Writing a scientific paper

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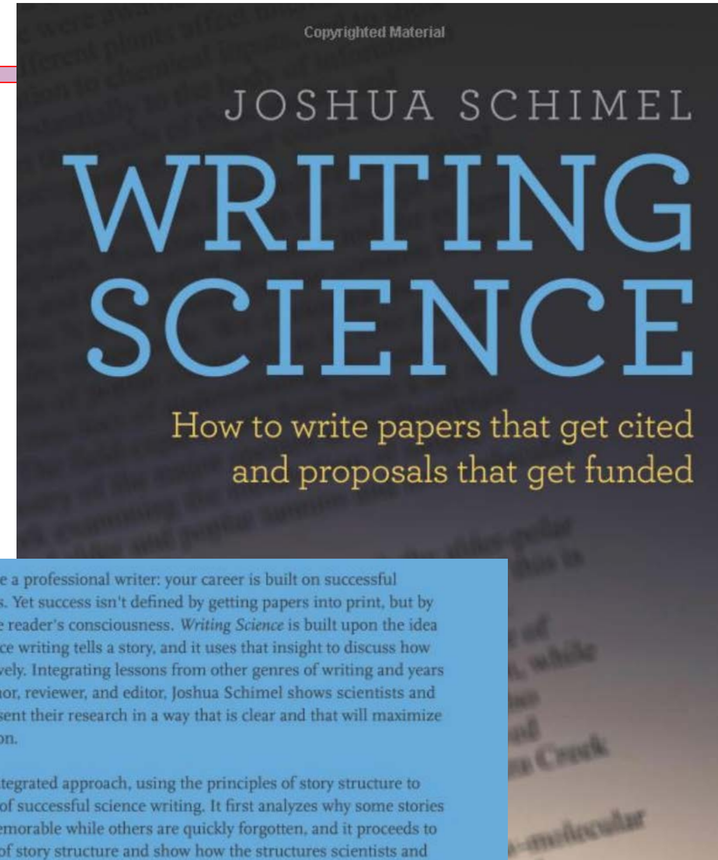
http://www.botany.uwc.ac.za/

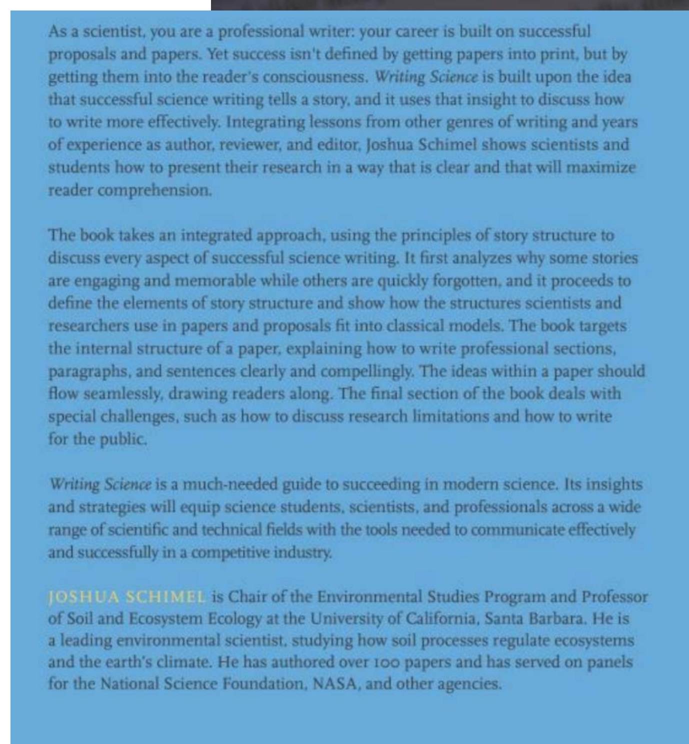
Outline

- What is a scientific paper?
- Structure and format
- The outline – *scope and plan*
- **The elements**
- Examples
- Writing
- Authorship and ethics
- The cycle of review
- A bit of grammar

Resources

- ***Writing Science*** - Joshua Schimel (Oxford)





As a scientist, you are a professional writer: your career is built on successful proposals and papers. Yet success isn't defined by getting papers into print, but by getting them into the reader's consciousness. *Writing Science* is built upon the idea that successful science writing tells a story, and it uses that insight to discuss how to write more effectively. Integrating lessons from other genres of writing and years of experience as author, reviewer, and editor, Joshua Schimel shows scientists and students how to present their research in a way that is clear and that will maximize reader comprehension.

The book takes an integrated approach, using the principles of story structure to discuss every aspect of successful science writing. It first analyzes why some stories are engaging and memorable while others are quickly forgotten, and it proceeds to define the elements of story structure and show how the structures scientists and researchers use in papers and proposals fit into classical models. The book targets the internal structure of a paper, explaining how to write professional sections, paragraphs, and sentences clearly and compellingly. The ideas within a paper should flow seamlessly, drawing readers along. The final section of the book deals with special challenges, such as how to discuss research limitations and how to write for the public.

Writing Science is a much-needed guide to succeeding in modern science. Its insights and strategies will equip science students, scientists, and professionals across a wide range of scientific and technical fields with the tools needed to communicate effectively and successfully in a competitive industry.

JOSHUA SCHIMEL is Chair of the Environmental Studies Program and Professor of Soil and Ecosystem Ecology at the University of California, Santa Barbara. He is a leading environmental scientist, studying how soil processes regulate ecosystems and the earth's climate. He has authored over 100 papers and has served on panels for the National Science Foundation, NASA, and other agencies.

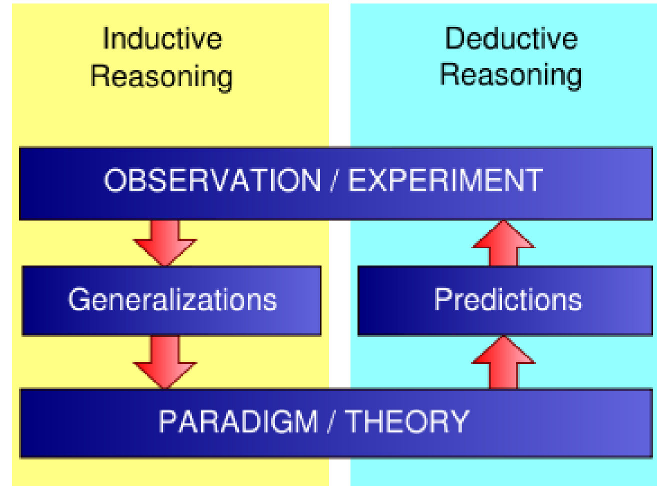
What is a scientific paper?

- A scientific paper contains information presented and organized such that peers (your colleagues) are able to:
  - Assess theoretical derivations or observations
  - Repeat key steps and experiments
  - Independently evaluate the discovery process
- A paper must be peer reviewed, become a permanent record (published), and be available to scientists without restrictions
- A scientific paper contains information written and presented in a particular format based on the path of the *scientific method*

The scientific method and its communication

The Scientific Method

- Observe and question
- Propose tentative hypotheses
- make predictions about unobserved phenomena
- Test by making observations
- Reject hypotheses that fail to predict new observations

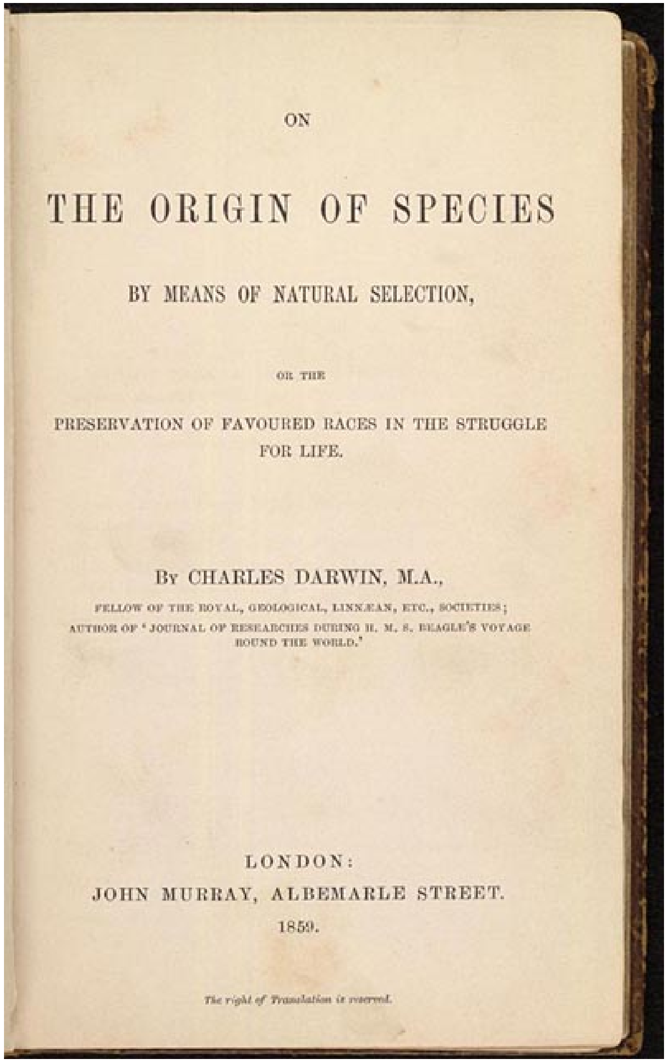


The Scientific communication path

1. Define the question
2. Gather information and resources
3. Formulate hypothesis
4. Perform experiment & collect data
5. Analyze data
6. Interpret and draw conclusions for new hypotheses
7. Publish/communicate results

The structure of a scientific paper

1. Title
2. Authors and affiliations
3. Abstract
4. Introduction
5. Theory/Methods
6. Results
7. Discussion
8. Summary and conclusions
9. Acknowledgements
10. References


ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

BY CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The right of Translation is reserved.

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Swiss Federal Institute of Technology Zurich

Types of scientific papers

- **Standard/primary research paper** – standard structure discussed next
- **Review paper** – critical overview of “the state of the art”
- **Technical note** – concise (4 pages) paper reporting a technical innovation
- **Position/opinion paper**
- **Comment/letter to the editor**

- Each of these formats serves different objectives or aspects of scientific communications

Structure and order of a scientific paper

Scientific process	Section of paper
Orienting readers	***Title***
What was done in a nutshell?	***Abstract***
What is the problem addressed?	***Introduction***
How did we solve the problem?	***Theory / Methods***
What did we find?	***Results***
What does it mean?	***Discussion***
What have we learned (in short)?	***Summary and conclusions***
Who helped us?	***Acknowledgements***
Whose previous work did we rely on?	***References***
Additional information	***Appendices***

The outline – *a valuable roadmap for the authors*

- Start with an outline – it is probably the most useful investment of time in the entire writing process

- Weave into basic paper structure your headings and subheadings down to titles of key paragraphs *(more details than in this TOC!)*

- For example, expand generic sections such as “introduction” to highlight main points to be discussed

- Be flexible - change and rearrange as you go

Universality of ac conduction in disordered solids

Jeppe C. Dyre and Thomas B. Schrøder
Department of Mathematics and Physics, Roskilde University, DK-4000 Roskilde, Denmark

Simplicity and clarity in writing

- Simplicity and clarity are complementary
- All words used in scientific writing should be:
  - Simple
  - Essential
  - Specific
  - Familiar

- Avoid redundancy (i.e., stating same thing more than once)
- Write to an imaginary reader, and assume the reader knows very little about the topic hence everything must be defined and clearly presented

The *Title*

- The title is probably the most visible (and important) element of a paper
- It is most likely part of the paper to be read
- Used for classification, indexing, “discovered” by modern search engines
- Should be extremely informative, simple and compact
- Avoid pompous wording and deceptive “promises”

The meaning of life

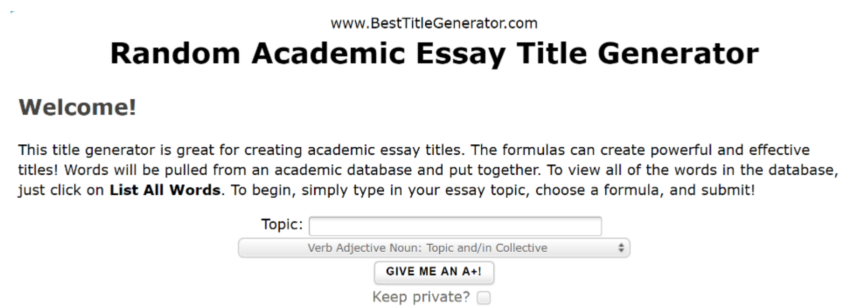
The advantage of short paper titles

Adrian Letchford, Helen Susannah Moat, Tobias Preis

Published 26 August 2015. DOI: 10.1098/rsos.150266

The *Title*

- Clever and amusing titles did not correlate with more citations…


www.BestTitleGenerator.com

Random Academic Essay Title Generator

Welcome!

This title generator is great for creating academic essay titles. The formulas can create powerful and effective titles! Words will be pulled from an academic database and put together. To view all of the words in the database, just click on **List All Words**. To begin, simply type in your essay topic, choose a formula, and submit!

Topic:

Verb Adjective Noun: Topic and/in Collective

GIVE ME AN A+!

Keep private?

- The tooth, the whole tooth and nothing but the tooth: how belief in the Tooth Fairy can engender false memories
- Technology: go ahead, make my DNA
- One giant leap for mankind? A cost-utility analysis of abolishing the law of gravity
- You Probably Think This Paper’s About You: Narcissists’ Perceptions of Their Personality and Reputation

The ***Abstract***

- An abstract provides in a single paragraph a summary of the entire paper
  - What was done and why?
  - How it was done
  - What were the main results
  - What are the main conclusions
- An abstract must be understandable without reference to the rest of the paper (it is the most read part after title)
- Typically contains **150-250 words**
- It should **NOT** contain
  - Any information not presented in the paper
  - Reference to tables or graphs
  - Details of methods
  - Referenced literature

http://users.ece.cmu.edu/~koopman/essays/abstract.html

What is an informative **abstract** (for a paper)?

An abstract summarizes, in one paragraph the major aspects of the entire paper in the following sequence:

1. *The question you investigated* (**Introduction**)
   - Clearly state the purpose in the first or second sentence
2. *The experimental design and methods used* (**Methods**)
   - clearly express the basic design of the study
   - briefly describe the basic methodology used (without detail), indicate key techniques used
3. *Major findings, key quantitative results or trends* (**Results**)
   - report results relevant to the questions asked
   - identify trends, relative change or differences
4. *A brief summary of your conclusions* (**Discussion**)
   - clearly state the implications of the results

The *Introduction*

- An introduction provides sufficient background to allow a reader to understand the study without the need to refer to previous publications, and supplies the rational for the study

- A good introduction:
    - Presents the scope of the problem
    - Reviews related literature
    - Sets the stage for the methods chosen
    - Ends with clear objectives (sometimes paper organization)

- Use the present tense (writing about what is known)

- Evaluate previous research - don’t just summarize

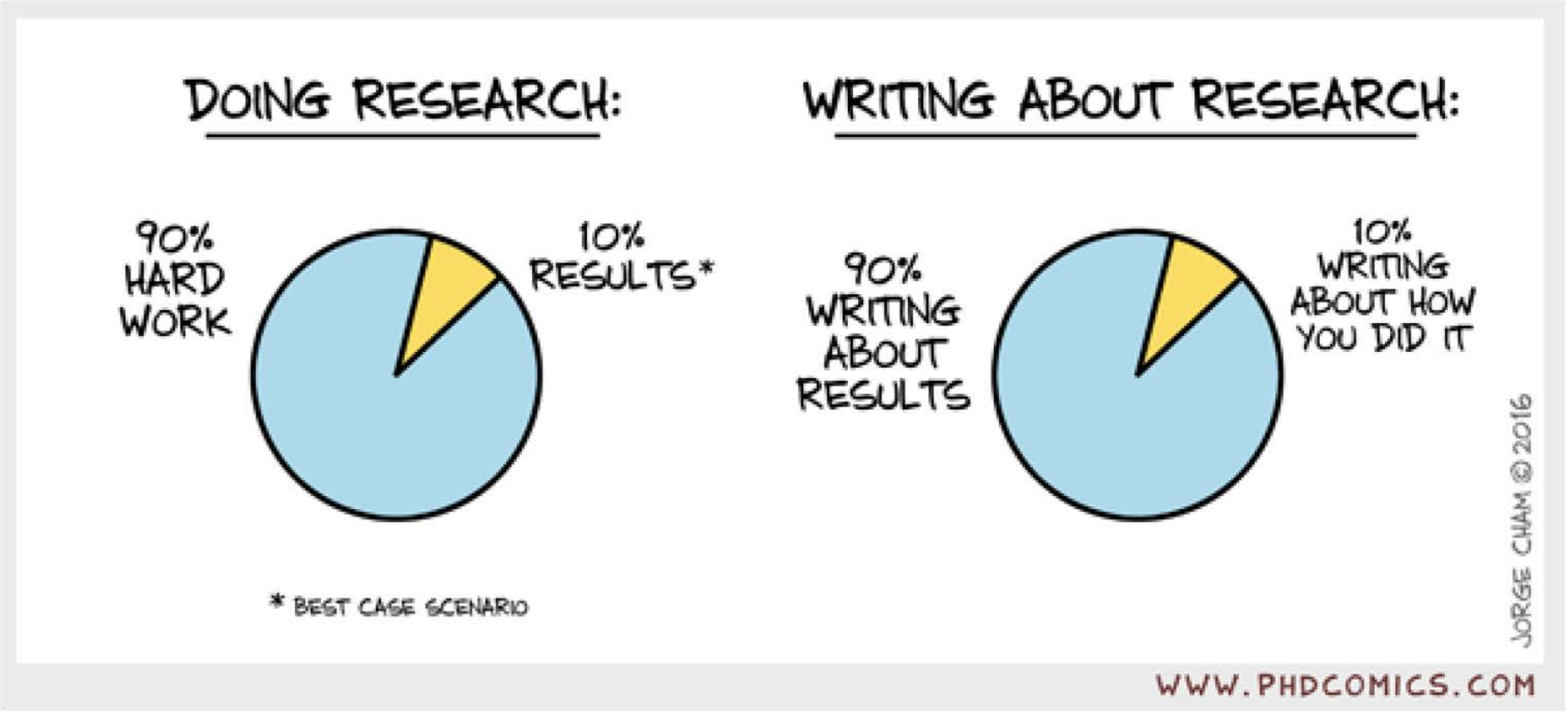
- Cite original sources only (things you have read or could be found)

- State overall question addressed or provide simple hypotheses

Materials and Methods

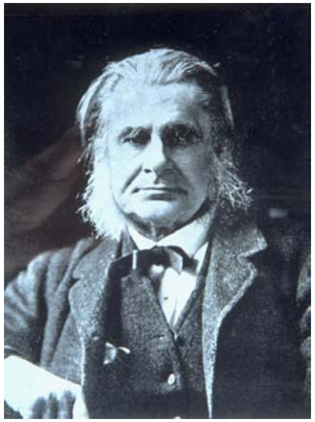
- The *Materials and Methods* section explains how the research was performed
- Provide sufficient detail to allow readers to:
  - Evaluate appropriateness of the methods
  - Assess validity of results
  - Replicate the study
- Justify your choice of methods (methods published elsewhere need only to be cited)
- Use the past tense (reporting what was done)
- Sometimes the structure would follow:
  - Materials, study site, numerical model
  - Measurement methods and observations
  - Procedures and data sources

The ***Results***... an inherent imbalance



The ***Results***

» *The great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact…*
Thomas Henry Huxley ['Collected Essays', 1894]



- The ***Results*** section is where facts are disclosed and hypotheses are tested
- Report results from which significant conclusions can be drawn (*even if contrary to expectations*)
- Do not selectively eliminate significant results – there are no “good” or “bad” results, there are simply “results”
- Use graphs, figures, and tables – don’t just repeat the caption, make a point when referring to these elements in the text
- Do not repeat methods (*a common flaw*)
- Use the past tense (*reporting what has been done*)

The *Discussion and conclusions*

- The ***Discussion*** explains importance and relevance of your findings
- **Do:**
  - Generalize based on your results
  - Point to exceptions and inconsistencies, limitations
  - Discuss shortcomings and open issues
  - Relate your work to previous studies
- **Do not:**
  - Repeat results
  - Digress to speculations not supported by data
  - Overemphasize shortcomings
  - Discuss insignificant findings (masking important ones)
  - Ignore alternative interpretations
  - Accept a null hypothesis with non-significant results – *absence of evidence is not evidence of absence*

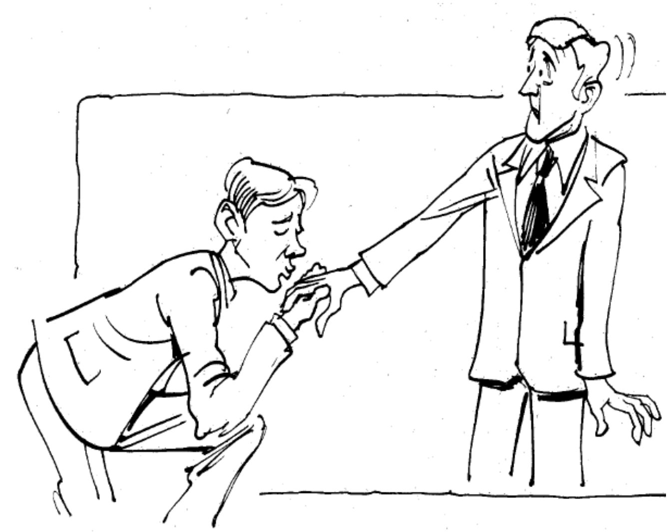
The *Acknowledgements*

- Acknowledgements are important - someone funded the research (and expects funding to be acknowledged), others may have helped with technical aspects, data collection and analyses

- Acknowledge sources of funding, host institutions, personal (technical, intellectual, and other help)

- If you are uncertain about how much credit to give someone who helped you along the way, err on the side of giving more credit than you are certain about…

- This is an opportunity to win friends, enlist advocates and solidify relationships



Figures - *elements, captions and referencing*

- Provide a clear caption for each figure
- Make sure elements are clearly labeled (axes, symbols, letters, units, dimensions) and captions explain the figure content
- Lines and symbols are distinguishable even in a black and white photocopy
- Make sure figures are referenced in the proper places in the text (typically shown following their reference, but not always)
- When referencing, make a point don't just repeat the caption or state the obvious

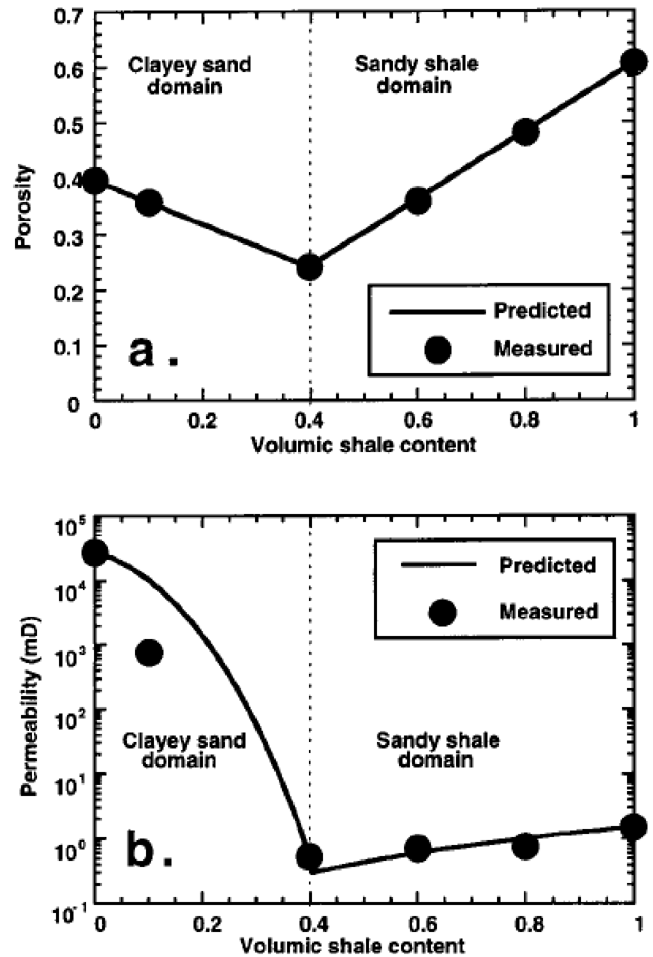


Figure 10. Porosity and permeability versus clay content (in volume). (Experimental data are from *Knoll and Knight* [1994]; the clay is kaolinite.) Parameters used are $\phi_{Sd} = 0.40$, $\phi_{Sh} = 0.60$, $k_{Sd} = 27 \times 10^3$ mD, and $k_{Sh} = 1.50$ mD; grain densities are 2650 kg m^{-3}.

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An example of a scientific paper (1)

1. The journal and key information for referencing
2. The title of the paper
3. Authors and affiliation
4. The abstract
5. The introduction
6. Objectives and paper organization
7. Theoretical considerations (in some papers this could be the "*Materials and Methods*" section)

1

WATER RESOURCES RESEARCH, VOL. 35, NO. 3, PAGES 651–662, MARCH 1999

2

Permeability of shaly sands

3

A. Revil[1] and L. M. Cathles III

Global Basin Research Network Group, Department of Geological Sciences, Cornell University, Ithaca, New York

4

Abstract. The permeability of a sand shale mixture is analyzed as a function of shale fraction and the permeability of the two end-members, i.e., the permeability of a clay-free sand and the permeability of a pure shale. First, we develop a model for the permeability of a clay-free sand as a function of the grain diameter, the porosity, and the electrical cementation exponent. We show that the Kozeny-Carman-type relation can be improved by using electrical parameters which separate pore throat from total porosity and effective from total hydraulic radius. The permeability of a pure shale is derived in a similar way but is strongly dependent on clay mineralogy. For the same porosity, there are 5 orders of magnitude of difference between the permeability of pure kaolinite and the permeability of pure smectite. The separate end-members' permeability models are combined by filling the sand pores progressively with shale and then dispersing the sand grains in shale. The

5

1. Introduction

Permeability is one of the most important and least predictable transport properties of natural materials. Permeability must be known to understand many natural phenomena including basin-scale hydrogeologic circulation [e.g., *Person et al.*, 1996], fault dynamics [e.g., *Wintsch et al.*, 1995], the safety of waste repositories [e.g., *Moore et al.*, 1982], and many other problems related to subsurface hydrology. Many permeability models have been proposed [e.g., *Walsh and Brace*, 1984; *Bethke*, 1989; *Berryman*, 1992; *Nelson*, 1994]. These models generally relate permeability to geometric parameters of the porous media, particularly the hydraulic radius (the pore volume divided by the grain water interface area) and the porosity (which is sometimes corrected for bulk tortuosity). A recognized problem with these Kozeny-Carman (KC)-type relationships is that the porosity in sands and sandstones usually consists of large, isolated, roughly equidimensional voids which are connected by much smaller throats [*Krohn*, 1988; *Bernabé*, 1995]. The throats control the transport properties but contribute very little to the total porosity which is used in the permeability prediction. Recently, electrical parameters that separate pore throat from total porosity and effective from total hydraulic radius have been introduced to improve KC-type models [e.g., *Kostek et al.*, 1992; *Bernabé*, 1995]. This paper presents a new model of permeability for sand shale mixtures based on these effective parameters. Clay type (illite, kaolinite, and smectite) is considered. The sand and shale end-members are combined using the geometric model of *Marion et al.* [1992]. The resulting permeability model for sand shale mixtures is shown to be compatible with available laboratory data and core measurements from the offshore Louisiana Gulf of Mexico and represents a significant improvement over the classical KC model. 6

[1]Now at Department of Geophysics, Centre Européen de Recherche et d'Enseignement de Géosciences de l'Environnement, Aix-en-Provence, France.

Paper number 98WR02700.
0043-1397/99/98WR-02700$09.00

2. Theory

7

2.1. Permeability of Clean Sand

The KC equation can be derived by considering a porous medium where the pores are cylindrical tubes of constant radius in the direction of flow. In such a case the filtration or Darcy velocity $\mathbf{J}_H$ is given by the Poiseuille's law [e.g., *Walsh and Brace*, 1984]:

$$\mathbf{J}_H = -\frac{R^2\phi}{8\eta_f}\nabla(p - \rho_f g z) \quad (1)$$

Here p is the fluid pressure, ρ_f is the density of the pore fluid, g is the gravity acceleration, z is the depth, R is the radius of the flow tubes, ϕ is the total porosity, and η_f is the dynamic shear viscosity of the fluid. The intrinsic permeability k is given by equating (1) to Darcy's law:

$$\mathbf{J}_H = -\frac{k}{\eta_f}\nabla(p - \rho_f g z) \quad (2)$$

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An example of a scientific paper (2)

8. Equations and equation numbers – definition of variables and symbols

$$k_{\mathrm{Sh}} = k_0(\phi_{\mathrm{Sh}}/\phi_0)^{3m_{\mathrm{Sh}}} \tag{13}$$

where k_0 and ϕ_0 are the permeability and porosity in a reference state, respectively (we take $\phi_0 = 0.50$). Using (13) and the

9. Figures and figure caption

Figure 5. Test of the model developed in that main text. Figure 5a shows the relationship between porosity and permeability of fine-grained and silty sandstones (data from *Chilindar* [1964, Figure 2, p. 73]). The average grain diameter derived from this model by fixing $m = 1.7$ and using a regression analysis on the data of Chilindar is 235 μm for the fine-grained sandstone and 103 μm for the silty sandstone in agreement with the observations. Figure 5b shows the comparison between the predictions of the Kozeny-Carman model and the present model (all the data from Figures 3, 4, and 5a are used).

10. Tables and table caption

Table 2. Permeability Porosity Relationship for Shales

11. "making a point" concerning Fig. 6

[e.g., *Mendelson and Cohen*, 1982]. The important point of Figure 6 is that it shows the porosity dependence of permeability of pure clays is predicted well by (13).

fective stress during compaction results mainly from porosity variations. From (12) the shale end-member permeability k_{Sh} is related to the shale end-member porosity ϕ_{Sh} by

$$k_{\mathrm{Sh}} = k_0(\phi_{\mathrm{Sh}}/\phi_0)^{3m_{\mathrm{Sh}}} \tag{13}$$

where k_0 and ϕ_0 are the permeability and porosity in a reference state, respectively (we take $\phi_0 = 0.50$). Using (13) and the permeability porosity data reported in Figure 6, we calculate m and k_0 for each end-member clay mineralogy (kaolinite, illite, and smectite), and we report them in Table 2. The cementation exponent range observed from this permeability analysis is in agreement with the values of m_{Sh} cited previously and with those resulting from electrical conductivity measurements

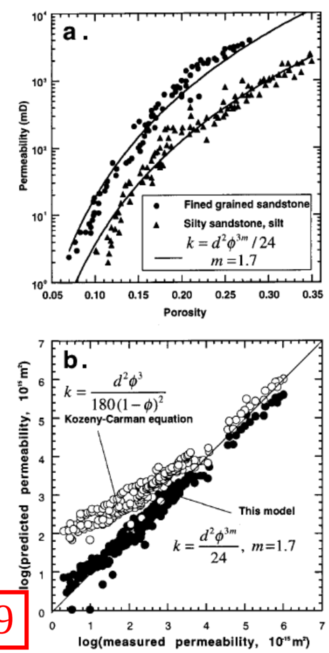

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Table 2. Permeability Porosity Relationship for Shales

Shale	m	$k_0(\phi_0 = 0.50)$, mD
Kaolinite	2.34–3.15	7.1–0.10
Illite	3.28	5.1×10^{-4}
Smectite	4.17	3.1×10^{-7}

Where $k = k_0(\phi/\phi_0)^{3m}$.

[e.g., *Mendelson and Cohen*, 1982]. The important point of Figure 6 is that it shows the porosity dependence of permeability of pure clays is predicted well by (13).

2.3. Porosity and Permeability of Sand Shale Mixture

In sand-shale mixtures, porosity is not a simple function of the shale fraction. Porosities of pure sand and shale are higher than the porosity of a sand shale mixture. Porosity is reduced as clay fills the pores of a sand or as sand is dispersed in a shale. For mixtures of sands and shales the porosity is given by *Marion et al.* [1992]:

$$\phi = \phi_{\mathrm{Sd}} - \varphi_V(1 - \phi_{\mathrm{Sh}}) \qquad \varphi_V \le \phi_{\mathrm{Sd}} \tag{14}$$

$$\phi = \varphi_V \phi_{\mathrm{Sh}} \qquad \varphi_V \ge \phi_{\mathrm{Sd}} \tag{15}$$

where φ_V is the clay volume fraction and ϕ_{Sd} and ϕ_{Sh} are the porosity of the clean sand and pure shale end-members, respectively (Figure 7). A sediment with a shale content which ranges from $\varphi_V = 0$ to that which just fills all the sand pores ($\varphi_V = \phi_{\mathrm{Sd}}$) is called a "clayey sand." A sediment with a greater shale content than this ($\varphi_V > \phi_{\mathrm{Sd}}$) is called a "sandy shale." The porosity of sand shale mixture has a minimum at the clayey sand-sandy shale boundary given by $\phi = \phi_{\mathrm{Sd}}\phi_{\mathrm{Sh}}$. *Koltermann and Gorelick* [1995] show that (14) and (15) are good first-order approximations to the porosity of a binary mixture assuming ideal packing (see *Koltermann and Gorelick* [1995] for nonideal packing). Ideal packing is a good approximation when the ratio between the coarsest and the finest grain size is large. This is the case for sand shale mixtures where sand grain diameters are larger than 50 μm and clay grain diameters are smaller than 5 μm. For practical reasons such as downhole measurements analysis it is very useful to have relationships between the shale fractions in volume and weight which are provided in Appendix B.

In the clayey sand domain we expect, from (12), that the permeability of a clayey sand ($k\phi$) is related to the permeability of a clean sand ($k_{\mathrm{Sd}}\phi_{\mathrm{Sd}}$):

$$k = k_{\mathrm{Sd}}\left(\frac{\phi}{\phi_{\mathrm{Sd}}}\right)^{3m_{\mathrm{cs}}} \tag{16}$$

where m_{cs} is the cementation exponent corresponding to the clayey sand domain. Because clays in the pore throats block flow, m_{cs} should depend strongly on the shale content, particularly near the boundary between the clayey sand and sandy shale domains. Because the flow blockage is severe near this boundary, we intuitively expect than m_{cs} is not only a positive function of the shale content but can reach values much higher than 2. Following the above logic, we expand m_{cs} as a power function of φ_V:

$$m_{\mathrm{cs}} = m^0_{\mathrm{cs}} + m^1_{\mathrm{cs}}\varphi_V + O(\varphi_V^2) \tag{17}$$

An example of a scientific paper (3)

12. Instead of ***Results*** this paper that involves model development discusses ***Application***

13. Subheading to orient readers – comparison with 3.1 laboratory data and with 3.2 field data

3.2. Evaluation by Comparison to Field Data

Equation (20) suggests that sandy shale permeability can be obtained by taking into account the flow blockage by the sand grains. The parameter F_{Sd} is the formation factor for the sand grain skeleton (Figure 8). Using Archie's law, $1/F_{Sd} = (\varphi_V)^{m_{Sd}}$, and (20), the permeability in the sandy shale domain is given by

$$k = k_{Sh}(\varphi_V)^{m_{Sd}} \qquad \varphi_V > \phi_{Sd} \tag{21}$$

Since permeability must be continuous across the clayey sand-sandy shale boundary, (19) must equal (21) at this boundary. The important result is that k_{Sh} can be determined by extrapolating permeabilities in the sandy shale domain to the known clayey sand boundary:

$$k_{Sh}(\phi_{Sd})^{m_{Sd}} = k_{Sd}(\phi_{Sh})^{2m_{Sd}+2m^{1}_{Cl}\phi_{Sd}} \qquad \varphi_V = \phi_{Sd} \tag{22}$$

Equation (22) can be also used to determine m^{1}_{Cl} from the permeability and porosity of the two end-members.

Equations (12), (17), (18), (21), and (23) represent a new model for the permeability of sand shale mixtures which describes permeability from clean sand ($\varphi_V = 0$) to pure shale ($\varphi_V = 1$). These permeability functions are plotted from different grain sizes as a function of shale content in Figure 9a. An important conclusion from Figure 9a is that the permeability of a sand shale mixture increases with increasing shale content past the clayey sand-sandy shale boundary because sand grains (with no intrinsic permeability) are replaced by shale (which has a permeability). The minimum permeability occurs at $\varphi_V = \phi_{Sd}$. In Figure 9b the permeability of sand shale mixtures is plotted as a function of porosity. The permeability variations in Figure 9b result only from shale content variations. There is no compaction contrary to Figure 5a.

12

3. Application

3.1. Evaluation by Comparison to Laboratory Data

Our permeability model is compared to experimental data in Figure 10. As shale content increases from 0 to $\varphi_V = \phi_{Sd} = 0.40$, permeability decreases sharply from 2.7×10^4 to 5.3×10^{-1} mD. Adding a small amount of clay to a clean sand has a dramatic effect on the permeability. As shale content increases from 0.40 to 1, permeability increases slightly to 1.5 mD. The agreement between the model and data is very good. An important point in Figure 10 is that it directly confirms that permeability increases with shale content past the clayey sand-sandy shale boundary and that permeability has a minimum when plotted as a function of the shale fraction. These are critical predictions of our model.

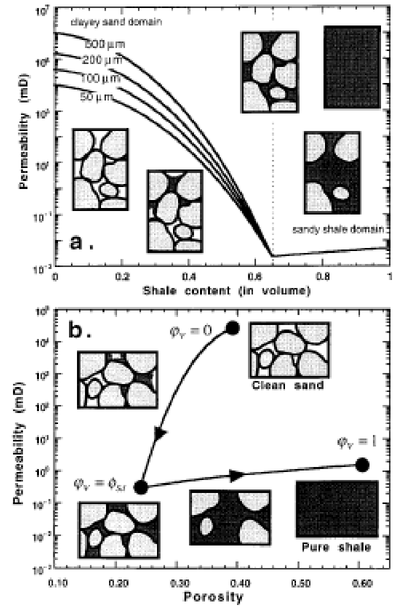

Figure 9. Permeability of sand shale mixtures. Figure 9a shows the permeability versus sand content (in volume). The permeability is plotted as a function of the shale content for four grain sizes of the sand (500, 200, 100, and 50 μm). There is a minimum in the permeability which corresponds to the limit between the clayey sand and sandy shale domains. The parameters used are $\phi_{Sd} = \phi_{Sh} = 0.65$, $k_{Sh} = 5 \times 10^{-2}$ mD, and $m_{Sd} = 1.80$. Figure 9b shows the permeability versus porosity for sand shale mixtures. The arrows correspond to an increase of the shale content from $\varphi_V = 0$ (clean sand), $\varphi_V = \phi_{Sd}$ (the sand is filled with clays), and $\varphi_V = 1$ (pure shale).

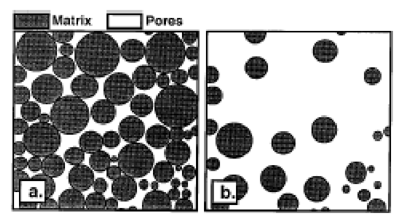

Figure 8. Sand grain skeleton in the sandy shale domain. The sand grain skeleton is obtained by replacing the clay particles by pore space in order to evaluate the electrical formation factor associated with the sand grains. (a) At the clayey sand-sandy shale limit the electrical formation factor of the sand grain skeleton is equal to the electrical formation factor of a clean sandstone. (b) In the limit of a shale the sand grain skeleton is equivalent to a dilute suspension of spherical particles, and its associated electrical formation factor is given by the Hashin-Shtrikman lower bound.

3.2. Evaluation by Comparison to Field Data

13

In sedimentary basins, detrital sand grains and clays are mixed in a broad range of sand shale ratios [*Matlack et al.*, 1988]. This is the case, for example, in the Gulf Coast [*Holland*, 1990]. We compare permeabilities predicted by our model to a very large data set of permeabilities determined on side-wall cores from the South Eugene Island (SEI) salt withdrawal

An example of a scientific paper (4)

14. The ***Discussion and Conclusions*** section

15. **Appendix** – serves as repository for detailed derivations that would affect the flow of the paper and mask the main message. *Interested readers can follow the derivations and assess the validity of the main results (most readers would accept the final result reported in the paper)*

grain diameter of kaolinite which explains the relatively high permeability of the shale fraction. Taking (13) with $k_0 = 7$ mD at $\phi_0 = 0.50$ (see Figure 6a for kaolinite) and $m = 3$, we obtain a permeability for the shale fraction equaling 1 mD at $\phi = 0.40$ in agreement with the shale permeability obtained from our permeability model (Table 3).

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4. Discussion and Conclusions

The conclusions reached in this paper are the following: (1) the classical Kozeny-Carman relationship is improved by using electrical parameters which separate pore throat from total porosity and hydraulic radius. We develop a model for the permeability of a clean sand as a function of the grain diameter, the porosity, and the electrical cementation exponent. The model predicts the permeability of clean sands inside 1 order of magnitude to over more than 6 orders of magnitudes. (2) The permeability of a pure shale is derived in a similar way but is strongly dependent on clay mineralogy. (3) We derive a permeability model able to predict the permeability of sand shale mixtures as a function of shale fraction and the permeability of the two end-members (clean sand and pure shale). The permeability of sand shale mixtures is shown to have a minimum at the critical shale content at which shale just fills the sand pores, and pure shale has a slightly higher permeability. Permeability decreases sharply with shale content as the pores of a sand are filled. These critical predictions of the model agree with experimental data sets within 1 order of magnitude over 11 orders of magnitude. (4) An application of the permeability model to Gulf Coast side-wall cores data suggests that our model predict very well the permeabilities of natural shaly sand formations.

Two questions are now discussed. What is the implication of our model for the understanding of the permeability of clay-bearing sands and sandstones?, and what is the particular value of the model in the area of water resources? As it has been demonstrated in this paper, the permeability model requires only accessible parameters: (1) the grain size distribution of the sand fraction, (2) the clay mineralogy, (3) and the shale content (either in volume or in weight). In addition to these parameters, we need to consider the state of compaction of the two end-members (clean sand and perfect shale). This model should only be considered as a first step in order to derive a

basin simulators which begin to be widely used to understand subsurface hydrological circulations [e.g., *Person et al.*, 1996]). The information required to determine permeability profiles from downhole measurement analysis are the following: (1) the clay mineralogy and the shale content which both can be determined from the inversion of natural radioactivity logs, (2) the grain distribution of the sand fraction which can be obtained from core samples or from downhole measurements, (3) the porosity (obtained from a lithodensity log) and a compaction model for sand shale mixtures which can also include some diagenetic effects (such as the smectite illite transformation). The development of logging tools of small diameters in the last decade makes such approaches particularly suitable in the area of water resources. A future paper will be dedicated to such a methodology.

Appendix A: The Effective Pore Radius

15

Bussian [1983] developed a model describing the electrical conductivity of a porous medium in which spheres of nonconducting material, representing the insulating mineral grains of a clean sand, are imbedded in a conducting material, which represents the saline water. He added surface conductivity to a model developed by *Bruggeman* [1935], *Hanai* [1960], and *Sen et al.* [1981]. Bussian's model relates the electrical conductivity of the porous medium σ, the pore fluid conductivity σ_f, and the grain surface conductivity σ_S to porosity ϕ:

$$\frac{\sigma - \sigma_S}{\sigma_f - \sigma_S}\left(\frac{\sigma_f}{\sigma}\right)^D = \phi \qquad \text{(A1)}$$

where D is the "depolarizing factor." Equation (A1) can be rewritten:

$$\sigma = \sigma_f \phi^m \left(\frac{1 - \sigma_S/\sigma_f}{1 - \sigma_S/\sigma}\right)^m \qquad \text{(A2)}$$

where $m \equiv 1/(1 - D)$ is the cementation exponent which appears in Archie's law, equation (6). Using the binomial expansion, the high-salinity limit $(\sigma_S/\sigma_f \ll 1)$ of (A2) is

$$\sigma = \frac{1}{F}\left[\sigma_f + m(F - 1)\sigma_S\right] \qquad \text{(A3)}$$

The surface conductivity σ_S is related to the specific surface conductivity Σ_S by [*Revil and Glover*, 1998] $\sigma_S = 2\Sigma_S/R$.

An example of a scientific paper (5)

16. Appendix B (*imagine the distraction if the material was placed within main text*)
17. Acknowledgment section
18. References – *often in alphabetical order in a prescribed format*

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Avellaneda, M., and S. Torquato, Rigorous link between fluid permeability, electrical conductivity, and relaxation times for transport in porous media, *Phys. Fluids A*, *3*, 2529–2540, 1991.

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19. Alternative references format: *Physical Review Letters*

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16

Appendix B: Shale Content

The relationships between the shale content by volume φ_V and by weight φ_W is [*Marion et al.*, 1992]:

$$\varphi_W = \frac{\varphi_V(1-\phi_{Sh})\rho_g^{Sh}}{\varphi_V(1-\phi_{Sh})\rho_g^{Sh} + (1-\phi_{Sd})\rho_g^{Sd}} \qquad \varphi_V \le \phi_{Sd} \tag{B1}$$

$$\varphi_W^{crit} = \frac{\phi_{Sd}(1-\phi_{Sh})\rho_g^{Sh}}{(1-\phi_{Sd})\rho_g^{Sd} + \phi_{Sd}(1-\phi_{Sh})\rho_g^{Sh}} \qquad \varphi_V = \phi_{Sd} \tag{B2}$$

$$\varphi_W = \frac{\varphi_V(1-\phi_{Sh})\rho_g^{Sh}}{\varphi_V(1-\phi_{Sh})\rho_g^{Sh} + (1-\varphi_V)\rho_g^{Sd}} \qquad \varphi_V \ge \phi_{Sd} \tag{B3}$$

Here ρ_g^{Sh} and ρ_g^{Sd} are the grain density of clay minerals without their bound water and quartz, respectively. From (14), (15), (B1), and (B3) the porosity is obtained from φ_W by

$$\phi = \phi_{Sd} - \frac{(1-\phi_{Sd})\rho_g^{Sd}\varphi_W}{\rho_g^{Sh}(1-\varphi_W)} \qquad \varphi_W \le \varphi_W^{crit} \tag{B4}$$

$$\phi = \frac{\phi_{Sh}\rho_g^{Sd}\varphi_W}{\rho_g^{Sd}\varphi_W + (1-\phi_{Sh})\rho_g^{Sh}(1-\varphi_W)} \qquad \varphi_W > \varphi_W^{crit} \tag{B5}$$

Appendix C: Permeability in the Sandy Shale Domain

The theoretical basis for (20) is again electrical conductivity equations for two-component mixtures. The electrical conductivity σ of a two-component mixture is given by the Bergman-Milton model [*Bergman*, 1978; *Milton*, 1980; *Korringa and LaTorraca*, 1986]:

$$\sigma = \frac{\sigma_i}{F_i} + \frac{\sigma_j}{F_j} + \int_0^\infty \left(\frac{\Theta(x)}{1/\sigma_i + x/\sigma_j}\right) dx \tag{C1}$$

where σ_i and σ_j are the electrical conductivity of the two components, F_i is the electrical formation factor found by taking all of region "i" to be the pore space and all of the region "j" to be the insulator (and symmetrically for F_j), and $\Theta(x) \ge 0$ is a resonance density which depends like $F_{i,j}$ on the topology of the two components. The integral in (C1) is known as a Stieltjes integral [*Baker*, 1975]. *Dagan* [1979] showed that the effective permeability of an inhomogeneous porous medium is determined by an equation similar to (C1) and thus that

$$k = \frac{k_i}{F_i} + \frac{k_j}{F_j} + \int_0^\infty \left(\frac{\Theta(x)}{1/k_i + x/k_j}\right) dx \tag{C2}$$

Dagan's argument is correct so long as both constituents have finite and comparable permeabilities k_i and k_j. If one of the regions is impermeable (as it would be if composed of solid grains), then the no-slip conditions arises for fluid flow (but not for electrical conductivity) and complicates the solution. However, because shale is not very permeable, the effect of the no-slip condition vanishes at very small distances from the

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Acknowledgments. We thank Pennzoil for the permeability data of the GA and HB sands and S. Losh for fruitful discussions. The project was made possible by funding from the Gas Research Institute to L. M. Cathles, funding from Elf Aquitaine to A. Revil, and the general support of the Corporate Sponsors of the Global Basin Research Network. We thank the two reviewers, E. Bekele and J. P. Raffensperger, and the Associate Editor, M. Person, for constructive reviews.

18

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A review paper (1)

1. The paper reviews and integrates knowledge about a certain subject or field
2. It is organized to cover the main areas in a systematic way
3. It adds interpretation and identify links among studies and subtopics
4. Does not follow the usual scientific paper structure

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doi: 10.1146/annurev.micro.56.012302.161120

First published online as a Review in Advance on April 19, 2002

MICROBIAL COMMUNITIES AND THEIR INTERACTIONS IN SOIL AND RHIZOSPHERE ECOSYSTEMS

Angela D. Kent[1] and Eric W. Triplett[2]
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Key Words culture-independent community analysis, 16S rRNA, community fingerprint, microbial diversity, plant-microbe interactions, microbial ecology

■ **Abstract** Since the first estimate of prokaryotic abundance in soil was published, researchers have attempted to assess the abundance and distribution of species and relate this information on community structure to ecosystem function. Culture-based methods were found to be inadequate to the task, and as a consequence a number of culture-independent approaches have been applied to the study of microbial diversity in soil. Applications of various culture-independent methods to descriptions of soil and rhizosphere microbial communities are reviewed. Culture-independent analyses have been used to catalog the species present in various environmental samples and also to assess the impact of human activity and interactions with plants or other microbes on natural microbial communities. Recent work has investigated the linkage of specific organisms to ecosystem function. Prospects for increased understanding of the ecological significance of particular populations through the use of genomics and microarrays are discussed.

CONTENTS

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

A review paper (2)

5. The review provides a summary of what is known, present gaps and future needs

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

General aspects of scientific paper writing

- be consistent (also in the use tenses, ...)
- use active form (simpler, easier, stronger)
- no contractions (e.g., it's, can't, ...)
- all images, figures, tables are labeled and referenced in the text
- all images, figures, tables, ... must have a caption describing their purpose
- All references are mentioned in the text (and reference to previous work in the text clearly cited in the list of references)
- no paragraph should have only one sentence
- use a spellchecker (however, do not rely on the spellchecker, it does not find every mistake)
- evidence is singular the word data is plural (data are reported)…but some exceptions for data…
- use simple and short sentences (break a sentence if needed)
- avoid abbreviations (except: i.e., e.g.) or clearly define early on

Writing consistently **boring** papers

Table 1. Top-10 list of recommendations for writing consistently boring publications.

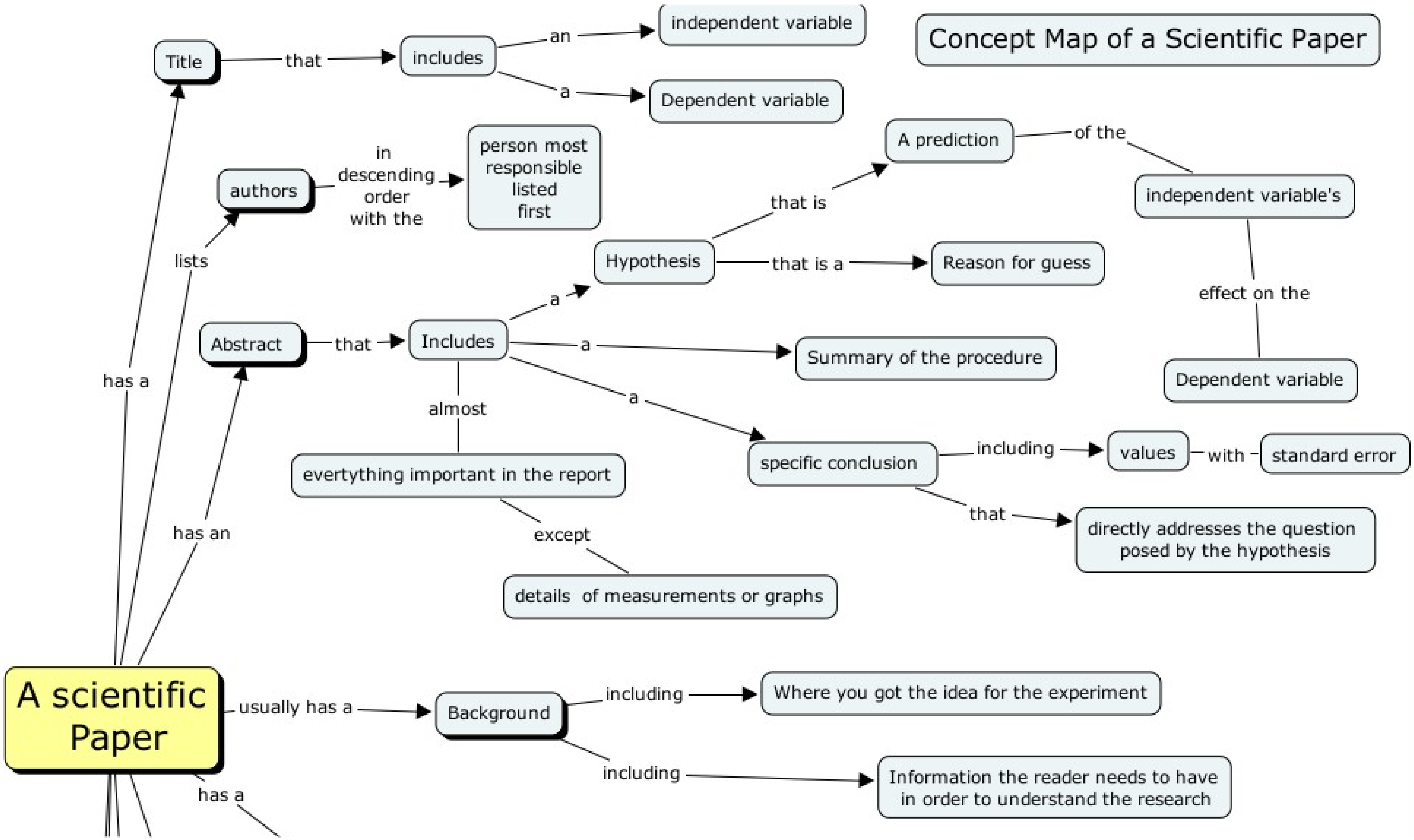
- Avoid focus
- Avoid originality and personality
- Write l o n g contributions
- Remove implications and speculations
- Leave out illustrations
- Omit necessary steps of reasoning
- Use many abbreviations and terms
- Suppress humor and flowery language
- Degrade biology to statistics
- Quote numerous papers for trivial statements

Types of scientific papers - *recap*

- **Standard/primary research paper** – standard structure discussed next
- **Review paper** – critical overview of “the state of the art”
- **Technical note** – concise (4 pages) paper reporting a technical innovation
- **Position/opinion paper**
- **Comment/letter to the editor**

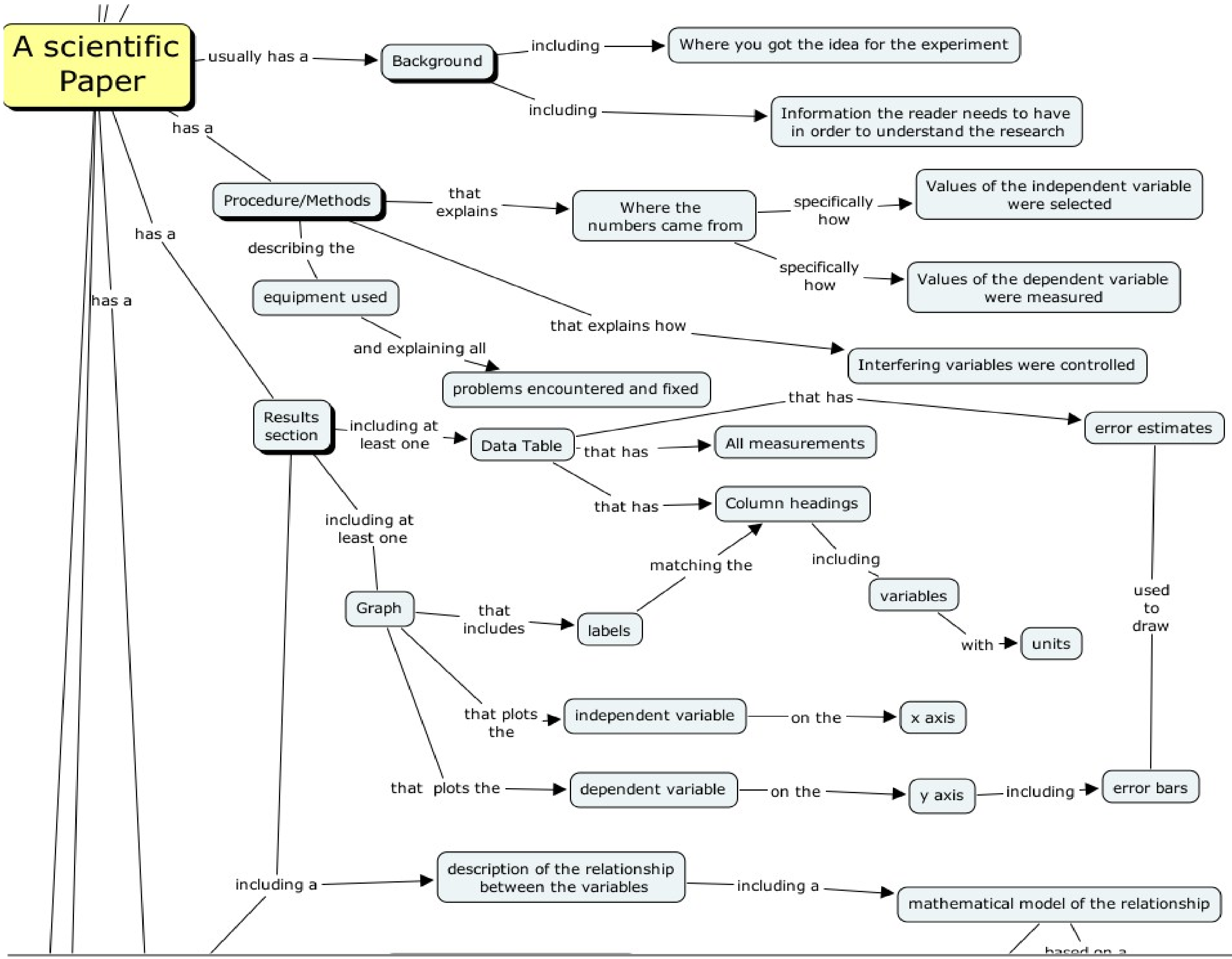
- Each of these formats serves different objectives or aspects of scientific communications
- All scientific papers are subjected to peer review process

Concept map of a scientific paper (1)

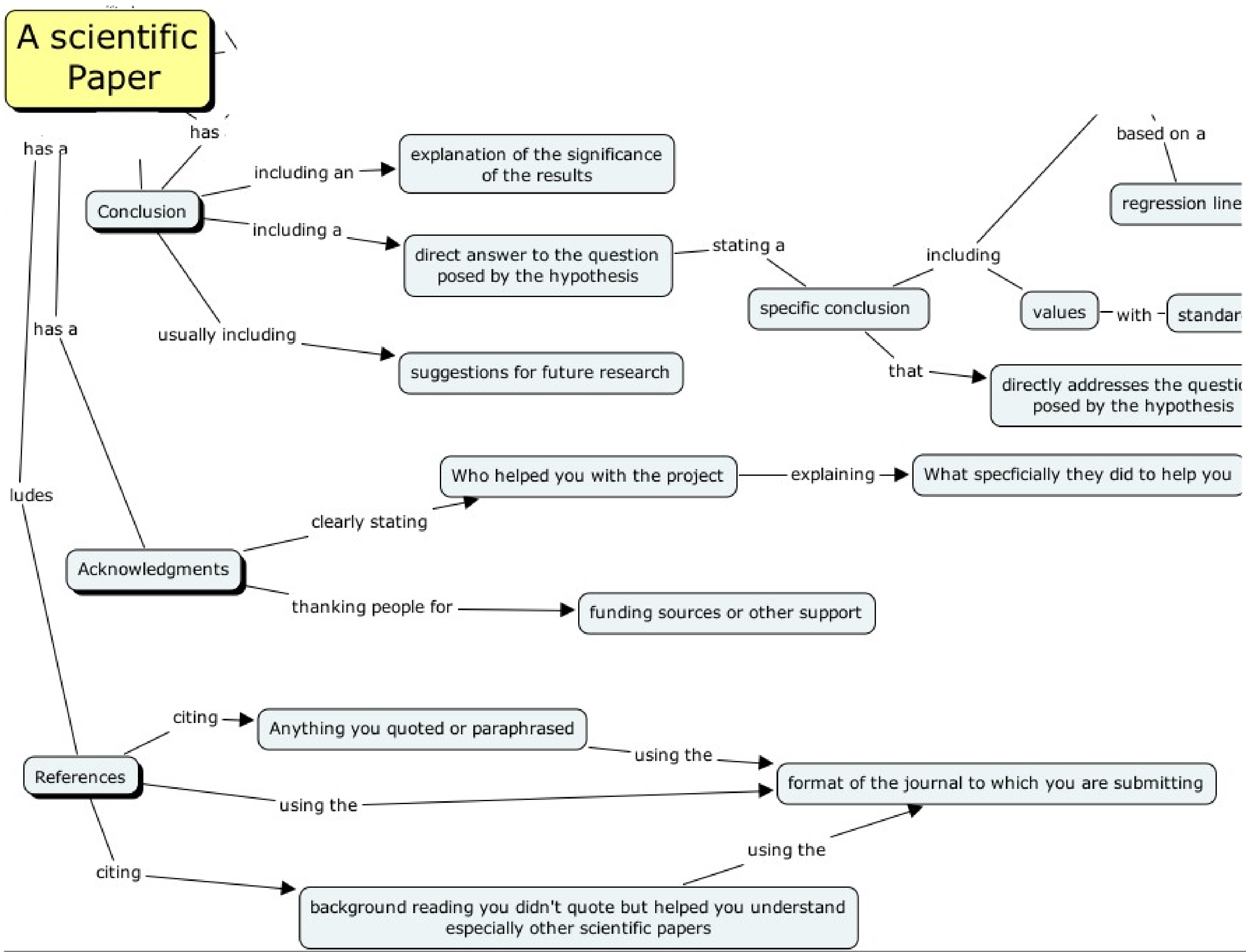


Jeff Adkins, 2005

Concept map of a scientific paper (2)



Concept map of a scientific paper (3)



Paper authorship

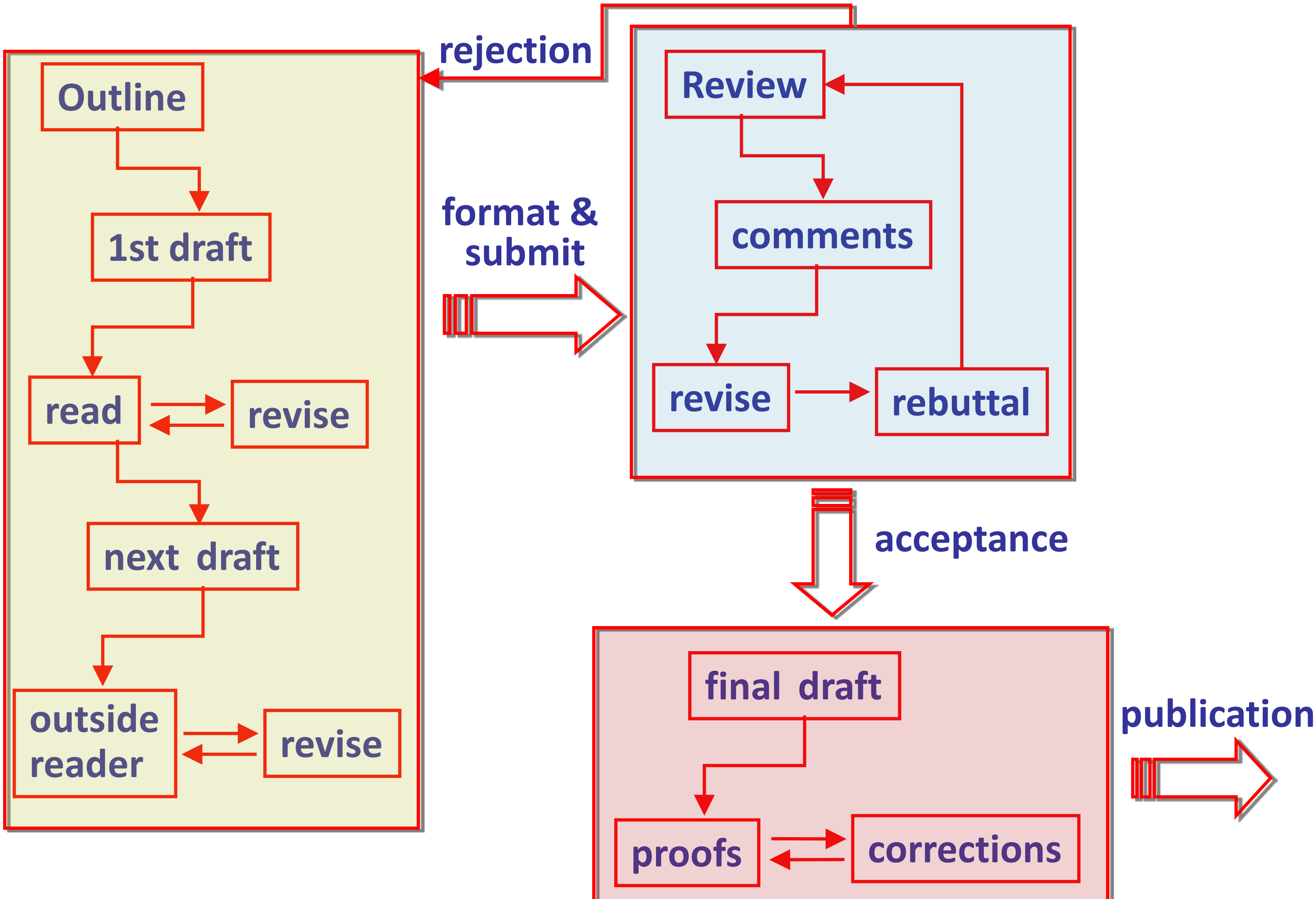
I'm not interested in what the paper is about, Dr Jones, I just want you to put me on the authors' list...

- In a perfect world all authors have contributed actively to the writing of the paper, and authorship order reflects the importance of their relative contributions
- Authors are typically originators of the idea, made partial contribution to the research, wrote or contributed to writing the paper – <u>authorship is best resolved upfront</u>
- In reality one faces with dilemmas and constraints such as how to include a senior scientist that provided funding but has not been active in the research…
- In addition to ethical questions, there are other practical issues ("politics") that must also be taken into consideration
- My "rule" - if a person didn't actively contribute to the writing of the paper, he or she will be acknowledged but not as co-authors… (*however, this "rule" has not always been applied*)

Ethics in science

- Integrity, honesty and fairness
- Acknowledgment of sources of information
  - Plagiarism (*easily identified with today's technology*)
  - *You didn't know this is an old idea (bad)*
  - *You knew but didn't disclose (very bad)*
- Respect for nature
- Ethical treatment of organisms
- Authorship issues

Key steps to publication



ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

The review process

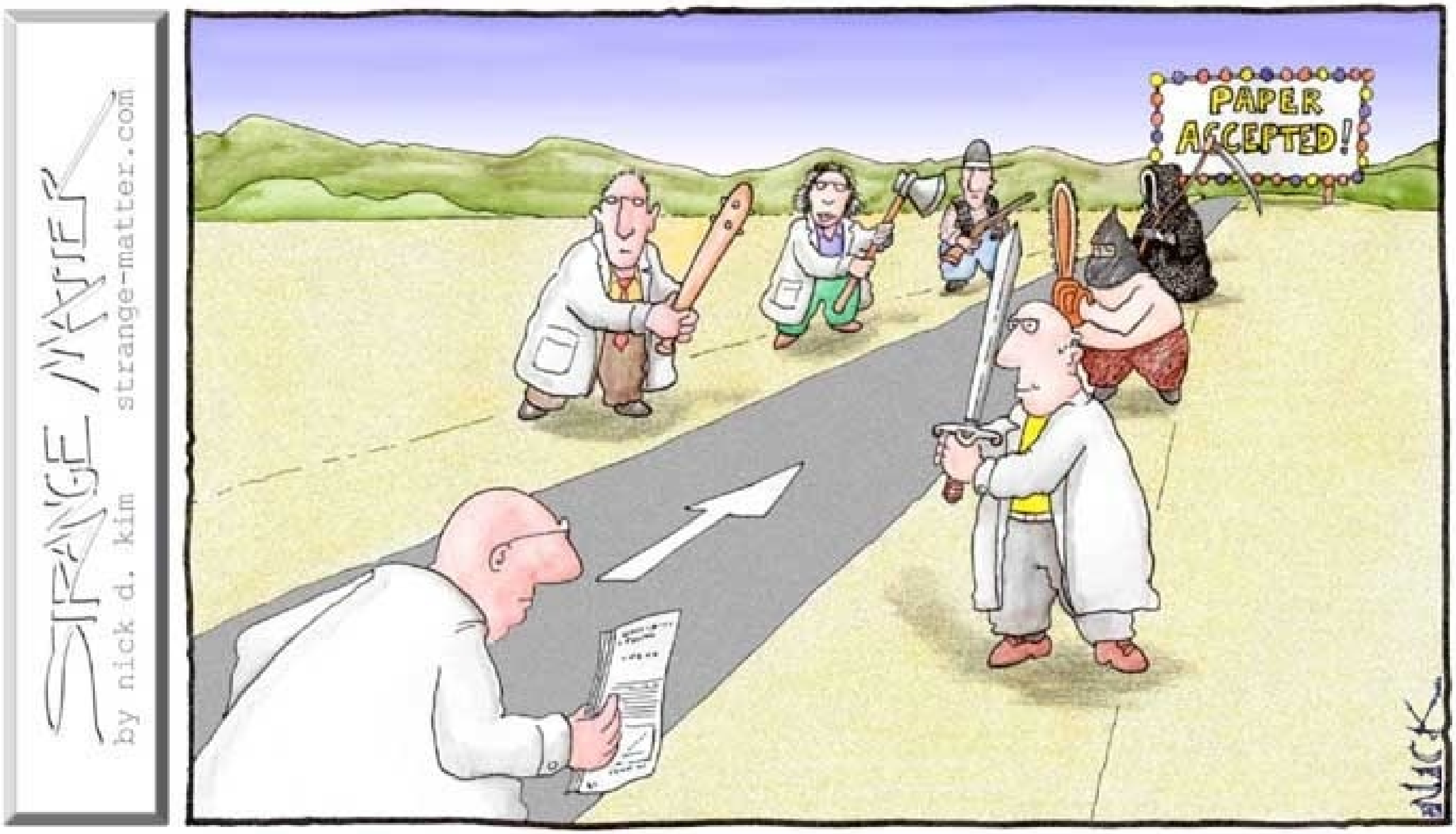
- Manuscript submission *(journal format etc.)*
- Review by peers + comments *(several months!)*
- Revisions *(long time after original writing)*
- Rebuttal letter *(point-by-point response to review comments)*
- Re-review *(examination of your revisions)*
- Acceptance/rejection

The concept of peer review

- Peer-review is performed by knowledgeable scientists who are not directly involved with the research being evaluated (and have no conflict of interest)
- Reviewers are often scientific competitors!
- To remove any bias from the review process, many manuscripts (*articles prior to publication*) are independently evaluated by 3 reviewers
- Reviewers consider: the validity of research approach, significance and originality of the findings, interest and timeliness to the scientific community, and manuscript clarity
- Reviewers then provide written feedback on the manuscript
- Journal editors rely on peer-review feedback to guide their publication decisions; authors use reviewers' comments to refine their manuscript

http://www.visionlearning.com/library/module_viewer.php?mid=123

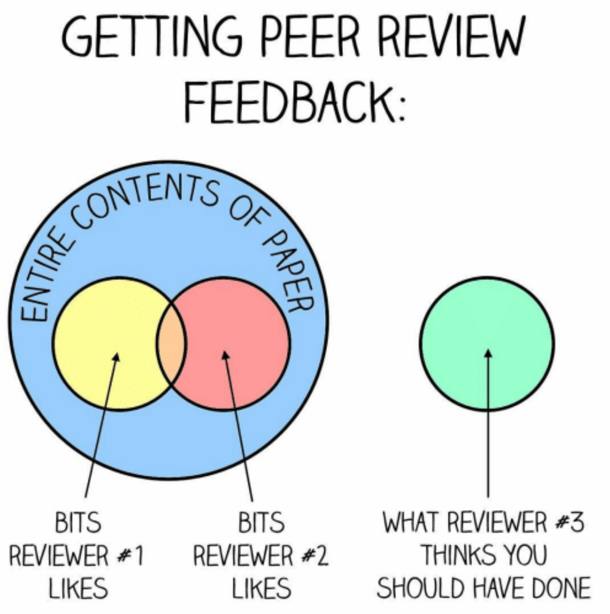
Publish or perish trying to…



Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'

Benefiting from review comments

- Read every criticism as a positive suggestion for something you could explain more clearly
- DO NOT respond “you stupid person, I meant X”
- Fix the paper so “X” is apparent even to the “stupidest” reader
- Thank reviewers warmly – they have given up their time for you



It's always reviewer 3.

The review process

Publishers Roulette

How to Beat the Odds

By Christopher Edwards

Abstract

Scientists who want to improve their publication records should consider reevaluating how and where to submit their articles. Developing a publishing strategy may help them to publish more quickly and reduce the number of negative reviews. Here are some steps that can help scientists to clarify their goals, learn from previous reviews, and more effectively convince editors to publish their work.

How to choose a scientific journal?

- The primary criterion is topic and scope of the journal
- Standing of the journal – impact factor, citation
- The readership of the journal – could you influence?
  would they have an impact on your career?
- The review process – fast? slow? transparent?
- Open access (*is very important by EU and SNF*) and publication costs
- Diversity and reaching new target audiences (*less so with Google*)

A bit of grammar - paragraph (1)

Paragraph structure

Topic sentence

Supporting sentences

Connecting (concluding) sentence

All paragraphs begin with a topic sentence, which is a concise statement of what the paragraph is all about. The idea of the topic sentence is supported by the sentences which follow. All of the supporting sentences should relate to the topic, and if not then they should be deleted. The last sentence should conclude the paragraph, and allow it to flow logically into the next paragraph.

The paragraph which follows should be related to the previous one, and its topic sentence should follow logically from the concluding sentence before it. If it does not flow logically, then there are two possibilities. Either the concluding sentence was poor, or the paragraph was out of context. One or the other will have to be rewritten.

A bit of grammar – paragraph (2)

Algae are a *diverse* group of simple plants. They show a diversity of forms, ranging from simple unicells, through colonies and filaments, to complex parenchymatous forms. Being polyphyletic, they also show diversity in their evolutionary lineages. Algae occur in a wide variety of environments, ranging from fresh water to marine and hypersaline habitats, as well as habitats as diverse as swimming pools, polar bear fur, arctic sea ice, and the human body. A diverse assortment of characters is used in their classification.

Some of the features used in algal classification have considerable controversy surrounding their acceptability…..

A bit of grammar – sentences (3)

- **Sentences should:**
  - Contain no more than one idea
  - Usually no more than one subordinate idea
  - Be simple
  - Never stray from the topic
  - Be connected and flow logically from one to the other (the paragraph rule)
  - Not contain filler words or unnecessary jargon
  - Not contain redundancy
  - Be properly punctuated

A bit of grammar – sentences (4)

- **One main idea:**
  - The dog is a rather strange mammal and my cat has soft fur.
  - **The dog is a rather strange mammal.**

- **One subordinate idea:**
  - The dog is a rather a strange mammal, my cat hates all dogs as do most cats, and dogs have peculiar relationships with people.
  - **The dog is rather a strange mammal, and it has peculiar relationships with people.**

A bit of grammar – sentences (5)

- **Very simple:**
  - The biota exhibited a 100% mortality response to the addition of high levels of the lethal pesticide.
  - **High levels of pesticide killed all organisms.**
- **Punctuated:**
  - That that is is that that is not is not
  - **That that is, is. That that is not, is not.**
- **No filler words:**

In order to	to
In the direction of	towards
At the present time	now
A considerable amount of	much
Accounted for by the fact that	because

Spellchecking

© *The Journal of Irreproducible Results*, vol. 39, #1,
January/February 1994, page 13, and vol. 45, # 5-6, 2000,

Candidate for a Pullet Surprise
Jerrold H. Zar

I have a spelling checker,
It came with my PC.
It plane lee marks four my revue
Miss steaks aye can knot sea.

Eye ran this poem threw it,
Your sure reel glad two no.
Its vary polished in it's weigh.
My checker tolled me sew.

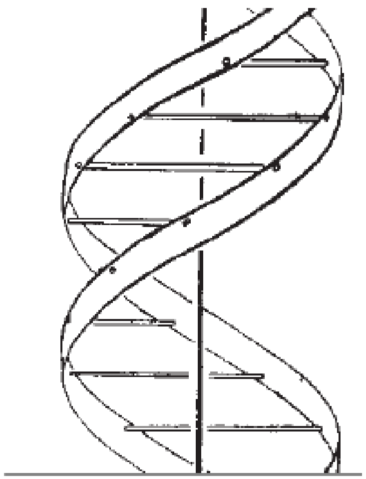
A checker is a bless sing,
It freeze yew lodes of thyme.
It helps me right awl stiles two reed,
And aides me when eye rime……

Example - *concise writing of great ideas*

MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.



We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate di-ester groups joining β-D-deoxy-ribofuranose residues with 3′,5′

738 NATURE April 25, 1953 VOL. 171

King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. WATSON
F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory, Cambridge.

April 2.

Exercise – write an outline

Individual: write a detailed outline (one page max) for a hypothetical research paper

Topics for paper outline:

- *Biofuel production in the tropics – A review*
- *The hydrologic cycle in the Alps – A review*
- *Global warming and methane emissions from permafrost soil*

You can't learn a lot about writing just by reading about how to do it - you must practice