When to Consider Minipigs as an Animal Model? – Current Trends

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The drug development process
Drug Development Success Rates 2006-2015

<table>
<thead>
<tr>
<th>Type of Drug</th>
<th>% Success (Approval)</th>
<th>Number Clinical Transitions (Phase 1,2,3 or Filing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Molecule</td>
<td>6</td>
<td>5,858</td>
</tr>
<tr>
<td>Oncology</td>
<td>5</td>
<td>3,163</td>
</tr>
<tr>
<td>New Combination or Reformulation</td>
<td>23</td>
<td>1,524</td>
</tr>
<tr>
<td>Biologics</td>
<td>12</td>
<td>2,277</td>
</tr>
<tr>
<td>Vaccines</td>
<td>16</td>
<td>238</td>
</tr>
<tr>
<td>Rare Diseases</td>
<td>25</td>
<td>521</td>
</tr>
<tr>
<td>All</td>
<td>10</td>
<td>9,985</td>
</tr>
</tbody>
</table>

*Likelihood of Approval from Phase 1, for 7,455 development projects in 1,103 companies*

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And the reason ...


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It is all about science!?

- Failures in Drug Development
  - Clinical Failure Rates > 80%
  - Investment > $1 billion / drug

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Can we trust preclinical data!?
Species selection – the good example

Minipigs in human relevant safety assessment - learnings from Roche (Safety Pharmacology & Toxicology/Pathology)

Susanne Mohr, Andrea Greiter-Wilke and Björn Jacobsen
Roche Innovation Center Basel
Webinar 13 June 2019

EMA FIH Guideline 2017 – Non-clinical aspects
Relevance of the animal model has to explored prior to FIH

- Need to justify or dis-qualify animal species for toxicity testing
  - Pharmacological activity
  - Metabolite pattern in animals compared to man
  - Limitations for PD readout of certain targets in healthy animals

- Is a species relevant?
  - Go with a rodent and a non-rodent, or go with single species
  - Go with a surrogate/homologue or in vitro data only
    - use of in vitro human cell systems or human-derived material could provide relevant information about translational differences

It will be always a case-by-case approach
What defines a responder species?
*Human Relevant Safety Assessment*

- Is target expression / tissue distribution in animals comparable to human?
- Degree of target / pathway homology between species?
- Do we expect same / similar target mediated effects as in human (pathway/regulatory mechanisms)?

Maximize the likelihood of identifying responses that are similar to those expected in human.

Timing of assessment of responder status

- **Target Assessment**
  - Evidence from the literature and data bases as to expression, tissue distribution and degree of homology of a given target in human and animal species of interest
- **During LI or early LO-phase** (if above info missing/insufficient)
  - Recommendation to close the target for binding/functional assays in animal species and/or
  - Establishment of functional assay to compare activity, if feasible
- **Selling point in the past:**
  - Information needed for informed selection of the tox-species to assure human relevant safety assessment and also to avoid producing potentially irrelevant findings
  - Judging potency for safety margin calculation for human starting dose

New guideline confirms importance of investigations on relevance of animal species.
Knowing the genetic background

Functional analysis and transcriptional output of the Göttingen minipig genome

Tobias Heckel, Roland Schmucki, Marco Berreca, Stephan Ringshandl, Laura Ball, Guido Steiner, Morgane Rayon, Eric Küng, Bernd Kuhn, Nicole A. Kratcohl, Georg Schmitt, Anna Nialainen, Corinne Noviaczyk, Hamina Daff, Ashwi Yhina Khan, Isaac Lekelo, Roger Pelle, Edward Ockrim, Richard Bishop, Claudia Daubenberger, Martin Ebeling, and Ulrich Cera

Abstract

Background: In the past decade the Göttingen minipig has gained increasing recognition as animal model in pharmaceutical and safety research because it recapitulates many aspects of human physiology and metabolism. Genome-based comparison of drug targets together with quantitative tissue expression analysis allows rational prediction of pharmacology and cross-reactivity of human drugs in animal models thereby improving drug attrition which is an important challenge in the process of drug development.

Conclusions: Genome based assessment of sequence conservation combined with gene expression data in several tissues improves the translational value of the minipig for human drug development. The genome and gene expression data presented here are important resources for researchers using the minipig as model for biomedical research or commercial breeding. Potential impact of our data for comparative genomics, translational research, and experimental medicine are discussed.

Keywords: Comparative genomics, Transcriptional profiling, Pseudogene, Long non-coding RNA, Drug development and safety, Minipig
Genetic standard – submitted last week!

Notification to co-authors of submission to BMC Genomics: GICS-D-19-01010

Dear author,

You are receiving this email because you have been listed as an author on a manuscript recently submitted to BMC Genomics. The manuscript details are below.

Title: Assessing breed integrity of Göttingen Minipigs
Authors: Christian Heinrich Ulrich Wilfried Reiner, Ngo To Thuy Hai, Ahmad Reza Sharif, Johannes Gebel, M.Sc.; Lars Fris Mikkelson, DVM; Martin Schäffer; Steffen Weagand; Henner Simonar

 Regards,
Lars EGM TALAS June 2019

Biomarkers in Toxicology, 2019
More Göttingen Minipigs to be used

CONCLUDING REMARKS AND FUTURE DIRECTIONS

Göttingen Minipigs are well-defined genetically and microbiologically, available worldwide, and are very similar to humans in their anatomy and physiology. For these reasons, they are widely used as nonrodent species in many types of pharmacological and toxicological studies. Significant improvements in areas such as gene-editing techniques, clinical diagnostic modalities, and analytical methods will likely render Göttingen Minipigs even more useful for such studies in the future. Gene-editing techniques have improved significantly.

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Obesity and metabolic syndrome

Importance of metabolic research
Prevalence of obesity and diabetes

- The global obesity epidemic has outpaced starvation as major cause of death and disability world-wide

- Metabolic syndrome, diabetes and cardiovascular disease follow closely behind

CDC’s division of Diabetes Translation, United States Diabetes Surveillance System available at http://www.cdc.gov/diabetes/data/
Obesity and Metabolic Syndrome

Human Metabolic Syndrome (MS)

Obesity/Visceral Obesity

Low HDL-Cholesterol

Dyslipidaemia

Metabolic Syndrome

Insulin Resistance

Hypertension

High Triglycerides

https://www.metabolicsyndromecanada.ca/about-metabolic-syndrome

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Obesity in Göttingen Minipigs

- Göttingen Minipigs becomes grossly obese (> 100 kg) on ad libitum chow feeding
- Obese Göttingen Minipigs share some of the metabolic impairments seen in obese humans
  - Hypertension and also increased heart rate
  - Significantly increased triglyceride levels compared to lean animals
  - High fat/high cholesterol diet induced dyslipidemia
  - Significant difference between obese and lean minipigs in fasting insulin levels
    - However, no difference in fasting blood glucose

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Diet-induced obese Göttingen Minipigs

• Severe obesity can be obtained
• Potential for translational read-outs
• Potential for studying effects on insulin sensitivity simultaneously with effects on appetite and bodyweight

Males or females

• Males do not become obese as easily as females
  – Unless they are castrated
• In females, ovariectomy might be considered to reduce cyclic reductions and related variations in food intake

Christoffersen BO et al. Steroids 2010;75:676-684
Standard or high-fat diet

- An energy-dense diet reduces the time needed to obtain the desired degree of obesity
- Extreme obesity can be obtained
  - 100% or more
- Daily exercise is necessary for welfare reasons
- Best to keep the animals below 100 kg

Johansen T et al. Comparative Medicine 2001;51:150-155

Body weight and body composition

- Imaging, e.g. by means of Dual-Emission X-ray Absorptiometry (DEXA) scanning can be used to obtain data on body composition
Food intake

- Food intake can be automatically recorded
  - Gives data on meal patterns in addition to accumulated food-intake
- A sensitive and dynamic read-out
  - Can document that reduced food-intake is an important mechanism behind the weight loss of a given treatment
  - Can help in for instance dose-filtration

Glucose metabolism

- At 11-12 weeks of age, after 2-3 weeks of high energy diet, the insulin sensitivity index, based on an OGTT (Oral Glucose Tolerance Test), was approximately halved in both sexes
- At 6 months of age, after 3-4 months of HED, female minipigs showed decreased insulin sensitivity

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Translational drug treatment effect

![Graph showing longitudinal treatment effect.]

Ran K et al. Obesity 2007;15:1780-1796

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DIO Göttingen Minipigs - summary

- Extreme obesity can be obtained by ad libitum feeding
- High quality data on food intake, body weight and body composition can be obtained
- Decreased insulin sensitivity can be induced by a high energy diet
  - In both sexes pre-pubertally
  - In females (or neutered animals) post-pubertally
- In the design of the study, it might be considered to
  - Use neutered animals
  - Use a high-fat diet
  - Exercise the minipigs daily
  - Reuse the minipigs for several studies

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Non-Alcoholic Steatohepatitis (NASH)

- Fatty liver affects 40-80% of patients with type 2 diabetes mellitus and 30-90% of obese patients.
- NASH develops in 10-20% of these patients and can progress into cirrhosis and hepatocellular carcinoma (HCC).
- LITMUS is a large EU-funded project aimed at finding better biomarkers.
  - Elleegaard Cöttingen Minipigs participates in LITMUS with the aim of developing and characterising a better animal model for NASH.

Non-alcoholic fatty liver disease and steatohepatitis

**Human NAFLD and NASH - definition**

- NAFLD is estimated to have a 25% prevalence worldwide.
- Ranges from simple steatosis to non-alcoholic steatohepatitis (NASH).
- Typical findings in humans are:
  - Steatosis (usually zone 3)
  - Lobular inflammation
  - Hepatocellular ballooning (usually zone 3)
  - Perisinusoidal fibrosis (zone 3)
  - Mallory-Denk bodies (in ballooned hepatocytes)

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Diet considerations

- High Fat-Fructose-Cholesterol (FFC) diets (i.e. atherogenic diets) have been used in several studies (incl. two recent studies in Ossabaw minipigs and one in Gottingen Minipigs).

  After several months of feeding, this diet results in practically no steatosis, moderate inflammation, and mild (and varying) fibrosis.

  To get a better model, we decided – together with Novo Nordisk – to perform a pilot study using a markedly different approach.

- Choline deficient diets are widely used in rodents and are known to have the potential to result in marked steatosis, steatosis-associated inflammation and fibrosis.

   ![Image of tissue sections](image-url)


Gene expression data clearly indicated induction of inflammation and fibrosis

<table>
<thead>
<tr>
<th></th>
<th>Inflammation (IL-1β, CD68, TNF)</th>
<th>Fibrosis (COL1, COL3, TIMP1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDAH, 8w</td>
<td>****</td>
<td>***</td>
</tr>
<tr>
<td>FFC 8w</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>FFC 12m</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Non-alcoholic fatty liver disease and steatohepatitis
Diet-induced pig models of NAFLD and NASH – FFC diet

- NAFLD/NASH is diet induced in minipig models
- Serial liver biopsies are possible to evaluate progression and drug effects
- Western diets (high fat, high sugar) may induce mild hepatic steatosis
- Fat, fructose and cholesterol diets (FFC) has been described in several minipig models and induce quite similar changes
  - Several strains

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Schumacher-Petersen, J Transl Med, 2019; Lee et al., Hepatology, 2013; Lang et al., PlosOne, 2013

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Cancer modeling thinks big with the pig

Under special conditions, the pigs are used for translational research to predict treatment outcomes in clinical trials.

Minipig as a potential translatable model for monoclonal antibody pharmacokinetics after intravenous and subcutaneous administration


Research and Early Development, Genentech, South San Francisco, CA, USA; †Drug Metabolism and Pharmacokinetics, Pharma Research and Early Development, Hoffmann-La Roche Inc., Nutley, NJ, USA; ‡Pharma Research and Early Development, F. Hoffmann-La Roche Ltd, Basel, Switzerland; ‡Drug Delivery, Pharma Technical Development, Genentech, South San Francisco, CA, USA

*These authors contributed equally to this work.
The minipigs and mAbs

Subcutaneous (SC) delivery is a common route of administration for therapeutic monoclonal antibodies (mAbs) with pharmacokinetic (PK)/pharmacodynamic (PD) properties requiring long-term or frequent drug administration. An ideal in vivo preclinical model for predicting human PK following SC administration may be one in which the skin and overall physiological characteristics are similar to that of humans. In this study, the PK properties of a series of therapeutic mAbs following intravenous (IV) and SC administration in Göttingen minipigs were compared with data obtained previously from humans. The present studies demonstrated: (1) minipig is predictive of human linear clearance; (2) the SC bioavailabilities in minipigs are weakly correlated with those in human; (3) minipig mAb SC absorption rates are generally higher than those in human and (4) the SC bioavailability appears to correlate with systemic clearance in minipigs. Given the important role of the neonatal Fc receptor (FcRn) in the PK of mAbs, the in vitro binding affinities of these IgGs against porcine, human and cynomolgus monkey FcRn were tested. The result showed comparable FcRn binding affinities across species. Further, mAbs with higher isoelectric point tended to have faster systemic clearance and lower SC bioavailability in both minipig and human. Taken together, these data lend increased support for the use of the minipig as an alternative predictive model for human IV and SC PK of mAbs.

The pig as model for human influenza infection and vaccination

Influenza A virus

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Current antiviral therapy is very expensive and less efficient if not applied early in the infection

New targets for
- Treatment
- Diagnostic/Prognostic/Monitoring

Several good reasons why the pig might be a good model

- Pigs are natural hosts and susceptible to human influenza strains
- Comparable clinical symptoms upon infection including fever and cough
- Respiratory system is physiologically and anatomically similar to humans
Guidance on the risk assessment of substances present in food intended for infants below 16 weeks of age

EFSA Scientific Committee,

The minipig as a translational animal model

For substances added intentionally to food for infants below 16 weeks of age, an Extended One-Generation Reproductive Toxicity Study (EOGRTS) (OECD TG 443) would be required. The EOGRTS should include cohorts to assess the potential impact of a test substance on the reproductive and developmental system, on the developing nervous system and on the developing immune system. Because exposure through mother's milk in experimental studies is usually substantially lower than the exposure through feed, the resulting doses in the neonatal animals may be insufficient for hazard characterisation. Therefore, for the purpose of this guidance, it is advised that direct dosing of the neonatal animals should be considered as soon as possible after birth. When standard toxicological studies do not show adverse effects in adult animals and the ADME studies show that a substance is not absorbed in relevant amounts, only a repeated dose study with direct oral administration to neonatal animals (e.g. in piglet models) is needed. This latter study should include analysis of possible local effects on the gastrointestinal tract and on a possible reduction in the bioavailability of nutrients.
Human digestive diseases

Table 1. Comparison of porcine and rodent models of digestive disease

<table>
<thead>
<tr>
<th>Animal model</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porcine</td>
<td>- Models exhibit pathophysiology and clinical signs of disease. - Approximate human age. - Xenotransplantation potential. - Total parenteral nutrition administration possible. - Share nutritional requirements. - Fulfill FDA requirement for pharmaceutical testing. - Comparable microbiota. - Possess highly developed central and peripheral nervous system. - Genome is only ~7% smaller than humans.</td>
<td>- Cost. - More difficult to manage. - Special housing facilities. - Few transgenic models available. - Time consuming.</td>
</tr>
<tr>
<td>Rodent</td>
<td>- Low cost. - Ease of maintenance. - Ease of genetic manipulation. - Rapid reproduction rate. - Number of available and well established models.</td>
<td>- Pathophysiological differences. - Absence of clinical signs of human disease in some models. - Technically difficult to create surgery models because of size. - Mortality rate. - Genome is ~14% smaller than humans.</td>
</tr>
</tbody>
</table>

Gonzalez et al, Translational Research 2015; 166: 12–27

Human digestive diseases...

- Pigs have shown promise for the study of intestinal barrier function, surgical tissue manipulation and intervention, as well as biomaterial implantation and tissue transplantation.
- Advantages of pig models include the physiological similarity to human intestine and mechanisms of human disease.
- Emerging future directions for porcine models of human disease include the fields of transgenics and stem cell biology.

The minipig as a paediatric animal model

Dosing up to maturation can be feasible in non-rodent species like the dog, minipig, and rabbit. These species mature over a period of a few to several months, and with relative consistency. In contrast, the interval between birth and maturity for NHPs is several years, making dosing during the entire developmental period not practical. Furthermore, NHPs show considerable inter-individual variation in the age of onset of puberty and maturity.
Repro-toxicology and juvenile studies

Species-related characteristics of non-rodent models

<table>
<thead>
<tr>
<th>Reproductive characteristics</th>
<th>Drought dog</th>
<th>Cynomolgus monkey</th>
<th>Göttingen minipig</th>
</tr>
</thead>
<tbody>
<tr>
<td>General remarks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often preferred non-rodent model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provocative to mating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More venous in the neck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public opinion is not evident</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy available from supplier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gestation duration (in weeks)</td>
<td>1-2 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offspring/litter</td>
<td>4-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colostrum length (in days)</td>
<td>58-65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal care</td>
<td>Rather easy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sexual maturity</td>
<td>7-12 months of age</td>
<td>4-5 years of age</td>
<td>3-5 months of age</td>
</tr>
</tbody>
</table>
Development milestones

- Postnatal age categories for minipigs compared with humans (ICH E11)

<table>
<thead>
<tr>
<th>Category</th>
<th>Human</th>
<th>Minipig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate</td>
<td>0-28 days</td>
<td>0-15 days</td>
</tr>
<tr>
<td>Infant</td>
<td>1-23 months</td>
<td>2-4 weeks</td>
</tr>
<tr>
<td>Child</td>
<td>2-12 years</td>
<td>4-14 weeks</td>
</tr>
<tr>
<td>Adolescent</td>
<td>12-16 years</td>
<td>4-6 months</td>
</tr>
</tbody>
</table>

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Juvenile studies

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ICH guidance

Guidance for Industry
S6 Preclinical Safety Evaluation of Biotechnology-Derived Pharmaceuticals

Species selection and translational value

C. Animal Species/Model Selection (3.3)

The biological activity together with species and/or tissue specificity of many biotechnology-derived pharmaceuticals often preclude standard toxicity testing designs in commonly used species (e.g., rats and dogs). Safety evaluation programs should include the use of relevant species. A relevant species is one in which the test material is pharmacologically active due to the expression of the receptor or an epitope (in the case of monoclonal antibodies). A variety of techniques (e.g., immunochemical or functional tests) can be used to identify a relevant species. Knowledge of receptor/epitope distribution can provide greater understanding of potential in vivo toxicity.

Relevant animal species for testing of monoclonal antibodies are those that express the desired epitope and demonstrate a similar tissue cross-reactivity profile as for human tissues. This would optimize the ability to evaluate toxicity arising from the binding to the epitope and any unintentional tissue cross-reactivity. An animal species that does not express the desired epitope may still be of some relevance for assessing toxicity if comparable unintentional tissue cross-reactivity to humans is demonstrated.
Use of genetically modified animals

In recent years, there has been much progress in the development of animal models that are thought to be similar to the human disease. These animal models include induced and spontaneous models of disease, gene knockout(s), and transgenic animals. These models may provide further insight, not only in determining the pharmacological action of the product, pharmacokinetics, and dosimetry, but may also be useful in the determination of safety (e.g., evaluation of undesirable promotion of disease progression). In certain cases, studies performed in animal models of disease may be used as an acceptable alternative to toxicity studies in normal animals (Note 1). The scientific justification for the use of these animal models of disease to support safety should be provided.
Genetic engineering toolbox for pigs

- 2014: Gene editing by using the CRISPR/Cas system
- 2012: Gene editing using TALENs
- 2011: Gene editing using ZFNs
- 2008: Adeno-associated virus-mediated gene targeting
- 2006: ICSI-mediated gene transfer
- 2003: Lentiviral gene transfer
- 2002: Gene targeting in somatic cells and SCNT
- 2001: Sperm-mediated gene transfer (SMGT)
- 1985: Pronuclear DNA microinjection

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THE CRISPR ZOO

CRISPR, THE DISRUPTOR

CRISPR patent probe begins

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Expression of the Alzheimer’s Disease Mutations AβPP695sw and PSEN1M146I in Double-Transgenic Göttingen Minipigs

Janik S. Jakobsen, Marianne G. Johansen, Mette Schröder, Ying Lin, Bengt Nilsson, Margarete Hofkost, Carina Marone, Yvonne Reuten, Thomas A. Bayet, Anders Lude Nielsen, Morten Rutzbøll, Paul E. Price, Les E. Bito, and Anne Lindergard

1 Department of Biomedical and Clinical Science, Unit of Molecular Neurosciences, Umeå University, Umeå, Sweden
2 Department of Neurology, University Hospital, Umeå, Sweden
3 Department of Biomedical and Clinical Science, Unit of Clinical Sciences, Umeå University, Umeå, Sweden
4 Department of Clinical Medicine, Aarhus University, Aarhus, Denmark
5 Department of Psychiatry, Aarhus University Hospital, Aarhus, Denmark

Abstract: Mutations in the transmembrane protein precursor gene (AβPP) and the presenilin-1 gene (PSEN1) are the most common genetic contributing factors to late-onset Alzheimer’s disease. Double-transgenic models of Alzheimer’s disease (AD) and late-onset AD have been developed by introducing mutant alleles of the AβPP and PSEN1 genes into the genetic background of laboratory mice. In this study, we developed a double-transgenic pig model expressing the AβPP695sw and PSEN1M146I mutations. We observed that the pigs expressing both mutations exhibited increased Aβ deposition in the brain and peripheral tissues, similar to that observed in human AD patients. These findings support the use of double-transgenic pigs as a valuable model for studying the pathogenesis of Alzheimer’s disease.

Key words: Alzheimer’s disease, transgenic, pig model, amyloid deposition, Aβ deposition.
Fig. 3. APP/PSI/PSI(146) transgenic pigs express both transgenic proteins. Western blots of extracts of fibroblasts from newborn APP/PSI/PSI(146) transgenic pigs 991, 391, and 392, and 1-month-old 94 pig. Lane marked WT2 cells contains extract from HEK293 cells stably overexpressing human APP (APPx). Primary antibodies: (a) polyclonal antibody Ab 141 specific of both human and pig APP; (b) monoclonal antibody AB13 specific of human APP; (c) monoclonal antibody CO8.2 specific of both human and pig APP (APPx). Note: no (b) robust expression and normal processing of the human is shown. PSF/APP(146) transgenic pig, in (a) high expression (991) and moderate expression (159, 152) of the human APP transgenic protein as compared to WT2 and HEK cells overexpressing human APP (APPx). APPx was correctly processed with increased production of Aβ(1-42). 36 µg transverse lane in (a) and (b) and 15 µg in (c). 3 µg of cell culture extract per lane marked WT2 cells. Exposure time 5 s.

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MINIPIG RESEARCH FORUM – VIENNA 2019

Growth hormone receptor deficient pigs – a model for Laron Syndrome

Dr. med. vet. Arne Hinrichs
Chair for Molecular Animal Breeding and Biotechnology;
Ludwig – Maximilians – University; Munich, Germany
Animal Model for Scientific Research

- The Göttingen Minipig is increasingly being selected for all aspects of pharmaceutical research
  - The smallest of all commercially available mini- and micro-pigs
  - Available in large uniform groups
  - Well-defined and managed genetics
  - Well-defined health status
  - More and more available background data
  - Easy to fulfill natural needs, socialize and train for scientific procedures
  - More accepted by the general public
Global supply of Göttingen Minipigs

- Ellegaard Göttingen Minipigs, Denmark
  - Barrier-bred animals
  - AAALAC accredited
  - Delivery in Europe and parts of Asia incl. China and India

- Marshall BioResources, USA
  - Barrier-bred animals
  - AAALAC accredited
  - Delivery in North America

- Oriental Yeast Co., Japan
  - Barrier-bred animals
  - AAALAC accredited
  - Delivery in Japan and Taiwan

- WoojungBio South Korea
  - DK barrier-bred animals
  - Delivery in South Korea

- University of Göttingen, Germany
  - Non-barrier bred animals
  - Internal use at the University of Göttingen

Global standard

- Ellegaard Göttingen Minipigs and our partners are global breeders and distributors of Göttingen Minipigs for biomedical research focusing on the advancement of quality of life and health

- By breeding microbiologically defined Göttingen Minipigs in barrier facilities, we fulfil the industry’s wish for an animal model with a high standard of health and high quality in general

- Göttingen Minipigs are subject to strict, unified genetic breeding-management procedures, and we give high priority to animal welfare in the housing, care and handling of the animals

- Göttingen Minipigs are suitable for companies seeking a genetically and microbiologically well-defined animal model for biomedical research
Today’s – and this years 50 years jubilee

Questions or comments?

- Acknowledgement
  - Henrik Duhlund Pedersen, CSO at Ellegaard Göttingen Minipigs
  - Kirsten Rosenmay Jacobsen, Laboratory Animal Veterinarian
  - Peter Vestbjerg, Head of Business Development
  - Various colleagues and scientific partners for sharing knowledge and providing slides for this presentation

- Feel free always to contact our team or me directly at lfm@minipigs.dk and to follow Ellegaard Göttingen Minipigs and me on LinkedIn