


SCIENCE

Scientific writing



Prof Peter O'Donoghue

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Normal scientific activities

doing


thinking

communicating

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SCIENCE WRITING

- bring together writer, topic, purpose, audience



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graph TD
    TOPIC[TOPIC]
    AUTHOR[AUTHOR]
    PURPOSE[PURPOSE]
    AUDIENCE[AUDIENCE]
    TOPIC --> AUTHOR
    AUTHOR --> TOPIC
    AUTHOR --> PURPOSE
    AUTHOR --> AUDIENCE
    PURPOSE <--> AUDIENCE
    
```

= "communications triangle"

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WRITER

Scientist (producer)

- researcher, research teams
- self-taught versus learnt skill

Journalist (reporter)

- science communication
- multi-media

Student (learner)

- part of educational process
- lab reports, lit reviews, summaries....

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TOPIC

Scientific disciplines (conventional/contemporary)
 Newly emergent fields (inter-disciplinary)

Specific content

- novel observations
- experimental results
- ideas, opinions
- technological advances

Pure versus applied science

- contextual relevance
- utility

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PURPOSE

- Information dissemination
- Claim ownership
- Education, engagement
- Promotion, solicitation
- Rationalization, justification
- Novelty (contribution to science)
- Reproducibility (= truth in science?)
- Subject to scrutiny
 - quality
 - impact

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AUDIENCE

Scientists write for other scientists

- using recognized journals
- conforming to prescribed formats
- dictated by publishers

Growing demand for:

- broader science communication to society
- less specialized/jargonized language

Spawned creation of:

- science writers (science journalists)
- knowledge brokers (intermediary, go-between)

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What do scientists write?

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Main types of documents

Scientists write:

- grant applications (seeking funds to do work)
- research papers (reporting results)
- reviews (summarizing progress)

All subject to peer review (referee process)

Instructions given to authors by:

- granting agencies (templates)
- publishing houses (format)
- editors (themes)

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Grant applications

- funding agencies (government, industry)
- project, program, institutional grants (1-7 yr)
- application process (must ask)
- eligibility (specific criteria)
- priority areas (contemporary foci)
- competitive review (panels, independents)
- expedient allocations (until source is dry)
- low success rate (~20%)
- high engagement (only game in town)
- track record (career = \$-in + papers-out)

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Grant format

Usually prescribed template

- catchy title (strong focus, do-able)
- succinct summary (intelligible to laypersons)
- specific objectives (logical, contextual)
- expected outcomes (relevance, impact)
- itemized budget (justifications for expenditure)
- actual project proposal
 - background
 - methodology
 - timetable

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Research papers

- Thematic journals (indicated by title)
- Variable distribution (international, regional)
- Variable availability (hard-copy → e-copy)
- Impact factor (uptake)
- Manuscripts (submitted, solicited)
- Peer review (≥ 2 referees)
- Editorial decision (yes/no, revise)
- Full papers, short communications
- Cost (page charges, reviewer fees, colour)

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Research paper format

Almost universal format (IMRAD)

- Introduction (background and objectives)
- Materials and Methods (resources, techniques)
- Results (O and E findings)
- Discussion (critical interpretation)

Plus:

- Title (descriptive, declarative)
- Acknowledgements (support)
- References (citations)
- ABSTRACT (summary of whole paper)

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Reviews

- Feature/lead articles
- Editorials/papers/chapters
- Commissioned works (citation indices)
- Integral to research (cf. review in every thesis)
- Variable styles
 - critical analyses/extrapolations
 - chronological summaries
 - opinion/interpretive pieces
 - compilations (databases, bibliographies...)

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Review format

- Usually 'hierarchy of headings' (ToC)
- but essentially rationalize own existence
 - justify objectives (problem, background)
 - summarize progress (compare/contrast)
 - make suggestions (direction, technologies...)
- Need to tell/sell a story
 - beginning
 - middle
 - end

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Data gathering

Need to read articles (and make notes)

Literature accessed as:

- Hard copy
 - periodicals in libraries
 - personal/institutional subscriptions
 - photocopies (document delivery)
- E-copies (IT revolution)
 - data-bases (abstracts, previews)
 - on-line journals (EndNote)



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Database Titles w - wzz - Microsoft Internet Explorer

Web of Science (from 1970) - Web of Science is a platform for searching individual ISI products or multiple products simultaneously. Access is to Web of Science, Current Contents Connect and ISI Journal Citation Reports...

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ISI Web of Knowledge v2.0 - Microsoft Internet Explorer

General Search

Enter terms or phrases separated by the operators AND, OR, NOT, or SAME. Then press SEARCH. The search is added to the Search History

Search using terms and limits entered below:

Enter terms to be searched in the article title, keywords, or abstract. Examples: development ecology

ENTER: Enter one or more author names as O'BRIAN C* OR O'BRIAN C*

SOURCE: Enter the source title or copy and paste from the source list

ADDRESS: Enter abbreviations from an author's affiliation as YALE UNIV SAME HOSP (see abbreviations list)

SET SEARCH LIMITS

Search using terms and limits entered above.

Clear all search terms entered above.

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Search terms

Smart search engines

- Enter whole phrases (without quote marks)
- Not case dependent (upper, lower, mixed)

Boolean operators

- x **AND** y (finds both x and y)
- x **OR** y (finds either x or y)
- x **SAME** y (includes all combinations/synonyms)
- x **NOT** y (excludes y)

Wildcards

- enzym* finds enzyme, enzymes, enzymology...
- wom?n finds woman, women
- vapo\$r finds vapor, vapour

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Search smart

TOPIC and REVIEW

Someone is bound to have reviewed the field
limit search to last 5 or 10 years

CAUTION:

Do not excessively depend on, or cite, reviews
You need to conduct your own review by
accessing the 'primary' literature

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What approach to use?

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Approach to writing

- Thought to be highly idiosyncratic, yet is often highly systematic
- Involves many cognitive skills
 - creativity, reasoning, reflection, expression...
- Involves effort
 - 10% inspiration, 90% perspiration
- Requires mental discipline to make:
 - progress, product
- Practice (gets better with repetition)

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Obstacles


Major common obstacles

- beginner's block (where to start?)
- care-free syndrome (not being motivated to write)
- care-less syndrome (not following a plan)
- panic syndrome (stressed over looming deadline...)
- forest-from-trees syndrome (fail to id scope/content...)
- generalization syndrome (motherhood statements)
- exception syndrome (bogged down with exceptions)
- over-justification syndrome (trying to qualify everything)
- perfection syndrome (trying to write the perfect draft)
- writer's block (part of rumination process)

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Helpful strategies

Doodling (planning)

- create your own flowchart, concept map 
- pen-n-paper (creative) v. keyboard (presentation)
- deconstructive approach (headings = logic train)
- keywords → phrases → sentences → paragraphs

Talking (reviewing)

- read drafts out loud (spoken v. written word)
- checks content continuity, connections...
- helps moderate language and grammar
- use an audience (for feedback, criticism)

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Scientific Method

- **Introduction**
 - provide background, state objectives/hypotheses
- **Materials and Methods**
 - detailed description to facilitate reproducibility
- **Results**
 - narrative of findings (accompanied by graphics)
- **Discussion**
 - interpretation, comparative discussion, conclusions

- **Abstract (**of paramount importance**)**
 - summary of paper (intent, findings, conclusions)
 - distributed widely in data-bases (CD-ROM, WWW)

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Writing guide

Be systematic (IMRAD)

Sequence of research	Format and Content	Elements of critical argument
the question to be answered	INTRODUCTION	the problem (question)
how the answer was sought	MATERIALS & METHODS	credibility of evidence
findings of study	RESULTS	evidence (data), initial answer
findings considered in light of other work; answer	DISCUSSION	supporting/contradictory evidence; assessment; answer

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Frankenstein's Guide to Scientific Writing

gather bones	assemble skeleton	flesh it out	dress the body
<ul style="list-style-type: none"> - identify key components - back-engineer title 	<ul style="list-style-type: none"> - provide logical structure - table of contents - paragraph headings 	<ul style="list-style-type: none"> - identify specific content - subheadings - keywords 	<ul style="list-style-type: none"> - write connecting text - grammar - punctuation
Planning phase	Construction phase		Writing phase
[4P's = Plan, Prepare, Practice, Proof]			

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Tips for first draft

- choose best time to write (alertness)
- choose suitable place (comfort, quiet)
- tackle easy sections first (most factual)
- visualize key results (tables, diagrams)
- convert to text (draft results)
- write quickly (keep ideas flowing)
- ignore grammar/expression (edit later)
- move on (when stuck, tackle another part)
- leave space (for notes, additions, corrections)
- take a break after 30-60 minutes

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IMRAD deconstructed

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Title

What is the paper about?

- describe subject (concise, accurate, informative)
- also indicate thrust, direction, essence of research
- carefully select keywords (searchable databases)
- avoid abbreviations and acronyms
- cut out waste words, punctuation where possible

Three patterns

1. summary of topic
[Comparison of parasitic infections of sheep and goats in Wales]
2. summary of findings
[Goats have fewer parasites than sheep in Wales]
3. topic: aspect
[Parasites of sheep and goats: prevalence in Wales]

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Author(s)

Ensure you conform to legal requirements re:

- Intellectual Property (ownership)
 - often vested in organization (check job description)
- Sole authorship
 - you can prove you did everything (lab records)
- Co-authorship (agreed number and sequence)
- Corporate releases (institutional review)
- Journal requirements (co-signatories)
- Patents (conditions and dates)
- Confidentiality agreements (dates)

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Address

Professional place of work (single/multiple)
More than postal address

Recognition of corporate support

- Physical/technical infrastructure
 - (labs, equipment, consumables, vehicles, etc.)
- Financial (costs, salaries, lighting, petrol, etc.)
- Personnel (admin, clerks, cleaners, etc.)
- Intellectual (cf. co-authors, acknowledgements)

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Abstract

- Stand-alone summary of whole paper
- Paramount importance (abstracted, most read)
- write the abstract last (draft several times)
- use novel sentences (not just cut-n-paste)
- keep text simple (one topic per sentence)
- be informative rather than descriptive
- comply with word limits
- get the right balance of IMRAD
 - some journals have introduced headings

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Einstein's Guide to Scientific Abstraction

Be methodical/systematic/scientific!

$$E = \cancel{m}a^2 \quad E = \cancel{m}b^2 \quad E = mc^2 \quad E = \cancel{m}d^2$$

Four categories of Scientific Method (hypothetico-deductive logic)

Introduction	Materials/methods	Results	Discussion
- identify topic	- sample strategy	- describe findings	- answer hypothesis
- specify problem	- main techniques	- enumerate data	- state significance
- state aims	- how analysed	- show links	- assess implications

read paper with pencil in hand and make notes of main points
write one sentence for each dot-point = 12 sentences = complete abstract

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Introduction

Background and objectives

- establish problem under investigation
- be careful with word 'hypothesis'
- provide context (field of study, previous work)
- define scientific/technical terminology
- be informative (not encyclopaedic)
- clearly state aims (+ approach, + main finding?)

Three main parts

1. general field of interest
2. findings of others that will be challenged/developed
3. specifies question to be addressed

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Materials and Methods

How was data gathered?

- describe experimental design/approach
 - state any assumptions/simplifications
- describe Materials
 - sources of samples, temporal/spatial variants, identifiers, demography, taxonomy, etc.
- describe Methods
 - test procedures, replicates/controls/standards, experimental conditions, analytical techniques, statistical tests, etc.
- include enough detail to facilitate reproduction
 - cite published methods, but describe variations

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Results

What were your findings?

- Narrative reporting of facts
 - do not validate, interpret or discuss findings
 - only use Tables/Figures to illustrate findings
- use pyramidal approach (demonstrate logic)
 - begin with main findings, scale down to subordinate findings
- be quantitative, and comparative
 - [infections were more prevalent in winter]
 - [infections were more prevalent in winter (75%) than summer (50%)]
 - include statistics [$F = 2.34$, $p = 0.04$, $n = 120$]
 - use SD to show variability, SE to show precision

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Tables

Matrix

[rows x columns] what size?

- complement, not supplant, text
- do not present raw or complex data sets
- summarize data, provide means, show trends
- ideal for comparative purposes (side-by-side)
- provide a clear concise legend

Tips

- follow style recommended by journal
- avoid clutter (grids, borders, shading)
- check values (significant figures, units)
- aim for clarity (does it highlight your main point?)

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Figures

Visual aids

[graphs, charts, maps, drawings, diagrams, photographs]

- complement, not supplant, text
- help understanding of complex data-sets
- representative illustrations, proof of existence
- summaries of analyses, establish trends/proportions
- stylistic renditions of complex/cryptic entities

Tips

- keep things simple (avoid >4 elements)
- annotate (label elements)
- have stand-alone legends (different from text)
- aim for acuity (contrast, balance, colour?)

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Discussion

What does it mean?

- interpret results and show significance
 - do not simply repeat results (esp. verbatim)
- have you answered your question?
- distinguish between facts/speculation
- provide contextual relevance (specific/general)
- be comparative (support/refute other work)
- be critical (constructive v. destructive)
- discuss implications (practical/theoretical)
- state conclusions, indicate future directions

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Acknowledgements

Critically assess level of contribution to:

- Intellectual Property
- Provision of resources
- Conduct of research
- Analysis and interpretation of results
- Writing tasks

Generally recognize contributions of:

- People (helpers, not co-authors)
- Organizations (not identified as addressee)
- Funding agencies (project grant)

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References

Always acknowledge the work of others
(facts, ideas, publications, quotes, etc.)

- Use in-text citations
- Use reference lists (cf. bibliography)
- Use quotations (sparingly in science)
- Use footnotes (arts v. science)

Avoid plagiarism (literary theft)

Avoid cut-n-paste (esp. in modern IT world)

Be careful with para-phrasing

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In-text citations

Author(s) + Date given with information (follow journal guidelines)
 ... as shown by Brown (2010).
 ... as shown previously (Brown, 2010).
 ... Brown and White (2010) or (Brown & White, 2010)
 ... Brown, White & Green (2010) = Brown *et al.* (2010)
 Multiple references: chronological, then alphabetical
 ... (White, 1960; Brown, 1970, Green *et al.* 1985; 1986)
 Quotations (plus source)
 ... "Imagination is more important than knowledge" (Einstein, 1920)

Avoid confusion with taxonomic authorities
 ... *Giardia duodenalis* (Davaine, 1875) Filice, 1952
 Davaine named species in another genus
 Filice later placed species in this genus

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List of references

Follow journal guidelines (alphabetical or numeric)

Research paper
 Brown, A. 2010. The joy of maths. *J. Appl. Math.* 3:2-9.

Book chapter
 Brown, A. 2010. The joy of maths. In: Green A. (ed.) *Enabling Sciences*. Batten Press, pp. 23-29.

Book
 Green, A. (ed.) 2010. *Enabling Sciences*. Batten Press, 250pp.

Internet source
 Brown, A. 2010. A look at science, XXX Tertiary Services, accessed 30 Feb. 2010, <<http://www.xxx.edu.au/xxx.html>>.

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Editing

- Edit your own work before seeking feedback (do not establish reputation as bad writer)
 - Edit using 2-step process
1. **Structural editing** (step-back, broad view)
 - content, structure, argument, continuity...
 2. **Stylistic editing** (step-in, close view)
 - expression, spelling, grammar, punctuation ...
- Now seek feedback
 - Reiterative process (3-5 drafts)

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Tips for editing

- Put away first draft for several days (fresh eyes)
- Print double-spaced (edit paper copy)
- Read out loud (comprehension, continuity)
- Compare tables/figures (standardization)
- Structural editing (substance)
- Stylistic editing (presentation)
- Check tedious details (esp. references)
- Seek feedback (co-authors, supervisor, friends)
- Treat all criticism as CONSTRUCTIVE

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Scientific language

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Scientific language

Characterized by:

- Specific vocabulary and terminology
- Impersonal (objective) tone
- Passive verbs
- Past tense
- Conciseness

Active:

Madame Curie discovered a new element that has radioactive properties. She called the new element radium. It has the chemical symbol Ra. The element has a mass number of 226 and was first found in 1898. The new element emits radiation of three kinds (called alpha, beta and gamma radiation) and has an estimated half-life of 1,602 years.

Passive:

Radium (Ra-226), a radioactive element, was first isolated in 1898 by Madame Curie. Ra-226 emits alpha, beta and gamma radiation, and has a half-life of 1,602 years.

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Language

Difference between spoken and written word

Which have you practiced most?

- KISS principle (Keep It Simple Stupid)
- clarity, continuity (not convolution, confusion)

Word-smithing

- paragraphs
- sentences
- words
- punctuation

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Paragraphs

Units of thought (one idea – one paragraph)

- manageable segments of information
- visual clues to transition between thoughts
- provide pauses to absorb information

- First sentence = topic sentence
- Middle sentences = expanders
- Last sentence = round off or connector

Continuous flow (smooth progression)

Her condition is serious, but improving. She expects to leave hospital soon.

Discontinuous flow (jerky)

Her condition is serious, but improving. Returning to work is not yet likely.

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Sentences

Six basic patterns

1. **Simple** sentences (1 IC*, unqualified observation)
The door leads to the garden.
2. **Compound** sentences (2+ IC, with conjunction)
The door leads to the garden, but it is hard to open.
3. **Complex** sentences (1 IC & 1+ DC, act as qualifiers)
Although the door led to the garden, she could not open it.
4. **Compound-complex** sentences (2+ IC & DC)
She could not open the door, it was made of iron and had rusted.
5. **Exclamations** (imperatives, interjections...)
Shut the door!
6. **Questions** (actual/rhetorical request for answer)
Who said that?

*IC = independent clause which can stand alone as sentence
(with subject, verb, object/predicate adjective)

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Sentences

- Subject-verb-object rule (topic-verb-new info)
- Avoid upside-down and inside-out sentences
"Have the students make mobiles, and then hang them in the classroom."
"A section of wing fell off a 747 on a flight from Manila to San Francisco. It returned and landed safely in Manila."
- Passive rather than active voice
- Third-person rather than first-person
(gives air of objectivity, sounds authoritative)
(but can lead to dull prose, ambiguity, circumlocution..)
- Use parallel structures (no. in NZ = 100, no. in Oz = 120)
- If you establish a pattern, do not break it (A-B-C)
- Avoid transpositional instructions ('as stated earlier')

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Words

- Word choice is critical
- Choose plain words for understanding
(simple nouns, lively verbs, clear adjectives)
"Keep up your bright swords, for the dew will rust them."
"Relinquish your luminous armory, for the atmospheric moisture would cause its deterioration."
- Avoid abbreviations and acronyms ('alphabet soup')
ELISA PAGE AIDS FISH
- Smothered verbs (add postfix to make abstract noun)
"The addition of X made an improvement to Y."
"Adding X improved Y."
- Singular/plural forms
datum/data, genus/genera, criterion/criteria..
hippopotamuses, apparatuses, forums...

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Check spelling

*I have a spelling checker
It came with my PC
It plainly marks for my revue
Mistakes I cannot sea.
I've run this poem threw it,
I'm sure your please to no,
Its letter perfect in it's weigh,
My checker tolled me sew.*

What version of English!

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Punctuation

Ancient Greek: REDRONISSETATSDETINUHEHTFOELPOEPEHTEW
TOFORMAMOREPERFECTUNIONESTABLISH

- Developed to help people read out loud
"In conversation you can use timing, a look, inflection, pauses.
But on the page all you have are commas, dashes, the number of syllables in a word. When I write, I read everything out loud to get the right rhythm" Fran Lebowitz
- Full-stop (.) marks end of sentence
- Comma (,) marks discrete sections of sentence
- Colon (:) indicates the concept "as follows"
- Semicolon (;) both separates and combines
- Hyphen (-) brings elements together in single unit
- Apostrophe (') indicates something has been left out

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Published product

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Submission

- Compose an accompanying letter to editor
- Comply with 'Instructions to Authors' (triple check)
 - ¼ are rejected by editor as 'not in scope of journal'
 - ¼ are rejected by editor as 'poor quality'
 - ½ are sent for review (2-3 independent referees)
- Peer review
 - referee mind-set is to find fault (so they will)
- Feedback (referee's reports)
 - take all critique as constructive to your product
 - if the referee did not get it, others won't either
 - revise manuscript accordingly, or defend *status quo* to editor
 - avoid paper wars (achieves nothing, casts you as an idiot)

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Publication

Four steps to gratification:

1. Manuscript accepted (at last!)
2. Galley proofs (looking good)
3. Published article (can't believe it!)
4. Reprints (who gets one?)

Be righteously proud, get a buzz going!!

- Fame and Fortune will follow (N = ???)

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Culmination of effort! Reward!

CASE REPORT

Fatal encephalitozoonosis in two koalas

JS NIMMO,^{1*} K SNOWDEN² and P O'DONOGHUE²

Two young koalas from a fauna park, recently out of the pouch and approximately 6 months old, were found dead with no previous clinical signs or gross lesions. On histopathological examination, large numbers of spores consistent with a microsporidian organism were present intracellularly within the small intestinal mucosa. Electron microscopy and polymerase chain reaction studies (concerning the 5' end of the SSU rRNA gene) identified the organism as *Encephalitozoon intestinalis* with 100% homology with those of previously reported human isolates. This is believed to be the first report of this organism in a marsupial.

Key words: koala, microsporidiosis, *Encephalitozoon intestinalis*

Aust Vet J 2007;85:428-432 doi:10.1111/j.1751-0813.2007.01985.x

AIDS	Acquired immunodeficiency syndrome
Bp	Base pair
EISA	Enzyme-linked immunosorbent assay
HIV	Human immunodeficiency virus
PAS	Periodic acid Schiff
PCR	Polymerase chain reaction

*specimens belonging to the phylum *Mycetozoa*, commonly has also been associated with 'traveller's diarrhoea', and infections have been reported in immunocompetent humans.³ *E. intestinalis* has rarely been reported in animal hosts. In a single study in Mexico, parasites were identified in faecal samples from a small number of domestic animals (pig, donkey, dog, cow, goat) using immunofluorescent staining and molecular methods.⁴ However, no additional animal surveys or epidemiological studies have confirmed these findings in domestic animal hosts.⁵ In a recent study from Spain, *E. intestinalis* was detected in 4% (5 of 124) of faecal samples from pigeons in community parks.⁶ In a third study, 3 of 100 faecal samples from 43 mountain gorillas (*Gorilla gorilla beringei*) were positive for *E. intestinalis* based on polymerase chain reaction (PCR) amplification of a portion of the small subunit rRNA gene (SSU rRNA).⁷ Several humans working with these habituated gorillas were also parasite positive, so the possibility of zoonotic transmission of the parasite (human to ape) was suggested. Overall, the zoonotic potential of this microsporidian organism is not well defined.

Case report
History and description of animals:
A fauna park on a resort island in Queensland had a 3 year history of unexplained deaths in both *Phascolarctos* and

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Don't spoil it!

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CHEATING

Employer/community/society expectation

- scientific integrity (honest, responsible)

Intellectual property (belongs where?)

- vested in organization, scientist, student

Scientific fraud (will get caught)

- fabrication, falsification, plagiarism

Plagiarism (will be detected)

- do not claim the work of others as your own
- intentional + un-intentional (beware para-phrasing)
- e-detection (TurnItIn, etc.)

Consequences (dire, life-long)

- legal, moral, ethical, financial, personal

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Science writing



**Have a great career!
Leave an enduring legacy!**

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