plinary biases. Anthropologists thinking about culture tend to emphasize difference, whereas cognitive psychologists thinking about thought tend to emphasize similarity. One of the charms of linguistics is that it stands at the crossroads of these two intellectual traditions, where neither emphasis can easily be ignored.

Of the human triumvirate of culture, thought, and language, language is the most accessible to rigorous intellectual study. Your tape recorder can give you an objective portrayal of what I say but not of my thoughts or my cultural understanding. If there is hope of solving the Code Talker paradox and thus achieving a more mature understanding of linguistic diversity, we will gain a useful metaphor for thinking about cultural and mental diversity as well. This could powerfully influence how we understand human nature and how we cope with life in a pluralistic world—whether we dread it, are defeated by it, or are able to relish it.

2

The Discovery of Atoms

THE KEY TO RESOLVING A PARADOX often lies in the imagination. In a paradox where some experience points to one conclusion and other experience seems to point to its opposite, what is needed is not simply more experience. Truth is not a democratic matter to be decided by simple majorities. Rather, what is needed is some new idea that can widen the space of hypotheses. Then the conflicting evidence that seemed to lead to contradictory conclusions can be seen to converge on this new possibility.

So it is with the Code Talker paradox. To do justice both to the facts that show that languages are very different from one another and those that show they are similar, we need a new concept. Linguists call their new concept the *parameter*.

Since linguistics is a relatively young and unfamiliar science, I introduce the history of the idea of a parameter by comparing linguistics to an older and more familiar discipline, namely, chemistry. Just as chemistry learned to address the paradoxical properties of physical substances and their transformations in terms of atoms, so linguistics addresses the paradoxical properties of languages in terms of parameters. We may think of parameters as the atoms of linguistic diversity.

In their subject matter, methodology, and historical development, chemistry and linguistics are not even distantly related. Chemistry is unquestionably a physical science; linguistics is generally classified as a social science or in the humanities. The two departments are almost never housed in the same building at the universities. Nor is the gap between chemistry and linguistics bridged by any of the compound fields that have become common in academia: There are no "chemolinguists" or "linguochemists" with joint appointments in both departments. What two objects of study could be more different than Navajo and nitroglycerin?

Nevertheless, there are some abstract similarities between the basic phenomena that chemistry and linguistics are concerned with. Like linguistics, the foundational paradoxes of chemistry concern the tensions between sameness and difference, between stability and change. Indeed, the root of the word *chemistry* comes from the Greek word *khēmeia,* meaning 'transmutation.' Chemistry was originally about how a substance with one set of properties (say, lead) could be changed into one with very different properties (with luck, gold). This is analogous to the question of how the Code Talkers could take a message in a language with one set of characteristics (English) and change it into a language with very different characteristics (Navajo). Chemistry is about *transmutation;* linguistics is about *translation.* At an abstract level they both encounter the same paradox: How can radically different entities yet be sufficiently alike that one may transform into another?

Thought about the chemical version of this paradox is very old, dating back to the pre-Socratic natural philosophers of ancient Greece. On the one hand, experience combined with reason told them that a pure substance left to itself would always remain pure: It could not come into existence, pass out of existence, or change its fundamental mode of existence. Pure water left undisturbed in a covered cup always remains pure water. On the other hand, they also observed that the properties of things did change over time. Wood burns, producing smoke, ashes, and flame, each of which has very different physical

characteristics from the original wood. It is unwise, for example, to build a house out of ashes, smoke, or flames. And they wrestled with the tension between these two basic observations. How could wood be so different from ashes and smoke and yet similar enough to be transformable from one to the other? This was their version of the Code Talker paradox incarnated in the physical world.

Eventually the ancient Greeks imagined a possible answer. They reasoned that most of the substances around them must be mixtures of more basic substances, which were the true elements of the universe. A basic substance such as water (they thought) truly could not change; it would be genuinely eternal and immutable within the scope of this creation. But basic substances could combine in various ratios and arrangements to form other, derived substances. The properties of a derived substance would be some kind of blend of the properties of the elements that make it up. In this way, the derived substance could be quite different from any elementary substance. This can in principle explain why so many different types of matter can arise from a limited number of basic elements (four, according to Empedocles). It also explains why most substances undergo change. Their properties change if the proportions of basic elements in them change. For example, wood is a derived substance made out of a certain amount of ashes (earth), some smoke (air), and a healthy dash of fire, with perhaps a hint of water thrown in to taste. Burning is not a fundamental change in substance but a coming apart of three basic substances that were temporarily mixed. In this way, substances with very different properties may still be considered commensurable, because they are made up of the same elementary building blocks.

Toward the end of this intellectual tradition, Democritus further realized that for this view to work, the elements themselves must come in discrete, very small pieces, which he called atoms (*átomos* means 'undivided' in Greek). Atoms must be tiny, because everyday-sized chunks of matter are always divisible. For example, wood does not contain visible pieces of ash, smoke, and fire, so the atoms must be too small to see. Water in an open glass will gradually, imperceptibly dis-

appear. If no element can come into or out of existence or change its essential nature, then this must be because tiny pieces of water fly off one at a time. Still, these basic chunks of matter could not be infinitely small, or else they couldn't combine into visible chunks. The sum 0 + 0 + 0 + . . . + 0 is 0 to infinity, and we know that there is more in the world than zero. Thus, the Greeks' best answer to the basic paradoxes of transmutation was atoms. And although they were wrong in all the details, they were right in the basic conception.

Maybe atoms can be answers in linguistics as well. Since the paradoxes of translation are partially analogous to the paradoxes of transmutation, it is reasonable to ask if they can be resolved in a similar way. Noam Chomsky, the Democritus of modern linguistics, has argued that this is the case (although without this chemical analogy in mind). Suppose languages are also composites of a finite number of more elementary factors, which Chomsky calls *parameters*. Different combinations of these parameters would yield the different languages we observe in the world. Indeed, a relatively small number of parameters might underlie the large number of possible human languages. If the parameters are also like chemical elements in that they interact with each other in complex and interesting ways, then the properties of the resulting languages might show striking variation. Chomsky writes:

> What we expect to find, then, is a highly structured theory of UG [universal grammar] based on a number of fundamental principles . . . with parameters that have to be fixed by experience. If these parameters are embedded in a theory of UG that is sufficiently rich in structure, then the languages that are determined by fixing their values one way or another will appear to be quite diverse, since the consequences of one set of choices may be very different from the consequences of another set; yet at the same time, limited evidence, just sufficient to fix the parameters of UG, will determine a grammar that may be very intricate . . . . What seems to me particularly exciting about the present period in linguistic research is that we can begin to see the glimmerings of what such a theory might be like.

On the face of it, it might seem astonishing that a language like Navajo is made up of the same basic parts as English or Japanese. But this is no more astonishing than the chemical fact that a tasty white condiment (table salt) can be made up of the same basic parts as an explosive gray metal (sodium) and a poisonous green gas (chlorine).

Such a theory can also do justice to the evidence that languages are commensurable. If Navajo and English are built from the same basic elements, with only the proportions and arrangements being different, then it is less surprising that there would be reliable algorithms for transforming one into the other. These algorithms are what the Code Talkers mastered and machine translation projects seek. Their function would be comparable to "translating" graphite into a diamond by rearranging the same chemical stuff.

The idea that all languages are combinations of a finite number of basic parameters also sheds light on the more fundamental paradox of language acquisition. If there are such things as parameters, then children can come to the task of language learning preloaded with a knowledge of these basic parameters and an ability to deduce the chemistry of their interactions. These parameters and regulating principles are what Chomsky calls "universal grammar." Children with an innate knowledge of this universal grammar would learn a language like English or Japanese or Navajo simply by establishing which of the parameters are present in that particular language and in which ratios or arrangements. Although not a trivial task, this is enormously easier than discovering linguistic structure from scratch. This can explain how children can have a big head start on the task of language learning that is equally applicable to learning English or Navajo or whatever other language their playmates happen to speak.

Finally, a theory based on parameters could explain the fact that languages also have a kind of mutability. Over time, a language like English can evolve to become grammatically more like Navajo and vice versa. (I mention specific examples in Chapters 4 and 7.) The change could happen if the parameters that define English changed one at a time until eventually they resembled the "linguistic formula" for Navajo. Since there are only a finite number of parameters and

ways of combining them, it is not astonishing that structurally similar languages should develop independently in different parts of the world, just as it is not surprising that methane should be formed independently on Jupiter and on Earth. Thus, a linguistic theory of parameters holds the promise of explaining any number of puzzles.

There is more to science than thought experiments and more to chemistry than Democritus. In the same way, there is more to linguistics than Chomsky. The best ideas must ultimately be tested against facts.

After Democritus, the next crucial contribution to chemistry came from the alchemists of the Middle Ages and the Renaissance, who were very different in temperament from the Greek natural philosophers. They thought less and did more. They didn't worry about how change was possible in principle. Instead, they strove to control change in practice so that they could make lead into gold, find the universal solvent, and live forever. They failed dramatically at these goals, but they gained practical experience with actual chemical reactions and developed the experimental procedures that eventually led to the discovery and isolation of the true chemical elements as alchemy gave way to chemistry. For however right the Greeks were about the existence of atoms and elements, they were dead wrong about what those elements were. Their favorite candidates—earth, water, fire, and air—turn out to be extremely heterogeneous substances chemically, about as far away from true elements as one could imagine.

If Chomsky is the Democritus of linguistics, then the anthropological linguists and the American structuralists have been its alchemists. Nineteenth-century European scholars, following in the wake of empire builders and missionaries around the world, began to get their first real impression of the true diversity of human language. This exposure increased markedly in the early twentieth century, as linguists who had come to America made a practice of studying American languages. Pioneers such as the anthropologist

Franz Boas, his student Edward Sapir, and their contemporary Leonard Bloomfield learned the intricacies of languages such as Lakhota, Paiute, and Menominee along with French, German, and Latin, and they taught others to do the same. Boas and Sapir in particular were driven by an urgent desire to obtain information about Native American languages before they disappeared and by a belief that studying these languages in their own terms (not through the lens of European grammatical concepts) would give deep insight into their cultures as well. Their work was particularly significant because Europe happens to be relatively homogenous linguistically. All European languages come from only two major families: the Indo-European family (the majority of them) and the Finno-Ugric languages (Finnish, Estonian, and Hungarian), together with one notable isolate, Basque. As such, their grammatical properties are rather similar. In contrast, Native North America contained ten or twelve major language families, each less closely related to the others than English is to Russian or Hindi. Those families in turn each included dozens of mutually unintelligible languages. The mountains of California alone had more linguistic diversity than all of Europe put together. Part of the legacy of Boas and his followers was to refute the myth that all North American languages were similar, characterized by a handful of evolutionarily "primitive" features. His generation also played a major role in developing the methodological infrastructure for investigating and describing non-Indo-European languages. Bloomfield not only credits Boas with providing masses of descriptive material but wrote that "Boas forged, almost single-handed, the tools of phonetic and structural description."

With this exposure, linguists came into contact with new evidence for the extreme differences among languages. They wrestled with exotic expressions like *inikwihlminih'isit* from Nootka and *wiitokuchumpunkurüganiyugwivantümü* from Paiute. Both these words are very complex; indeed, complexity of words is a distinctive property of many North American languages. The Nootka word is made up of five distinct parts: It is *inikw* 'fire' or 'burn,' plus *ihl* 'in the house,' plus *minih* 'plural,' plus *'is* 'small,' plus *it* 'past.' The

Paiute word contains no fewer than nine parts, working together to give the meaning 'they who are going to sit and cut up a black cow with a knife.'

Beyond their raw complexity, Nootka words seem to transcend the distinction between nouns and verbs that has always been central to European linguistics. *Inikwihlminih'isit* can be used equally well as a noun or a verb. As a noun, it is translated into English as 'the little fires that were once burning in the house'; as a verb, a suitable translation would be 'several small fires were burning in the house.' Apparently, Nootka grammar does not make use of this most basic European notion. Thus, Edward Sapir wrote in 1921 that "speech is a human activity that varies without assignable limit as we pass from social group to social group." It seemed that with language anything goes.

This great descriptive project continues to the present. Since the 1970s, Australian scholars have devoted enormous effort to characterizing their continent's aboriginal languages. For the most part, these languages do not have individual words that are as complex as those cited above from North American languages. But they have wonders all their own. For example, the words of a phrase in languages like English must appear next to each other. In a sentence like *These small children chased those big dogs,* we know that the children are small and the dogs are big because the word *small* appears next to *children* and the word *big* appears next to *dog*. Warlpiri and other Australian languages, however, have special features that allow their phrases to be split up and scattered across the sentence. This English sentence thus could be translated into Warlpiri in any of the following ways, among many others:

These-SU big-OB children-SU chased those-OB small-SU dogs-OB.
These-SU big-OB small-SU chased children-SU dogs-OB those-OB.
Dogs-OB big-OB chased children-SU small-SU those-OB these-SU.

Warlpiri's secret is that it puts certain endings, called *case markers,* on each word to indicate whether that word applies to the subject or the object. In my pretend-Warlpiri examples, I give a sense of this by

putting *SU* (for *subject*) or *OB* (for *object*) at the end of each English word. Since information about which is which is encoded in this way, it is not necessary to group related words into phrases in Warlpiri the way it is in English. Rather, word order expresses other aspects of the message, such as what is important new information. If one knew only the modern European languages, one might falsely conclude that sentences like these were impossible.

This kind of work goes on today as more areas become accessible. In South America linguists have discovered languages that consistently have objects at the beginning of the sentence, a pattern that was once unheard of. The island of New Guinea has also been of special interest, because its high mountains and heavy rainfall have kept people relatively isolated from one another. As a result, New Guinea is home to 14 percent of the world's languages, virtually all of them unknown to linguists until recently. Linguists feel an increasing urgency to advance the task of describing and preserving the world's languages, as the forces of globalization, habitat destruction, and prejudice conspire to push more and more of them toward extinction. Just as a mature chemistry would not have been possible without the discovery of elements such as phosphorus and arsenic, which were unknown to the ancient Greeks, so a mature linguistics is not possible without knowledge of Nootka and Paiute and Warlpiri—and whatever rare elements may exist in the languages of the upper Amazon and the New Guinea highlands.

Once a critical mass of chemical elements had been found, chemists began to notice larger-scale patterns: Groups of elements have systematic similarities in their physical properties and chemical behavior. In the 1820s, Johann Wolfgang Döbereiner, an early leader in this project, found several groups of three elements, which he called "triads," that had similar chemical characteristics and whose atomic weights formed arithmetic progressions. For example, chlorine, bromine, and iodine form similar compounds, and the atomic weight of bromine (80) is (approximately) the average of the atomic weights

of chlorine (35.5) and iodine (127). The existence of these triads pointed toward a systematic, law-governed relationship between atomic weight and chemical behavior. These patterns were essential stepping-stones to a deeper and more unified understanding of chemical phenomena.

Similarly, once a critical mass of languages had been described, broader linguistic patterns started to become visible. The linguistic answer to Döbereiner is Joseph Greenberg, who in the 1960s originated the typological approach to the study of language. Greenberg was particularly interested in word order patterns. To study this, he collected a sample of thirty languages from a variety of language families and different parts of the world. Before Greenberg, linguists typically compared a language like Italian with neighboring languages like French, Spanish, and Sardinian, looking for the similarities and differences that related to the languages' shared histories. Greenberg, by contrast, compared Italian to languages like Yoruba and Thai and Guarani, looking for similarities that had nothing to do with any historical relationship. And he discovered some striking patterns.

In Chapter 1 I mentioned that the basic word orders employed by Navajo and Japanese are quite similar, even though the two languages are historically and culturally unrelated. For example, in both languages the direct object comes after the subject and before the verb:

Ashkii	at'ééd	yiyiiltsą́.	(Navajo)
Boy	girl	saw	
'The boy saw the girl.'			

John-ga	Mary-o	butta.	(Japanese)
John-SU	Mary-OB	hit	
'John hit Mary.'			

Also, in both languages the noun phrase associated with a preposition comes before the preposition (which is therefore properly called a *post*position.)

'éé'	biih	náásdzá.		(Navajo)
clothing	into	I-got-back		
'I got back into (my) clothes.'				

John-ga	Mary	to	kuruma	da	Kobe	ni	itta. (Japanese)
John-SU	Mary	with	car	by	Kobe	to	went
'John went to Kobe by car with Mary.'							

A third property they share is that a phrase that expresses the possessor of a noun always comes before the possessed noun.

Chidí	bi-jáád	(Navajo)
Car	its-leg	
'the wheel of a car.'		

John-no	imooto-ga	sinda.	(Japanese)
John-'s	sister-SU	died	
'John's sister died.'			

English differs from Navajo and Japanese in these respects, but it is far from unique. Its basic word orders are also replicated in historically and culturally unrelated languages, such as the Edo language of Nigeria. In both English and Edo, objects come *after* the verb:

Òzó	miẹ́n	Àdésúwà.
Ozo	found	Adesuwa

In both, the noun phrase associated with a preposition comes *after* that preposition.

Òzó	rhié	néné	èbé	nè	Àdésúwà.
Ozo	gave	the	book	to	Adesuwa

Edo is also the opposite of Navajo and Japanese in that the possessor comes after the possessed noun:

Ọmọ Ọzó rré.
child Ozo come
'A child of Ozo's came'; 'Ozo's child came.'

This word order is also a possibility in English (although not the only one).

One might think that these similarities have arisen purely by chance. After all, an object can go in only a limited number of places relative to a verb: either before it or after it. Since there are more than two languages in the world, some will inevitably have the same order of object and verb. What makes Greenberg's results interesting is not that these particular combinations of word orders exist; it is that many other reasonable-looking combinations of word orders do not, or at least are very rare. For example, one can imagine a language that is halfway between English and Navajo in having objects after the verb but also postpositions. A sentence in such a language might look like this:

Chris put the book the table on.

This combination is not found in Greenberg's sample. Conversely, one could expect to find a language with the object before the verb but with prepositions:

Chris the book on the table put.

This is rare in Greenberg's sample. If languages were random collections of specific rules and properties, one would expect such languages not only to exist but to be approximately as common as languages with the Navajo/Japanese or English/Edo word order. But they aren't. Greenberg stated these discoveries in the form of implicational universals, such as the following:

- Universal 3: Languages with dominant Verb-Subject-Object order are always prepositional.

- Universal 4: With overwhelmingly greater than chance frequency, languages with normal Subject-Object-Verb order are postpositional.
- Universal 2: In languages with prepositions, the genitive [i.e., the possessor noun phrase] almost always follows the governing noun [i.e., the possessed noun], while in languages with postpositions it almost always precedes.

Overall, Greenberg found forty-five such "universals" of language, with varying degrees of statistical reliability. This showed clearly for the first time that human languages have similarities that do not emerge from shared culture and history but rather from general properties of human cognition and communication. Contrary to Sapir's view, there *are* assignable limits to the variation found in human languages. Just as Döbereiner's triads pointed to the existence of some deeper underlying structure in the world of chemistry, Greenberg's universals point to the existence of deeper linguistic structure.

Success is to be imitated. Döbereiner's observations led other chemists to try their own organizational schemes on the elements, including Beguyer de Chancourtois's "telluric screw" and John Newlands's music-based system, which revealed an eightfold rhythm to the elements. In the same way, Greenberg's universals have created a cottage industry of typologists looking for similar discoveries. Some have continued to examine approximately the same issues that Greenberg considered, trying to test, refine, and extend his generalizations to a larger sample of languages. For example, Matthew Dryer at SUNY-Buffalo uses a 625-language sample, carefully controlled for history and geography, together with sophisticated statistical techniques, in an effort to distinguish true correlations from accidental similarities.

Others seek universals in areas besides word order. Joanna Nichols, for example, has brought out another important dimension. Whereas Greenberg focused on the word orders of subjects, objects, and verbs, Nichols explores other ways in which languages can dis-

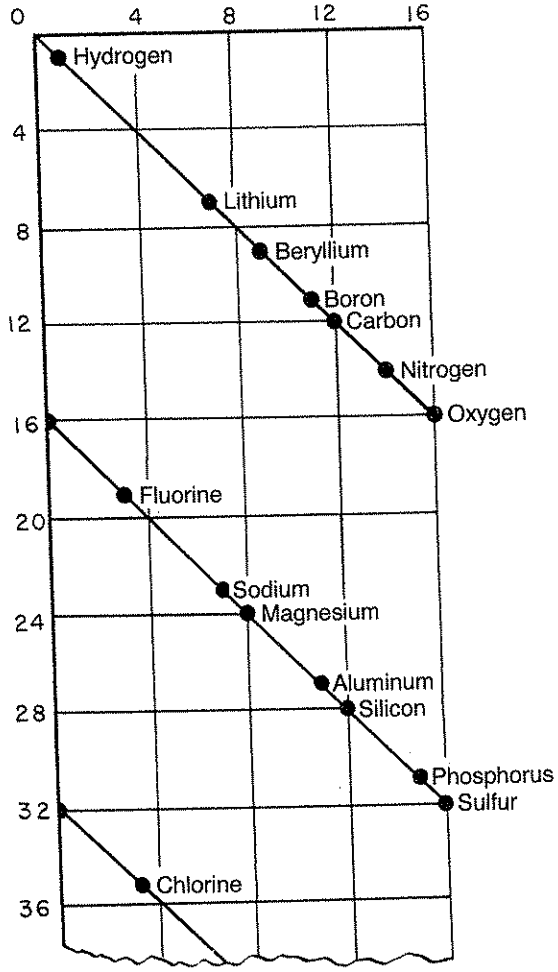

FIGURE 2.1 Beguyer de Chancourtois's "Telluric Screw"—a Precursor to the Periodic Table
SOURCE: *The Discovery of the Elements*, by Willy Ley, © 1968 by Willy Ley. Used by permission of Doubleday, a division of Random House.

tinguish the subject from the object of the same clause. She identifies two. One technique, which we have already seen, is to put case markers on noun phrases that say "this is the subject" or "this is the object." The Australian language Warlpiri involved one example of this. Japanese has another: The subject consistently has the suffix *-ga* added to it, and the object consistently bears the suffix *-o*.

John-ga	Mary-o	butta.	(Japanese)
John-SU	Mary-OB	hit	
'John hit Mary.'			

If these two suffixes are switched, the meaning of the sentence changes in a predictable way, even with no change in the word order. A Japanese speaker would thus understand *John-o Mary-ga butta* as meaning 'Mary hit John,' not 'John hit Mary.' Other languages, like Mohawk, tolerate flexibility in word order, but for a different reason. In Mohawk no markers are added to the nouns to denote subject and object. Instead, Mohawk changes a prefix on the verb. Compare the following two sentences:

Sak	Uwári	shako-núhwe's.
Jim	Mary	he/her-likes
'Jim likes Mary.'		

Sak	Uwári	ruwa-núhwe's.
Jim	Mary	she/him-likes
'Mary likes Jim.'		

The prefix *shako-* is used only if the understood subject of the sentence is a masculine singular noun phrase (like *Sak*) and the understood object is feminine singular (like *Uwari*). If the subject is feminine and the object is masculine, as in the second example, then the prefix *ruwa-* is used instead. Mohawk has fifty-eight prefixes of this kind, each of which communicates a different combination of subject and object. Such elements are called *agreement markers* be-

cause the choice of the affix on the verb must agree with the properties of the nouns in the sentence. Linguists often refer to the verb as the "head" word of a sentence in that it provides the core that the sentence is built around. Noun phrases are "dependents" of the verb because the number and kinds of noun phrases to be included depend on what verb is chosen. With this terminology in mind, Nichols calls Japanese a *dependent marking* language because it adds affixes to the noun phrases and Mohawk a *head-marking* language because it adds affixes to the verb.

So far this is mostly terminological. What makes Nichols's distinction interesting is that languages tend to use head marking and dependent marking in consistent ways. Consider, for instance, how Japanese and Mohawk distinguish a possessed noun from its possessor within a noun phrase. In both languages word order is part of the answer: The possessor usually comes before the possessed noun. But Japanese also adds a suffix, *-no,* to the possessor noun:

John-no imooto-ga
John-'s sister-SU
John's sister

A parallel expression in Mohawk leaves the possessor unmarked but puts a prefix on the possessed noun that says that its possessor is masculine and singular:

Sak rao-wise'
Jim his-glass
'Jim's glass'

Thus, the way these languages mark possession inside a noun phrase is parallel to the way they mark subjects and objects inside a sentence. The possessed noun is the head of the noun phrase because it defines what is being talked about; the possessor is a dependent that modifies this head. Given this, Mohawk noun phrases use head marking just as Mohawk sentences do, and Japanese noun phrases use dependent marking just as Japanese sentences do. It is unusual for a language to have other combinations of these properties. Languages that mark the noun phrases in a sentence but the possessed noun in a noun phrase are rare at best. Once again, we see that not all imaginable combinations of grammatical properties are permissible. It seems there are deep underlying principles that determine what properties can and cannot occur together in natural languages.

A discipline really gets interesting when the ideas of the thinkers begin to converge with the empirical discoveries of the doers. Such a moment arrived in chemistry with the work of John Dalton. Dalton did not discover any new elements, nor was he the first to propose the concept of the atom. But he was the first to bring the two traditions together in a fruitful way by showing how the long-neglected Greek notion of an atom could explain the discovery that elements combine to make compounds only in exact fixed ratios. For example, starting from the experimental result that water is always made up of 12.6 parts by weight of hydrogen and 87.4 parts of oxygen, together with his hypothesis that individual hydrogen atoms combine with individual oxygen atoms in the simplest way, Dalton concluded that oxygen atoms must be seven times heavier than hydrogen atoms. This convergence between a priori reasoning and exact empirical discovery earns Dalton a special place in the history of chemistry.

Since modern linguistics has a shorter history than chemistry, Chomsky gets to be Dalton as well as Democritus. The two roles were not split, for the linguistic data needed to gave shape and substance to Chomsky's conceptual conclusions came to light without those conclusions' being neglected for centuries. Greenberg's universals or Nichols's typological distinctions could have performed this function. In fact, however, Chomsky's distinctive notion of parameters as the atoms of linguistic diversity emerged out of a specific comparison between French and Italian.

That these two languages should provide the paradigm-forming comparison is partly because of accidents of circumstance and per-

sonality. One of Chomsky's first and greatest students, Richard Kayne, began his career by applying Chomsky's early theories to highly detailed analyses of French. He also taught in France for many years. There a young Italian named Luigi Rizzi met him, absorbed this particular way of looking at natural languages, and began the project of translating many of Chomsky and Kayne's crucial examples into his native Italian. There were many similarities—not surprising, given that English, French, and Italian are closely related. But there were differences as well. In a remarkable twist, many of these differences appeared to cluster into a discernible pattern.

The simplest Italian sentences look very much like the simplest French and English sentences: They consist of a subject noun phrase followed by a verb that is marked for tense (an indication of whether the event was past, present, or future).

Jean	arrivera.	(French)
Jean	will-arrive	

Gianni	verrà.	(Italian)
Gianni	will-come	

Italian differs from French and English, however, in that the subject can also come after the verb. Thus, a perfectly acceptable alternative Italian sentence is:

Verrà	Gianni.
Will-come	Gianni

In French, however, one would not say:

**Arrivera*	*Jean.*
Will-arrive	Jean

A second difference comes when the subject of a sentence refers to someone who is already known from the context. In French and English, it is normal in these circumstances not to repeat the name but to use a subject pronoun instead. So if Jean has already been discussed, one would say *Il arrivera* 'He will arrive.' Italian, in contrast, permits a more radical reduction: When the people in a conversation already know whom they are talking about, one can say just the verb with no subject noun phrase at all, not even a pronoun. Thus, *Verrà* qualifies as a complete and well-formed sentence in Italian, meaning 'He or she will come.' **Will come* and **arrivera* do not count as complete sentences in English and French, however.

These first two differences between French and Italian are the kinds of matters one would expect to come up quickly in an Italian 101 class. But the two languages also differ in more subtle ways. English, French, and Italian share a common method of making questions. Some noun phrase in a complete sentence represents the unknown information. That noun phrase is replaced by a suitable question word, and the question word is moved to the front of the sentence. For example, suppose that we wanted to make a question corresponding to the following piece of information:

Chris will see someone in the park.

One substitutes a question word for the unknown part:

Chris will see whom in the park?

Then one relocates the question word at the beginning of the sentence, leaving a gap where the object would normally be:

Whom will Chris see _____ in the park?

(Note that the future tense auxiliary *will* also shifts to come before the subject in this sentence. This detail is peculiar to English, and I ignore it here.) But this simple procedure has limitations in English and French. Consider a more complex initial sentence, in which one clause appears embedded inside another:

You said that Chris saw Pat in the park.

Tu	veux	que	Marie	épouse	Jean.	(French)
You	want	that	Marie	marry	Jean	

If one replaces the object of the embedded clause with a question word, the rule works as before in both languages:

Whom did you say that Chris saw _____ in the park?

Qui	veux-tu	que	Marie	épouse	_____?	(French)
Whom	want-you	that	Marie	marries?		

If one replaces the *subject* of the embedded clause with a question word and moves it to the front with no extra changes, however, the result is ungrammatical:

*Who did you say that _____ saw Chris in the park?

*Qui	veux-tu	que	_____	épouse	Jean?	(French)
Who	want-you	that	_____	marries	Jean?	

These sentences need to be fixed by changing the word that introduces the embedded sentence: In standard English the conjunction *that* must be omitted; in French the parallel word *que* must be changed to *qui*.

Who did you say _____ saw Chris in the park?

Qui	veux-tu	qui	_____	épouse	Jean?	(French)
Who	want-you	that	_____	marries	Jean?	

In Italian, in contrast, the normal rule that question words move to the beginning applies in its most pristine form even to subjects of embedded clauses. Italian also has a designated word for introducing embedded clauses, namely, *che* (cognate to the French *que*):

Credi	che	Gianni	verrà.
You-think	that	Gianni	will-come

Che is neither deleted nor changed when one questions the embedded subject in Italian:

Chi	credi	che	_____	verrà?
Who	you-think	that	_____	will-come?

This is a much subtler but still significant difference between Italian grammar and the grammars of French and English. One can imagine even completely fluent speakers making mistakes on this point, although native speakers would notice this as an error.

Why did Kayne and Rizzi argue that all these differences between Italian and French (and English) are interrelated? Why aren't they just three random differences, each independent from the others? There are at least three reasons. The first involves comparison with other Romance languages, such as Spanish and Romanian. Spanish also allows the subject to follow the verb, allows "redundant" subjects to be omitted, and allows the subject of an embedded clause to be questioned with no readjustments. In all these respects, Spanish is grammatically more like Italian than French, even though by the normal criteria of historical linguistics it is more closely related to French. At the other edge of the ancient Roman Empire is Romanian. Although it has been isolated geographically from the other Romance languages for centuries, it also behaves systematically like Italian rather than French in these respects. If these three properties were unrelated, one would expect them to appear in more or less random mixtures in the various Romance languages. But that is not what we find.

A second reason to think that these facts are interrelated comes from historical linguistics. We have extensive written records in French that can be used to trace its history in considerable detail. Examination of older texts reveals that earlier stages of French were like Italian and Spanish for all three of these properties and that each of these Italian-like features (originally derived from Latin, the common ancestor) phased out between Middle French and Modern French. Thus, French changed from being a pure Italian-type language to

being a pure French-type language over a century or two. That these properties changed together and at roughly the same time gives further credence to the claim that they are all related.

These first two reasons would not by themselves have led Chomsky and his colleagues to the idea of a parameter, however. The third and most important reason for thinking these differences are interrelated is that all three have a discernible common theme: All involve the subject in one way or another. That does not seem like a coincidence.

Indeed, we can be more precise. English and French have a requirement that (almost) every clause with a tensed verb must have a visible subject of some kind. The most striking demonstration of this comes from sentences that concern the weather. These typically begin with *it* in English or the equivalent *il* in French:

Il pleut.
It is raining.

Superficially, these sentences look just like *It is boiling,* but there is an important difference. The *it* in *It is boiling* is a kind of abbreviation for a full noun phrase that can be recovered from the context. *It is boiling* means *The soup on the stove is boiling* in a situation where we needn't bother saying *the soup on the stove*. The *it* of *It is raining* is not short for anything. This sentence can be used without any physical gesture or earlier sentence to define what *it* is. Indeed, sentences in which an ordinary noun phrase appears as the subject of these verbs sound very strange:

*The cloud is raining.
*The weather is raining.
*Montreal is raining.

Apart from metaphorical uses such as *Confetti rained down on the heroes,* we do not think of raining as the sort of activity that things do; it is something that just happens spontaneously. There is usually no semantic subject for a verb like *rain*. Nevertheless, English and French have such a strong requirement that tensed clauses have subjects that

speakers feel a need to make one up. Since *it* and *il* are the noun phrases in these languages with the least inherent meaning, they are pressed into duty. This shows that the need for a subject is a grammatical requirement that holds even when there is no semantic subject to talk about. Italian and Spanish are different in this respect; statements about the weather in these languages show up as bare verbs.

Piove.	(Italian)
Llueve.	(Spanish)
Is-raining	

Italian and Spanish speakers do not feel the same compulsion to make up a subject just to have one. We thus have a fourth basic difference between Italian-like languages and French-like languages, which can be stated as follows:

In some languages (French, English, the Nigerian language Edo, etc.) every tensed clause must have an overt subject.
In some languages (Italian, Spanish, Romanian, Japanese, Navajo, etc.) tensed clauses need not have an overt subject.

What is important about this is that the other three differences between French and Italian I enumerated above can all be seen as consequences of this one fundamental difference. The most obvious application is that one must say *She will come* in English and French whereas a simple *Verrà* will do in Italian. This example is slightly different from the weather sentences, because here the subject pronoun is not a mere placeholder but stands for a real, meaningful noun phrase. Here, too, however, Italian and Spanish speakers need not bother with a subject, whereas French and English speakers must include at least a pronoun.

Consider next that subjects may come after the verb in Italian: *Verrà Gianni* ('comes Gianni') is possible as well as *Gianni verrà*. I implied above that such reversals of word order are not possible in English and French, but that was not quite accurate. A similar change is sometimes possible in these languages—but a dummy pro-

noun must appear in the normal, preverbal subject position. Although one cannot say **Appeared a boat* in English, then, or **Est arrivé Jean* in French, one can say:

There appeared a boat on the horizon.					
Il	est	arrivé	trois	hommes.	(French)
It	is(has)	arrived	three	men	

The difference between Italian and both French and English is not exactly what we thought at first. The "logical subject" can be bumped out of its usual position in all three languages, but in French and English a new subject must be added, to satisfy the condition that any clause that has a tensed verb also has a subject. This requirement is not active in Italian. Therefore, no dummy subject pronoun appears in inverted sentences in Italian, just as no subject pronoun is needed with weather verbs or verbs whose subject is recoverable from context.

The last contrast we observed had to do with questioning the subject of an embedded clause. In Italian this is possible with no adjustments, whereas in French and English it is not:

Chi	credi	che	_____	verrà?	(Italian)
Whom	you-think	that		will-come?	
*Whom did you say that _____ will come?					
*Qui	veux-tu	que	_____	vienne?	(French)
Whom	want-you	that	_____	come?	

Now we can see why this difference arises. Moving a question word to the front of the sentence again leaves behind a tensed clause with no overt subject—the configuration that we know is easily tolerated in Italian but not in French or English.

This proposal elegantly explains why questioning an embedded subject is problematic in French and English, but other questions are not. For example, the difference doesn't show up when one questions the subject of a simple sentence like *Who will come?* Such questions

are equally possible in all three languages. Here the question word didn't need to move anywhere to get to the front of the sentence. It can stay in the normal subject position, satisfying the French and English requirement. We can also explain why no difference shows up when one questions the *object* of an embedded clause. Crucially, there is no requirement that clauses in French and English have direct objects; English speakers feel no need to add a dummy object to *rains* to form **It rains it,* for example. Question movement can thus remove the object from an embedded clause freely, with no adjustments in any of these languages. (For instance, *Chris thinks that I bought a dog* easily becomes *What does Chris think that I bought?*) Thus, even though the grammatical rule about subjects says nothing about questions directly, it has implications for questions that are predictably different in the different languages.

This comparison between English and French versus Italian and Spanish is what led Chomsky to propose the idea of a parameter. At first glance these languages seem to differ in many ways. Some of the differences are obvious to anyone trying to learn these languages; others are extremely subtle and had never been noticed until linguists realized what to look for (including some differences I have not presented here). Chomsky realized, however, that French and Italian actually diverge only in a single feature, which expresses itself differently in different grammatical constructions. If there were really six differences instead of one (the four I discussed, plus two others I omitted), we would expect them to vary independently from each other, resulting in (approximately) $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$ different kinds of Romance languages. In reality there are only (approximately) two kinds of Romance languages in these respects: the French type and the Italian/Spanish/Romanian type. If there were really six differences instead of one, it would be surprising that French changed from a uniformly Italian-type language to a uniformly English-type language. Moreover, the single feature can be isolated and identified by linguistic analysis: The difference, whatever it is exactly, has to do with whether sentences need subjects or not. Chomsky called such a single feature a *parameter*. More specifically, this par-

ticular feature is referred to as the *null subject parameter,* for obvious reasons. Such parameters can be "set" in at least two ways: For example, a language might require subjects, or it might not. The collection of observable consequences that follows when a language chooses one setting of a parameter rather than another is known as a *parametric cluster*.

Chomsky further observed that parameters like this could take away some of the mystery of how children can learn something as complex as a natural language so easily and reliably. One cannot expect all English-speaking children to notice that adults don't say sentences like **Who does Pat think that will marry Chris?* whereas they do say sentences like *Whom does Pat think that Chris will marry?* Children have relatively little exposure to sentences this complex, particularly in the early stages of learning a language. One can, however, expect children to notice whether one uses a subject pronoun in a sentence like *It is raining*. Once children learn this, they can deduce that subjects must be obligatory in English. Similarly, when children in Italy hear sentences like *Piove,* they can conclude that subjects are not obligatory in Italian. Without needing any direct exposure to the exact structures, both groups of children are then able to infer (unconsciously) the consequences of this rule for complex sentences involving embedded clauses and questions. Because the differences among languages cluster into stable patterns, children can learn parts of the pattern indirectly, as a consequence of learning another, more accessible part. Parameters thus simplify the logical problem of language acquisition enormously. Encouraged by this, Chomsky made the bold conjecture that this difference between French and Italian is typical. In 1981 he proposed that all differences among languages are to be thought of in this way, as different choices that languages make with respect to a finite number of parameters.

The atomic theory in chemistry made the bold and surprising claim that the vast diversity of substances we observe can be characterized as different arrangements of a smallish number of discrete elements. The parametric hypothesis makes a similar claim: The diverse array of languages we observe can all be characterized as different arrangements of a smallish number of discrete parameters. Both hypotheses treat what looks like a continuous analog-style phenomenon as being essentially digital. Furthermore, the original Greek word for 'atom' means 'uncuttable': It implies there is a smallest unit of matter that cannot be further subdivided. Similarly, parameters create parametric clusters that are also in a sense uncuttable. The null subject parameter of Italian is an irreducible feature of that language; it should not be cut apart into smaller features such as an ability to omit pronouns and an ability to question embedded subjects. Just as atoms gave chemistry a way of resolving its foundational paradoxes, so parameters give linguistics a way of resolving its foundational paradoxes of similarity and difference. Parameters are the atoms of linguistic diversity.

Some people, particularly some language scholars, have been scandalized by these proposals. Chomsky's own research has focused mostly on the details of English grammar, together with some comparison with closely related languages such as French, Italian, and Spanish. How, these critics ask, can one infer anything about a universal grammar or the nature of all human languages from such a limited sample? The enterprise seems to smack of ethnocentrism, of the presupposition that everything must be like English. It also seems not to do justice to the continuous variation that the theory's opponents think they see in language. Still, we know from watching a digitally mastered movie or trying to catch a glimpse of the droplets in a stream of water coming from a faucet that things that are made up of discrete pieces can easily look continuous to our unaided senses. Moreover, the "limited sample" argument is specious: When one needs a new idea for addressing a paradoxical situation, more facts often just add to the confusion. What is really needed is a new perspective on the observations already in hand. Chomsky's conclusions about universal grammar and the existence of parameters are no more astonishing than Democritus' conclusions about the existence of atoms. Democritus, too, observed only a tiny number of the substances known to modern chemistry. By the standards of the scien-

tific method and modern instrumentation, he didn't even observe them very closely. But he did think about what he saw and reached a correct conclusion by valid reasoning.

I should confess that not every linguist would assign so much importance to the notion of a parameter or understand it in exactly the same way. Within the Chomskyan paradigm, there are many linguists who accept the terminology of parameters but have somewhat different views about exactly what a parameter is and what the best examples are. Outside the paradigm, many linguists object (sometimes strenuously) to the terminology of parameters and some of the intellectual background associated with it, preferring a different terminology and different associations. But beneath the surface of controversy and debate, there is a growing understanding that the differences among languages are to be grouped into relatively stable patterns that do not arise as accidents of particular histories or cultures.

Where does this leave the historical development of linguistics? It is always tricky to understand the present. But in light of the growing awareness that something like the parameter exists, linguistics in my view is ready and waiting for its Mendeleyev.

Chemistry had to get ready for Mendeleyev for some time. One cannot hope to have a correct and explanatory classification of the chemical elements until one has discovered a certain percentage of those elements and observed their basic properties. Chemists needed to calculate various atomic weights and discover similarities in various chemical reactions. The basic concept of an atom had to be in place, to provide an effective way of thinking about both atomic weights and the formation of chemical compounds. These basic preconditions were satisfied in the middle of the nineteenth century. Since the 1820s, scientists like Döbereiner had begun to discern that sometimes there were systematic relationships between an element's atomic weight and its chemical properties. By 1860 an important confusion over how to calculate atomic weights had been resolved. As a result, chemists called a congress to be held in that year at Karlsruhe, Germany, to explore the possibility of using real atomic weights as a comprehensive classification system for the chemical elements—a system that could bring order to their ever-increasing knowledge about those elements. This desire was stimulated by their envy of the zoologists and the botanists, who already had classification schemes that encompassed all living things.

Dmitry Mendeleyev, who attended the Karlsruhe congress, deliberately took up this project. When he returned to his native Russia in 1861, one of his responsibilities was to write a textbook. He wrestled with the question of how to present his knowledge in an orderly and systematic way that would be easy for his students to understand. To this end, he spent eight years gathering information, writing countless letters to research centers all over Europe to get the best figures on atomic weights and other numerical properties. He also used his love of solitaire games by writing the name of each element on a playing card and dealing the cards out in endless arrangements. Finally, in 1869, he hit upon the scheme of ordering the elements by their atomic weights into two short "periods" of seven elements each, followed by three long "periods" of seventeen elements, with some gaps left for elements that had not been discovered yet. His breakthrough was largely ignored at first, until the better-connected German Lothar Meyer published the beginnings of the same system in 1870. The primacy and greater completeness of Mendeleyev's work was soon recognized, however. When in the ensuing years three of Mendeleyev's missing elements were discovered and found to have properties that accurately matched Mendeleyev's predictions, chemists began fully to appreciate the genius of his system. Some inadequacies needed to be fixed: Mendeleyev did not know where to fit in hydrogen, he was completely ignorant of the noble gases, and he made wrong predictions as well as right ones when it came to sorting out the rare earth metals. But the basic vision was sound. Today nearly every chemistry textbook, classroom, and laboratory has a version of Mendeleyev's periodic table displayed prominently. The periodic table is special because every natural element is included, each in its proper place in relation to all the others. All the

TABLE 2.1 Mendeleyev's Periodic Table

Groups	*Higher Salt Forming Oxides*		*Typical 1st Small Period*	*Large Periods* 1st	2nd	3rd	4th	5th
I.	R_2O		Li = 7	K 39	Rb 85	Cs 133	—	—
II.	RO		Be = 9	Ca 40	S 87	Ba 137	—	—
III.	R_2O_3		B = 11	Sc 44	Y 89	La 138	Yb 173	—
IV.	RO_2		C = 12	Ti 48	Zr 90	Ce 140	—	Th 232
V.	R_2O_5		N = 14	V 51	Nb 94	—	Ta 182	—
VI.	RO_3		O = 16	Cr 52	Mo 96	—	W 184	Ur 240
VII.	R_2O_7		F = 19	Mn 55	—	—	—	—
VIII.				Fe 56 Co 58.5 Ni 59	Ru 103 Rh 104 Pd 106	— — —	Os 191 Ir 193 Pt 196	— — —
I.	R_2O	H = 1.	Na = 23	Cu 63	Ag 108	—	Au 198	—
II.	RO		Mg = 24	Zn 65	Cd 112	—	Hg 200	—
III.	R_2O_3		Al = 27	Ga 70	In 113	—	Tl 104	—
IV.	RO_2		Si = 28	Ge 72	Sn 118	—	Pb 206	—
V.	R_2O_5		P = 31	As 75	Sb 120	—	Bi 208	—
VI.	RO_3		S = 32	Se 79	Te 125	—	—	—
VII.	R_2O_7		Cl = 35.5	Br 80	I 127	—	—	—
			2nd Small Period	*1st*	*2nd*	*3rd*	*4th*	*5th*
				Large Periods				

basic properties of those elements are expressed. Indeed, the most important properties are expressed in a particularly natural way, as Mendeleyev's table revealed for the first time the correct relationship between atomic weight and chemical valency. In this respect, the periodic table surpassed the zoological and botanical classification systems, which express some important biological relationships but not others. Mendeleyev's ability to recognize unknown elements as gaps in the table and make precise predictions about them was also unprecedented. No zoologist could predict the existence of a new animal based on his observations of known animals, but Mendeleyev was able to predict that there would be such a thing as germanium from his analysis of silicon. These striking successes were possible because chemistry had, for the first time, a theory of what combinations of properties an element could have and of what logically possible combinations an element could never have. There cannot, for example, be a halogen that forms compounds similar to those of chlorine but that has an atomic weight between those of aluminum and silicon. By extension, the table also expresses what kinds of compounds can in principle be built from elements, given their valence. This theory brought order to what was known, revealed its underlying symmetries, and made strikingly correct predictions about not-yet discovered elements. It remains the organizing principle of chemistry today, standing as a landmark in the maturing of chemistry as a science and as one of the great achievements of the human mind.

Linguistics now seems to be in a stage similar in many ways to where chemistry was in the mid-nineteenth century, just prior to Mendeleyev. The key theoretical idea of the parameter is in place, together with an appreciation of how it can be used to solve linguistic problems. We also have practical experience with a certain number of actual parameters. The null subject parameter seems to be one. At least one more is lurking in Greenberg's universals concerning word order: Languages seem to make one choice that determines whether verbs will come before their objects, prepositions before their noun phrases, and nouns before their possessors, or whether it will be the other way around. A third parameter is to be found in Nichols's dis-

tinction between head-marking languages and dependent-marking languages: Languages choose whether verbs will bear agreement affixes that are determined by the noun phrases or whether noun phrases will have case affixes that are determined by the verb. There are others as well. We even have some understanding of how these different parameters can interact with each other to give more complex patterns, comparable to chemists' knowledge of how atoms can combine to form compounds. Thus, we are approaching the stage where we can imagine producing the complete list of linguistic parameters, just as Mendeleyev produced the (virtually) complete list of natural chemical elements.

This list of parameters will be sufficient to characterize the grammatical skeleton (though, of course, not the "skin" of pronunciation, idiom, or figure of speech) of any natural human language, ancient or contemporary. Properly organized, such a list will constitute a kind of periodic table of languages. We might even be in a position to describe possible languages that no one has yet observed. This will happen when we recognize that the known parameters can combine in some logically consistent way to form a language with distinctive properties that is so far unknown. Then we can hope that this prediction will be confirmed by some linguist working with a yet undescribed language from a remote jungle or a philologist considering an ancient text or a dialectologist looking at a newly formed speech variety. But even apart from the predictive power it might have, this imagined periodic table of languages will have value in succinctly and gracefully summarizing what is known about languages, including what is possible and what is not, in a way that reveals the true elegance under the bewildering wealth of facts. Then one great historical thrust of linguistics will have reached fulfillment, bringing the field to a new level of maturity. With a coherent organization of the atoms of language and their modes of combination, we will be ready to move on—to discover the linguistic equivalents of radioactivity and quantum mechanics, whatever those turn out to be.

3

Samples Versus Recipes

When most people hear the phrase *atoms of language,* what comes to their minds is words. Words are the little pieces of language that we consciously look up in dictionaries and piece together into sentences when we write. Learning vocabulary is perhaps the largest and most laborious aspect of acquiring another language. Basic words are like the Greek notion of atoms in that they cannot be divided into smaller meaningful parts. Therefore, it seems that words must be the atoms of language. Where, then, does talk of parameters come in?

This common reaction is correct—in one sense. But like most terms we use in everyday speech, *language* has more than one sense. You can get a flavor for this by opening any largish dictionary to a random page and scanning the entries. Almost every word listed has multiple meanings, and even so dictionaries do not capture every technical sense or extended use that is adapted to the needs of the moment. For example, when physicists or engineers speak of *work,* they are not talking about whatever you do to get a paycheck but about force exerted in the direction of motion times distance. These two senses of work are not entirely unrelated (there are reasons physicists picked this label for a key concept in their theories), but