birman (Sacred Cat of Burma), European Shorthair, Javanese, Oriental Shorthair (OSH), Peterbald, Seychellois, Siamese, Thai, Tonkinese
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	MPS6 is a lysosomal storage disease resulting in a clinically mild and a severe MPS VI phenotype, characterised by severe disorders of the bone structure and the nervous system as well as dwarfism. First clinical signs of the severe phenotype appear after only a few weeks of life.

Mucopolysaccharidosis Type VII (MPS7)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	MPS7 is a rare lysosomal storage disease that leads to bone and cartilage malformation, corneal clouding and enlarged abdominal organs due to a dysfunction in the breakdown of mucopolysaccharides. This can already be seen from the age of two months onwards.

Myotonia congenita

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Myotonia congenita is a disease that affects the skeletal muscles. Signs of the disease are mainly stiff-legged gait as well as a protruding tongue and a mandible which can hardly be opened. Dysphagia and excessive salivation are often seen.

Osteochondrodysplasia (OCD)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Scottish Fold
Inheritance	Autosomal dominant
Duration	1 – 2 weeks
Note	A mutation in the TRPV4 gene leads to the characteristic forward-folded ears in Scottish Fold. Furthermore, this mutation causes osteochondrodysplasia in this breed with malformation in bones and joints of the distal limbs and tail. Homozygous affected cats seem to develop severe malformations, therefore it is not recommended to mate Scottish fold cats with one another.

Polycystic Kidney Disease (PKD)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Birman (Sacred Cat of Burma), British Longhair, British Shorthair (BSH), Chartreux, Colourpoint Shorthair, Exotic Shorthair, Persian, Ragdoll, Russian Blue, Scottish Fold, Selkirk Rex, Turkish Angora
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	In PKD, in addition to the formation of cysts in the liver and pancreas, fluid-filled cysts form in the kidneys which can eventually cause renal failure leading to the death of an affected cat.

Primary Congenital Glaucoma (PCG)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Siamese
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Cats with primary glaucoma often have congenital malformations in the eye causing increased intraocular pressure. This results in damage of the retinal ganglion cells and the optic nerve, which leads to blindness within the first months of life.

Progressive Retinal Atrophy (PRA)

b-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Bengal

Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	Bengal progressive retinal atrophy causes destruction of the retinal photoreceptors from about 7 weeks of age onwards and leads to a dilation of the pupils. b-PRA progresses slowly until the cat already has very limited vision at about 2 years of age. Time varies until complete blindness develops.

pd-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Birman (Sacred Cat of Burma), British Longhair, British Shorthair (BSH), Chartreux, Colourpoint Shorthair, Exotic Shorthair, Persian, Ragdoll, Russian Blue, Scottish Fold, Selkirk Rex, Turkish Angora
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	Progressive retinal atrophy (pd-PRA) causes photoreceptor degradation in affected animals already at 5 weeks of age, leading to complete blindness by 16 weeks of age. The main signs are uncoordinated eye movements. The ocular fundus shows increased reflectivity.

rdAc-PRA

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Abyssinian, American Curl, American Wirehair, Balinese, Bengal, Colourpoint, Cornish Rex, Javanese, Munchkin, Ocicat, Oriental Shorthair (OSH), Peterbald, Seychellois, Siamese, Singapura, Somali, Thai, Tonkinese
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The onset of clinical signs is usually at the age of 1.5 to 2 years (so-called late onset). At the final stage of the disease, usually at the age of 3 – 5 years, the photoreceptors are completely destroyed and the cat becomes totally blind.

rdy-PRA

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Abyssinian, Ocicat, Somali
Inheritance	Autosomal dominant
Duration	1 – 2 weeks
Note	Already at the age of about three weeks, retinal malformations are visible during examinations (so-called early onset); affected cats usually go almost completely blind at the age of about seven weeks.

Pyruvate Kinase Deficiency (PK)	
Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay, if necessary sequencing
Breed	Abyssinian, Bengal, Egyptian Mau, European Shorthair, LaPerm, Maine Coon, Norwegian Forest Cat, Ocicat, Savannah, Siberian, Singapura, Somali, Turkish Angora
Inheritance	Autosomal recessive
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	PK is characterised by chronic regenerative haemolytic anaemia. Severe haemolytic crises also occur, especially in case of stress or infection. Occasionally, an enlarged spleen is palpable.

Skeletal Dysplasia (SD)	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	British Shorthair (BSH)
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A mutation in the LTBP3 gene causes skeletal dysplasia, which is associated with paralysis of the hind legs, lordosis and scoliosis, myelopathy and motility disorders of the gastrointestinal tract. The first signs were seen at 8 weeks of age. In affected kittens, deformation of several thoracic vertebral bodies, spinal stenosis, compression of the spinal cord and coprostasis occurred, resulting in the kittens being euthanised.

Spinal Muscular Atrophy (SMA)	
Material	EB 1 ml, buccal swab
Method	FLP
Breed	Maine Coon
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	SMA is characterised by muscle atrophy and muscle weakness which are associated with the degeneration of spinal motoneurons and already occur at the age of about 12 weeks.

20.3.2 Coat Colour/Coat Structure Cat

Coat Colour Amber

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	Norwegian Forest Cat
Duration	3 – 5 days

Coat Colour Brown (chocolate/cinnamon)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Coat Colour Copal

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Kurilian Bobtail
Duration	1 – 2 weeks

Coat Colour Russet

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Burmese
Duration	1 – 2 weeks

Coat Colour Variant Agouti

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Coat Colour Variant Albino

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Coat Colour Variant Charcoal

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bengal
Duration	1 – 2 weeks

Coat Colour Variant Colourpoint (Siam/Mink/Burma)

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All, except for Bengal
Duration	3 – 5 days

Coat Colour Variant Dilution

Material	EB 1 ml, buccal swab
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Coat Colour Variant Gold (copper)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	British Shorthair (BSH)
Duration	1 – 2 weeks
Note	The colour variant gold is a modification of the tabby pattern.

Coat Colour Variant Gold (sunshine, extreme sunshine)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Kurilian Bobtail, Siberian
Duration	1 – 2 weeks
Note	The colour variant gold or sunshine is a modification of the tabby pattern.

Coat Colour Variant Snow

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Bengal
Duration	1 – 2 weeks
Note	Snow is the name for colourpoint colouration in Bengals.

Coat Colour Variant Tabby (mackerel, blotched)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Coat Colour Variant Ticked

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Coat Colour Variant White (dominant white/white spotting)

Material	EB 1 ml, buccal swab
Method	FLP
Breed	All
Duration	1 – 2 weeks
Note	White spotting (ws) and dominant white (W) are caused by insertions of the endogenous retrovirus FERV1 in the KIT gene; ws is a complete insertion, W is a partial insertion. W is dominant over ws and both are dominant over the wild type (w+). Hearing loss or deafness always occur in the genotype WW, and sometimes occur in Wws and Ww+. The W allele also leads to a typical blue colouration of the iris; in Wws and Ww+, again, penetrance is incomplete.

Coat Length (long or short hair)

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks
Note	This test detects all four known alleles for long hair.

Coat Variant Curly in Selkirk Rex

Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Selkirk Rex
Duration	1 – 2 weeks

Coat Variant Sphynx/Devon Rex	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Devon Rex, Sphynx
Duration	1 – 2 weeks

20.3.3 LABOGenetics XXL Cat

LABOGenetics XXL Cat analyses over 50 genetic variants. It provides information on hereditary diseases, genetic risk factors, coat colours, coat characteristics and the genetic blood group.

The benefits of LABOGenetics XXL Cat are clear:

- **Comprehensive testing:** It provides detailed results for all genetic tests included.
- **Universally applicable:** It is recommended for cats of all breeds as well as for mixed breeds with an unknown genetic background.
- **Bonus information:** Even if a specific part of the tests is of primary interest, choosing LABOGenetics XXL provides additional genetic information free of charge.

Material	EB 1 ml/ special swabs on request
Species	Cat
Breed	All breeds and their mixes
Duration	2 – 3 weeks

For further information and details of the tests included, please visit:
https://shop.labogen.com/labogenetics-xxl

20.4 Rabbit

20.4.1 Hereditary Diseases

Megacolon (MC)	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	Flemish Giant
Inheritance	Autosomal recessive with incomplete penetrance
Duration	1 – 2 weeks
Note	Congenital megacolon is a disease that is characterised by a dilated colon, impaired intestinal motility and digestive problems and results

in reduced viability. A mutation in the KIT gene is responsible for the disturbed intestinal peristalsis. The disease is associated with spotting in rabbits.

20.4.2 Coat Structure in Rabbits

Rex Shorthair	
Material	EB 1 ml, buccal swab
Method	Sequencing
Breed	All
Duration	1 – 2 weeks
Note	There are three known loci that are associated with the development of the very soft, short Rex coat in rabbits. The r1 mutation is caused by a change in the LIPH gene and is the most common variant of the Rex coat.

20.5 Horse

20.5.1 Hereditary Diseases

Androgen Insensitivity Syndrome (AR1)	
Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Quarter Horse and related breeds
Inheritance	X-linked recessive
Duration	1 – 2 weeks
Note	In androgen insensitivity syndrome, XY (genetically male) horses have a female phenotype (female external genitalia) and internal testes. These horses often behave like stallions, but are not capable of reproduction.

Androgen Insensitivity Syndrome* (AR2, AR3, AR4, AR5)	
Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	Tennessee Walking Horse, thoroughbreds, warmbloods
Inheritance	X-linked recessive
Duration	4 – 6 weeks
Note	see AR1

Cerebellar Abiotrophy (CA)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Arabian
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	CA is a neurological disease in which affected foals are born without symptoms; the first signs usually appear at the age of 6 weeks (up to 4 months): neurological deficits such as head shaking, ataxia and other deficiencies can occur in varying degrees of severity.

Congenital Stationary Night Blindness* (CSNB2)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	Tennessee Walking Horse, Standardbred, Missouri Fox Trotter
Inheritance	Autosomal recessive
Duration	4 – 6 weeks
Note	In congenital stationary night blindness (CSNB), affected animals cannot see in low light or darkness. CSNB is not progressive. Some typical signs of CSNB are fear of unfamiliar places in the dark,difficulty finding food or water buckets at night, or being prone to injuries at night-time. CSNB in horses is often not detected by the owner. The definitive diagnosis of CSNB is made by electroretinogram. Similar to humans and other animals, there are probably several different genes that contribute to this disease in horses, and these genes are thought to be breed-specific. Based on population screening, it is estimated that one in one hundred Tennessee Walking Horses is homozygous for this variant and therefore likely to be night blind. Congenital stationary night blindness can also be caused by a homozygous mutation in the leopard gene. To test for the presence of this mutation, the Leopard Complex test should be requested (see Chapter 20.5.2, p. 392).

Distichiasis*

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	Friesian
Inheritance	Unknown
Duration	4 – 6 weeks
Note	Abnormal growth of eyelashes from the Meibomian glands leads to misplaced eyelashes. They can cause irritation and inflammation of

the cornea, excessive tearing, squinting and pain up to ulceration and scarring of the cornea. Loss of vision may occur or the eye may need to be removed. In some horses, there are no signs of abnormal growth of the eyelashes, so it may remain undetected that these horses will transmit this genetic variant in any case.

Dwarfism

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Friesian
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Dwarfism in Friesian horses is characterised by growth retardation of the ribs and limbs, while the head and back appear normal. Hyperextension of the fetlock joints is particularly noticeable. The flexor tendon becomes longer. This leads to an abnormal gait with extreme rotation at the carpus and hocks. The ribcage is wider than normal with a thickening of the costo-chondral junction (Th 10-16). The back appears disproportionately long, but the legs are greatly shortened. The abdomen is usually rounded, the muscles of the whole body are only poorly developed.

Dwarfism (ACAN, Chondrodysplasia)

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	American Miniature Horse, Shetland Pony
Inheritance	See note
Duration	1 – 2 weeks
Note	Dwarfism is most common in Shetland Ponies and Miniature Horses. Phenotypic features include deformed mouths and cleft palates (respiratory problems), limb deformities, a disproportionately large head, a short neck and abdominal hernia. Four different mutations in the ACAN gene (D1, D2, D3*, D4), which are inherited in an autosomal recessive manner, can also cause disease in a compound heterozygous form, i.e. two different heterozygous mutations of the same gene are present. Compound heterozygous variants combined with the D1 variant (except for N/D1) often lead to death. A combination with the D2 variant is considered to be the mildest form.

Equine Malignant Hyperthermia (EMH)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	The clinical signs appear after halothane anaesthesia or succinylcholine injection and include hyperthermia (> 40 °C) and metabolic acidosis. The animals show generalised spasms of the skeletal muscles, followed by cardiac arrhythmia and renal dysfunction.

Foal Immunodeficiency Syndrome (FIS)

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Dales Pony, Fell Pony
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Foals with FIS are born apparently healthy but as they lack immunity, they develop a number of diseases, especially pneumonia and diarrhoea at a few weeks of age. Foals also suffer from severe progressive anaemia and usually die before the age of three months.

Glycogen Branching Enzyme Deficiency (GBED)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Appaloosa, Paint Horse, Quarter Horse and related breeds
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Clinical signs of GBED are abortion, stillbirth or birth of weak foals, sudden cardiac death (especially on the pasture) or death caused by seizures, high respiratory frequency due to weakened respiratory muscles or general weakness (especially when getting up).

Hereditary Equine Regional Dermal Asthenia (HERDA)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Appaloosa, Paint Horse, Quarter Horse and related breeds
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The skin of affected horses is hyperextensible, scarred, and often shows severe lesions.

Hereditary Myotonia

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	New Forest Pony
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	The first signs of congenital myotonia already appear at a few weeks of age. Foals have a stiffed-legged gait, are recumbent and have considerable difficulty getting back on their feet after a long period of lying.

Hoof Wall Separation Disease (HWSD)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	American Miniature Horse, Connemara Pony, German Riding Pony
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Hoof wall separation disease (HWSD) is characterised by a very unstable hoof wall which can crack and break without any particular strain. Symptoms already appear in the first weeks of life and can be of varying severity.

Hydrocephalus

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Friesian
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Hydrocephalus in Friesian horses often results in stillbirth of affected foals and dystocia in dams.

Hyperkalaemic Periodic Paralysis (HYPP)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Appaloosa, Paint Horse, Quarter Horse and related breeds
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	The horses are usually very well-muscled and can be successful show/sport horses between episodes of illness with general weakness, muscle spasms and fasciculations. The first episodes of illness are often observed at the age of 3 to 7 years.

Life-threatening complications are cardiac arrhythmia (secondary to hyperkalaemia) and danger of suffocation by laryngospasm.

Idiopathic Hypocalcaemia

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Thoroughbred
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Foals affected by the lethal hypocalcaemic syndrome suffer from muscle spasms, stiff gait and increased sweating. They die soon or are euthanised within a few weeks. A genetic variant in the RAPGEF5 gene is inherited homozygously and associated with hypoparathyroidism. The reduced PTH production leads to calcium deficiency. Since the breed is used for improvement breeding, it cannot be ruled out that this hereditary disease is bred into other breeds.

Immune-Mediated Myositis & MYH1 Myopathy (MYHM)

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Appaloosa, Paint Horse, Quarter Horse and related breeds
Inheritance	Autosomal dominant with incomplete penetrance
Duration	1 – 2 weeks
Note	A variant in the gene MHY1 inhibits the function of the myosin protein and is associated with muscle diseases known as MYH1 myopathy (MYHM). This genetic variant leads to 2 clinical pictures - immune-mediated myositis (IMM) in 8- to 17-year-old horses and non-exertional rhabdomyolysis in young horses. **IMM** is a muscular autoimmune disorder with mainly lymphocytic infiltration into muscle fibres and surrounding blood vessels. IMM can lead to weakness, stiffness and severe muscle atrophy with loss of up to 40% of muscle mass in 72 hours. In addition to the genetic disposition, further adverse factors are important triggers. For example, about 39% of IMM-affected horses have suffered from infections like Streptococcus equi subsp. equi or EHV4 for a long time. In young Quarter Horses, **non-exertional rhabdomyolysis** causes severe, sudden muscle damage which occurs without any physical exertion and is not necessarily associated with muscle atrophy. Inheritance is autosomal dominant with incomplete penetrance. Thus, not all horses that have one or two alleles of the genetic variant will suffer from the disease. Horses with two alleles may be more severely affected.

Junctional Epidermolysis Bullosa (JEB1)

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Belgian Draft
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	Shortly after birth, foals lose skin parts on the head, neck and trunk. The hoof horn also separates from the hoof corium.

Junctional Epidermolysis Bullosa* (JEB2)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	American Saddlebred
Inheritance	Autosomal recessive
Duration	4 – 6 weeks
Note	see JEB1

Lavender Foal Syndrome (LFS)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Arabian
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	Affected foals show a range of neurological signs, including convulsive seizures, opisthotonus or nystagmus. They are normally unable to stand and nurse from their mother and are usually euthanised if they do not die immediately after birth.

Naked Foal Syndrome (NFS)

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Akhal-Teke
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	NFS is a genodermatosis in which foals are born with almost no hair. They show a mild form of ichthyosis and mostly die in the first weeks after birth. So far, the reason for the early death is unknown; only few horses reach an age of up to 2.5 years.

Occipitoatlantoaxial Malformation* (OAAM)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	Arabian
Inheritance	Autosomal recessive
Duration	4 – 6 weeks
Note	OAAM is characterised by a fusion of the occipital bone with the atlas. An additional malformation of the axis with an accompanying shortened dens can cause an unstable connection between the atlas and axis. Subluxation of the atlantoaxial joint is also possible. The resulting compression of the spinal cord can cause neurological signs. Affected horses show an abnormal head and neck posture and reluctance to move the neck. Clinical signs range from weakness of the limbs to progressive ataxia. In addition to the deletion in the homeobox gene cluster (HOX), several mutations seem to be the cause of OAAM in Arabian horses.

Ocular Squamous Cell Carcinoma (SCC)

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Belgian Draft (Ardennais, Brabant), Haflinger
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	A variant in the DDB2 gene was detected as a genetic risk factor (R) for squamous cell carcinoma in the horse's eye in Haflingers and related breeds. Homozygous horses (R/R) develop SCC 5.6 times (Haflinger) or 4.0 times (Belgian Draft) more often than horses with one copy (R/N) or no copy (N/N). This risk factor does not explain all cases of SCC, but seems to be a significant contributor in Haflingers and Belgian Drafts. In homozygous horses (R/R), routine eye examinations and UV protection are advisable.

Overo Lethal White Syndrome (OLWS)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Frame overos of all breeds, Paint Horse and related breeds
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	OLWS (also called lethal white overo syndrome, LWO) mainly occurs when mating frame overo horses. Affected foals are born completely white and die within 24 – 48 hours after birth due to intestinal aganglionosis and the resulting ileus.

Polysaccharid Storage Myopathy Type 1 (PSSM)

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Inheritance	Autosomal dominant
Duration	3 – 5 days
Note	The clinical signs are similar to those of sporadic exertional rhabdomyolysis and include the entire spectrum from reluctance to move to muscle tremor, muscle stiffness, sweating, alternating lameness, stretching of the hind legs up to immobility. Episodes usually begin after 10 – 20 minutes of light exercise. Laboklin owns the exclusive license to perform this genetic test.

Severe Combined Immunodeficiency (SCID)

Material	EB 1 ml, hair roots
Method	FLP
Breed	Arabian
Inheritance	Autosomal recessive
Duration	1 – 2 weeks
Note	SCID is a primary, lethal immunodeficiency disease characterised by the inability to produce B and T lymphocytes. Affected foals are extremely susceptible to infections.

Skeletal Atavism* (SA)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	American Miniature Horse, Shetland Pony
Inheritance	Autosomal recessive
Duration	4 – 6 weeks
Note	Skeletal atavism is characterised by the ulna and fibula growing too long and failing to fuse with the radius and tibia, respectively. This results in severe angle anomalies and deformation of the carpal joint and hocks, typically short limbs, a low rectangular body shape, abnormal limb position and impaired movement. The angles of the limbs and the movement pattern become more abnormal as the foal ages and in most cases the horse has to be euthanised within six months. A Swedish research team has identified two independent overlapping regions in the SHOX gene in which DNA sequences were lost (deletions) in affected ponies.

SynchroGait* (DMRT3) ➢ **see Chapter 20.5.3, p. 395**

Tiger Eye* ➢ **see Chapter 20.5.2, p. 394**

Warmblood Fragile Foal Syndrome (WFFS)	
Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	Warmblood, Appaloosa, Thoroughbred, Haflinger, Mustang, Paint Horse, Quarter Horse
Inheritance	Autosomal recessive
Duration	3 – 5 days
Note	WFFS is an inherited connective tissue disorder; its signs are similar to those of Ehlers-Danlos syndrome in humans. The skin is extremely fragile and tears at even the slightest touch. Not all foals are born after a normal period of gestation; premature births and miscarriages due to WFFS are also known. In Germany, Laboklin owns the exclusive license to perform this genetic test.

20.5.2 Coat Colour/Coat Structure Horse

Agouti (Bay/Black)	
Material	EB 1 ml, hair roots
Method	FLP
Breed	All
Duration	1 – 2 weeks

Appaloosa Pattern 1 (PATN1)	
Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Brindle 1	
Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Camarillo White – W4*

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	All
Duration	4 – 6 weeks

Champagne

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Chestnut

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Cream

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days

Curly

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Inheritance	See note
Duration	1 – 2 weeks
Note	Curly Coat leads to a curly coat structure. Curly horses are popular because this coat structure leads to milder or no allergic symptoms in many horse-allergic people. Curly is caused by variants in the genes KRT25 and SP6, which are both separately examined in the test. Horses with variants in both genes or only in KTR25, do not only have curly coat but also develop hypotrichosis. Horses which only have a variant in SP6 just have a curly coat.

Dominant White W5, W10, W13, W20, W22*

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	All
Duration	4 – 6 weeks

Dun

Material	EB 1 ml, hair roots
Method	FLP
Breed	All
Duration	1 – 2 weeks

GQ Santana Dominant White W10*

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	All
Duration	3 – 4 weeks

Greying*

Material	Mane/tail hair only
Method	Partner laboratory
Breed	All
Duration	3 – 4 weeks
Note	A duplication in the STX17 gene leads to loss of hair pigmentation in the first 6 – 8 years. Heterozygous animals often stay dapple grey or flea-bitten grey. Melanoma formation is also associated with the STX17 mutation. 70 – 80% of greys over 15 years of age have one or more melanomas. The risk is higher in homozygous greys than in heterozygous greys and higher in greys that were born black than in those that were born bay.

Incontinentia Pigmenti

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Duration	1 – 2 weeks
Note	IP is an ectodermal dysplasia in which pruritic, exudative skin lesions occur soon after birth, sometimes developing into verrucous lesions. There may be areas with alopecia where woolly hair might re-grow. From birth, affected horses show stripes in the coat and can also

develop dental, hoof and ocular abnormalities. Due to the X-linked dominant inheritance, IP symptoms can only be seen in mares (affected male embryos die in utero).

Leopard Complex

Material	EB 1 ml, hair roots
Method	TaqMan SNP assay
Breed	All
Duration	3 – 5 days
Note	The leopard gene (LP) is inherited in a dominant manner and is responsible for the leopard pattern. From birth, homozygous carriers of the gene (LP/LP) are almost always affected by congenital stationary night blindness (CSNB).

Mushroom

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Shetland Pony
Duration	1 – 2 weeks

Pearl

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Roan Zygosity*

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	On request
Duration	4 – 6 weeks

Sabino-1

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Silver Dapple

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Duration	1 – 2 weeks
Note	The dominantly inherited silver dapple gene leads to the dilution of black and bay hair, especially on mane and tail. There is a connection between this mutation and ocular malformations. These are more pronounced in homozygous animals than in heterozygous animals, where they can also remain undetected.

Snowdrop

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Tinker Horse/Gypsy Cob
Duration	1 – 2 weeks

Splashed White (SW 1 – 4)

Material	EB 1 ml, hair roots
Method	Sequencing and FLP
Breed	All
Duration	1 – 2 weeks
Note	Splashed White is characterised by an extremely wide blaze, or bald face, often with blue eyes and bright white legs. So far, 4 causative mutations have been identified (SW 1 to SW 4), which are inherited in a dominant manner. Some horses with this pattern are deaf, especially if the ears are also white. SW 2 and SW 3 seem to be homozygous lethal.

Splashed White* (SW 5 – 8)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	All
Duration	4 – 6 weeks
Note	As well as SW 1 – SW 4, SW 5 – SW 8 also lead to splashed white markings with a similar phenotype, but the extent of the white pattern is variable. It is thought to be controlled by other genes, some of them known, some unknown. It is not known whether the mutations are homozygous lethal. However, due to the nature of the mutation and the role the MITF gene plays in development, it is

assumed that SW6/SW6 may be embryonically lethal. Horses carrying combinations of the splashed white mutations, tobiano or overo lethal white may have extensive white markings or their coats may be completely white.

Sunshine	
Material	EB 1 ml, hair roots
Method	Sequencing
Breed	All
Duration	1 – 2 weeks

Tiger Eye*	
Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	Paso Fino
Inheritance	Autosomal recessive
Duration	4 – 6 weeks

Tobiano	
Material	EB 1 ml, hair roots
Method	FLP
Breed	All
Duration	1 – 2 weeks

20.5.3 Performance Horse

Predictive Height Test	
Material	EB 1 ml, hair roots
Method	TaqMan SNP assay, if necessary sequencing
Breed	Warmblood
Duration	3 – 5 days (1 – 2 weeks for sequencing)
Note	The height of warmblood horses is influenced by a variant in the LCORL gene in addition to factors such as feeding, husbandry and how young horses are reared. If the genotype is known, the height of the horse can be estimated. When mating, the chance of the desired phenotype (withers height) can be increased if, at best, the genotype of both parents is known.

Speed Gene* (Myostatin Mutation)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	Thoroughbred
Duration	1 – 2 weeks
Note	The protein myostatin is responsible for inhibiting muscle growth. Variants in the myostatin gene MSTN influence the development of different muscle types (proportion of muscle mass in relation to total weight). The test provides information about which racing distance is the best for the horse being tested, but does not provide any information about whether the horse is actually suitable as a racehorse.

SynchroGait* (DMRT3)

Material	EB 1 ml, hair roots
Method	Partner laboratory
Breed	American Bashkir Curly Horse, American Miniature Horse, American Saddlebred, Appaloosa, Icelandic Horse, Kentucky Mountain Saddle Horse, Mangalarga Marchador, Missouri Fox Trotter, Morgan Horse, Paint Horse, Paso Fino, Paso Peruano, Quarter Horse, Scandinavian Coldblood Trotter, Trotter, Tennessee Walking Horse
Inheritance	Autosomal recessive
Duration	4 – 6 weeks
Note	SynchroGait is a diagnostic DNA test for a genetic variant (A) that has a major impact on the gait and coordination of horses. The mutation facilitates lateral gates, which is a basic requirement for pace, and inhibits the transition from trot or pace to canter. AA horses have a natural talent for pace and excellent leg coordination in trot at high speed. In Icelandic horses, AA horses have a predisposition to perform five gaits (incl. tölt and pace). CA and CC Icelandic horses are more likely to perform only four gaits (tölt, but no pace).

Tractability

Material	EB 1 ml, hair roots
Method	Sequencing
Breed	Thoroughbred
Duration	1 – 2 weeks
Note	The test is intended to show a horse's willingness to learn and perform. Tractability is influenced by anatomical conditions and diseases, so the genotype does not necessarily have to match the phenotype.

20.6 Cattle

Sampling instructions
There should **not** be any **blood samples** sent in for **cattle from multiple births** because of a possible blood chimerism, but if the test allows it, hair roots, sperm or tissue samples can be used. One exception to this is the **free martin test,** for which a **blood sample is mandatory.**

20.6.1 Hereditary Diseases

Arachnomelia* (spider limbs)	
Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	Brown Swiss, Fleckvieh
Duration	Approx. 2 weeks
Note	Hereditary arachnomelia of Fleckvieh cattle and Brown Swiss is passed on in an autosomal recessive manner. It is characterised by a developmental disorder of the skeletal system leading to the birth of dead or malformed calves and an increased risk of injury to the mother.

Bovine Leukocyte Adhesion Deficiency (BLAD)	
Material	EB 1 ml
Breed	Holstein Friesian
Duration	Approx. 2 weeks
Note	BLAD is a lethal autosomal recessive disease of the immune system in Holstein cattle. Affected calves suffer from immunodeficiency and die before reaching sexual maturity. Clinical signs include in recurrent non-specific infections of the respiratory system and the gastrointestinal tract, delayed wound healing and reduced weight gain as well as leukocytosis with granulocytosis and lymphopenia as laboratory findings.

Bovine Progressive Degenerative Myeloencephalopathy* (Weaver Syndrome)	
Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	Brown Swiss
Duration	Approx. 2 weeks
Note	Weaver syndrome is a hereditary CNS disease in Brown Swiss. At the age of a few months, the first signs appear as weakness of the hind legs, problems getting up and unsteady gait. Disorders are progressive and, after 1 – 3 years, lead to recumbency and death. Weaver syndrome is inherited in an autosomal recessive manner.

Bovine Spinal Dysmyelination* (SDM)	
Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	Brown Swiss
Duration	Approx. 2 weeks
Note	SDM occurs in Brown Swiss, is autosomal recessive and leads to insufficient myelination. After birth, calves lie down in a lateral position with their limbs stretched forward. The head is often in a "moon-gazing position"; sometimes hyperreflexia can be observed. The animals are usually euthanised shortly after birth.

Free Martins*	
Material	EB 1 ml
Breed	All
Duration	3 – 4 weeks
Note	In case of twins of different sexes, about 90% of infertile, externally female calves occur during pregnancy, so-called free martins, due to the transfer of male cells to the female embryo. Already in newborn twins of different sexes, the phenotypically female calves can be examined to see whether they develop as free martins.

Spinal Muscular Atrophy* (SMA)	
Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	Brown Swiss
Duration	Approx. 2 weeks
Note	This autosomal recessive disease in Brown Swiss calves leads to the destruction of motor neurons and, at the age of a few weeks, to spinal muscular atrophy. The animals are recumbent, usually without losing their appetite. Spinal reflexes are reduced, pumping respiration is seen, and the animals often develop secondary pneumonia and die after a few weeks.

20.6.2 Breed Characteristics Cattle

Milk Protein

The composition of milk proteins is of considerable importance for further milk processing. In particular, the cheese-making properties of the milk strongly depend on the milk composition. 90% of the proteins in milk consist of the six proteins αS1-casein, αS2-casein, β-casein, kappa-casein, α-lactalbumin and β-lactoglobulin.

β-Kasein

Material	EB 1 – 2 ml, about 30 hairs with roots, tissue, sperm
Breed	All
Duration	2 – 3 days
Note	The genetic variants A1 and A2 ß-casein can be detected.

Kappa-Kasein*

Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	All
Duration	Approx. 2 weeks
Note	The kappa-casein gene influences important parameters for milk processing. Kappa-casein variant B is particularly favourable for further processing.

Polledness*

Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	All
Duration	Approx. 2 weeks
Note	In polled cattle, the painful procedure of dehorning is no longer required. Reservations regarding loss of performance in polled lines have largely been eliminated. However, the test cannot evaluate the genetic predisposition for scurs and has not been validated for zebu cattle.

Red Factor*

Material	EB 3 – 5 ml, about 50 hair roots, tissue, sperm
Breed	Black pied Holstein Friesian cattle
Duration	Approx. 2 weeks
Note	Black pied cattle of the breed Holstein Friesian with a predisposition for a red coat (“red factor”) are popular crossbreeds in red pied breeding. The determination of the genotype of the MSHR gene allows to differentiate between black pied cattle with red factor (Ee) and without red factor (EE).

20.7 Small Ruminants and New World Camels

20.7.1 Hereditary Diseases

Arachnomelia* (spider lamb syndrome)	
Material	20 – 30 hairs with roots
Species	Sheep of all breeds
Duration	3 – 4 weeks
Note	Hereditary chondrodysplasia leads to underdeveloped muscles in the lamb and, at about 4 – 6 weeks of age, to skeletal deformities of the head, spine, ribs and abnormally long and bent/twisted limbs (spider lambs). The autosomal recessive disease first occurred in black-headed sheep of the Suffolk and Hampshire breeds and is based on a mutation in the gene FGFR3 (Fibroblast Growth Factor Receptor 3).

Free Martins*	
Material	EB 3 – 6 ml
Species	Sheep, goat, llama, alpaca
Duration	3 – 4 weeks
Note	In case of twins of different sexes, the transfer of male cells to the female embryo during pregnancy can result in infertile, externally female animals, so-called free martins. In llamas and alpacas, the risk is 90%, for sheep and goats < 1%, but increases with multiple pregnancies with four or more animals. Already in newborn twins of different sexes, the phenotypically female calves can be examined to see whether they develop as free martins.

Predisposition for Scrapie	
Material	EB 1 – 2 ml
Species	Sheep
Duration	1 – 2 weeks
Note	Scrapie is a transmissible prion disease in sheep and goats. Prions are proteins. If they are pathologically altered, they induce their own proliferation and the vacuolation of nerve cells, especially in the brain stem. Initially, affected animals are lazy, later they show increasing excitability and an unnatural gait and die within six months after the onset of the disease. In sheep, there is a genetic predisposition to the classical form of scrapie. Genotype classes are distinguished according to the amino acid pattern. The risk of scrapie varies from an extremely low ("resistant") to a very high risk depending on the genotype class.

20.7.2 Breed Characteristics Small Ruminants

Milk Protein α-S1-Kasein*	
Material	20 – 30 hairs with roots
Species	Goats of all breeds
Duration	3 – 4 weeks
Note	The αS1-casein gene influences the casein and fat content of goat milk. A high content of αS1-casein is positive for cheese production, a low content is beneficial for people with milk intolerance. The gene variants A and B are associated with high αS1-casein contents, while only little αS1-casein is formed in E, F and N.

20.8 Pig

Malignant Hyperthermia (MH)*	
Material	EB 1 ml
Species	Pig
Duration	Approx. 2 weeks
Note	MH syndrome or porcine stress syndrome (PSS) is passed on recessively and is mainly found in breeds with increased muscle mass and reduced amount of fat. The disease is caused by a mutation of the ryanodine receptor in the skeletal muscle, which leads to a disturbance of the Ca^2 ion exchange and a lowered threshold for muscle cell contraction. It is accompanied by hypermetabolism and increased body temperature caused by inhalation narcotics, muscle relaxants and stress. Damage to nerve, liver and kidney tissue occurs.

21 DNA Profile, Breed, Species

21.1 Identity and Parentage

The DNA profile of an animal is also called genetic fingerprint. In contrast to other marking methods, like microchips or tattoos, it cannot be manipulated or destroyed by external factors, such as injuries. It remains unchanged for a lifetime.
On the one hand, a DNA profile provides a lifelong, doubtless identification of the animal. On the other hand, parentage (fatherhood or parenthood) can be proven with certainty by comparing the genetic fingerprints of the family members.

Comparison of DNA Profiles (parentage/paternity test) Schlagworte??	
Material	EB 1 ml, buccal swab Horse and water buffalo: 20 – 30 hairs with roots
Method	Microsatellite analysis (STRs)
Species	Dog, cat, horse, cattle, sheep, goat, llama, alpaca, water buffalo, pig
Duration	1 – 2 weeks 4 – 5 weeks (alpaca, llama, water buffalo)
Note	The proof of parentage (paternity test) makes it possible to check which parents the offspring has. The DNA profiles of the parents and offspring are the basis for this. **What is important to know:** Even if only the paternity should be clarified, please send in samples from both parents. In dogs, this applies to the Classic STR DNA profiles (ISAG 2006). The Premium SNP DNA profile (ISAG 2020) in dogs has the potential to solve parentage cases for which only one parent is available (breeds on request).

DNA Profile (ISAG 2006) **Dog: Classic STR DNA Profile (ISAG 2006)**	
Material	EB 1 ml, buccal swab Horse and water buffalo: 20 – 30 hairs with roots
Method	Microsatellite analysis (STRs) (according to ISAG 2006)
Species	Dog, cat, horse, cattle*, sheep*, goat*, llama*, alpaca*, water buffalo*, pig*
Duration	1 – 2 weeks (dog, cat, horse) 3 – 5 weeks (all other species)
Note	To create a DNA profile, we test so-called microsatellite markers (e.g. 22 markers in dogs), recommended in 2006 by the "International Society for Animal Genetics (ISAG)". The DNA profiles we generate are internationally comparable with laboratories working according to the recommendations of ISAG.

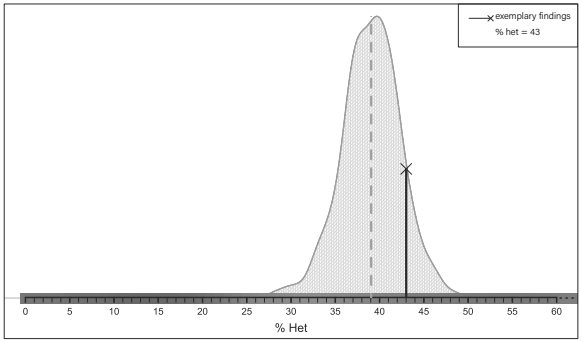
Dog: Classic STR DNA Profiles (ISAG 2006) and Premium SNP DNA Profiles (ISAG 2020) are not compatible and cannot be used simultaneously within the same parentage analysis.

Premium SNP DNA Profile (ISAG 2020)

Material	EB 1 ml, also possible from special swabs (see Chapter 1.7, p. 24)
Method	SNP analysis
Species	Dog (all breeds)
Duration	2 – 3 weeks

Note

The Premium SNP DNA Profile follows the recommended 2020 ISAG guidelines (International Society for Animal Genetics) by analysing 230 SNPs (single nucleotide polymorphisms) and allows international comparability between laboratories. Test reliability and power of exclusion for parentage analysis are well above 99.99%.
The Premium SNP DNA profile also has the potential to solve parentage cases for which only one parent is available (breeds on request).
Furthermore, the Premium SNP DNA Profile includes an analysis of the genetic variability (**heterozygosity**, see figure). Animals with a high heterozygosity are less affected by inbreeding than animals with a low heterozygosity.
Please note: Premium SNP DNA Profiles and Classic STR DNA Profiles are not compatible and cannot be used simultaneously within the same parentage analysis.
The Premium SNP DNA Profile also includes the **Diversity Check** – see diversity.labogen.com.



Heterozygosity
grey shaded area:
genetic variability of the entire breed population which has been examined (n > 100);
dashed line:
mean value of the breed;
cross/solid line:
tested dog (value in the example: 43% het.)

Biostatistical Calculation (relationship analysis)	
Material	EB 1 ml, buccal swab
Method	Microsatellite analysis (STRs) + database analysis
Species	Dog
Duration	2 – 3 weeks
Note	If only one parent (e.g. the father) is available for a proof of parentage, this test allows to calculate a so-called probability value. Values can also be determined to evaluate full or half siblings if only samples of the potential siblings are available. **What is important to know:** The test is limited to the breeds in our database (current information can always be found on our homepage).

21.2 Breed and Species

Breed Determination (database analysis)	
Material	EB 1 ml, buccal swab
Method	Microsatellite analysis (STRs) + database analysis
Species List	Dog, cat
Duration	3 – 4 weeks
Note	The genetic breed determination provides the statistical calculation of a matching probability to breeds in our database. The test can be used to verify purity of breeding as well as to detect first-generation mongrels. Thus, the test primarily provides a clarification of genetic proportions of so-called “listed dog breeds” or serves to detect non-purebred animals. Among others, the DNA profile of the animal serves as a basis for the test. **What is important to know:** The test is limited to the breeds in our database (current information can always be found on our homepage).

Species Differentiation, Molecular Biological

Material	Various (possibly consultation by telephone)
Method	Sequencing and database analysis
Duration	2 – 3 weeks
Note	This method allows, for example, to assign certain signs to an animal species, because it is rarely possible to draw conclusions about the origin of samples such as faeces, trails of blood, etc. with the naked eye or with the help of common laboratory methods. In this test, a specific region of mitochondrial DNA is duplicated by PCR, sequenced and its origin analysed. Since this is a comparatively sensitive method, even the smallest sample quantities can be assigned (e.g. blood spatter). The differentiation of animal species using the latest molecular biological methods can be applied to a large number of questions, e.g. "Does the neighbour's dog/cat do its business in our garden?" We would be pleased to inform you in advance by telephone in order to clear up any confusion regarding the test.

22 Aquarium/Pond Water

Laboklin can test the water used to keep freshwater and saltwater fish as well as invertebrates.

Combi **Water Profile + Bacteriology (aerobic)**	
Material	500 ml water (cooled, if possible) + swab with medium (e.g. gills, wounds), tissue
Parameter	pH, total hardness (fresh water), conductivity (salt water), carbonate hardness, nitrate, nitrite, phosphate, copper, ammonium, bacteriology (aerobic)
Note	See Large Water Profile.

Large **Water Profile**	
Material	500 ml water (cooled, if possible)
Parameter	pH, total hardness (fresh water), conductivity (salt water), carbonate hardness, nitrate, nitrite, phosphate, copper, ammonium
Note	▪ Please indicate whether it is a freshwater or a saltwater sample. ▪ Determination of the essential chemical water parameters of an aquarium/pond. ▪ For clarification of intoxications, differential diagnosis if infectious fish diseases are suspected or for setting ideal husbandry/breeding conditions. ▪ Assessment of the acid-base balance (e.g. pH, carbonate hardness), the organic load of the water (e.g. ammonium, nitrite, nitrate) and the purification capacity of the filter. ▪ Determination of phosphate and copper is indicated in case of algae problems or suspected copper intoxication, especially in invertebrates.

Small **Water Profile**	
Material	500 ml water (cooled, if possible)
Parameter	pH, total hardness (fresh water), conductivity (salt water), carbonate hardness, nitrate, nitrite, ammonium
Note	See bullet points 1 – 4 of the Large Water Profile.

23 Hygiene Examinations

In the veterinary practice, hygiene is one decisive prerequisite for successful treatment. For this purpose, the proper functioning of sterilisers should be checked on a regular basis. The same holds true for testing the disinfection of surfaces or endoscopes. Data from our research indicates that a noteworthy percentage of the devices we tested in the practice no longer showed any level of sterilisation at all.

Please only use printed submission forms to **order** hygiene tests (no online orders). You can request hygiene submission forms from Laboklin or print them out yourself (PDF in My Lab).

The **test materials** for the following tests will be sent to you after we have received your submission form. With the exception of the test kits for instrument cleaning and disinfection devices, you have until the expiry date of the test kit to take samples, provided that this kit is stored in accordance with the specifications in the accompanying documents. For more information on pre-analytics, see Chapter 1.3, p. 21. The invoice will be issued after receipt of the order.

Hygiene tests are **not offered** in **Switzerland** (test materials (bioindicators) are only delivered within the EU).

23.1 Profiles Hygiene

Hygiene Monitoring – Steriliser + Surface Disinfection Efficacy Testing	
Material	Bioindicators + contact plates
Method	Culture
Duration	7 – 8 days
Note	▪ Monitoring of a steriliser (heat or steam) + monitoring of 3 surfaces (with contact plates) after disinfection. ▪ For information on pre-analytics, see Chapter 1.3, p. 21. ▪ If you participate regularly (2 x per year), you will get a certificate stating the successful annual monitoring of the disinfection performance of your steriliser and the surface disinfection test. ▪ This test is not available to third countries.

23.2 Single Tests

Disinfectant Testing

Material	Disinhibitor broth
Method	Culture
Duration	3 days
Note	For testing the sterility of disinfectants.

Endoscope Control

Material	Swab with medium, 2 rinse samples, 1 water sample from the endoscopy water bottle
Method	Culture
Duration	3 – 5 days
Note	▪ For information on pre-analytical details, see Chapter 1.3, p. 21.

Heat Steriliser Control

Material	Bioindicators (contaminated with Bacillus atrophaeus)
Method	Culture
Duration	7 – 8 days
Note	▪ For information on pre-analytical details, see Chapter 1.3, p. 21. ▪ If you participate regularly (2 x per year), you will get a certificate stating the annual monitoring of the disinfection performance of your heat steriliser. ▪ This test is not available to third countries.

Steam Steriliser Control (autoclave)

Material	Bioindicators (contaminated with Bacillus atrophaeus and Geobacillus stearothermophilus)
Method	Culture
Duration	7 – 8 days
Note	▪ For information on pre-analytical details, see Chapter 1.3, p. 21. ▪ If you participate regularly (2 x per year), you will get a certificate stating the annual monitoring of the disinfection performance of your autoclave. ▪ This test is not available to third countries.

Surface Contamination Testing

Material	Contact plates
Method	Culture
Duration	2 – 4 days
Note	▪ The surface is tested without prior disinfection. ▪ For information on pre-analytics, see Chapter 1.3, p. 21. ▪ This test is also suitable for testing hand contamination. ▪ Where applicable, the following multidrug-resistant pathogens can be identified: MRSA (methicillin-resistant Staphylococcus aureus) and/or MRSE (methicillin-resistant Staphylococcus epidermidis) and/or ESBL (pathogens that produce extended-spectrum β-lactamase). For this, additional costs will be incurred. ▪ For testing surface contamination after disinfection, the service "Surface Disinfection Efficacy Testing" is available.

Surface Disinfection Efficacy Testing

Material	Contact plates
Method	Culture
Duration	2 – 4 days
Note	▪ This test is also suitable for testing the effectiveness of hand disinfection. ▪ Where applicable, the following multidrug-resistant pathogens can be identified: MRSA (methicillin-resistant Staphylococcus aureus) and/or MRSE (methicillin-resistant Staphylococcus epidermidis) and/or ESBL (pathogens that produce extended-spectrum β-lactamase). For this, additional costs will be incurred. ▪ For information on pre-analytics, see Chapter 1.3, p. 21. ▪ If you participate regularly (2 x per year), you will get a certificate stating the annual monitoring of the disinfection performance of your surface disinfection test. ▪ For testing the initial contamination, see the service "Surface Contamination Testing".

Testing of Air Settlement Plates

Material	Air settlement plate
Method	Culture
Duration	2 – 4 days
Note	For monitoring the microbiological air quality in practice rooms. This test is not suitable for examinations of barns and stables!

Hygiene Monitoring of the cleaning and disinfection performance of devices for the reprocessing of surgical instruments

Material	Bioindicators (screws with blood and *E. faecium*)
Method	Culture
Duration	3 – 7 days
Note	▪ For information on pre-analytics, see Chapter 1.3, p. 18. ▪ If you participate regularly (2 x per year), you will get a certificate stating the annual monitoring of the disinfection of your device. ▪ This test is not available to third countries.

24 Reference Ranges

24.1 Dog, Cat, Horse

24.1.1 Clinical Chemistry

	unit	dog	cat	horse
Enzymes 37 °C				
ALT (GPT)	U/l	< 88	< 99	-
α-Amylase	U/l	< 1650	< 1850	< 50
AP	U/l	< 147	< 65	< 352
AST (GOT)	U/l	< 51	< 58	< 568
Cholinesterase	U/l	1347 – 2269	1000 – 2000	> 2344
CK	U/l	< 200	< 398	< 452
GLDH	U/l	< 8	< 10	< 13
γ-GT	U/l	< 10	< 5	< 44
α-HBDH	U/l	< 65	< 55	< 221
LDH	U/l	< 91	< 108	< 455
Lipase (DGGR)	U/l	< 120	< 26	< 20
Substrates				
Albumin	g/l	25 – 44	26 – 56	25 – 54
Albumin/globulin (A/G) ratio		> 0.59	> 0.6	> 0.7
Bile Acids	µmol/l	< 20, post-prandial < 40	< 20, post-prandial < 40	< 12
Bilirubin, total	µmol/l	< 3.4	< 3.4	8.6 – 59.9
Cholesterol	mmol/l	3.1 – 10.1	1.8 – 3.9	1.8 – 4.7
Creatinine	µmol/l	< 125	< 168	71 – 159
Fructosamines	µmol/l	< 374	< 340	< 360
Globulins	g/l	< 45	< 55	< 51
Glucose	mmol/l	3.05 – 6.1	3.1 – 6.9	3.1 – 5.0
β-HBA	mmol/l	< 0.6	< 0.75	< 0.6
Lactate	mmol/l	0.5 – 3.0	< 1.0	0.5 – 2.0
NEFA	mmol/l	0.1 – 0.5	0.1 – 0.5	0.1 – 0.5
Protein (total)	g/l	54 – 75	57 – 94	55 – 75
SDMA	µmol/l	< 0.65	< 0.75	< 0.75
Triglycerides	mmol/l	< 3.9	< 1.14	< 0.97
Urea	mmol/l	3.3 – 8.3	5.0 – 11.3	3.3 – 6.7
Electrolytes and Trace Minerals				
Calcium	mmol/l	2.3 – 3.0	2.3 – 3.0	2.5 – 3.4
Chloride	mmol/l	96 – 113	110 – 130	95 – 105
Copper	µmol/l	15.7 – 18.9	13.4 – 16.9	7.9 – 21.0
Iron	µmol/l	15 – 45	8 – 31	17.9 – 64.5
Magnesium	mmol/l	0.6 – 1.3	0.6 – 1.3	0.5 – 0.9
Manganese	µg/l	< 20	< 20	1.11 – 2.96
Phosphate	mmol/l	0.7 – 1.6	0.8 – 1.9	0.7 – 1.5
Potassium	mmol/l	3.5 – 5.1	3.0 – 4.8	2.8 – 4.5
Selenium	µg/l	80 – 250	80 – 250	100 – 200
Sodium	mmol/l	140 – 155	145 – 158	125 – 150
Zinc	µmol/l	7.7 – 19.9	12.2 – 15.3	5.0 – 14.4

Selenium horse: Up to 40 µg/l are marginal, more than 250 µg/l high/critical. Foals and Icelandic horses are sometimes well below these levels.

	unit	dog	cat	horse
Further parameters				
PLI	µg/l	< 180 (questionable: 180 – 310)	< 3.0 (questionable: 3.0 – 4.0)	-
TLI	µg/l	5 – 50	12.0 – 82.0	-
Vitamin B12	pg/ml	300 – 800	300 – 800	-
Folic Acid	ng/ml	3.0 – 10.0	3.0 (4.0) – 10.0	-
SAA	µg/ml	-	< 0.75	< 0.75

24.1.2 Haematological Reference Ranges Dog, Cat, Horse

	unit	dog	cat	horse
Erythrocytes	T/l	5.5 – 8.5	5.0 – 10.0	6.0 – 12.0
Haematocrit	l/l	0.44 – 0.52	0.3 – 0.44	0.3 – 0.5
Haemoglobin	g/l	150 – 190	90 – 150	110 – 170
Leukocytes	G/l	6 – 12	6 – 11	5 – 10
Segmented	%	55 – 75	60 – 78	45 – 70
Lymphocytes	%	13 – 30	15 – 38	20 – 45
Monocytes	%	0 – 4	0 – 4	0 – 5
Eosinophils	%	0 – 6	0 – 6	0 – 4
Basophils	%	0	0 – 1	0 – 2
Unsegmented	%	0 – 4	0 – 4	0 – 6
Hypochromasia		neg.	neg.	neg.
Anisocytosis		neg.	neg.	neg.
Platelets	G/l	150 – 500	180 – 550	90 – 300
Differential blood count (absolute numbers)				
Segmented	G/l	3 – 9	3 – 11	3 – 7
Lymphocytes	G/l	1 – 3.6	1 – 4	1.5 – 4
Monocytes	G/l	0.04 – 0.5	0.04 – 0.5	0.04 – 0.4
Eosinophils	G/l	0.04 – 0.6	0.04 – 0.6	0.04 – 0.3
Basophils	G/l	< 0.04	< 0.04	0 – 0.15
Unsegmented	G/l	< 0.5	< 0.6	0 – 0.6
Reticulocytes	/nl	< 110	< 60	-

24.1.3 Hormones Dog, Cat, Horse

	unit	dog	cat	horse
ACTH	pg/ml	6 – 58	< 110	**mid Nov. - mid July:** negative: < 30 borderline: 30 – 50 positive: > 50 **mid July - mid Nov.:** negative: < 50 borderline: 50 – 100 positive: > 100
Anti-Müllerian Hormone	ng/ml	m-neutered: < 0.1 m-intact: > 2.0 f-neutered: < 0.02 f-intact: > 0.5	m-neutered: < 0.1 m- intact: > 4.8 f-neutered: < 0.1 f-intact: > 2.0	mare intact: < 4 mare/borderline: 4 – 7 mare with granulosa theca cell tumour: > 7 male neutered: < 0.1 male/borderline: 0.1 – 2 male intact: > 2
Cortisol	ng/ml	5 – 65	3 – 50 (130)	30 – 70
Insulin	µU/ml	8 – 25	10 – 30	< 20.0
Oestradiol	pg/ml	prooestrus: 25 – 65 oestrus: < 25 anoestrus: < 30 neutered: < 10 males: < 15 Sertoli cell tumour: > 30	interoestrus: < 20 oestrus: 20 – 60 - - - -	prooestrus: 1.2 – 6.2 oestrus: 7.1 – 13.0 dioestrus: 3.7 – 5.0 - - -
Progesterone	ng/ml	prooestrus: < 1.0 oestrus: < 30 ovulation*: 4.0 – 8.0 anoestrus: < 1.0	preov: < 1.0 postov: > 1.0 - -	luteal activity: >/= 1*** - - -
Testosterone	ng/ml	m: 1.5 – 8.5 f: < 0.4 m-neutered: < 0.5	m: 2.5 – 7.0 - m-neutered: < 0.5	stallion: 1.0 – 5.0 gelding: < 0.04 mare: < 0.04**
TSH	ng/ml	< 0.6	-	-
TSH	µU/ml	-	> 0.04	-
T3	ng/dl	20 – 206	33 – 167	25 – 180
f**T3**	pmol/l	3.7 – 9.2	0.8 – 1.4	1.1 – 7.2
T4	µg/dl	1.3 – 4.5	0.9 – 2.9	1.3 – 4.1
f**T4**	pmol/l	7.7 – 47.6	6.4 – 33.3	9.0 – 44.9

* Time of mating for female dogs: Optimum 24 to 48 hours, maximum 96 hours after ovulation
** Testosterone mare: Increased levels indicate a granulosa theca cell tumour.
*** The test does not distinguish between cyclic and gestational corpus luteum.

24.2 Reference Ranges Rabbit, Guinea Pig and Ferret

24.2.1 Clinical Chemistry

	unit	rabbit	guinea pig	ferret
Enzymes 37 °C				
ALT (GPT)	U/l	< 113	< 113	< 450
α-Amylase	U/l	< 459	< 3159	< 62
AP	U/l	< 640	< 674	< 228

	unit	rabbit	guinea pig	ferret
AST (GOT)	U/l	< 64	< 205	< 324
Cholinesterase	U/l	< 5569	< 12581	< 1590
CK	U/l	< 2281	< 5102	< 1740
GLDH	U/l	< 31	< 27	< 4
γ-GT	U/l	< 23	< 23	< 25
LDH	U/l	< 519	< 468	< 1619
Lipase (DGGR)	U/l	< 1587	< 152	< 351
Substrates				
Albumin	g/l	-	-	28 – 44
Bile Acids	µmol/l	0.76 – 19.63	< 84.5	< 28.9
Bilirubin	µmol/l	0.3 – 2.5	< 1.6	< 3.3
Cholesterol	mmol/l	0.3 – 1.7	0.3 – 1.7	2.4 – 7.1
Creatinine	µmol/l	51.4 – 154.4	< 77	23 – 77
Fructosamines	µmol/l	248.1 – 501.4	< 271	121 – 202
Glucose	mmol/l	5.8 – 14.8	5.0 – 16.0	3.0 – 8.5
Protein (total)	g/l	47.7 – 73.6	44 – 66	55 – 78
Triglycerides	mmol/l	0.5 – 3.4	0.3 – 2.4	0.5 – 2.8
Urea	mmol/l	2.6 – 10.3	3.3 – 10.3	4.8 – 16.9
Electrolytes				
Calcium	mmol/l	3.0 – 4.3	2.4 – 3.1	2.0 – 2.6
Iron	µmol/l	20 – 59	26 – 76	12 – 56
Magnesium	mmol/l	0.7 – 1.5	1.0 – 2.6	0.9 – 1.6
Phosphate	mmol/l	0.5 – 2.2	1.0 – 7.0	1.0 – 3.1
Potassium	mmol/l	3.5 – 6.0	4.5 – 8.8	3.9 – 5.9
Sodium	mmol/l	132.6 – 154.0	130 – 150	140.1 – 169.7
Hormones				
Androstenedione	ng/dl	-	-	< 428
Anti-Müllerian Hormone	ng/ml	f-neutered: < 0.07* f-intact: > 1.53* m-neutered: < 0.07 (prel.)	-	-
17-OH-Progesterone	ng/dl	-	-	< 26.1
Oestradiol	pg/ml	-	-	5.0 – 16.5
T4	µg/dl	0.6 – 1.98	1.1 – 5.2	1.1 – 2.8
f**T4**	pmol/l	< 20 (30)	15.9 – 32.3	-

* Values in the questionable range should be retested, but may occur if small amounts of residual ovarian tissue are present.
prel. = preliminary reference range

Testosterone gelöscht

24.2.2 Haematological Reference Ranges Rabbit, Guinea Pig, Ferret

	unit	rabbit	guinea pig	ferret
Erythrocytes	T/l	4.4 – 7.4	4.51 – 6.36	7.4 – 13.0
Haematocrit	l/l	0.28 – 0.48	0.39 – 0.55	0.4 – 0.7
Haemoglobin	g/l	89.6 – 153.8	117 – 169	139 – 219
Leukocytes	G/l	2.7 – 12.2	2.9 – 14.4	3.0 – 16.8
Segmented	%	32 – 64	12 – 62	17 – 82
Lymphocytes	%	13 – 54	28 – 84	13 – 81
Monocytes	%	3 – 14	< 9	1 – 7
Eosinophils	%	< 3	< 14	< 6
Basophils	%	< 9	< 2	< 1
Unsegmented	%	0	< 1	< 1
Reticulocytes	/nl	59.1 – 302.2	11.0 – 241.7	-
Hypochromasia		neg.	neg.	neg.
Anisocytosis		neg.	neg.	neg.
Platelets	G/l	225.5 – 905.3	273 – 745	172 – 1281
Differential blood count (absolute numbers)				
Segmented	G/l	0.9 – 7.8	0.9 – 5.1	0.9 – 7.4
Lymphocytes	G/l	0.4 – 6.6	1.4 – 10.7	0.6 – 10.5
Monocytes	G/l	0.08 – 1.7	< 0.7	< 0.5
Eosinophils	G/l	0.07 – 0.2	< 1.5	< 0.7
Basophils	G/l	0.06 – 1.1	< 0.11	< 0.2
Unsegmented	G/l	0	< 0.07	< 0.1

24.3 Reference Ranges Birds

24.3.1 Clinical Chemistry

	unit	parakeets	amazon parrots	parrot
Enzymes 37 °C				
ALT (GPT)	U/l	5 – 11	5 – 11	5 – 12
α-Amylase	U/l	205 – 490	205 – 510	210 – 530
AP	U/l	20 – 250	15 – 150	20 – 160
AST (GOT)	U/l	160 – 383	141 – 437	109 – 305
Cholinesterase	U/l	450 – 3200	780 – 6180	710 – 12450
CK	U/l	58 – 245	125 – 345	228 – 322
γ-GT	U/l	1 – 30	–	1 – 10
LDH	U/l	120 – 455	155 – 425	145 – 465
Lipase (DGGR)	U/l	30 – 280	35 – 225	35 – 350
Substrates				
Bile acids	µmol/l	44 – 108	33 – 154	12 – 96
Cholesterol	mmol/l	3.63 – 9.32	4.66 – 7.90	4.14 – 11.01
Creatinine	µmol/l	7.63 – 30.5	7.63 – 30.5	7.63 – 30.5
Glucose	mmol/l	13.82 – 20.15	12.27 – 16.76	11.43 – 15.26
Protein (total)	g/l	24 – 48	30 – 52	32 – 52
Triglycerides	mmol/l	0.51 – 2.26	0.55 – 2.15	0.51 – 1.64
Urea	mmol/l	1.04 – 1.78	–	1.07 – 1.93
Uric acid	µmol/l	210 – 650	120 – 520	160 – 520
Electrolytes				
Calcium	mmol/l	1.82 – 2.67	2.05 – 2.73	1.93 – 2.83
Phosphate	mmol/l	1.03 – 1.55	1.0 – 1.78	1.03 – 1.74
Potassium	mmol/l	2.4 – 4.6	3.0 – 4.5	2.9 – 4.6
Sodium	mmol/l	130 – 153	125 – 155	157 – 165

24.3.2 Haematological Reference Ranges Birds

	unit	parakeet	amazon parrots	parrot
Erythrocytes	T/l	3.1 – 4.4	2.45 – 3.18	2.84 – 3.62
Haematocrit	l/l	0.43 – 0.57	0.41 – 0.53	0.45 – 0.53
Haemoglobin	g/l	102 – 147	122 – 159	127 – 159
Leukocytes	G/l	5 – 11	6 – 17	6 – 13
Heterophils	%	46 – 72	31 – 71	45 – 73
Lymphocytes	%	26 – 60	20 – 54	19 – 50
Monocytes	%	0 – 1	1 – 3	0 – 2
Eosinophils	%	0 – 2	1 – 3	0 – 1
Basophils	%	0 – 1	0 – 1	0 – 1
Unsegmented	%	0	0	0
Hypochromasia		neg.	neg.	neg.
Anisocytosis		neg.	neg.	neg.

24.4 Reference Ranges Farm Animals

24.4.1 Clinical Chemistry

	unit	cattle	sheep	goat	pig	alpaca	llama
Enzymes 37 °C							
ALT (GPT)	U/l	< 93	< 33	< 32	< 126	< 93	<93
α-Amylase	U/l	< 161	< 120	< 120	< 3500	< 161	< 161
AP	U/l	< 484	< 359	< 1942	< 274	< 269	< 192
AST (GOT)	U/l	< 182	< 126	< 135	< 80	< 370	< 330
Cholinesterase	U/l	78 – 156	78 – 156	78 – 156	317 – 788	78 – 156	78 – 156
CK	U/l	< 595	< 208	< 268	< 4769	< 238	< 238
GLDH	U/l	< 48	< 76	< 20	< 6	< 50	< 50
γ-GT	U/l	< 88	< 63	< 63	< 79	< 75	< 45
GPx	U/g Hb	> 130	< 130	-	-	-	-
α-HBDH	U/l	< 909	< 700	< 909	< 390	< 700	< 700
LDH	U/l	< 1364	< 1325	< 972	< 545	< 900	< 700
Lipase (DGGR)	U/l	2 – 8	-	2 – 8	-	2 – 8	2 – 8
Substrates							
Albumin	g/l	30 – 40	24 – 30	30 – 40	18 – 31	29 – 43	29 – 50
Bile acids	µmol/l	15 – 80	< 10	-	-	-	-
Bilirubin, total	µmol/l	< 5.0	< 8.5	< 8.5	< 4.3	< 6.8	< 8.6
Bilirubin, direct	µmol/l	< 3.4	< 3.4	< 3.4	< 1.7	< 3.4	< 3.4
Cholesterol	mmol/l	2.07 – 3.88	1.2 – 1.9	2.07 – 3.88	2.0 – 3.3	0.4 – 2.3	0.34 – 2.3
Creatinine	µmol/l	88 – 177	50 – 120	50 – 120	40 – 130	88 - 212	80 – 248
Globulins	g/l	< 48	< 48	< 48	< 64	< 31	< 32
Glucose	mmol/l	1.94 – 3.05	2.2 – 5.2	2.2 – 5.2	3.9 – 6.4	5.7 – 8.3	5.7 – 7.0
Haptoglobin	g/l	< 0.35	< 0.35	< 0.27	< 0.68	-	-
β-HBA	mmol/l	0.2 – 1.0	< 0.6	< 0.6	< 0.6 (prel.)*	< 0.6	< 0.6
Lactate	mmol/l	0.5 – 3.0	1 – 1.4	1 – 1.4	-	0.5 – 3.0	0.5 – 3.0
NEFA	mmol/l	< 0.8	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Protein (total)	g/l	60 – 80	50 – 70	60 – 80	55 – 86	57 – 72	47 – 73
SAA	µg/ml	< 8.8	-	-	-	-	-
Triglycerides	mmol/l	0.17 – 0.51	0.06 – 0.34	0.17 – 0.51	< 0.5	< 0.6	< 0.27
Urea	mmol/l	< 8	4.5 – 10.7	4.5 – 10.7	3.3 – 8.3	3.6 – 10.1	3.2 – 12.8
Electrolytes and Trace Minerals							
Calcium	mmol/l	2.3 – 2.8	2.1 – 2.7	2.2 – 2.8	2.4 – 3.5	2.1 – 2.5	1.9 – 2.7
Chloride	mmol/l	90 – 110	75 – 114	97 – 110	102 – 106	109 – 141	105 – 130
Cobalt	µg/l	1.0 – 3.5	1.0 – 3.5	1.0 – 3.5	-	1.0 – 3.5	1.0 – 3.5
Copper	µmol/l	8 – 24	7 – 24	16 – 32	16 – 39	2.1 – 12.5	6.1 – 7.9
Iron	µmol/l	20 – 40	20 – 30	16 – 35	16.7 – 35.3	18.8 – 37.4	18.6 – 30.8
Magnesium	mmol/l	0.8 – 1.3	0.8 – 1.0	0.8 – 1.0	1.1 – 1.5	0.7 – 1.0	0.8 – 1.1
Manganese	µg/ml	3.5 – 20	< 20	< 20	-	< 20	< 20
Phosphate	mmol/l	1.1 – 2.4	1.2 – 2.5	1.61 – 2.26	2.1 – 3.3	1.1 – 2.5	1.5 – 3.6
Potassium	mmol/l	3.5 – 4.5	3.5 – 4.5	4.5 – 6.5	4.0 – 5.0	4.0 – 5.7	3.6 – 6.2
Selenium	µg/l	40 – 85	55 – 170	62 – 158	100 – 200	> 99	> 99
Sodium	mmol/l	135 – 145	145 – 155	135 – 157	140 – 160	146 – 155	148 – 158
Zinc	µmol/l	8 – 24	11.0 – 20.5	10.7 – 19.9	10 – 20	3.0 – 14.6	4.1 – 12.4

*prel. = preliminary reference range

	unit	cattle	sheep	goat	pig	alpaca	llama
Vitamins							
β-carotene	µg/l	> 2500	-	-	-	-	-
Vitamin A	µg/l	130 – 380	-	600 – 1500	-	-	-
Vitamin B12	pg/ml	> 100	> 100	100 – 1500	300 – 800	95 – 1192	-
Vitamin D (25OH)	nmol/l	75 – 125	-	-	-	-	-
Vitamin E	mg/l	> 3	> 3	> 3 (prel.)	1.6 – 4.6	> 3	-
Hormones							
Insulin	µU/ml	< 5	-	-	-	-	-
Progesterone	ng/ml	follicular phase: < 1 corpus luteum*: 1 – 10	-	-	-	not pregnant: < 1 questionable: 1 – 2 pregnant: > 2**	-
T4	µg/dl	3.4 – 8.2	-	-	-	6.7 – 20.6	6.6 – 19.3
ft**4**	pmol/l	-	-	-	-	14.0 – 32.0	12.1 – 29.2
T3	ng/dl	78 – 150	-	-	84 – 156	77.4 – 361.3	67.1 – 298.8
ft**3**	pmol	-	-	-	-	3.5 – 10.9	2.8 – 9.2
Other values							-
Haptoglobin	g/l	< 0.35	-	-	< 0.68	-	-
IgG (young animal)	mg/dl	> 800	> 800	-	-	> 800	> 800

* Values over 1.0 indicate luteal activity. It is not possible to differentiate between pregnant and non-pregnant by looking at the progesterone level. Between days 17 – 19, progesterone levels > 1 ng/ml indicate a lack of luteolysis, which is indicative of early pregnancy. The determination of PAG (pregnancy-associated glycoprotein) is recommended to diagnose pregnancy.

** Pregnancy determination by measuring progesterone from 3 weeks after mating. Results that are within the questionable range should be checked again after 2 – 3 weeks, as spontaneous ovulation can occur without successful conception. During the last 7 – 10 days before giving birth, the progesterone level drops significantly.

prel. = preliminary reference range

24.4.2 Haematological Reference Ranges Farm Animals

	unit	cattle	sheep	goat	pig	alpaca	llama
Erythrocytes	T/l	5.0 – 10.0	7.3 – 11.3	8 – 18	5.8 – 8.1	9.4 – 18.1	9.9 – 17.7
Haematocrit	l/l	0.28 – 0.38	0.29 – 0.38	0.24 – 0.48	0.33 – 0.45	0.22 – 0.45	0.25 – 0.46
Haemoglobin	g/l	90 – 140	80 – 120	80 – 120	108 – 148	102 – 193	115 – 195
Leukocytes	G/l	4 – 10	4 – 10	4 – 13	10 – 22	7.1 – 18.6	8.9 – 22.4
Segmented	%	25 – 45	10 – 50	30 – 48	10 – 39	49 – 65	49 – 65
Lymphocytes	%	45 – 65	40 – 80	50 – 70	49 – 85	21 – 25	21 – 25
Monocytes	%	2 – 6	0 – 15	0 – 4	2 – 4	0 – 5	0 – 5
Eosinophils	%	1 – 10	0 – 8	1 – 8	0 – 6	6 – 22	6 – 22
Basophils	%	0 – 2	0 – 4	0 – 1	0 – 5	0 – 0.5	0 – 1
Unsegmented	%	0 – 3	0 – 4	0 – 2	0 – 7	0	0 – 1
Platelets	G/l	300 – 800	200 – 800	200 – 800	175 – 580	200 – 600	200 – 600

Reticulocytes gelöscht

	unit	cattle	sheep	goat	pig	alpaca	llama
Differential blood count (absolute numbers)							
Segmented	G/l	1.0 – 3.5	0.7 – 4.0	1.2 – 6.2	1.0 – 8.2	3.5 – 12.1	4.6 – 16
Lymphocytes	G/l	2.5 – 5.5	2.0 – 4.0	2.0 – 8.0	6.0 – 16.0	1.5 – 4.7	0.7 – 4.8
Monocytes	G/l	0 – 0.33	0 – 0.7	0 – 0.4	0 – 1.0	0 – 0.9	0 – 1.0
Eosinophils	G/l	0.3 – 1.5	0.1 – 1.0	0.05 – 0.6	0 – 1.3	0.4 – 4.0	0 – 3.3
Basophils	G/l	0 – 0.1	0 – 0.3	0 – 0.12	0 – 0.05	0 – 0.1	0 – 0.3
Unsegmented	G/l	0 – 0.2	0 – 0.2	0 – 0.2	0 – 1.5	0	0 – 0.15

24.5 App for Reference Values

The **LaboRef app** provides frequently required reference values, sorted by category and animal species, and can be accessed anytime and anywhere. Please find more information in the App Store and the Play Store.

25 Conversion Table for Laboratory Diagnostic Parameters

On the diagnostic findings compiled by us, you will find the measured values as well as information on the standard ranges in the internationally valid SI units. During follow-up checks, you may want to compare the measured values of different findings using identical units of measurement. The conversion factors for the parameters for which we have changed the unit of measurement are listed below.

To convert from one unit of measurement to the other, the corresponding measured value must be multiplied with the conversion factor (e.g. bilirubin in mg/dl x 17.104 = bilirubin in µmol/l).

25.1 Clinical-chemical Parameters

	Old unit	Conversion factor to SI unit	SI unit	Conversion factor to old unit
Substrates				
Albumin	g/dl	144.9	µmol/l	0.0069
Bilirubin	mg/dl	17.104	µmol/l	0.0585
Cholesterol	mg/dl	0.0259	mmol/l	38.664
Creatinine	mg/dl	88.402	µmol/l	0.0113
Fibrinogen	mg/dl	0.01	g/l	100
Glucose	mg/dl	0.0555	mmol/l	18.016
Lactate	mg/dl	0.111	mmol/l	9.0080
Protein (total)	g/dl	10	g/l	0.1
Triglycerides	mg/dl	0.0114	mmol/l	87.500
Urea	mg/dl	0.1665	mmol/l	6.0060
Uric acid	mg/dl	59.48	µmol/l	0.0168
Electrolytes and Trace Minerals				
Calcium	mg/dl	0.2495	mmol/l	4.0080
Chloride	mg/dl	0.2821	mmol/l	3.5453
Copper	µg/dl	0.1574	µmol/l	6.3532
Iron	µg/dl	0.1791	µmol/l	5.5847
Magnesium	mg/dl	0.4113	mmol/l	2.4312
Phosphate	mg/dl	0.3229	mmol/l	3.0974
Potassium	mg/dl	0.2557	mmol/l	3.9102
Sodium	mg/dl	0.4350	mmol/l	2.2989
Zinc	µg/dl	0.1530	µmol/l	6.5370

25.2 Blood Parameters

	Old unit	Conversion factor to SI unit	SI unit	Conversion factor to old unit
Erythrocytes	Mio/µl	1	T/l	1
Haematocrit	%	0.01	l/l	100
Haemoglobin	g/dl	10	g/l	0.1
Leukocytes	1/µl	0.001	G/l (= 109/l)	1000
Platelets	1/µl	0.001	G/l (= 109/l)	1000
Reticulocytes	%	0.001	1	1000

You will find a converter for easily comparing diagnostic findings with parameters in different units – our **SI calculator** – on our website www.laboklin.com under the menu item "specialist information".

26 Courier Service

LABOKLIN offers courier services in most EU countries. The samples are generally delivered to LABOKLIN within 24/48 hours. For more information, including prices and the possibilities of sample collection in your area, please contact our Service Department or your local LABOKLIN office.

Our contacts: see p. 10 and following.

27 Invoicing

All prices listed on the submission forms are quoted without the applicable Value Added Tax (VAT). To receive VAT-free invoices, please provide your international tax number (EU only). We issue invoices at the beginning of the next month with detailed information on costs per sample and tests performed in the previous month, together with animal and owner name. If an invoice is to be sent to the owner, we invoice with a factor 1.4 plus 19% German VAT. This is only possible for genetic tests and when the owners' signature and complete data are supplied.

There are discounts available to veterinarians depending on the monthly invoice revenue: For more information, please contact us or your local LABOKLIN office.

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