Biological Scientific Writing (BIOL 825)

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Course Webpage

Lecture Notes -- Scientific Writing and Grammar

Also read and refer to the textbook by Robert A. Day and Nancy Sakaduski. 2011. *Scientific English: A Guide for Scientists and Other Professionals*, 3rd edition.

Research

- In research, do not set out to prove something; keep an open mind.
- Research should be designed to test, document, or describe.
 - *WRONG*: The purpose of this experiment was to demonstrate that fathead minnows from saline streams have a higher tolerance for dissolved chlorides than fathead minnows from non-saline streams.
 - *CORRECT*: The purpose of this experiment was <u>to determine whether</u> fathead minnows from saline streams have a higher tolerance for dissolved chlorides than fathead minnows from non-saline streams.
- Integrity is essential in all aspects of science, including presentation of your results.

Scientific Writing versus Literary Writing

- Be clear and be concise (without sacrificing clarity).
- Use simple, straightforward words, sentences, and paragraphs not 'prose'.
- The purpose of scientific writing is to record (to document) research...
 - o ...to inform peers (some of whom do not speak English as their first language), and
 - o to educate subsequent generations.
- Present your research in a way that your target audience will understand it.
 - o Your audience influences the presentation of the content.
 - It usually would be inappropriate (and ineffective) to use the same written summary (or oral presentation) of your research for a group of specialists in your field and for the general public.

Importance of 'Good' Writing

- You will be judged both on the content and the quality of all of your writing: CV, letters, e-mails, funding proposals, manuscripts, and reviews.
- How do you become a good writer?
 - o Read! Good writers (in any field of study, not just biology) also read extensively.
 - o Always think about what you are writing, whether it is a manuscript or an e-mail.
 - Learn from your mistakes, do not simply correct them. Ask colleagues to critique your writing, and submit your manuscripts or proposals for formal peer review.
 - Review the writing of others, whether it is informal reviews for colleagues or professional reviews for a journal.

English

- English is a complex language, which enhances its power to communicate subtle concepts.
- The complexity of the language also makes it easy to misuse (aka, 'the danger of the thesaurus').
 - For example, it is not good practice to use many synonyms to refer to a single entity: "A recent *book* on diatom systematics would be a valuable resource. A well-written *volume* would include updated names of taxa from North America. In addition, the relationships among higher taxa should be outlined in a thorough *tome*. Unfortunately, the cost of *compendiums* with specialized audiences is high."

'Book' would be fine for all of the terms above highlighted in italics.

 An unfortunately widespread example of mistaken synonyms: the word 'may' is now often used as a synonym of both 'might' and 'can'; however, in US English

'may' implies permission — "You <u>may</u> use me as a reference."
'might' refers to an undocumented possibility — "It <u>might</u> rain tomorrow."
'can' refers to a documented ability — "Fish <u>can</u> swim."
[Note: In British English, the meanings of 'may' and 'might' are reversed.]

In any written documents that you *might* want me to critique, you *may* use 'may' as a synonym for either 'might' or 'can' when pigs *can* fly.

'Rules' of Grammar

Actually, there are no rules, only styles of writing.

• Agreement of subject and verb (use common sense).

Dick runs. [singular] Dick and Jane run. [plural]

A bunch of grapes <u>is</u> on the table. [Grapes are connected in a single bunch (singular noun).] A bunch of apples <u>are</u> on the table. [Apples typically are individual fruits (plural context).]

A series of experiments <u>was</u> performed. [Series is a single unit (singular noun).]
A number of experiments <u>were</u> performed. [Number represents multiple (plural context).]

One hour later, 3 mL of reagent <u>was</u> added to the solution. [3 mL added as a single volume.] One hour later, we added 3 mL of reagent to the solution. [Active voice is better. '3 mL' becomes the direct object rather than the subject.]

A total of four Arkansas darters (was, were) collected in this reach of the river. We collected four Arkansas darters in this reach of the river. [Active voice is still better.]

The data <u>are</u> incomplete. [Datum is singular form.]

We detected only one species of bacterium in our samples. [Bacteria is the plural term.]

We sampled for the species in our study site, but none (was, were) collected.

• Syntax (word order) is important. Place modifiers as close as possible to the words or phrases they modify. More on this later.

Mary saw a triggerfish snorkeling in Hawai'i. [Triggerfish do not snorkel; they have gills.]

WORDS

Nouns

- Individual(s), place(s), object(s), or idea(s).
- Subject or object of sentence (usually).
- Proper nouns and common nouns.

Formalin [proprietary name is capitalized]: similar to Crescent wrench (i.e., adjustable wrench) and Kleenex (i.e., facial tissue)

Formaldehyde (gas) is not a proprietary name: formaldehyde solution [not capitalized]

• Collective nouns represent a <u>countable</u> group or collection (e.g., total, number).

A number of test tubes are on the table.

The <u>number</u> of test tubes on the table <u>is</u> four.

Mass nouns represent an uncountable unit.

Amount = measurable but not countable. [Number = countable]

WRONG: The amount of students in class is five.

RIGHT: The number of students in class is five.

Pronouns

- Pronouns replace nouns (nouns = antecedents).
- Clarity and meaning are improved if the pronoun is near its antecedent.

It is all right to give raw milk to your baby, but first boil it.

Typically it is best to not use pronouns more than one sentence after the sentence with the antecedent noun; however, context is your best guide.

• Difference between 'its' and 'it's'.

A dog knows its master. [Possessive 'its' has no apostrophe.]

A dog knows <u>it's</u> master. [Contraction for 'it is' has apostrophe.]

Verbs

- Describe the subject or convey action.
- Nominalizations: turning verbs into nouns (often have '-tion' or '-ment' or similar endings).

<u>Installation</u> of the computer can be performed in three days.

<u>Development</u> of the project took three days.

Nominalizations are 'smothered verbs'.

It is better to 'activate' these verbs (make sentences clearer, more concise, and easier to read).

We can <u>install</u> the computer in three days.

We <u>developed</u> the project in three days.

• Overworked verbs: improving your 'verb-al' skills.

'Found' is probably the most overworked verb in scientific writing, and it deserves a rest. Consider:

- 1) Smith and Jones (2006) <u>found</u> significantly more pine seedlings in burned areas than in unburned areas.
- 2) Smith and Jones (2006) found ponderosa pines along the ridges.
- 3) Smith and Jones (2006) found the samples missing in the lab since 1996.

In these examples, Smith and Jones 'found' 1) a relationship in their statistics, 2) the occurrence of a species on the landscape, and, perhaps most appropriately, 3) the whereabouts of lost samples. The first 2 sentences could be improved with more descriptive verbs appropriate to their context. For example:

- 1) Smith and Jones (2006) <u>reported</u> significantly more pine seedlings in burned areas than in unburned areas.
- 2) Smith and Jones (2006) observed ponderosa pines along the ridges.

One caution about choosing your verbs. Choose the best verb and stick with it in each context. Do not lose control and have your writing mimic a sportscaster on the evening news reading a list of scores: "Kansas City trounced New York, Chicago destroyed Miami, Portland squeaked by Denver, …"

In a world where 'carbohydrates' have become 'carbs', why do people prefer the word 'utilize' to the word 'use'? Save your syllables for a more important word.

Females with young utilized riparian areas.

Females with young <u>used</u> riparian areas. [BETTER]

Modifiers: Adjectives and Adverbs

• Adjectives modify a noun or pronoun.

A red apple.

Adverbs modify verbs, adjectives, or other adverbs.

He proceeded slowly.

He moved very slowly.

[NOTE: avoid 'very', 'quite', 'rather', and similarly vague adverbs in scientific writing.]

Place adjectives and adverbs as close as possible to the word they modify.

Articles: a and an (indefinite articles), the (definite article)

• Their purpose is to identify nouns, but remove them if clarity is not impaired.

Plan moves slowly. ['plan' and 'moves' can be nouns or verbs — two meanings possible] <u>The plan</u> moves slowly. [plan is identified as the noun; moves is the verb] Plan the moves slowly. [plan is the verb; moves is identified as the noun]

- 'A' and 'an' are used in the singular; 'the' is used in either singular or plural.
 - ... the river. (singular; definite article refers to a specific river)
 - ... the rivers. (plural; definite article refers to a specific group of rivers)
 - ... a river. (singular, as is 'an'; indefinite article refers to rivers in general)
- In current English usage, it is most logical to use 'a' before a consonant sound and 'an' before a vowel sound, although you will still see traditional uses, such as 'an historical note'.
 - ... a Master of Science degree.
 - ... an M.S. degree. [an 'em']
 - ... a Ph.D. [a 'pee']

It is an honor. ['h' is not pronounced so the word begins with a vowel sound]

It is a hotel. ['h' is pronounced so the word begins with a consonant sound]

<u>A useful</u>, consistent rule of grammar would be <u>an unexpected</u> revelation. ['yuseful'; 'y' is a consonant sound]

A cell with a nuclear membrane is referred to as a eukaryotic cell. ['yu' is a consonant sound]

Conjunctions: connect words, phrases, or sentence clauses

- Coordinating conjunctions connect equal parts. There are seven: and, but, or, nor, for, yet, so.
 - We compared our data sets with a t-test, but none of the differences was significant.
- Subordinating conjunctions connect unequal parts, with one part 'dependent' on the other. Among these are: because*, since*, if, when, although, before, after, *etc*.

We observed an additional individual <u>after</u> the sample period had ended. After the sample period had ended, we observed an additional individual.

- * 'Since' indicates a time relationship. Do not use 'since' as a replacement for 'because'.
- Coordinating adverbs connect equal parts: however, therefore, consequently, *etc*. They are preceded by semicolon and followed by comma within a sentence (see 'Clauses' below).

Prepositions

- Combine with nouns and pronouns to form phrases that usually express direction or location. to, in, on, under, of, *etc*.
- Preposition should be placed as close as possible to the word it modifies.

For sale, car owned by lady with dent in rear.

• Do not double prepositions.

NOT GOOD: Many animals lived inside of the national park.

BETTER: Many animals lived <u>inside</u> the national park.

NOT GOOD: Three <u>out of</u> the 10 samples were significantly higher than the control.

BETTER: Three of the 10 samples were significantly higher than the control.

• Do not use a preposition to link an adjective to the rest of the sentence.

NOT GOOD: She is too good of a person to complain.

BETTER: She is too good a person to complain.

• Avoid ending a sentence with a preposition.

NOT GOOD: Biology was what he took his degree <u>in</u>.

BETTER: He took his degree in biology.

NOT GOOD: Where are you at?

BETTER: Where are you?

• Avoid superfluous prepositions.

NOT GOOD: In lab, we had to key out preserved specimens.

BETTER: In lab, we had to key preserved specimens.

Prefixes and Suffixes

• Prefixes usually change the meaning of a word.

antibacterial, undeveloped

• Suffixes change the status of a word.

populate to population (verb to noun)

• Not separated from root word by a hyphen unless repeated letters could create confusion.

anti-insect, camel-like

PHRASES, CLAUSES, and SENTENCES

Keep phrases as close as possible to the words or phrases they modify.

Prepositional Phrases

- Begin with a preposition.
- Serve as adjectives or adverbs keep them close to the word they modify.

NOT GOOD: Substantial literature <u>has accumulated</u> on the cell walls of staphylococci. *BETTER*: <u>Substantial literature</u> about the cell walls of staphylococci has accumulated.

• Prepositional phrases can be used to avoid stacked modifiers (prepositions *highlighted*).

NOT GOOD: We searched *for* the Arkansas darter *in* small, clear, cool, vegetated, perennial streams.

BETTER: We searched for the Arkansas darter in small, perennial streams with clear, cool water and vegetation.

Infinitive Phrases

- Consist of 'to' with a verb.
- Split infinitives (some people avoid them, but they can benefit clarity and flow; use no more than one word to split your infinitive).

The treatment failed <u>to delay</u> further signs of infection. ['further' refers to 'signs'] The treatment failed <u>to</u> further <u>delay</u> signs of infection. ['further' refers to 'delay']

Participial Phrases

- Participle = '-ing' verb used as an adjective.
- Dangling participles (no noun to modify or the noun is not closest to the participle).

NOT GOOD: Lying on top of the intestine, *you* can perhaps see a thin, transparent thread. [refers to 'you']

BETTER: You can perhaps see a thin, transparent <u>thread lying on top of the intestine</u>. [refers to 'thread']

Gerund Phrases

• Gerund = '-ing' verb used as a noun.

Writing is difficult. [used as subject]
I enjoyed writing my thesis. [used as object]

Independent and Dependent Clauses

• Independent clause is a portion of a sentence that could stand alone as a sentence.

No amount of experimentation can prove me right; a simple experiment may at any time prove me wrong. [Albert Einstein]

I tried to find my way out of the forest; <u>however</u>, I became hopelessly lost. ['however' connected by semicolon and comma]

I tried to find my way out of the forest, <u>but</u> I became hopelessly lost. ['but' connected by comma]

• Dependent clause is introduced by subordinating word (if, when, whether, after, before, etc.).

We will all go together when we go. [no comma for clause at the end of a sentence]

When we go, we will all go together. [comma following introductory clause]

A cynic is a man who, when he smells the flowers, looks around for a coffin. [H. L. Mencken] [commas separate embedded clauses]

• Restrictive dependent clauses (that) and nonrestrictive dependent clauses (which and who).

My car was the only one in the accident that was not wrecked. [no commas with 'that']

'My car was the only one in the accident' does not have the same meaning — the restrictive clause is essential.

My car was not wrecked, which is fortunate. [use comma(s) with 'which']

The phrase 'which is fortunate' is not essential to the core meaning of the sentence — a nonrestrictive clause.

Alkaloids that contain nitrogen can be poisonous. [refers only to alkaloids with nitrogen, not other alkaloids]

Alkaloids, which contain nitrogen, can be poisonous. [implies that all alkaloids contain nitrogen]

Parallelism

• Words and phrases in sentences and paragraphs should be parallel.

First, ... Secondly, ... should be First, ... Second,

Pines are tall, slender, and have flexibility. should be

Pines are tall, slender, and flexible.

Sentences

- Use declarative sentences; avoid questions and exclamations in scientific writing.
- Transitional sentences help to connect paragraphs and maintain flow.

In addition, ... Smith (1990) obtained similar results ...

Although ... Thus, ... Consequently, ...

- Place items at end of sentence that you want to emphasize.
- Mix sentence lengths.

VOICE, PERSON, and TENSE

Active and Passive Voices

• Active voice emphasizes subject; passive voice emphasizes action.

If the subject of a sentence is the 'doer' of the action, then the sentence is in active voice. If the subject of a sentence is the 'recipient' of the action, then the sentence is in passive voice.

<u>Selman Waksman</u> <u>discovered</u> streptomycin, the first effective cure for tuberculosis. [active voice]

<u>Streptomycin</u>, the first effective cure for tuberculosis, <u>was discovered</u> by <u>Selman</u> Waksman. [passive voice]

- Active voice is generally more concise.
- Some journals 'require' active or passive voice, but a mix dominated by active voice is usually appropriate.

Person

• First person was formerly considered egotistical but is now typically preferred.

<u>We collected</u> 30 species of fish. [first person, active voice] Thirty species of fish were collected. [passive voice]

Tense

- Use of present tense and past tense in scientific writing.
 - Established knowledge: present tense

Thirty species of fish occur in Big Creek.

Description of methods and results: past tense

We collected 30 species of fish in Big Creek.

o Presentation: present tense

Table 1 lists the 30 species of fish in Big Creek.

Attribution: past tense

Eberle et al. (1986) <u>reported</u> that 30 species of fish <u>occurred</u> [might no longer occur] in Big Creek.

• Future tense.

The rainy season will commence in October.

Perfect tenses.

Eberle et al. (1986) <u>had</u> reported 30 species of fish in Big Creek. [limit your use of perfect tense in scientific writing]

ABBREVIATIONS, JARGON, PROBLEM WORDS

Abbreviations and Acronyms

Abbreviations.

DNA mL HCl

'sp.' refers to a single species ('Lepomis sp.')

'spp.' refers to two or more species ('Lepomis spp.')

Notice that, in neither instance, is the 'sp.' or 'spp.' italicized.

Quivira National Wildlife Refuge (Quivira NWR)

Latin abbreviations are falling out of favor, but are still widely used in scientific writing. e.g. = $exempli\ gratia$ (for example) et al. = $et\ alia$ (and others) i.e. = $id\ est$ (that is)

Acronyms: abbreviations that become words.

SWAN (Southwestern Association of Naturalists)

• *Opinion* (= class rule): Abbreviations and acronyms can be useful when space is limited (e.g., in figures and tables), but they are sometimes overused to the point of being rude to readers. Government documents are especially rude in this context to the point of being unintelligible to intelligent people outside the government or specific agency. Thus, overuse of nonstandard abbreviations is elitist, lazy, and contrary to the purpose of scientific writing to inform others. In general, use of abbreviations and acronyms whose meanings are widely accepted and understood without definition are appropriate (e.g., DNA, mL). Otherwise, strive to be kind to your readers and limit the use of abbreviations and acronyms or at least try to limit them to broader subjects (e.g., Quivira National Wildlife Refuge should be Quivira NWR rather than ONWR).

Unnecessary Words [see Day and Sakaduski (2011: Appendix 3)]

• Be concise.

complimentary free gift past history

• Unnecessary words and phrases frequently used in scientific manuscripts.

three different species (As opposed to 'three same species'?)

in order to sample

time period or period of time (It will be clear from the context that you are referring to time rather than punctuation.)

was located in (It will be clear from the context that you are referring to a location.)

 Necessary words that should always be used in scientific manuscripts — complete standard common names.

largemouth bass ('largemouths' could refer to talkshow hosts.) bighorn sheep ('bighorns' could refer to a mountain range in Wyoming.)

Problem Words and Phrases [see Day and Sakaduski (2011: Appendix 2)]

Sex, in biology, refers to anatomical features and their role in reproduction. Gender refers additionally to behavior.

Always use *male* and *female*, not vernacular names, such as bucks, does, etc. ('Does' could be a noun or a verb, which makes its use confusing.)

PUNCTUATION

Commas

• Separate independent clauses that have a conjunction.

The species was abundant in clear streams, and it was absent from turbid streams. The species was abundant in clear streams and was absent from turbid streams.

• Separate introductory words, phrases, or clauses. Sometimes omitted after single words or short phrases, but it is better to get in the habit of using the comma (removes any doubt).

On our trip down the coast, we saw four species of seals and sea lions.

Yesterday, we saw four species of seals and sea lions.

Yesterday we saw four species of seals and sea lions.

• Separate interrupting words and phrases (parenthetical or balancing commas).

Biology, <u>like many subjects</u>, requires much study. ['like many subjects' is a parenthetical phrase not necessary to understand the sentence]

Data like these should be omitted. ['like these' is essential to sentence]

A single comma should never separate a subject from its verb in a sentence.

Biology, like many subjects requires much study.

• Separate three or more 'equal' words or phrases, including the one following the conjunction.

NOT GOOD: He had a large head, thick chest holding a strong heart and big feet. *BETTER*: He had a large head, thick chest holding a strong heart, and big feet.

• Separate two or more unrelated modifiers (if you insert 'and', does it still make sense?).

There was a clear, moonless sky. ["...clear <u>and</u> moonless sky." Comma replaces 'and'.] Overhead was a dark blue sky. ["Overhead was a dark and blue sky."]

• Separate smaller units from larger units.

We live in Hays, Ellis County, Kansas. [Commas replace prepositions, such as 'in': ... Hays *in* Ellis County *in* Kansas.]

October 1, 1999 (comma inserted because units are not in a hierarchical sequence) 1 October 1999 (no commas; units in sequence from shortest to longest; preferred scientific style]

October 1999 (no comma)

• Separate groups of three digits to the left of the decimal in numbers.

1,000 10,000 100,000

Some journals (especially in Europe) use a space in place of the comma.

100 000

Semicolons

• Separate independent clauses.

Chloride levels in Little Salt Marsh ranged from 700 to 1,200 mg/L; however, chloride levels in Big Salt Marsh were between 2,000 and 2,800 mg/L.

Colons

• Used to introduce a word, phrase, clause, or sentence.

There was only one appropriate choice: repeat the experiment.

• Used to separate a title from a subtitle.

Scientific English: A Guide for Scientists and Other Professionals.

Periods

• Periods and Abbreviations.

DNA mL HCl [no periods]
M. E. Eberle or ME Eberle U.S.A. or USA ["it depends"]

• Periods separate numbers on the left and on the right of a decimal.

27.6°C P < 0.05 (there is always a number left of the decimal, even if only a '0')

• Used as a leader in Tables of Contents and similar lists.

Ellipsis

Three periods in a sequence ('...') used within a quote when part of the sentence is omitted. Can be used at the start or end of a truncated sentence or within a sentence.

"A woman drove me to drink, and I never even had the courtesy to thank her." W. C. Fields "A woman drove me to drink, and I never ... had the courtesy to thank her." W. C. Fields

Apostrophes

Avoid them in scientific writing, especially in contractions.

NOT GOOD: Eberle's (1999) results ... We can't ... 1990's GTA's BETTER: The results of Eberle (1999) ... We cannot ... 1990s GTAs TROUBLESOME: the letters A, I, and U (As and A's)

• One of the most troublesome uses (non-uses) of an apostrophe is with the word 'species' when used in a possessive context.

For example, 'the species distribution' and similar phrases are commonly used in scientific writing with no apostrophe. These phrases are incorrect.

'Its' is the only word accorded this special apostrophe-free status in the possessive form.

If you wrote 'the plant's distribution', an apostrophe clearly would be needed to indicate 'possession'.

The best solution is to develop the habit of using the prepositional phrase: 'the distribution of the species' *etc*.

Hyphens

The tendency is for words to lose hyphens through time (e.g., co-operation becomes cooperation).

• Used to link two or more words (adjectives) that jointly modify the noun that follows.

We used seines with a <u>6-mm</u> mesh. ['6' and 'mm' jointly modify 'mesh'; hyphen] The mesh of our seines was <u>6 mm</u>. [no hyphen]

• Used to combine the parts of compound words (e.g., common names of some species).

Some names are hyphenated or combined because they were borrowed from other taxa.

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<u>Incense-cedar</u> (Calocedrus decurrens) is hyphenated, but western <u>redcedar</u> (Thuja plicata) is not; neither species is a 'true' cedar (Cedrus sp.).
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Greater <u>prairie-chicken</u> (*Tympanuchus cupido*) and lesser <u>prairie-chicken</u> (*T. pallidicinctus*) are grouses rather than chickens.

Common names of vertebrates might have hyphens in compound names.

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<u>Black-crowned night-heron</u> (Nycticorax nycticorax)
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Black-tailed prairie dog (Cynomys ludovicianus)

However, for some common names, the two words have been combined without a hyphen.

<u>Roughskin</u> newt (*Taricha granulosa*) is used rather than <u>rough-skinned</u> newt. Bighorn sheep (*Ovis canadensis*) is used rather than big-horned sheep.

• Used to separate prefixes from proper nouns or numbers.

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pre-Sputnik pre-1990
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• Now infrequently used to separate suffixes from root words.

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ball-like (would have 3 consecutive Ls)
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• Hyphenated words with a common base word and different prefixes listed in a series.

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... inter- and intra-specific competition ... or ... inter- and intraspecific competition ... surface- and ground-water features ... or ... surface- and groundwater features ...
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Alternatively, you could choose to avoid language laziness and write:

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... interspecific and intraspecific competition ... ... surface-water and groundwater features ...
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• Use common-sense. Does the hyphen improve clarity?

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an <u>old-house</u> owner [house is old] recreation: what you do to relax an old <u>house-owner</u> [owner is old] re-creation: something created again
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En-dash and em-dash

The en-dash is longer than a hyphen and shorter than an em-dash.

The names are derived from the relative widths of the letters 'n' and 'm'.

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hyphen: - en-dash: — em-dash: —
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The en-dash is often used to separate a range of numbers (e.g., page numbers, 25–27°C).

The em-dash is used occasionally in place of parentheses or parenthetical commas.