

OECD GUIDELINE FOR THE TESTING OF CHEMICALS

Uterotrophic Bioassay in Rodents: A short-term screening test for oestrogenic properties

INTRODUCTION

1. The OECD initiated a high-priority activity in 1998 to revise existing guidelines and to develop new guidelines for the screening and testing of potential endocrine disrupters (1). One element of the activity was to develop a Test Guideline for the rodent Uterotrophic Bioassay. The rodent Uterotrophic Bioassay then underwent an extensive validation programme including the compilation of a detailed background document (2)(3) and the conduct of extensive intra- and interlaboratory studies to show the relevance and reproducibility of the bioassay with a potent reference oestrogen, weak oestrogen receptor agonists, a strong oestrogen receptor antagonist, and a negative reference chemical (4)(5)(6)(7)(8)(9). This Test Guideline 440 is the outcome of the experience gained during the validation test programme and the results obtained thereby with oestrogenic agonists.

2. The Uterotrophic Bioassay is a short-term screening test that originated in the 1930's (27)(28) and was first standardized for screening by an expert committee in 1962 (32)(35). It is based on the increase in uterine weight or uterotrophic response (for review, see 29). It evaluates the ability of a chemical to elicit biological activities consistent with agonists or antagonists of natural oestrogens (e.g. 17 β -estradiol), however, its use for antagonist detection is much less common than for agonists. The uterus responds to oestrogens in two ways. An initial response is an increase in weight due to water imbibition. This response is followed by a weight gain due to tissue growth (30). The uterus responses in rats and mice qualitatively are comparable.

3. This bioassay serves as an *in vivo* screening assay and its application should be seen in the context of the "OECD Conceptual Framework for the Testing and Assessment of Endocrine Disrupting Chemicals" (Annex 2). In this Conceptual Framework the Uterotrophic Bioassay is contained in Level 3 as an *in vivo* assay providing data about a single endocrine mechanism, i.e. oestrogenicity.

4. The Uterotrophic Bioassay is intended to be included in a battery of *in vitro* and *in vivo* tests to identify substances with potential to interact with the endocrine system, ultimately leading to risk assessments for human health or the environment. The OECD validation program used both strong and weak estrogen agonists to evaluate the performance of the assay to identify estrogenic compounds (4)(5)(6)(7)(8). Thereby the sensitivity of the test procedure for oestrogen agonists was well demonstrated besides a good intra- and interlaboratory reproducibility.

5. With regard to negative compounds, only one "negative" reference chemical already reported negative by uterotrophic assay as well as *in vitro* receptor binding and receptor assays was included in the validation programme, but additional test data, not related to the OECD validation programme, have been evaluated, giving further support to the specificity of the Uterotrophic Bioassay for the screening of oestrogen agonists (16).

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INITIAL CONSIDERATIONS AND LIMITATIONS

6. Oestrogen agonists and antagonists act as ligands for oestrogen receptors α and β and may activate or inhibit, respectively, the transcriptional action of the receptors. This may have the potential to lead to adverse health hazards, including reproductive and developmental effects. Therefore, the need exists to rapidly assess and evaluate a chemical as a possible oestrogen agonist or antagonist. While informative, the affinity of a ligand for an oestrogen receptor or transcriptional activation of reporter genes *in vitro* is only one of several determinants of possible hazard. Other determinants can include metabolic activation and deactivation upon entering the body, distribution to target tissues, and clearance from the body, depending at least in part on the route of administration and the chemical being tested. This leads to the need to screen the possible activity of a chemical *in vivo* under relevant conditions, unless the chemical's characteristics regarding Absorption – Distribution – Metabolism – Elimination (ADME) already provide appropriate information. Uterine tissues respond with rapid and vigorous growth to stimulation by oestrogens, particularly in laboratory rodents, where the oestrous cycle lasts approximately 4 days. Rodent species, particularly the rat, are also widely used in toxicity studies for hazard characterization. Therefore, the rodent uterus is an appropriate target organ for the *in vivo* screening of oestrogen agonists and antagonists.

7. This Guideline is based on those protocols employed in the OECD validation study which have been shown to be reliable and repeatable in intra- and interlaboratory studies (5)(7). Currently two methods, namely, the ovariectomised adult female method (ovx-adult method) and the immature non-ovariectomised method (immature method) are available. It was shown in the OECD validation test program that both methods have comparable sensitivity and reproducibility. However, the immature, as it has an intact hypothalamic-pituitary-gonadal (HPG) axis, is somewhat less specific but covers a larger scope of investigation than the ovariectomized animal because it can respond to substances that interact with the HPG axis rather than just the oestrogen receptor. The HGP axis of the rat is functional at about 15 days of age. Prior to that, puberty cannot be accelerated with treatments like GnRH. As the females begin to reach puberty, prior to vaginal opening, the female will have several silent cycles that do not result in vaginal opening or ovulation, but there are some hormonal fluctuations. If a chemical stimulates the HGP axis directly or indirectly, precocious puberty, early ovulation and accelerated vaginal opening result. Not only chemicals that act on the HPG axis do this but some diets with higher metabolizable energy levels than others will stimulate growth and accelerate vaginal opening without being estrogenic. Such substances would not induce an uterotrophic response in OVX adult animals as their HPG axis doesn't work.

8. For animal welfare reasons preference should be given to the method using immature rats, avoiding surgical pre-treatment of the animals and avoiding also a possible non-use of those animals which indicate any evidence entering oestrous (see paragraph 30).

9. The uterotrophic response is not entirely of oestrogenic origin, i.e. compounds other than agonists or antagonists of oestrogens may also provide a response. For example, relatively high doses of progesterone, testosterone, or various synthetic progestins may all lead to a stimulative response (30). Any response may be analyzed histologically for keratinization and cornification of the vagina (30). Irrespective of the possible origin of the response, a positive outcome of an Uterotrophic Bioassay should normally initiate actions for further clarification. Additional evidence of oestrogenicity could come from *in vitro* assays, such as the ER binding assays and transcriptional activation assays, or from other *in vivo* assays such as the female pubertal assay.

10. Taking into account that the Uterotrophic Bioassay serves as an *in vivo* screening assay, the validation approach taken, served both animal welfare considerations and a tiered testing strategy. To this end, effort was directed at rigorously validating reproducibility and sensitivity for oestrogenicity - the main concern for many chemicals-, while little effort was directed at the antioestrogenicity component of the

assay. Only one antioestrogen with strong activity was tested since the number of substances with a clear antioestrogenic profile (not obscured by some oestrogenic activity) is very limited. Thus this Test Guideline is dedicated to the oestrogenic protocol, while the protocol describing the antagonist mode of the assay is included in a Guidance Document. The reproducibility and sensitivity of the assay for substances with purely anti-oestrogenic activity will be more clearly defined later on, after the test procedure has been in routine use for some time and more substances with this modality of action are identified.

11. It is acknowledged that all animal based procedures will conform to local standards of animal care; the descriptions of care and treatment set forth below are minimal performance standards, and will be superseded by local regulations. Further guidance of the humane treatment of animals is given by the OECD (25).

12. As with all assays using live animals, it is essential to ensure that the data are truly necessary prior to the start of the assay. For example, two conditions where the data may be required are:

- high exposure potential (Level 1 of the Conceptual Framework, Annex 2) or indications for oestrogenicity (Level 2) to investigate whether such effects may occur in vivo
- effects indicating oestrogenicity in Level 4 or 5 in vivo tests to substantiate that the effects were related to an oestrogenic mechanism that cannot be elucidated using an *in vitro* test.

13. Definitions used in this Test Guideline are given in Annex 1.

PRINCIPLE OF THE TEST

14. The Uterotrophic Bioassay relies for its sensitivity on an animal test system in which the hypothalamic-pituitary-ovarian axis is not functional, leading to low endogenous levels of circulating oestrogen. This will ensure a low baseline uterine weights and a maximum range of response to administered oestrogens. Two oestrogen sensitive states in the female rodent meet this requirement:

- i) immature females after weaning and prior to puberty and
- ii) young adult females after ovariectomy with adequate time for uterine tissues to regress.

15. The test substance is administered daily by oral gavage or subcutaneous injection. Graduated test substance doses are administered to a minimum of two treatment groups (see paragraph 33 for guidance) of experimental animals using one dose level per group and an administration period of three consecutive days for immature method and a minimum administration period of three consecutive days for ovx-adult method. The animals are necropsied approximately 24 hours after the last dose. For oestrogen agonists, the mean uterine weight of the treated animal groups relative to the vehicle group is assessed for a statistically significant increase. A statistically significant increase in the mean uterine weight of a test group indicates a positive response in this bioassay.

DESCRIPTION OF THE METHOD

Selection of animal species

16. Commonly used laboratory rodent strains may be used. As an example, Sprague-Dawley and Wistar strains of rats were used during the validation. Strains with uteri known or suspected to be less responsive should not be used. The laboratory should demonstrate the sensitivity of the strain used as described in paragraphs 26 and 27.

17. The rat and mouse have been routinely used in the Uterotrophic Bioassay since the 1930s. The OECD validation studies were only performed with rats based on an understanding that both species are expected to be equivalent and therefore one species should be enough for the world-wide validation in order to save resources and animals. The rat is the species of choice in most reproductive and developmental toxicity studies. Taking into consideration that a vast historical data base exists for mice and thus to broaden the scope of the Uterotrophic Bioassay Test Guideline in rodents to the use of mice as test species, a limited follow-up validation study was carried out in mice (16). A bridging approach with a limited number of test chemicals, participating laboratories and without coded sample testing has been selected in keeping with the original intent to save resources and animals. This bridging validation study shows for the Uterotrophic Bioassay in young adult ovariectomized mice that qualitatively and quantitatively, the data obtained in rats and mice correspond well with each other. Where the Uterotrophic Bioassay result may be preliminary to a long-term study, this allows animals from the same strain and source to be used in both studies. The bridging approach was limited to the OVX mice and the report doesn't provide a robust data set to validate the immature model, thus the immature model for mice is not considered under the scope of the current Test Guideline.

18. Thus, in some cases mice may be used instead of rats. A rationale should be given for this species, based on toxicological, pharmacokinetic, and/or other criteria. Modifications of the protocol may be necessary for mice. For example, the food consumption of mice on a body weight basis is higher than that of rats and therefore the phytoestrogen content in food should be lower for mice than for rats (9)(20)(22).

Housing and feeding conditions

19. All procedures should conform with local standards of laboratory animal care. These descriptions of care and treatment are minimum standards and will be superseded by local regulations, when present. The temperature in the experimental animal room should be 22°C (with an approximate range $\pm 3^\circ\text{C}$). The relative humidity should be a minimum of 30% and preferably should not exceed a maximum 70%, other than during room cleaning. The aim should be relative humidity of 50-60%. Lighting should be artificial. The daily lighting sequence should be 12 hours light, 12 hours dark.

20. Laboratory diet and drinking water should be provided *ad libitum*. Young adult animals may be housed individually or be caged in groups of up to three animals. Due to the young age of the immature animals, social group housing is recommended.

21. High levels of phytoestrogens in laboratory diets have been known to increase uterine weights in rodents to a degree enough as to interfere with the Uterotrophic Bioassay (13)(14)(15). High levels of phytoestrogens and of metabolizable energy in laboratory diets may also result in early puberty, if immature animals are used. The presence of phytoestrogens results primarily from the inclusion of soy and alfalfa products in the laboratory diets and concentrations of phytoestrogens have been shown to vary from batch-to-batch of standard laboratory diets (23). Body weight is an important variable, as the quantity of food consumed is related to body weight. Therefore, the actual phytoestrogen dose consumed from the same diet may vary among species and by age (9). For immature female rats, food consumption on a body weight basis may be approximately double that of ovariectomised young adult females. For young adult mice, food consumption on a body weight basis may be approximately quadruple that of ovariectomised young adult female rats.

22. Uterotrophic Bioassay results (9)(17)(18)(19), however, show that limited quantities of dietary phytoestrogens are acceptable and do not reduce the sensitivity of the bioassay. As a guide, dietary levels of phytoestrogens should not exceed 350 μg of genistein equivalents/gram of laboratory diet for immature female Sprague Dawley and Wistar rats (6)(9). Such diets should also be appropriate when testing in young

adult ovariectomised rats because food consumption on a body weight basis is less in young adult as compared to immature animals. If adult ovariectomised mice or more phytoestrogen-sensitive rats are to be used, proportional reduction in dietary phytoestrogen levels must be considered (20). In addition, the differences in available metabolic energy from different diets may lead to time shifts for the onset of puberty (21)(22).

23. Prior to the study, careful selection is required of a diet without an elevated level of phytoestrogens (for guidance see (6)(9)) or metabolizable energy, that can confound the results (15)(17)(19)(22)(36). Ensuring the proper performance of the test system used by the laboratory as specified in paragraphs 26 and 27 is an important check on both of these factors. As a safeguard consistent with GLP, representative sampling of each batch of diet administered during the study should be conducted for possible analysis of phytoestrogen content (e.g. in the case of high uterine control weight relative to historic controls or an inadequate response to the reference oestrogen, 17 alpha ethinyl estradiol). Aliquots should be analyzed as part of the study or frozen at -20°C or in such a way as to prevent the sample from decomposing prior to analysis.

24. Some bedding materials may contain naturally occurring oestrogenic or antioestrogenic substances (e.g. corn cob is known to affect the cyclicity of rats and appears to be antioestrogenic). The selected bedding material should contain a minimum level of phytoestrogens.

Preparation of animals

25. Experimental animals without evidence of any disease or physical abnormalities are randomly assigned to the control and treatment groups. Cages should be arranged in such a way that possible effects due to cage placement are minimized. The animals should be identified uniquely. Preferably, immature animals should be caged with dams or foster dams until weaning during acclimatization. The acclimatization period prior to the start of the study should be about 5 days for young adult animals and for the immature animals delivered with dams or foster dams. If immature animals are obtained as weanlings without dams a shorter duration of the acclimatization period may become necessary as dosing should start immediately after weaning (see paragraph 29).

PROCEDURE

Verification of Laboratory Proficiency

26. Two different options can be used to verify laboratory proficiency:

- Periodic verification, relying on an initial baseline positive control study (see paragraph 27). At least every 6 months and each time there is a change that may influence the performance of the assay (e.g. a new formulation of diet, change in personnel performing dissections, change in animal strain or supplier, etc.), the responsiveness of the test system (animal model) should be verified using an appropriate dose (based on the baseline positive control study described in paragraph 27) of a reference oestrogen: 17 α -ethinyl estradiol (CAS No. 57-63-6) (EE).
- Use of concurrent controls, by including a group administered with an appropriate dose of reference oestrogen in each assay.

If the system does not respond as expected, the experimental conditions should be examined and modified accordingly. It is recommended that the dose of reference oestrogen to be used in either approach be approximately the ED70 to 80.

27. **Baseline Positive Control Study** – Before a laboratory conducts a study under this Test Guideline for the first time, laboratory proficiency should be demonstrated by testing the responsiveness of the animal model, by establishing the dose response of a reference oestrogen: 17 α -ethinyl estradiol (CAS No. 57-63-6) (EE) with a minimum of four doses. The uterine weight response will be compared to established historical data (see reference (5)). If this baseline positive control study does not yield the anticipated results the experimental conditions should be examined and modified.

Number and condition of animals

28. Each treated and control group should include at least 6 animals (for both immature and ovx-adult method protocols).

Age of immature animals

29. For the Uterotrophic Bioassay with immature animals the day of birth must be specified. Dosing should begin early enough to ensure that, at the end of test substance administration, the physiological rise of endogenous oestrogens associated with puberty has not yet taken place. On the other hand, there is evidence that very young animals may be less sensitive. For defining the optimal age each laboratory should take its own background data on maturation into consideration.

As a general guide, dosing in rats may begin immediately after early weaning on postnatal day 18 (with the day of birth being postnatal day 0). Dosing in rats preferably should be completed on postnatal day 21 but in any case prior to postnatal day 25, because, after this age, the hypothalamic-pituitary-ovarian axis becomes functional and endogenous oestrogen levels may begin to rise with a concomitant increase in baseline uterine weight means and an increase in the group standard deviations (2)(3)(10)(11)(12).

Procedure for ovariectomy

30. For the ovariectomised female rat and mouse (treatment and control groups), ovariectomy should occur between 6 and 8 weeks of age. For rats, a minimum of 14 days should elapse between ovariectomy and the first day of administration in order to allow the uterus to regress to a minimum, stable baseline. For mice, at least 7 days should elapse between ovariectomy and the first day of administration. As small amounts of ovarian tissue are sufficient to produce significant circulating levels of oestrogens (3), the animals should be tested prior to use by observing epithelial cells swabbed from the vagina on at least five consecutive days (e.g., days 10-14 after ovariectomy for rats). If the animals indicate any evidence entering oestrous, the animals should not be used. Further, at necropsy, the ovarian stubs should be examined for any evidence that ovarian tissue is present. If so, the animal should not be used in the calculations (3).

31. The ovariectomy procedure begins with the animal in ventral recumbency after the animal has been properly anesthetized. The incision opening the dorso-lateral abdominal wall should be approximately 1 cm lengthways at the mid point between the costal inferior border and the iliac crest, and a few millimetres lateral to the lateral margin of the lumbar muscle. The ovary should be removed from the abdominal cavity onto an aseptic field. The ovary should be disconnected at the junction of the oviduct and the uterine body. After confirming that no massive bleeding is occurring, the abdominal wall should be closed by a suture and the skin closed by autoclips or appropriate suture. The ligation points are shown schematically in **Figure 1**. Appropriate post operative analgesia should be used as recommended by a veterinarian experienced in rodent care.

Body weight

32. In the ovx-adult method, body weight and uterine weight are not correlated because uterine weight is affected by hormones like oestrogens but not by the growth factors that regulate body size. On the contrary, body weight is related to uterine weight in the immature model, while it is maturing (34). Thus, at the commencement of the study the weight variation of animals used, in the immature model, should be minimal and not exceed $\pm 20\%$ of the mean weight. This means that the litter size should be standardized by the breeder, to assure that offspring of different mother animals will be fed approximately the same. Animals should be assigned to groups (both control and treatment) by randomized weight distribution, so that mean body weight of each group is not statistically different from any other group. Consideration should be given to avoid assignment of littermates to the same treatment group as far as practicable without increasing the number of litters to be used for the investigation.

Dosage

33. In order to establish whether a test substance can have oestrogenic action *in vivo*, two dose groups and a control are normally sufficient and this design is therefore preferred for animal welfare reasons. If the purpose is either to obtain a dose-response curve or to extrapolate to lower doses, at least 3 dose groups are needed. If information beyond identification of oestrogenic activity (such as an estimate of potency) is required, a different dosing regime should be considered. Except for treatment with the test substance, animals in the control group should be handled in an identical manner to the test group subjects. If a vehicle is used in administering the test substance, the control group should receive the same amount of vehicle used with the treated groups (or highest volume used with the test groups if different among groups).

34. The objective in the case of the Uterotrophic Bioassay is to select doses that ensure animal survival and that are without significant toxicity or distress to the animals after three consecutive days of chemical administration up to a maximum dose of 1000 mg/kg/d. All dose levels should be proposed and selected taking into account any existing toxicity and (toxic-) kinetic data available for the test compound or related materials. The highest dose level should first take into consideration the LD50 and/or acute toxicity information in order to avoid death, severe suffering or distress in the animals (24)(25)(26). The highest dose should represent the maximum tolerated dose (MTD); a study conducted at a dose level that induced a positive uterotrophic response would be accepted too. As a screen, large intervals (e.g. one half log units corresponding to a dose progression of 3.2 or even up to one log units) between dosages are generally acceptable. If there are no suitable data available, a range finding study may be performed to aid the determination of the doses to be used.

35. Alternatively, if the oestrogenic potency of an agonist can be estimated by *in vitro* (or *in silico*) data, these may be taken into consideration for dose selection. For example, the amount of the test chemical that would produce uterotrophic responses equivalent to the reference agonist (ethinyl estradiol) is estimated by its relative *in vitro* potencies to ethinyl estradiol. The highest test dose would be given by multiplying this equivalent dose by an appropriate factor e.g. 10 or 100.

Considerations for range finding

36. If necessary, a preliminary range finding study can be carried out with few animals. In this respect, OECD Guidance Document n°19 (25) may be used defining clinical signs indicative of toxicity or distress to the animals. If feasible within this range finding study after three days of administration, the uteri may be excised and weighed approximately 24-hours after the last dose. These data could then be used to assist the main study design (select an acceptable maximum and lower doses and recommend the number of dose groups).

Administration of doses

37. The test compound is administered by oral gavage or subcutaneous injection. Animal welfare considerations as well as toxicological aspects like the relevance to the human route of exposure to the chemical (e.g. oral gavage to model ingestion, subcutaneous injection to model inhalation or dermal adsorption), the physical/chemical properties of the test material and especially existing toxicological information and data on metabolism and kinetics (e.g. need to avoid first pass metabolism, better efficiency via a particular route) have to be taken into account when choosing the route of administration.

38. It is recommended that, wherever possible, the use of an aqueous solution/suspension be considered first. But as most oestrogen ligands or their metabolic precursors tend to be hydrophobic, the most common approach is to use a solution/suspension in oil (e.g. corn, peanut, sesame or olive oil). However, these oils have different caloric and fat content, thus the vehicle might affect total metabolizable energy (ME) intake, thereby potentially altering measured endpoints such as the uterine weight especially in the immature method (33). Thus, prior to the study, any vehicle to be used should be tested against controls without vehicles. Test substances can be dissolved in a minimal amount of 95% ethanol or other appropriate solvents and diluted to final working concentrations in the test vehicle. The toxic characteristics of the solvent must be known, and should be tested in a separate solvent-only control group. If the test substance is considered stable, gentle heating and vigorous mechanical action can be used to assist in dissolving the test substance. The stability of the test substance in the vehicle should be determined. If the test substance is stable for the duration of the study, then one starting aliquot of the test substance may be prepared, and the specified dosage dilutions prepared daily.

39. Dosage timing will depend of the model used (refer to paragraph 29 for the immature model and to paragraph 30 for ovx-adult model). Immature female rats are dosed with the test substance daily for three consecutive days. A three-day treatment is also recommended for ovariectomised female rats but longer exposures are acceptable and may improve the detection of weakly active substances. With ovariectomised female mice, an application duration of 3 days should be sufficient without a significant advantage by an extension of up to seven days for strong oestrogen agonists, however, this relation was not demonstrated for weak oestrogens in the validation study (16) thus dosage should be extended up to 7 consecutive days in ovx-adult mice. The dose should be given at similar times each day. They should be adjusted as necessary to maintain a constant dose level in terms of animal body weight (e.g., mg of test substance per kg of body weight per day). Regarding the test volume, its variability, on a body weight basis, should be minimized by adjusting the concentration of the dosing solution to ensure a constant volume on a body weight basis at all dose levels and for any route of administration.

40. When the test substance is administered by gavage, this should be done in a single daily dose to the animals using a stomach tube or a suitable intubation cannula. The maximum volume of liquid that can be administered at one time depends on the size of the test animal. Local animal care guidelines should be followed, but the volume should not exceed 5 ml/kg body weight, except in the case of aqueous solutions where 10 ml/kg body weight may be used.

41. When the test substance is administered by subcutaneous injection, this should be done in a single daily dose. Doses should be administered to the dorsoscapular or lumbar regions via sterile needle (e.g. 23- or 25-gauge) and a tuberculin syringe. Shaving the injection site is optional. Any losses, leakage at the injection site or incomplete dosing should be recorded. The total volume injected per rat per day should not exceed 5 ml/kg body weight, divided into 2 injection sites, except in the case of aqueous solutions where 10 ml/kg body weight may be used.

Observations

General and clinical observations

42. General clinical observations should be made at least once a day and more frequently when signs of toxicity are observed. Observations should be carried out preferably at the same time(s) each day and considering the period of anticipated peak effects after dosing. All animals are to be observed for mortality, morbidity and general clinical signs such as changes in behaviour, skin, fur, eyes, mucous membranes, occurrence of secretions and excretions and autonomic activity (e.g. lacrimation, piloerection, pupil size, unusual respiratory pattern).

Body weight and food consumption

43. All animals should be weighed daily to the nearest 0.1 g, starting just prior to initiation of treatment i.e., when the animals are allocated into groups. As an optional measurement, the amount of food consumed during the treatment period may be measured per cage by weighing the feeders. The food consumption results should be expressed in grams per rat per day.

Dissection and measurement of uterus weight

44. Twenty-four hours after the last treatment, the rats will be humanely killed. Ideally, the necropsy order will be randomized across groups to avoid progression directly up or down dose groups that could subtly affect the data. The bioassay objective is to measure both the wet and blotted uterus weights. The wet weight includes the uterus and the luminal fluid contents. The blotted weight is measured after the luminal contents of the uterus have been expressed and removed.

45. Before dissection the vagina will be examined for opening status in immature animals. The dissection procedure begins by opening the abdominal wall starting at the pubic symphysis. Then, uterine horn and ovaries, if present, are detached from the dorsal abdominal wall. The urinary bladder and ureters are removed from the ventral and lateral side of uterus and vagina. Fibrous adhesion between the rectum and the vagina is detached until the junction of vaginal orifice and perineal skin can be identified. The uterus and vagina are detached from the body by incising the vaginal wall just above the junction between perineal skin as shown in [Figure 2](#). The uterus should be detached from the body wall by gently cutting the uterine mesentery at the point of its attachment along the full length of the dorsolateral aspect of each uterine horn. Once removed from the body, uterine handling should be sufficiently rapid to avoid desiccation of the tissues. Loss of weight due to desiccation becomes more important with small tissues such as the uterus (23). If ovaries are present, the ovaries are removed at the oviduct avoiding loss of luminal fluid from the uterine horn. If the animal has been ovariectomised, the stubs should be examined for the presence of any ovarian tissue. Excess fat and connective tissue should be trimmed away. The vagina is removed from the uterus just below the cervix so that the cervix remains with the uterine body as shown in [Figure 2](#).

46. Each uterus should be transferred to a uniquely marked and weighed container (e.g. a petri-dish or plastic weight boat) with continuing care to avoid desiccation before weighing (e.g. filter paper slightly dampened with saline may be placed in the container). The uterus with luminal fluid will be weighed to the nearest 0.1 mg (wet uterine weight).

47. Each uterus will then be individually processed to remove the luminal fluid. Both uterine horns will be pierced or cut longitudinally. The uterus will be placed on lightly moistened filter paper (e.g. Whatman No. 3) and gently pressed with a second piece of lightly moistened filter paper to completely remove the luminal fluid. The uterus without the luminal contents will be weighed to the nearest 0.1 mg (blotted uterine weight).

48. The uterus weight at termination can be used to assure that the appropriate age in the immature intact rat was not exceeded, however, the historical data of the rat strain used by the laboratory are decisive in this respect (see paragraph 56 for interpretation of the results).

Optional investigations

49. After weighing, the uterus may be fixed in 10% neutral buffered formalin to be examined histopathologically after Haematoxylin & Eosin (HE)-staining. The vagina may be investigated accordingly (see paragraph 9). In addition, morphometric measurement of endometrial epithelium may be done for quantitative comparison.

DATA AND REPORTING

Data

50. Study data should include:

- the number of animals at the start of the assay,
- the number and identity of animals found dead during the assay or killed for humane reasons and the date and time of any death or humane kill,
- the number and identity of animals showing signs of toxicity, and a description of the signs of toxicity observed, including time of onset, duration, and severity of any toxic effects, and
- the number and identity of animals showing any lesions and a description of the type of lesions.

51. Individual animal data should be recorded for the body weights, the wet uterine weight, and the blotted uterine weight. One-tailed statistical analyses for agonists should be used to determine whether the administration of a test substance resulted in a statistically significant ($p < 0.05$) increase in the uterine weight. Appropriate statistical analyses should be carried out to test for treatment related changes in blotted and wet uterine weight. For example, the data may be evaluated by an analysis of covariance (ANCOVA) approach with body weight at necropsy as the co-variable. A variance-stabilizing logarithmic transformation may be carried out on the uterine data prior to the data analysis. Dunnett and Hsu's test are appropriate for making pair wise comparisons of each dosed group to vehicle controls and to calculate the confidence intervals. Studentised residual plots can be used to detect possible outliers and to assess homogeneity of variances. These procedures were applied in the OECD validation program using the PROC GLM in the Statistical Analysis System (SAS Institute, Cary, NC), version 8 (6)(7).

52. A final report shall include:

Testing facility:

- Responsible personnel and their study responsibilities
- Data from the Baseline Positive Control Test and periodic positive control data (see paragraphs 26 and 27)

Test Substance:

- Characterization of test substances
- Physical nature and where relevant physicochemical properties
- Method and frequency of preparation of dilutions

- Any data generated on stability
- Any analyses of dosing solutions

Vehicle:

- Characterization of test vehicle (nature, supplier and lot)
- Justification of choice of vehicle (if other than water)

Test animals:

- Species and strain and justification for their choice
- Supplier and specific supplier facility
- Age on supply with birth date
- If immature animals, whether or not supplied with dam or foster dam and date of weaning
- Details of animal acclimatization procedure
- Number of animals per cage
- Detail and method of individual animal and group identification

Assay Conditions:

- Details of randomization process (i.e., method used)
- Rationale for dose selection
- Details of test substance formulation, its achieved concentrations, stability and homogeneity
- Details of test substance administration and rationale for the choice of exposure route
- Diet (name, type, supplier, content, and, if known, phytoestrogen levels)
- Water source (e.g., tap water or filtered water) and supply (by tubing from a large container, in bottles, etc.)
- Bedding (name, type, supplier, content)
- Record of caging conditions, lighting interval, room temperature and humidity, room cleaning
- Detailed description of necropsy and uterine weighing procedures
- Description of statistical procedures

Results**For individual animals:**

- All daily individual body weights (from allocation into groups through necropsy) (to the nearest 0.1 g)
- Age of each animal (in days counting day of birth as day 0) when administration of test compound begins
- Date and time of each dose administration
- Calculated volume and dosage administered and observations of any dosage losses during or after administration
- Daily record of status of animal, including relevant symptoms and observations
- Suspected cause of death (if found during study in moribund state or dead)
- Date and time of humane killing with time interval to last dosing
- Wet uterine weight (to the nearest 0.1 mg) and any observations of luminal fluid losses during dissection and preparation for weighing
- Blotted uterine weight (to the nearest 0.1 mg)

For each group of animals:

- Mean daily body weights (to the nearest 0.1 g) and standard deviations (from allocation into groups through necropsy)
- Mean wet uterine weights and mean blotted uterine weights (to the nearest 0.1 mg) and standard deviations
- If measured, daily food consumption (calculated as grams of food consumed per animal)
- The results of statistical analyses comparing both the wet and blotted uterine weights of treated groups relative to the same measures in the vehicle control groups.
- The results of statistical analysis comparing the total body weight and the body weight gain of treated groups relative to the same measures in the vehicle control groups.

53. Summary of the important guidance facts of the Test Guideline

	Rat	Mice
Animals		
Strain	Commonly used laboratory rodent strain	
Number of animals	A minimum of 6 animals per dose group	
Number of groups	A minimum of 2 test groups (see paragraph 33 for guidance) and a negative control group For guidance on positive control groups see paragraphs 26 and 27	
Housing and feeding conditions		
T° in animal room	22°C ± 3°C	
Relative humidity	50-60% and not below 30% or above 70%	
Daily lighting sequence	12 hours light, 12 hours dark	
Diet and drinking water	Ad libitum	
Housing	Individually or in groups of up to three animals (social group housing is recommended for immature animals)	
Diet and bedding	Low level of phytoestrogens recommended in diet and bedding	
Protocol		
Method	Immature non-ovariectomised method (the preferred one). Ovariectomised adult female method	Ovariectomised adult female method
Age of dosing for immature animals	PND 18 at the earliest. Dosing should be completed prior to PND 25	Not relevant under the scope of the current TG.
Age of ovariectomy	Between 6 and 8 weeks of age.	
Age of dosing for ovariectomised animals	A minimum of 14 days should elapse between ovariectomy and the 1 st day of administration.	A minimum of 7 days should elapse between ovariectomy and the 1 st day of administration.
Body weight	Body weight variation should be minimal and not exceed ± 20% of the mean weight.	
Dosing		
Route of administration	Oral gavage or subcutaneous injection	
Frequency of administration	Single daily dose	
Volume amount for gavage and injection	≤ 5ml/kg body weight (or up to 10 ml/kg body weight in case of aqueous solutions) (in 2 injection sites for subcutaneous route)	
Duration of administration	3 consecutive days for immature model Minimum of 3 consecutive days for the OVX model	7 consecutive days for the OVX model
Time of necropsy	Approximately 24 hours after the last dose	
Results		
Positive response	Statistically significant increase of the mean uterus weight (wet and/or blotted)	
Reference oestrogen	17 α -ethinyl estradiol	

GUIDANCE FOR THE INTERPRETATION AND ACCEPTANCE OF THE RESULTS

54. In general, a test for oestrogenicity should be considered positive if there is a statistically significant increase in uterine weight ($p < 0.05$) at least at the high dose level as compared to the solvent control group. A positive result is further supported by the demonstration of a biologically plausible relationship between the dose and the magnitude of the response, bearing in mind that overlapping oestrogenic and antioestrogenic activities of the test chemical may affect the shape of the dose-response curve.

55. Care must be taken in order not to exceed the maximum tolerated dose to allow a meaningful interpretation of the data. Reduction of body weight, clinical signs, and other findings should be thoroughly assessed in this respect.

56. An important consideration for the acceptance of the data from the Uterotrophic Bioassay is the uterine weights of the vehicle control group. High control values may compromise the responsiveness of the bioassay and the ability to detect very weak oestrogen agonists. Literature reviews and the data generated during the validation of the Uterotrophic Bioassay suggest that instances of high control means do occur spontaneously, particularly in immature animals (2)(3)(6)(9). As the uterine weight of immature rats depends on many variables like strain or body weight, no definitive upper limit for the uterine weight can be given. As a guide, if blotted uterine weights in immature control rats are comprised between 40 and 45 mg, results should be considered as suspicious and uterine weights above 45 mg may lead to rerun the test. However, this needs to be considered on a case by case basis (3)(6)(8). When testing in adult rats incomplete ovariectomy will leave ovarian tissue that can produce endogenous oestrogen and retard the regression of the uterine weight.

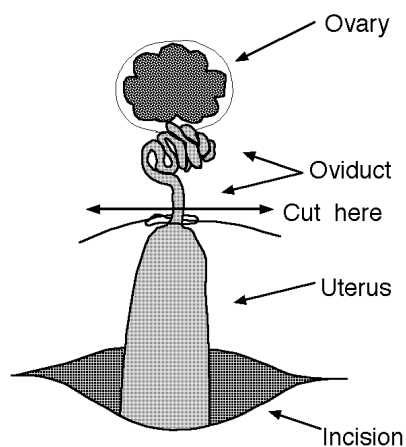
57. Blotted vehicle control uterine weights less than 0.09% of body weight for immature female rats and less than 0.04% for ovariectomised young adult females appear to yield acceptable results [see Table 31 (2)]. If the control uterine weights are greater than these numbers, various factors should be scrutinized including the age of the animals, proper ovariectomy, dietary phytoestrogens, and so on, and a negative assay result (no indication for oestrogenic activity) should be used with caution.

58. Historical data for vehicle control groups should be maintained in the laboratory. Historical data for responses to positive reference oestrogens, such as 17 α -ethinyl estradiol, should also be maintained in the laboratory. Laboratories may also test the response to known weak oestrogen agonists. All these data can be compared to available data (2)(3)(4)(5)(6)(7)(8) to ensure that the laboratory's methods yield sufficient sensitivity.

59. The blotted uterine weights showed less variability in the course of the OECD validation study than the wet uterine weights (6)(7). However, a significant response in either measure would indicate that the test substance is positive for estrogenic activity.

60. The uterotrophic response is not entirely of oestrogenic origin, however, a positive result of the Uterotrophic Bioassay should generally be interpreted as evidence for oestrogenic potential in vivo, and should normally initiate actions for further clarification (see paragraph 9 and the "OECD Conceptual Framework for the Testing and Assessment of Endocrine Disrupting Chemicals", Annex 2).

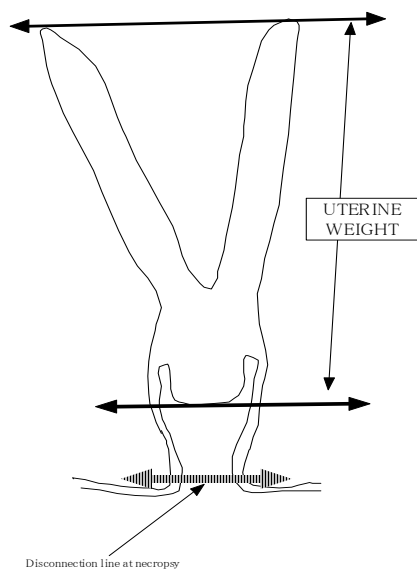
Figure 1: Schematic diagram showing the surgical removal of the ovaries



Mesometrium, vasculature and fat pad not shown

The procedure begins by opening dorso-lateral abdominal wall at the mid point between the costal inferior border and the iliac crest, and a few millimetres lateral to the lateral margin of the lumbar muscle. Within the abdominal cavity, the ovaries should be located. On an aseptic field, the ovaries are then physically removed from the abdominal cavity, a ligature placed between the ovary and uterus to control bleeding, and the ovary detached by incision above the ligature at the junction of the oviduct and each uterine horn. After confirming that no significant bleeding persists, the abdominal wall should be closed by suture, and the skin closed, e.g., by autoclips or suture. The animals should be allowed to recover and the uterus weight to regress for a minimum of 14 days before use.

Figure 2: The removal and preparation of the uterine tissues for weight measurement.



The procedure begins by opening the abdominal wall at the pubic symphysis. Then, each ovary, if present and uterine horn is detached from the dorsal abdominal wall. Urinary bladder and ureters are removed from the ventral and lateral side of uterus and vagina. Fibrous adhesion between the rectum and the vagina are detached until the junction of vaginal orifice and perineal skin can be identified. The uterus and vagina are detached from the body by incising the vaginal wall just above the junction between perineal skin as shown in the figure. The uterus should be detached from the body wall by gently cutting the uterine mesentery at the point of its attachment along the full length of the dorsolateral aspect of each uterine horn. After removal from the body, the excess fat and connective tissue is trimmed away. If ovaries are present, the ovaries are removed at the oviduct avoiding loss of luminal fluid from the uterine horn. If the animal has been ovariectomised, the stubs should be examined for the presence of any ovarian tissue. The vagina is removed from the uterus just below the cervix so that the cervix remains with the uterine body as shown in the figure. The uterus can then be weighed.

ANNEX 1

DEFINITIONS

Antioestrogenicity is the capability of a chemical to suppress the action of estradiol 17 β in a mammalian organism.

Date of birth is postnatal day 0.

Dosage is a general term comprising of dose, its frequency and the duration of dosing.

Dose is the amount of test substance administered. For the Uterotrophic Bioassay, the dose is expressed as weight of test substance per unit body weight of test animal per day (e.g. mg/kg body weight/day).

Maximum Tolerable Dose (MTD) is the highest amount of a substance that, when introduced into the body does not kill test animals (denoted by DL₀) (IUPAC, 1993)

Oestrogenicity is the capability of a chemical to act like estradiol 17 β in a mammalian organism.

Postnatal day X is the Xth day of life after the day of birth.

Sensitivity is the proportion of all positive/active substances that are correctly classified by the test. It is a measure of accuracy for a test method that produces categorical results, and is an important consideration in assessing the relevance of a test method.

Specificity is the proportion of all negative/inactive substances that are correctly classified by the test. It is a measure of accuracy for a test method that produces categorical results and is an important consideration in assessing the relevance of a test method.

Uterotrophic is a term used to describe a positive influence on the growth of uterine tissues.

Validation is a scientific process designed to characterize the operational requirements and limitations of a test method and to demonstrate its reliability and relevance for a particular purpose.

ANNEX 2

Note: Document prepared by the Secretariat of the Test Guidelines Programme based on the agreement reached at the 6th Meeting of the EDTA Task Force

OECD Conceptual Framework for the Testing and Assessment of Endocrine Disrupting Chemicals

<p>Level 1 Sorting & prioritization based upon existing information</p>	<ul style="list-style-type: none"> - physical & chemical properties, e.g., MW, reactivity, volatility, biodegradability, - human & environmental exposure, e.g., production volume, release, use patterns - hazard, e.g., available toxicological data 	
<p>Level 2 <i>In vitro</i> assays providing mechanistic data</p>	<ul style="list-style-type: none"> - ER, AR, TR receptor binding affinity - Transcriptional activation - Aromatase and steroidogenesis <i>in vitro</i> - Aryl hydrocarbon receptor recognition/binding - QSARs 	<ul style="list-style-type: none"> - High Through Put Prescreens - Thyroid function - Fish hepatocyte VTG assay - Others (as appropriate)
<p>Level 3 <i>In vivo</i> assays providing data about single endocrine Mechanisms and effects</p>	<ul style="list-style-type: none"> - Uterotrophic assay (estrogenic related) - Hershberger assay (androgenic related) - Non-receptor mediated hormone function - Others (e.g. thyroid) 	<ul style="list-style-type: none"> - Fish VTG (vitellogenin) assay (estrogenic related)
<p>Level 4 <i>In vivo</i> assays providing data about multiple endocrine Mechanisms and effects</p>	<ul style="list-style-type: none"> - enhanced OECD 407 (endpoints based on endocrine mechanisms) - male and female pubertal assays - adult intact male assay 	<ul style="list-style-type: none"> - Fish gonadal histopathology assay - Frog metamorphosis assay
<p>Level 5 <i>In vivo</i> assays providing data on effects from endocrine & other mechanisms</p>	<ul style="list-style-type: none"> - 1-generation assay (TG415 enhanced)¹ - 2-generation assay (TG416 enhanced)¹ - reproductive screening test (TG421 enhanced)¹ - combined 28 day/reproduction screening test (TG 422 enhanced)¹ <p>¹ Potential enhancements will be considered by VMG mamm</p>	<ul style="list-style-type: none"> - Partial and full life cycle assays in fish, birds, amphibians & invertebrates (developmental and reproduction)

VMG mamm: Validation Management Group on Mammalian Testing and Assessment

Notes to the Framework

Note 1: Entering at all levels and exiting at all levels is possible and depends upon the nature of existing information needs for hazard and risk assessment purposes

Note 2: In level 5, ecotoxicology should include endpoints that indicate mechanisms of adverse effects, and potential population damage

Note 3: When a multimodal model covers several of the single endpoint assays, that model would replace the use of those single endpoint assays

Note 4: The assessment of each chemical should be based on a case by case basis, taking into account all available information, bearing in mind the function of the framework levels.

Note 5: The framework should not be considered as all inclusive at the present time. At levels 3,4 and 5 it includes assays that are either available or for which validation is under way. With respect to the latter, these are provisionally included. Once developed and validated, they will be formally added to the framework.

Note 6: Level 5 should not be considered as including definitive tests only. Tests included at that level are considered to contribute to general hazard and risk assessment.

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