Chemical Information: Conception and Prenatal Care*

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Chemical information originates in the minds of chemists and chemical engineers working in a laboratory or pilot plant, in the field, library or factory. Or, perhaps, the information is not being actively sought and may originate as a spontaneous idea while on the job or sitting in a duck blind or fishing on the river bank.

Here is a starting point in the system of steps which we call "Chemical Documentation," the process by which this basic raw material—chemical information—is purified, processed, packaged and distributed.

This paper is concerned with the starting point just mentioned, the chemist's preliminary activities, physical and mental. Some techniques facilitate his reception of ideas. Some techniques enhance the utility of his new information and permit its survival so it can go through the subsequent documentary steps and eventually become a useful commodity.

Figure 1 shows a tabulation of some of the topics which are significant. Obviously, they cannot be discussed exhaustively in an article of this length. I emphasize that it is a tabulation, not an outline or classification. There is no order of logic or relative importance. A moment's reflection will reveal that each separate topic is intimately related with each of the others. The order in which they are discussed is necessarily arbitrary.

INFORMATION	ORIGINAL NOTES
Things	Purpose
Events	Mechanics
Abstractions	Physical form
Relationships	Mental processes and activity
LEARNING, RECEIVING COMMUNICATIONS	ABSTRACTING (MENTAL PROCESS)
Asking	Concepts
Observing	recognize
Reading	designate
Listening	analyze or synthesize
Discussing	

Receiving Communications.—Much has been said and written about the need for better communication. We must tune the transmitter to the wave length of the receiver, and so on, all of which is indisputable. Now, I want to talk about the other side. I want to emphasize that we, the receivers, also have responsibilities. Let's explore the means we can use to get the most out of the communications we now have. Furthermore, I think that communication never can be perfect in the sense that we can fully understand and use the information communicated, without any mental or physical effort on our part.

We can't always wait for the appropriate communication to come along. We have to keep *asking*.

We should know something about semantics, human behavior and the workings of the human mind in general, our own as well as others. We should be on the lookout for vague and abstract words and emotion laden words, words that mean different things to different people. We should try to "back-wash" our own mental and emotional filters so as not to filter out or color the meaning intended by the writer or speaker. In this area the minimum requirement is constant vigilance and keen awareness of the difference between "reports" and "judgments."[1-10]

Observing.—The origin of chemical information, mentioned at the beginning of this talk, is observation. Experimenting and observing consist of asking questions and trying to interpret the answers. These arts have been discussed so eloquently for so many years[11] that little more need be said here than to urge their study and to emphasize especially the art of observing. Here we are trying to receive communications which The Sender has not tried to make easy for the receivers.

The art of experimenting is less important than the art of observing. Sometimes when we set up experiments for "unbiased" observation, the conditions we choose to vary are unavoidably an expression of preconceived bias. When we don't know the answers, we can't always ask intelligent questions. However, one will always observe *something* even with a poorly designed experiment if one has developed the well known necessary mental attributes, such as appropriate intellectual background, burning interest, and above all, intense and avid attention. In this area, even if we ask a stupid question, we'll get an intelligent—not necessarily intelligible—answer.

Not that I recommend it as a way of life, but sometimes it pays to make mistakes, to spill something and be untidy. One time I neglected to clean up and dispose of an experiment which had been closed. Months later, when I needed bench space, I *had* to clean up. Before throwing out the old experiment, I looked it over. I recalled that one of the materials was found to have a certain undesirable effect when the experiment was "closed." Now I noticed that experimental inks containing this material had a striking effect in inhibiting the aging and hardening of soft rubber fountain pen reservoir sacs. This could be perceived only after long standing. "Time" was a significant variable, which I had "chosen" only accidentally.

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Such "accidental" observations happen to all of us of course, but infrequently. All we can do is be prepared to take advantage of them when they come. Our daily bread and butter depends on our daily, planned experiments and observations. In order for all of these small daily bits of information to become most useful, they must be accumulated in an orderly manner for later correlation and use. For this reason, effective note taking is essential.

Note Taking: Original Observations and Ideas.—The most fundamental of all scientific records are the *original* notes written by the observer. Observations and measurements should be set down *at once*, with date, in their *initial* and most primitive form, without waiting for recalculation or transformation. Otherwise, the validity of the reasoning and calculations is lost. Such notes, especially numerical data, should be entered in the notebook or other permanent record *initially* and not copied from scraps of paper. Copying courts errors.

Notes on observations should be as complete as possible, little if anything left to the memory. It is desirable to write complete sentences and use only standard symbols and abbreviations. Telegraphic jottings and indiscriminate abbreviating may result in ambiguity. However, it should be remembered that such notes are the only scientific records not written for reading by others. They serve their minimum purpose if they are intelligible only to the writer.

Graphs and sketches should be drawn or pasted in notebooks. Apparatus and machinery used should be described or indicated by naming manufacturer, type, size or number. Illustrations too large for the notebook should be filed systematically and cross-referenced in the notebook. Similarly, for chemicals and other materials used, the source, grade, lot or other identification should be recorded.

When making accurate measurements, one should examine for oneself the sequence of steps by which the calibration of the measuring instrument is referred back to a primary standard and the corrections should be recorded.

Audible and Pictorial "Notes."—Tape recorders and dictating machines have been recommended for recording all sorts of observations, especially observations of a rapidly changing phenomenon and instrument readings. A portable recorder is useful for taking down observations and interviews on plant and field trips.

Especially useful are photographs to show progressive results of tests, before and after effects, construction progress, and to record wiring, piping and other details which later will be obscured or buried, and to serve as pictorial "notes" on plant and field trips.

Facility in free-hand sketching is an aid to clarity in graphical note taking. Courses of instruction have been offered and books are available.[12-20]

Other aspects of the mechanics of record making and keeping are described in numerous publications.[21-30] Well covered are such things as size and types of notebooks, carbon and microfilm copies, filing and cross-referencing of charts, illustrations, samples and experimental batches, and special forms for routine analyses and measurements.

So far, we have been talking about original observations, measurements, ideas. Methods of note taking for other sources of information will be discussed in a later section, but for *original* observations a notebook is essential. A diary type record in a bound notebook with pre-numbered pages is recommended for general use. Such a record is essential for patent applications and litigation which may not have been anticipated when the record was made. Loose pieces of paper do not carry much weight in patent procedures. Other techniques of record keeping for patent purposes are well covered in many publications.[31-34]

Reading.—Now we'll consider how to accumulate and use information and ideas other than our own.

We can't acquire information passively. We must try to tune in on the transmitter. We have to make some mental and physical effort. A requisite for effective reading is a wide knowledge of the meaning and usage of words. This can come only from extensive reading and study. So, effective reading is an autocatalytic reaction.

Many articles, books and courses of instruction have been offered lately for teaching faster reading.[35-39] It is reported that in following the recommended techniques one gains greatly improved comprehension as well as faster reading. Perhaps one reason for the effectiveness of rapid reading is that closer attention is required, greater concentration.

When studying a subject that is new to me, I find it is helpful to read a discourse on the subject by *other* authors before rereading the first one. The sequence A-B-C-A-B-C is more effective than A-A-B-B-C-C, which is more effective than A-A-A-A-A-A.

Almost everyone "prereads" articles and books to eliminate time wasted in reading material that contains nothing we're interested in, and to find the portions that do interest us. Reading and authorship are complementary and reciprocal skills. Facility in one helps gain facility in the other. While prereading, one skilled in organization and composition will look first for the introductory orienting section. Then he will look for subdivision titles, then for topic sentences and transitional passages, and finally for summary and conclusions.

After one has decided to read the article or book, he can find information on how to read a book, as well as how to acquire effective study habits, and something about elementary psychology of learning.[21, 40-45] When studying, use not only *memory*, but strive for *understanding*. Still further, try to evaluate and correlate.

Note Taking: While Reading.—The object of this type of note taking may be to help the note taker assimilate the subject being studied, or the object may be to use the measurements, observations and ideas in one's own work, or in preparing a survey or summary. In all cases, the source of the information should be recorded.

Whatever the ultimate object, usually the first step after the notes are taken is organization, arranging the bits of information into a new and meaningful pattern. For this purpose it is usually most convenient to make the notes on uniform sized cards or slips of paper. Each reference can be on a separate card on which is written the source followed by an abstract or extracts from the reference. One might use a separate slip for each chemical compound, or material of construction, and make multiple entries, each properly identified, on each sheet. Sometimes it's convenient to use a card for each separate idea. The information can then be studied by arranging and rearranging the cards into whatever order serves the purpose.

Even though self-instruction is the only object of the

reading and study, it is recommended that notes of some sort be taken. I have read suggestions that one should underline significant passages and make brief marginal notes. I disagree, not only because that can apply only to one's own books, but for another and very fundamental reason. Actually writing down an idea, not merely copying the text, but abstracting what one reads or sees, clarifies the idea and is an adjunct to learning and clear thinking.

To assimilate an idea or concept, it is necessary to do more than passively read the text or stare at a diagram or map. The mind must take the information, reassemble it into an articulate pattern and *put out* something. The putting out must take the form of physical activity such as repeating or, preferably, resynthesizing the idea or concept in writing. The derivation of the word "Education" is significant: *E duco*, "Lead out" (not "Put in").

Holmstrom[21] says, "Few people read in the fuller sense that what they read serves to start them upon articulated chains of thought of their own. The essential adjunct of this kind of reading is the habit of taking and keeping notes in a methodical way." He says, furthermore, that notes, suitably filed, serve as aids to—not substitutes for—one's memory. They help the person who made them to pick up and pursue further a line of thought he once began and to combine this, from the point at which he left it, with convergent lines of thought from different origins.

Listening.[39, 46]—The basic principles of learning, some of which have been mentioned, must be modified to fit the one-dimensional nature of listening. We can't "prelisten" or "relisten." This means our attention and concentration must be intensified. We have to listen at a rate about one-fourth the rate at which we can think. That means we must avoid boredom and jumping to faulty conclusions ahead of the speaker. When listening, our note taking must necessarily be sketchy. We can't understand everything the speaker says if we're scribbling constantly while he's talking. Thoughtfully chosen key words and phrases will be guides and reminders when we amplify our notes as soon as possible after the talk. Sometimes the nature of the talk may be such that we can prepare a form or outline to be filled in while listening.

When you disagree, listen harder. We should try to avoid the common tendency to win arguments in the privacy of our subconscious minds, no matter what happens outside.

If you find something you hear exciting, watch out for errors of exaggeration in your understanding of it.

If you find something boring, watch out for errors of transposition. That is more dangerous than having that part of the message blotted out completely.

When you hear something familiar, don't turn your mind off with the thought, "I've heard all that before." Listen harder, look for something new to follow or a new relationship or viewpoint among the familiar. Keep tuned in on the speaker. While listening, use some of your surplus thinking speed by abstracting. Reconstruct the speaker's ideas in your own "words" or thoughts. What is the principal idea or concept, what are the relationships with subordinate and related ideas? During and after the talk, reconstruct the basic ideas in your own words, then check this for accuracy with source, if possible. This should always be done when talking and listening face-to-face with one person or only a few people. This is especially important when receiving instructions, say, for a laboratory project.

Discussing.—Here the whole can be greater than the sum of its parts. From time to time we've all had a sudden idea as a result of hearing someone say something. The idea may have seemed foreign to the remark, but we wouldn't have had the idea if we hadn't heard the remark. Then we tell our idea and maybe that will give someone else an idea he wouldn't have had otherwise. ("Chain reaction," we scientists call it. The "critical mass" hasn't been determined.)

There's another advantage of discussions. We learn also by *telling*. More than once, when telling someone about what I've been studying, I find myself thinking of new things about it I hadn't thought of before. Of course, that *always* happens when we *write*.

The rules for discussions are dictated by good sense and courtesy, mostly. One important point remains: It's futile to interrupt someone, no matter how important you think your remark is. The other fellow isn't going to hear a word you say until he's finished what he started.

Abstracting.—Don't think about "writing abstracts." Don't think of "abstract" as merely a condensation or digest of something longer. Think of the *mental process* of recognizing what is the over-all idea, and what are lesser details, and what is their relationship with the problem at hand.

I'm using "abstract" in the broad sense of including something of analysis, synthesis and organization.

We abstract every time we speak, write, read, listen or think (communicate with ourselves).

The things discussed in the preceding sections involved, essentially, recognizing and marshalling significant facts, ideas and relationships. This must be done purposefully.

We all should cultivate the abstracting talent. We should reflect on the nature of concepts, what is a unit of information. One time it may suit our purpose to consider as a unit of information, an analytical procedure described in a paper or book. Another time the central idea may be the effect of 0.4 mg. of methyl, ethyl, dipropyl stuff used in the analytical procedure. Again, "Analytical Chemistry" might be considered as only a small bit of information related to the central over-all concept.

We think in terms of concepts, we think also in an articulate fashion. We should be able to recognize concepts, and be able to designate and delineate, provide them with a handle for manipulating them into a meaningful pattern.

Now that it's time for summing up, you'll see that more has been left unsaid than was said. I have tried to emphasize the viewpoint or aspect less frequently discussed, and skim over or merely refer to the topics which are already well covered in print, merely point out their places in the scheme of things. We've been discussing, "Conception and prenatal care of chemical information."

I have emphasized "receiving," the reciprocal of the more frequently discussed "sending," and pointed out the complementary relationship between the two.

I've tried to emphasize the mental and intellectual aspects and merely make reference to source of information about the physical and mechanical aspects.

When a scientist or engineer seeks *specific* data, he can ask, and someone else can get it for him. When he seeks

ideas, he must study for himself, and read and browse far afield.

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RESEARCH: (11) "... Scientific (or Chemical or Industrial) Research"

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"Invitation to ..."	"Genius of ..."
"Art of ..."	"Practice of ..."
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