Principles of scientific research and writing

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CANADA
LOW HILLS MOUNTAINS
400 mi
400 km
©GraphicMaps
Arctic Ocean
Axel Heiberg Island
Ellesmere Island
Quttinirpaaq Nat. Park
Alert
Nares Strait
Greenland Sea
Queen Elizabeth Islands
McClure Strait
Aulavik Nat. Park
Banks Island
Melville Sound
Resolute
Devon I.
Sirmilik Nat. Park
Pond Inlet
Baffin Bay
Greenland
Beaufort Sea
Victoria Island
Amundsen Gulf
Queen Maud Gulf
Gulf of Boothia
Igloolik
Clyde River
Baffin Island
Auyuittug Nat. Park
Ivvavik Nat. Park
Alaska
Inuvik
Tuktut Nogait Nat. Park
MacKenzie River
Coppermine
Cambridge Bay
Taloyoak
Pelly Bay
Foxe Basin
Davis Strait
ARCTIC CIRCLE
Yukon River
Dawson
Great Bear Lake
Nunavut
Wager Bay
Coral Harbor
Iqaluit
Nuuk
Kluane Nat. Park
Yukon
Mackenzie Mtns.
Deline
Baker Lake
Rankin Inlet
Southampton Island
Great Slave Lake
Nahanni Nat. Park
Yellowknife
Whitehorse
Northwest Territories
Liard River
Hay River
Ennadai
Arviat
Salluit
Hudson Strait
Torngat Mountains Nat. Park
Wapusk Nat. Park
Hudson Bay
Peace River
Wood Buffalo Nat. Park
Lake Athabasca
Fort Nelson
Churchill
Port Nelson
Inukjuak
Kuujjuaq
Torngat Mtns.
Labrador Sea
Mt. Logan
Coast Mountains
Rocky Mts.
Grand Prairie
Athabasca River
Reindeer Lake
Manitoba
Belcher Islands
Nain
Queen Charlotte Islands
British Columbia
Saskatchewan
Thompson
Nelson River
Winisk
Prince George
Alberta
Edmonton
Jasper Nat. Park
Prince Albert
Saskatchewan River
Shield
James Bay
Akimiski Island
Happy Valley
Goose Bay
Newfoundland & Labrador
Fraser River
Saskatoon
Lake Winnipeg
Albany River
Labrador City
Prince Rupert
Kamloops
Red Deer
Regina
Canada
Eastmain
Gross Morne Nat. Park
Kelowna
Calgary
Medicine Hat
Moose Jaw
Lake of the Woods
Ontario
Quebec
St. Lawrence River
Gulf of St. Lawrence
Nanaimo
Vancouver
Lethbridge
Winnipeg
Brandon
Lake Nipigon
Canadian Shield
Ottawa River
Saquenay
Laurentian Mtns.
Anticosti Island
Vancouver Island
Victoria
Abbotsford
Banff Nat. Park
Water Lakes Nat. Park
Steinbach
Thunder Bay
Pukaskwa Nat. Park
Rimouski
Trois-Rivieres
Quebec City
P.E.I.
Charlottetown
Columbia River
Sudbury
Sault Ste. Marie
Ottawa
Cabot Strait
Pacific Ocean
Great Lakes
Fredericton
Cape Breton Island
Mississauga
Toronto
Sherbrooke
Halifax
Kitchener
Montreal
New Brunswick
Nova Scotia
Windsor
Niagara Falls
London
USA
Atlantic Ocean
WorldAtlas.Com

Importance of Science & Scientific Writing

- Good science and scientific writing is not a matter of life and death……
- It is much more important than that!

Communication in Science
Why write?

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- **Official answer:** work not published = work not done
- **Science is global …**
- Others interested, from all corners of the world
- Not written = not recorded and not available

- **If nobody knows what you have done and found …**
  You have wasted your energy and time
  You have wasted resources … money!!
- Without publication, science is dead Gerard Piel

- So, you must write, and you must write well
- Unfortunately, you must write in **English**

Writing in English

- English is the primary language of science
- 90% of papers in Index Medicus in 1999 were written in English
- English is not the first language of many in the scientific world
- Many persons for whom English is a first language are not good writers
- The best English is that which gives the sense in the fewest short words

Journal Selection

- Numerous options!
- Identify target audience and journals they read
- Look at recent issues
- Check Instructions to Authors/Guide to Authors

Assessing a Journal's Quality

- Huge variation!
- Impact factors, citation index, origin, circulation
- Look at recent issues
- Do a literature search to identify where the best articles are being published
- Seek advice (from experienced authors)

Journal Format and Service

- Consistent with your paper (full paper versus short/brief communication)
- Quality of published images
- Layout, appendices
- Interval from submission to publication

Cost of Publication

- Page charges
- Color images
- Reduced fees for membership
- Potential sources of support

Final Choice

- Among the journals that are suited for publication of your paper, choose the most prestigious one that you think is LIKELY to accept your paper
- Be realistic!
- Don't be a 1-journal author

Marketing Your Work

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- Strive to have your papers read and cited
- Readers are busy and have many options
- Clear objective, summary of major finding(s)
- Several key locations: title, start and end of abstract, end of introduction, last paragraph of discussion

Author's Responsibilities

- Primary responsibility is to submit a well-written paper, prepared in journal format
- Respect the editor and reviewers
- Failure to respect the editor and reviewers often has serious consequences!

Guide/Instructions to Authors

- Read carefully and ensure you follow it!
- Often on-line (check website)
- Usually in first or last issue of volume/year
- Use recent issues as an example

Scientific Paper

- Primary way of communicating research results (not ‘real’ science until published and understood)
- Demonstrates productivity
- Maintains accountability
- First publication of original results
- Sufficient detail to repeat study
- Published in journal or other source

‘Anatomy’ of a Scientific Paper

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- IMRAD format
- Introduction: What question/problem was studied?
- M & M: How was the problem studied?
- Results: What were the findings?
- Discussion: What do the findings mean?
- Keep everything where it belongs!

Title

- Attract attention to your paper (many read the title, but only a few read the paper)
- Short and easy to read (+/- a sentence)
- Quite specific (include critical words that will be found in searches)
- Fewest possible words that adequately describe the contents of the paper
- Minimize abbreviations, acronyms, slang
- May need to provide ‘running title’
- Check format regarding capitalization

Title: Common Errors

- Most common error is poor syntax (word order)
- Titles are often too long, too general, or simply boring
- Most titles that are too short include general rather than specific terms

Examples of Titles

- Estrus, ovulation and pregnancy rates in beef cows and heifers given a CIDR, with estradiol or GnRH to synchronize wave emergence, PGF at CIDR removal, and estradiol or GnRH to synchronize ovulation
- Reproductive performance in progesterone-treated beef cattle given estradiol and gonadotropin releasing hormone

Authorship

- Assessing productivity (recognition, promotions)
- Substantial/critical input
- Familiar with content, able to defend (can be difficult in a multidisciplinary study)
- May need to formally list involvement
- List conflicts of interest
- Pressures and expectations

Order of Authors

- First author has primary responsibility
- Second author generally also important
- May have statement that first two authors contributed equally (only one can be ‘first’)
- Last author is often senior scientist
- No formal policy; perhaps in order of importance to the work?

Title Page

- According to Instructions/Guide to Authors
- Complete affiliations and addresses
- Degrees and qualifications?
- Phone, fax and e-mail
- Present address (if have moved)
- Clearly indicate corresponding author

Abstract

- First (perhaps only) access to paper
- Should contain all elements of a paper
- Background information (0-2 sentences)
- Clear statement of objectives/hypotheses
- Combine Mat. & and Methods and Results?
- Means, SD or SEM (define), and P-values (no statistical methods)

Abstract (continued)

- Brief discussion, primary conclusion(s) and strong final sentence
- Generally a single paragraph
- ‘Stand alone’ from remainder of paper
- ‘Rich’and descriptive (high-impact words)
- Respect word limits (250 words, may be truncated)
- Exclude information/conclusions not in paper

Abstract: Common Errors

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- Does not ‘stand alone’
- Missing or inadequate means and P values
- Too general, too long
- Excessive background and/or materials and methods
- Weak conclusion (e.g. more work needed)

Key Words

- Frequently required
- Respect maximum number words/characters
- Can be same as in title, but ideally should be complementary (e.g. cow versus cattle)
- Decreasing order of importance
- Choose terms carefully; consult reference lists (e.g. MESH) or other papers

Introduction

- Describe problem, include nature and scope
- Brief review of knowledge
- Explain how your study will challenge, expand or improve existing knowledge
- Objectives/hypotheses at the end
- Be as specific as possible
- ‘Functional,’ testable hypotheses
- Summary (ONLY if journal demands it)

Hypotheses

- Estradiol affects ovarian follicular development.
- In a heifer with elevated plasma progesterone concentrations, estradiol suppresses plasma FSH concentrations, followed by an FSH surge and emergence of a new follicular wave.
- Can have a null hypothesis
- Hypothesis is usually in present tense

Introduction: Common Errors

- Excessive detail/length (like a thesis); suggest 2 page limit (double spaced)
- Lacks focus
- Too many citations (suggest $\leq$ 20)
- Objectives absent, inappropriate, or inconsistent (with other sections of paper)
- Including a brief summary of results (at the end of the introduction)

Materials and Methods

- Allow replication by competent investigator
- Describe all equipment, materials, software, etc., and source (city, state, country)
- Reference common procedures (explain modifications)
- Avoid ‘classic’, inappropriate references
- Chronological and easy to follow

Experimental Animals, Plants and Microorganisms

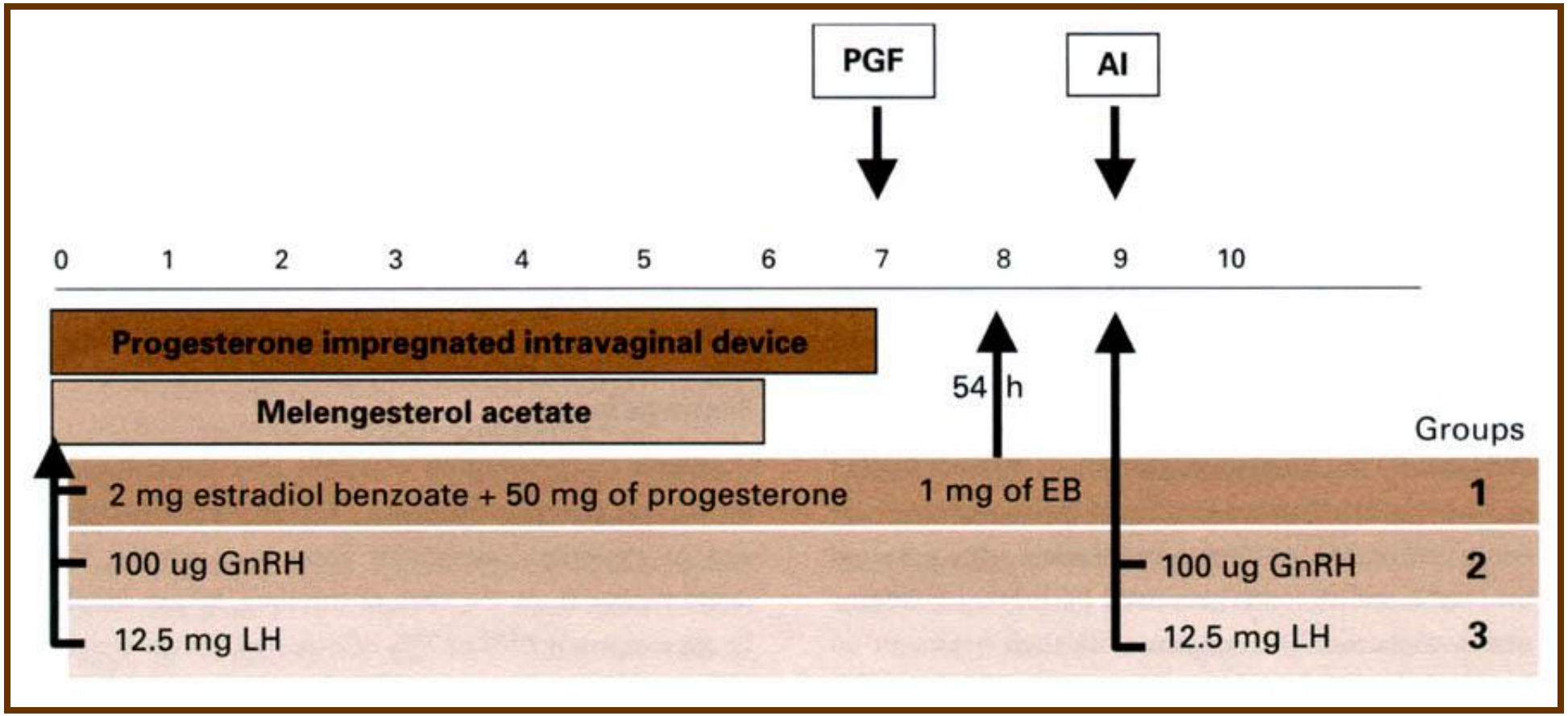
- List genus, species, strain/breed (do not need genus or species for domestic livestock)
- Journal may require statement regarding animal care, reference to animal care guide, or indication that the study was approved by Institutional Animal Care Committee
- Increasing standards for animal care

Definitions

- Frame of reference (define start of treatment or day of ovulation as Day 0)
- Define terms used
- Give considerable thought (conventional is easiest)
- Minimize exceptions

Figures, Flow Charts and Tables

- Effectively illustrate treatments or groups
- One picture = 1000 words
- Simple and easy to interpret
- Text only highlights displayed information
- Avoid excessive detail and duplication


PGF
AI
0
1
2
3
4
5
6
7
8
9
10
Progesterone impregnated intravaginal device
Melengesterol acetate
54 h
Groups
2 mg estradiol benzoate + 50 mg of progesterone
1 mg of EB
1
100 ug GnRH
100 ug GnRH
2
12.5 mg LH
12.5 mg LH
3

Statistical Analyses

- Appropriate
- Describe in sufficient detail to enable replication
- Comprehensive

Results

- Provide a description of what you did, without repeating details already in the Materials and methods
- Present the data

Text of Results

- Refer to tables and figures
- Highlight (NOT repeat)
- Use text if there are only a few numbers or a lack of significant differences
- State whether variation is SD or SEM (or do that in M&M)
- More detail if only presentation of data
- Present (NOT discuss)

Reporting Data

- Use appropriate units (minimize zeros); use scientific notation (3.5×10^6)
- Generally report to 1 decimal place
- Use ‘0’ before decimal (e.g. 0.5)
- Remember to use a period and not a comma (1.5 vs 1,5)

Numbers

- Follow instructions regarding numbers < 10
- Never start a sentence with an Arabic number
- Avoid consecutive numbers (10 3 cm lids; use: 10 lids (3 cm)
- Avoid use of term ‘billion’
- Give original number first, e.g. 209 (7.2%) of the 2901 oocytes reached the blastocyst stage

‘Rounding’ Data

- If the last number is 5, round data to nearest ‘even’ number (2.55 and 2.65=2.6)
- Column of percentages does not have to sum to 100% (if 100.1, make a note regarding rounding error)

Photos

- Representative (NOT ‘perfect’), high quality, cropped and described, with scale
- Avoid excessive ‘manipulation’ of image
- Digital (high-resolution and appropriate format)
- Conversion of color photos to half-tones (black and white)

Discussion

- Summarize major findings
- Discuss limitations and problems of current study
- Discuss scientific and clinical implications
- Suggest further work (NOT in last paragraph)
- Provide a clear conclusion

Discussion (continued)

- Explain relationships among observed facts; do NOT simply repeat results
- Consider similarities, differences, advantages, disadvantages, ± future studies
- Do not exceed 40% of paper (general rule)

Discussion (continued)

- Objectives consistent with work
- Conclusions supported by the data
- Arguments progress logically; each paragraph leading the reader step by step

Order of Presentation

- First paragraph: address major findings, objectives and hypotheses
- Second paragraph and thereafter: prioritize major points and present in decreasing order of importance
- Odd and unusual
- Strong concluding paragraph
- Discuss fully and then move on (may need 2+ paragraphs for one finding); avoid going forward, then going backward

Presenting & Discussing a Finding

- Refer to own data FIRST, then literature, then discuss and interpret your work in context of literature
- Brief reminder of your finding (+/- cite figure or table), varying degree of detail regarding literature
- Avoid ‘showed’ and ‘found’

Significance

- P < 0.05 (best to cite actual P value, especially in the Results)
- Cite P value OR say ‘significant’
- Include means or ‘direction’ of difference
- P > 0.05 but < 0.10 is a tendency (may be of biological relevance or inadequate power)
- Amann, R.P. Theriogenology 63:698-715, 2005

Significant, or Not?

- If something is significant, then say that it was different (otherwise it appears that you do not believe your own data)
- Do not ‘pretend’ something is significant when it is not significant
- Minimize statements regarding ‘numerical’ differences
- Suggest giving P values in abstract and results, ‘significant’ in discussion

Comparisons

- Direct (planned)
- Indirect (unplanned, combinations or non-contemporaneous); comparison by inference
- Seemed or appeared

Statistical Terms

- Significant, tendency, corrrelated
- Use ONLY in strict statistical sense

Unexpected and Unexplainable (Odd and Unusual)

- Speculate if possible, but be brief
- Some things are simply unexplainable

Tense

- Present study is described in past tense
- Well-accepted literature in present tense
- Recent literature (not well accepted) may be in past tense
- Hypothesis in present tense
- Conclusion in present tense? (may be a cultural difference)

Conclusion

- Final paragraph of discussion
- Summarize major findings (that are supported by the data)
- Avoid citing references and new speculation
- Strong concluding sentence; do not ‘waste’ this opportunity

Acknowledgements

- Short and focused (avoid ‘wish’)
- Institutional reference number (if applicable)
- Money, in-kind, people (with permission)
- Previous publication (abstract or proceedings, not peer-reviewed, limited data or limited distribution)

Citations and Bibliography

- In text, at logical location (not necessarily at end of sentence)
- Verify original source
- If not original, state ‘cited by’
- Bibliography should follow format and be checked for errors
- Errors are very common

Foreign Language Citations

- Cite original title
- [English translation in square brackets]
- Do not abbreviate foreign-language journal titles

Submitting Your Paper

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- Follow Instructions for Authors
- Ensure correct format (line and page numbers, line spacing, etc.)
- Easy to read font, 12 point
- Left justified versus fully justified?
- For on-line, follow instructions (special characters, verify receipt)

Cover Letter

Please find attached an original paper (cite title) for your consideration for publication in (cite journal). All co-authors are familiar with the contents of this paper and are in agreement that it be submitted. We look forward to your decision.

Confirmation of Receipt of Paper

- Usually immediate or within a day or so
- Polite inquiry if delayed

Reviews

- 4-8 wk after arrival (inquire after 6-8 wk)
- Several possible outcomes
- Accept with no revisions (rare)
- With minor revisions
- Revise and re-review
- Reject

Revisions

- Reply promptly (enforced time limit)
- If an improvement or equivocal, make the change
- Firm stand and rebuttal on points of strong disagreement or principle
- Indicate changes on point-by-point basis
- You have the right to withdraw the paper

Language revisions

- Enlist assistance of a colleague
- Commercial assistance available

Reject

- MAY be able to appeal to editor, especially if you feel that they have a fundamental misinterpretation of the paper
- Generally simply have to accept the decision
- Once the paper is formally rejected, you are free to submit it to another journal

Preparation for Writing

- Objectives and hypotheses
- Analyze data and summarize
- Prepare draft versions of figures and tables
- Literature search, summary of major points
- Prepare brief outline

Practical Steps for Writing

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- Write it down; …..and then write it up!
- Let ideas flow; do not be constrained
- Consult other papers for key sentences
- Materials & Methods/Results; mirror image
- Discussion (descending order)
- Abstract
- Bibliography (cross-reference and format)

Practical Considerations

- Small, descriptive words (eliminate extra words) and short sentences
- Be as specific as possible (heifer, cow, cattle, animals)
- Consistency in terminology and order
- Use abbreviations sparingly
- If you cannot force yourself to read it….

Final Thoughts

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- Imagination, effort and attention to detail
- Focus on science, not methodology
- Respect resources and other people
- Develop a network of contacts
- Read many papers and practice your writing
- Publish good papers (in quality journals) to bring honor and positive recognition

Contact Information

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