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Transforming Science Into Law: Transparency and Default Reasoning in International Trade Disputes

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Transparency in Law versus Transparency in Science

The principles of transparency that are part of the framework for this book, as applied to governmental fact finding, require the fact finder to make several aspects of decision making clear to all interested parties: the evidence behind a finding of fact, the fact finder's evaluation of that evidence, and the reasoning connecting the evidence to the finding. Ideally, all parties could understand which evidence the fact finder took into account and how the fact finder assessed the probative value of that evidence in arriving at the findings. A similar ideal of transparency occurs in science. The design and analysis of empirical studies should be so transparent that other scientists can critique the methods used and replicate the research. All interested researchers should have access to the data-gathering methods, if not the data itself, and should be able to evaluate for themselves the degree of evidentiary support for the scientific findings. With regard to transparency, therefore, law and science share the same ideal. There would seem to be no conflict of principles when scientists provide the evidentiary basis for legal fact finding.

From a legal perspective, this ideal of transparency is closely connected to other ideals: the predictability and legitimacy of the law, and the rule of law itself. If legal rules transparently govern the outcomes in particular cases, and if similar cases are decided similarly, then the law is more likely to be predictable and fair. Moreover, governmental institutions are less likely to abuse their powers. A major goal in founding the World Trade Organization (WTO) was to achieve predictability and legitimacy in the resolution of international trade disputes by requiring transparent reasoning

for the findings of fact that resolve those disputes. When those findings are about the risks of harm posed by imported products, the WTO relies on scientific evidence and reasoning. And if transparent scientific reasoning can help make international trade law more predictable and fair, there would seem to be no harmful downside for science.

A central thesis of this chapter, however, is that the involvement of science in legal fact finding pressures scientists to transform their reasoning patterns into those of legal reasoning, and to transform the practice of science into a regulatory enterprise. Due to the logical nature of scientific reasoning, this involvement makes the politicization of science not only likely, but inevitable and perhaps even rational. A default-logic model of legal and scientific reasoning helps us to understand why this is so, and fact finding in WTO trade disputes provides a good example of the dynamic involved.

The analysis suggests that the pressure to increase the transparency of scientific reasoning can have countervailing costs, especially in the case of fact finding about risks that have significant scientific uncertainty. Principles of transparency, however, help us to keep those costs to acceptable levels. If we are to rescue science from politics, we need to understand the underlying logic of legal fact finding, and the role of science within it. Otherwise, an unreflective pursuit of transparency runs the risk of politicizing science even further.

Transparent Dispute Settlement in the WTO: The Role of Legal Rules

A major goal behind the establishment of the WTO in 1995 was to create a system of transparent and predictable rules governing trade.[1] Other goals were to clarify the rights and responsibilities of global trading partners

[1] Understanding on Rules and Procedures Governing the Settlement of Disputes, art. 3, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization (hereinafter WTO Agreement), Annex 2, Legal Instruments – Results of the Uruguay Round, vol. 31, 33 I.L.M. 112 (1994) (available at http://www.wto.org/english/docs_e/legal_e/28-dsu.pdf) (hereinafter DSU Agreement); Agreement on the Application of Sanitary and Phytosanitary Measures, preamble, April 15, 1994, WTO Agreement, Annex 1A, 33 I.L.M. 1125 (1994) (available at http://www.wto.org/english/docs_e/legal_e/15-sps.pdf) (hereinafter SPS Agreement). Background information on the WTO, as well as all of the WTO documents discussed in this chapter, can be found on the WTO website (http://www.wto.org).

and to establish a dispute settlement mechanism that would adjudicate particular trade disputes using those trade rules. That dispute settlement process employs fact-finding panels appointed to decide particular cases, and a standing Appellate Body established to resolve the issues of law arising in the disputes. While a panel's decisions about issues of law are subject to reversal by the Appellate Body, a panel's findings of fact are considered final.[2]

A mechanism of dispute settlement, however, could be governed by procedural rules without satisfying transparency principles. Those principles require more than transparent procedures. They require that policy makers relying on scientific research must be careful to represent the scientific findings accurately, including the limitations of the scientific research. This principle applies to WTO fact-finding panels when they rely upon scientific research as evidentiary support for a finding of fact. Such findings are the foundation of a major WTO agreement called the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). The SPS Agreement establishes the rights and responsibilities of WTO members when they take measures to protect the health or life of humans, animals, or plants (so-called "sanitary or phytosanitary measures"). Such measures that affect international trade can include testing requirements, quarantines, or outright bans on products. The concern among trading partners is that a member state might impose restrictions on imported products in order to protect its own domestic industry from foreign competition, but try to justify those restrictions as being necessary to protect health or life.

The SPS Agreement, while acknowledging each member's sovereign right to take *legitimate* protective measures, provides that such measures are in fact legitimate only if they have a foundation in scientific fact. The SPS Agreement uses science as a "neutral arbiter" in trade disputes over sanitary or phytosanitary measures. The agreement requires WTO members to "ensure that any sanitary or phytosanitary measure is applied only to the extent necessary to protect human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence."[3] In addition, "[m]embers shall ensure that their

[2] DSU Agreement, arts. 6–8, 11–12, 17.
[3] SPS Agreement, art. 2.2.

sanitary or phytosanitary measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organizations."[4] The SPS Agreement requires WTO members to justify their protective measures by means of scientific risk assessments. Two important cases explained the application of these broad standards.

The Beef Hormones Case

In the first dispute adjudicated under the SPS Agreement, the United States and Canada complained against the European Communities over a European ban on imports of meat and meat products derived from cattle raised using certain growth-promoting hormones (the *EC – Hormones* case).[5] The European Communities argued that the hormones employed are carcinogenic and that the residues in meat products increase the risk of cancer to consumers. The WTO fact-finding panel found that the European Communities were acting inconsistently with the requirement that a measure must be based on a risk assessment.

In deciding the appeal of the case, the Appellate Body developed several new legal rules relating to the scientific basis required under the SPS Agreement. First, the banned products must pose a risk that is "ascertainable" – that is, a risk that is not merely "theoretical," although it need not be so certain as to provide "absolute certainty."[6] Second, the measure must be "sufficiently supported or reasonably warranted" by a risk assessment.[7] Third, the supporting evidence must be "sufficiently specific" to the risk posed by the particular products, although that evidence need not be quantitative or represent a consensus view among scientists.[8] Because the Appellate Body created these new rules as interpretations of the SPS Agreement, fact-finding panels are bound to apply them in deciding later cases. The final decision in the *EC – Hormones* case was

4 Ibid., art. 5.1.
5 WTO Appellate Body Report, EC Measures Concerning Meat and Meat Products (Hormones), WT/DS26/AB/R & WT/DS48/AB/R, para. 2 (Jan. 16, 1998) (available at http://docsonline.wto.org/DDFDocuments/t/WT/DS/26ABR.WPF).
6 Ibid., paras. 182–6.
7 Ibid., paras. 186, 193.
8 Ibid., paras. 187, 194, 198–201.

that the European Communities had in fact failed to base the product ban on a "risk assessment that reasonably supports or warrants the import prohibition."[9]

The Salmon Case

A later case under the SPS Agreement (the *Australia – Salmon* case) involved a dispute over an Australian prohibition on the importation of fresh, chilled, or frozen salmon, ostensibly to protect against the spread of pests or disease within Australia's territory.[10] In addition to applying the rules developed in the *EC – Hormones* case, the Appellate Body in *Australia – Salmon* held that an adequate risk assessment must evaluate the "likelihood" or "probability" of the entry, establishment, or spread of disease, not merely the "possibility" of entry, establishment, or spread.[11] Such evidence need not be complete, however, and it can be either quantitative or qualitative.[12] The final decision in the *Australia – Salmon* case was that the report on which Australia relied was not in fact an adequate risk assessment satisfying WTO requirements. Therefore, Australia's prohibition was not consistent with its obligations under the SPS Agreement.

Legitimate Science or Inadequate Risk Assessment?

As these two cases make clear, the SPS Agreement's approach of using scientific research as a neutral arbiter over the legitimacy of sanitary and phytosanitary measures depends upon the WTO's being able to distinguish legitimate or sound science from an inadequate risk assessment. Legal rules about trade responsibilities must rest upon legal rules about what counts as an adequate scientific assessment of risk. The WTO approach is that in a trade dispute over a governmental measure, the disputing members should lay their reasoning about the measure transparently on the table, in such a way that a fact-finding panel can inspect that reasoning and decide

[9] Ibid., para. 208.

[10] WTO Appellate Body Report, Australia – Measures Affecting Importation of Salmon, WT/DS18/AB/R, para. 1 (Oct. 20, 1998) (available at http://docsonline.wto.org/DDFDocuments/t/WT/DS/18ABR.DOC) (hereinafter Salmon Appellate Body Report).

[11] Ibid., para. 123.

[12] Ibid., paras.125, 130.

whether the measure is "based on scientific principles" and is supported by "sufficient scientific evidence," as required by the SPS Agreement. The legal rules presuppose, therefore, that we can make additional rules about when reasoning is scientific and sound.

Logical Features of Legal Rules

Before analyzing scientific reasoning in contrast with legal reasoning, it is useful to summarize several logical features of legal rules. First, legal rules are *conditional* propositions of the form "if p, then q," where p and q stand for propositions. A legal rule states that finding proposition p to be true is a sufficient condition for finding q to be true. For example, "if a sanitary measure is supported by an adequate scientific risk assessment, then it satisfies the requirements of the SPS Agreement."

Second, the conditional proposition must be adopted by proper legal authority in order to have the force of law. Legal rules, in order to be valid, must be adopted by a person or institution that has the authority to adopt them, and adopted in a manner that satisfies the applicable procedural rules. Finally, legal rules must apply universally: They must govern all situations that satisfy the antecedent condition in the "if" clause. They should decide the outcomes in all cases to which they apply. Any exceptions from the rule should be identified and governed by additional rules.

In law, the goal is to use rules to decide cases objectively and consistently, not subjectively and by the inscrutable whim of the decision maker. Universal rules are also a primary method of achieving transparency. Legal fact finding is transparent to the extent that the process is governed by adopted procedural rules, the issues to be decided are determined by the substantive legal rules, and the evidence is evaluated and the findings are made by applying the evidentiary rules. To the extent that explicit legal rules govern the outcomes of the cases, the legal system operates transparently.

Default Reasoning in Science: The Role of Generalizations

To understand the similarities and dissimilarities between legal reasoning and scientific reasoning, we can view them both as instances of what

logicians call "default reasoning."[13] Default reasoning relies on available evidence to warrant probabilistic conclusions that are subject to future revision. Such reasoning is dynamic, because the degree of support provided by the reasoning and evidence to the conclusion can change over time, as we acquire new information or rethink old information. Default reasoning is also defeasible, meaning that new information or a reanalysis can defeat the prior conclusion or undermine its evidentiary support. Nevertheless, in the absence of such defeating considerations, default reasoning is presumptively valid: It is reasonable to treat the (provisional) conclusion as being probably true. That makes default reasoning practical, because we can use it to reach conclusions about objects and events in the real world, and we can rely on those conclusions to guide our decisions and actions. This section describes how scientific reasoning has these characteristics, and the role that generalizations play in that reasoning.

Scientists use default reasoning in all aspects of their work, both in generating and confirming theories and in applying those theories to particular events.[14] Scientists begin with empirical observations about objects or events in the world. They generate "data" by systematically classifying those objects or events into categories, using explicit measurement criteria whenever possible. Examples of measurement or classification variables are height, age, the concentration of hormone residue in meat, and whether a person has a malignant tumor. The classification or measurement criteria must be as transparent and explicit as possible, so that numerous researchers can be trained to gather data in consistent ways, and future studies can produce data compatible with past studies. Nevertheless, uncertainty about measurement data is a fact of scientific life – such uncertainty includes both whether there is human or instrument error in particular data

13 For discussions of the logic of default reasoning, see Henry E. Kyburg, Jr., and Choh Man Teng, *Uncertain Inference* (Cambridge, UK: Cambridge University Press, 2001); John L. Pollock, *Nomic Probability and the Foundations of Induction* (New York: Oxford University Press, 1990); Henry Prakken, *Logical Tools for Modelling Legal Argument* (Dordrecht: Kluwer, 1997); Stephen Toulmin et al., *An Introduction to Reasoning* (New York: Macmillan, 2nd ed., 1984); Douglas N. Walton, *Argument Schemes for Presumptive Reasoning* (Mahwah, NJ: Lawrence Erlbaum Associates, 1996); Douglas Walton, *Legal Argumentation and Evidence* (University Park, PA: Pennsylvania State University Press, 2002).

14 Vern R. Walker, "Restoring the Individual Plaintiff to Tort Law by Rejecting 'Junk Logic' about Specific Causation," *Alabama Law Review* 56, no. 2 (2004): 381, 386–452; Vern R. Walker, "Theories of Uncertainty: Explaining the Possible Sources of Error in Inferences," *Cardozo Law Review* 22, no. 5–6 (2001): 1523, 1543–59.

entries and whether the measurement processes themselves are sufficiently reliable and valid, given the kinds of conclusions that scientists wish to draw.

Moreover, scientists usually gather their data only from samples of objects or events, not from the entire population that they wish to study. Examples of samples are the meat products actually tested for hormone residues, the people who are the subjects in a cancer study, and the events included in a study's time frame. There is always uncertainty about whether the sample used to provide the data is adequately representative of the population about which scientists want to draw conclusions. First, an available sample might be systematically unrepresentative or biased. For example, for certain variables, older voters might not be representative of the general voting population, laboratory rats might not be representative of humans, and adults might not be representative of children. Second, even if a sample is randomly drawn from the target population, a researcher might draw an unrepresentative sample merely by chance. As explained by Professor David Adelman in Chapter 9 of this book, scientists employ various tests of statistical significance in order to characterize and reduce the uncertainty created by random sampling. It is reasonable to rely on conclusions about populations only if both measurement uncertainty and sampling uncertainty are within acceptable bounds.

Whenever scientific research reaches conclusions based on measurements of samples, generalizations are at the heart of scientific reasoning. A "generalization" is an assertion that a proposition is true of only a portion of a group, but not the entire group. Examples are propositions about "most" people, "a few" people, "5 percent of" American males, and "14 percent of" the products tested. A generalization is also a probabilistic assertion – it asserts only that the proposition has some degree of plausibility or some specified likelihood of being true. For example, a generalization might assert that a proposition is "probably true," or is "unlikely to be true," or has "a 0.25 probability of being true." Scientists engage in default reasoning when they couch their conclusions or their supporting reasoning in generalizations.

Often, both the conclusion and the reasoning contain generalizations. For example, if a scientist concludes that eating hormone residues in meat products *probably* causes cancer *in a small percentage of* consumers who eat such products, then the evidence might include an epidemiological study that the scientist believes has acceptable measurement and sampling

uncertainty. This latter belief may be supported by the generalizations that 99 percent of the laboratory measurements of hormone residues in the study are *probably* within 3 percent of the true values for the products tested (measurement validity), and that 95 percent of the samples drawn in the way they were drawn for this study *probably* have a mean residue concentration that is within 5 percentage points of the actual mean concentration for meat products generally (sample representativeness). In other words, when we analyze how scientists normally reason, we find layers upon layers of generalizations.

In addition, conclusions about causation add a kind of uncertainty beyond measurement and sampling, and international trade disputes are focused on the harms that imported products can cause. The central issue in *EC – Hormones*, for example, was whether eating meat products from farm animals that had been treated with certain hormones for growth-promotion purposes could cause cancer in humans. As evidence of causation, it is not enough merely to observe that some percentage of people who eat beef containing hormone residues develop cancer. There is a substantial background rate of cancer in people and there are many possible causal factors. Scientific evidence to answer whether eating hormone-treated beef *increases* that baseline risk of cancer requires that studies be designed so that appropriate analyses of the data can discover statistical evidence of causation. There can be good-faith scientific debates about which methods to use to analyze the sample data, about the likelihood of confounding causal factors for which there are no data, and about the relative plausibility of the causal interpretations that are consistent with the data. In reaching any conclusion about causation, a scientist will rely on those generalizations that she or he considers best supported by the data, by current theories, and by general experience.

Finally, when scientists use causal theories to predict or explain specific events or cases, they encounter an additional layer of uncertainty. Examples include predicting the results of retesting a particular meat product, estimating the risk for an individual who has eaten some amount of hormone-treated beef, and explaining the probable causes of a particular case of cancer. Some scientists do not regard such predictions and explanations as scientific, whereas other scientists believe that a major task of science is to make progress on predicting when the next earthquake will occur or what its effects will be, as well as the likelihood that a disease will spread from a particular cattle herd.

How well scientists understand a particular case depends on how completely they understand the mechanisms causing the type of harm, and how adequately the available causal models match that particular case. For most kinds of controversial risks, there is such high variability from individual to individual that we may have only weak generalizations about small percentages of cases. And even when there is adequate evidence of causation in a (small) percentage of cases, it may be impossible to identify which particular cases are likely to be affected. Any predictions or explanations necessarily rest on a large number of generalizations.

When scientific research about risk involves significant uncertainty, any findings usually rest on many generalizations about what is likely to be true in some but not all cases. Any scientific conclusions are tentative and defeasible, and they rest on judgments about the acceptability of the uncertainty in the measurements and data, in the samples employed, in the causal models developed, and in the predictions and explanations of particular events. Science makes progress by engaging in default reasoning based on generalizations. The reasoning given for one generalization often employs more generalizations. Scientific reasoning is often saturated with uncertainty, and scientists can never make all of the generalizations explicit. Practicing scientists take most of their generalizations for granted and do not even try to make them explicit.

Principles of transparency require honesty in accurately representing the limitations of scientific research, and sets the goal of making explicit as much of the scientific reasoning as possible. Honesty about uncertainty, however, means frustration about achieving complete transparency. This outcome is especially true for findings about the kinds of risk that parties to WTO disputes litigate. When litigated disputes involve uncertainty about what risks a product poses, any scientific reasoning will be based on numerous default generalizations, and uncovering all of the inherent assumptions may be impossible. As we will see, the pursuit of complete transparency in scientific reasoning must be combined with honest reporting about when complete transparency is not possible.

Default Reasoning in WTO Fact Finding: The *Japan – Apples* Case

Legal systems also rely heavily on default reasoning in their fact-finding processes. Legal fact finding is by nature practical. In every type of legal

setting – whether judicial, administrative, or legislative, and whether national or international – the legitimacy of particular governmental actions usually depends upon findings that particular propositions are (probably) true. Such fact-finding processes have the objective of producing accurate findings warranted by the available evidence, but they balance that objective against such goals as ensuring due process and achieving administrative efficiency.[15]

For example, in emergency situations posing immediate threats to health, safety, or the environment, the law might authorize precautionary measures after an abbreviated fact-finding process or despite considerable uncertainty about the danger. If, however, the risk is remote in time, or the potential harm is minor or reversible, then the law might require more deliberate procedures or more certainty before authorizing any action, especially if the economic disruption due to the governmental action is certain and substantial. Such a mix of epistemic and nonepistemic objectives is also present in the fact finding involved in WTO disputes.

In 2003, the WTO Appellate Body decided the appeal of the trade dispute entitled "Japan – Measures Affecting the Importation of Apples" (the "*Japan – Apples*" case).[16] The dispute involved a complaint by the United States about several measures that Japan had imposed on apples imported from the United States. Japan defended its measures as protecting Japan against the entry of fire blight – a disease in which the bacterium *Erwinia amylovora* (*E. amylovora*) infects apple trees, destroying the fruit and potentially killing the plants.

The fire blight bacterium apparently had originated in North America, but had spread in the twentieth century across much of Europe and through the Mediterranean. An example of Japan's protective measures was its prohibition on all imported apples from the United States except those from orchards designated to be fire blight–free, which at that time were only in

15 Vern R. Walker, "Epistemic and Non-epistemic Aspects of the Factfinding Process in Law," *APA Newsletter* 3, no. 1 (2003): 132, reprinted in *The Journal of Philosophy, Science and Law* 5 (May 2005) (available at http://www.psljournal.com/archives/all/walkerpaper.cfm).

16 WTO Panel Report, Japan – Measures Affecting the Importation of Apples, WT/DS245/R (July 15, 2003) (available at http://docsonline.wto.org/DDFDocuments/t/WT/DS/245R.doc) (hereinafter Apples Panel Report); WTO Appellate Body Report, Japan – Measures Affecting the Importation of Apples, WT/DS245/AB/R (Nov. 26, 2003) (available at http://docsonline.wto.org/DDFDocuments/t/WT/DS/245ABR.doc) (hereinafter Apples Appellate Body Report).

the states of Washington and Oregon. The United States argued that this and other protective measures were inconsistent with Japan's obligations under the SPS Agreement.

As discussed previously, the SPS Agreement provides that any phytosanitary measure against imports must be based on "sufficient scientific evidence."[17] Because the United States was the complaining party, it bore the initial burden of proving that Japan's measures did not have sufficient scientific evidence.[18] By the time of the *Japan – Apples* case, several decisions by the Appellate Body had elaborated additional legal rules for how a party could prove that the available evidence is "sufficient."[19] The available evidence must be "scientific" in nature and "relevant" to the issue at hand, and it must have some "rational or objective relationship" to the particular measure under consideration.

The logic diagram shown in Figure 8.1 is one way of depicting these substantive rules. The arrows in the diagram represent logical implications. When an arrow connects two propositions, this means that if the proposition at the blunt end of the arrow is true, then the proposition at the pointed end of the arrow is also true. Because legal reasoning begins by knowing which conclusions are at issue in the case, we can place the proposition to be proved at the top, with implication arrows running upward to that proposition. An implication whose lower-level propositions are connected to the upper-level proposition by an "AND" represents an inference in which *all* of the lower-level propositions must be true in order for the upper-level proposition to be true.

17 The entire SPS Article 2.2 reads:

> Members [of the WTO] shall ensure that any sanitary or phytosanitary measure is applied only to the extent necessary to protect human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence, except as provided for in paragraph 7 of Article 5 [which provides for provisional measures when available scientific evidence is insufficient and the member seeks to obtain additional information]. Vern R. Walker, "Keeping the WTO from Becoming the 'World Trans-Science Organization': Scientific Uncertainty, Science Policy, and Factfinding in the Growth Hormones Dispute," *Cornell International Law Journal* 31, no.2 (1998): 251, 255–77.

18 Apples Appellate Body Report, para. 153.

19 The caselaw is summarized in WTO Appellate Body Report, Japan – Measures Affecting Agricultural Products, WT/DS76/AB/R, paras. 72–84 (Feb. 22, 1999) (available at http://docsonline.wto.org/DDFDocuments/t/WT/DS/76ABR.DOC).

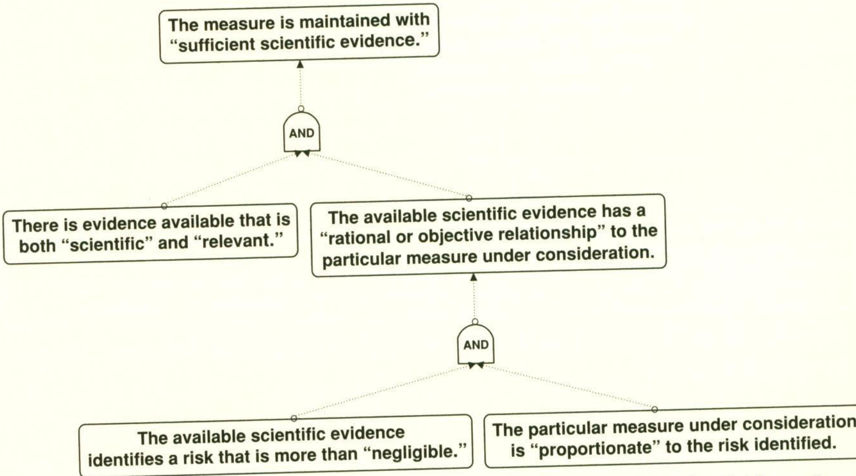

Figure 8.1. Implication Tree of the Legal Rules for "Sufficient Scientific Evidence"

Default-logic diagrams such as those in Figure 8.1 allow us to model the reasoning behind a finding, by tracing the reasoning through lower branches of the inverted implication tree. In each dispute decided by the WTO, new rules may be added to extend numerous branches. For example, with regard to proving whether any proffered evidence is "scientific," the *Japan – Apples* Panel adopted the rule that such evidence must be "gathered through scientific methods" or must be "scientifically produced," and it excluded from consideration what it called "insufficiently substantiated information" and any "non-demonstrated hypothesis."[20] Moreover, it added that evidence could be gathered using scientific methods, yet have various degrees of probative value in relation to possible findings. Although this line of new legal rules invites further development in later cases (which might adopt new rules for which methods are "scientific" or when a hypothesis is "sufficiently substantiated"), here we will follow the Panel's reasoning down the rightmost branch of reasoning in Figure 8.1.

With regard to proving whether there is a "rational or objective relationship" between the available scientific evidence and Japan's measures, the Panel found that from the standpoint of assessing risk, it is relevant to distinguish "mature, symptomless apples" from immature or

20 Apples Panel Report, paras. 8.90–8.99.

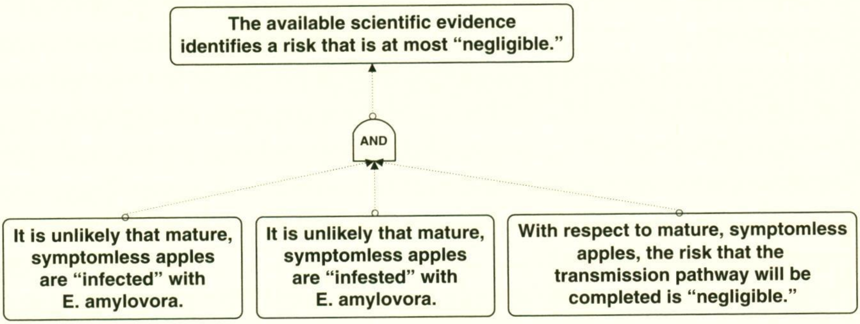

Figure 8.2. Logic Diagram of the Warrant for Finding a "Negligible" Risk from "Mature, Symptomless Apples"

identifiably infected apples.[21] As one branch of its inquiry, therefore, the Panel addressed whether mature, symptomless apples could cause the entry of fire blight into Japan. The Panel assessed the risk of this occurring, and "compared" that risk with Japan's measures. The Panel reasoned that in order to prove that there is a "rational or objective relationship" of the kind required by the SPS Agreement, one would have to prove two propositions: that the available scientific evidence identifies a risk that is more than "negligible," and that the measure must be "proportionate" to that risk. This reasoning is also represented in the diagram in Figure 8.1.

After reviewing the evidence and arguments in the *Japan – Apples* case, the Panel made a finding that there was *not* a "rational or objective relationship" between the available scientific evidence and Japan's measures, and gave two reasons for its conclusion. First, the Panel found that the risk of mature, symptomless apples introducing fire blight into Japan was in fact "negligible." Second, it found that Japan's measures were "clearly disproportionate" to the risk so identified.

Figure 8.2 diagrams the Panel's reasoning behind the first of these two findings – namely, its finding that the available scientific evidence identifies a risk that is at most "negligible."[22] First, the Panel found that mature applies are "unlikely" to be *infected* by fire blight if they do not show any

[21] The reasoning discussed in this paragraph and Figure 8.3 can be found in the Apples Appellate Body Report, paras. 159–60, 163–8, 243, and in the Apples Panel Report, paras. 8.89, 8.123–8.199, 8.224.

[22] The reasoning discussed in this paragraph and Figure 8.2 can be found in the Apples Panel Report, paras. 2.12–13, 8.123–39, 8.142, 8.147.

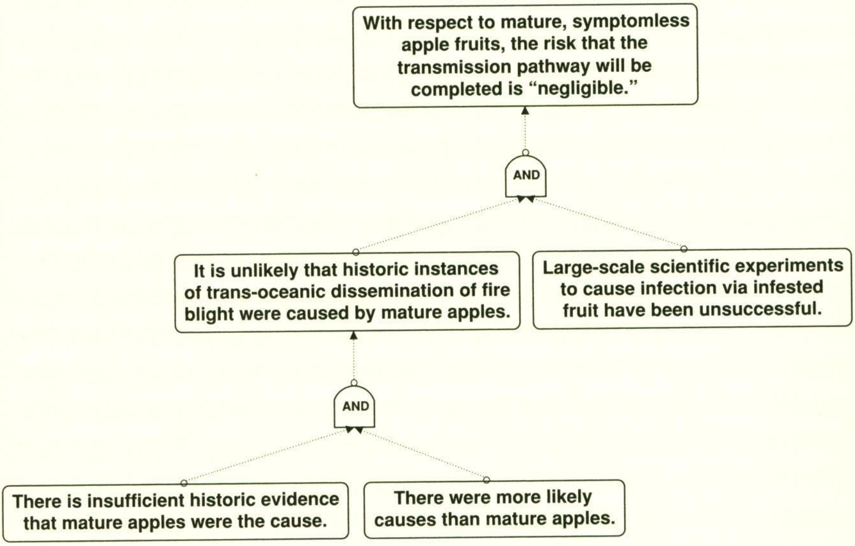

Figure 8.3. Logic Diagram of the Warrant for Finding a "Negligible" Risk of a Completed Transmission Pathway

symptoms. "Infection" is a pathogenic condition in the apple, as distinguished from "infestation," which is contamination that is not pathogenic. Second, with regard to possible *infestation*, the Panel found there was not "sufficient scientific evidence" that mature, symptomless apples either would contain populations of bacteria inside the fruit or are "likely" to carry on their outer surface populations of bacteria that are capable of transmitting *E. amylovora*. In concluding that bacteria populations on the surface of mature, symptomless apples are possible but "very rare," the Panel relied on the generalization that "the number of apples" contaminated with surface bacteria, even in severely blighted orchards, is "a very small percentage."

Third, because infestation on the surface of mature apples cannot be excluded as a possibility, the Panel assessed the evidence that the transmission pathway could be completed – namely, that such bacteria would survive through commercial handling, storage, and transportation, and that there would be a "vector" or means of contaminating a host plant in Japan.[23] Figure 8.3 models the Panel's reasoning in finding that the risk of a

[23] The reasoning discussed in this paragraph and Figure 8.3 can be found in the Apples Panel Report, paras. 4.63–81, 6.20–40, 6.50–71, 8.142–53.

completed pathway is "negligible." Even if past instances of trans-oceanic dissemination of fire blight could be documented, the Panel concluded that there is insufficient historic evidence that apple fruit was the cause, and it believed that alternative explanations are more probable. Moreover, large-scale scientific experiments to cause infection via surface and calyx-infested fruits had all been unsuccessful, and the Panel believed that, given the complexity of the transmission process feared by Japan, "it may be very difficult to experimentally replicate all possible pathways and combinations of circumstances and thus exclude categorically all possibilities of transmission." Therefore, the Panel found the risk of a completed transmission to be "negligible," agreeing with the opinions of those experts who considered any such risk to be "unlikely," "very remote," "insignificant," "extremely low," or "extremely unlikely." At bottom, therefore, the Panel's findings rested on generalizations about infection, infestation, and completed pathways, as well as generalizations about the uncertainties inherent in the evidence.

The Role of Scientists in Creating New Legal Reasoning

This brief examination of one narrow chain of reasoning in the *Japan – Apples* case illustrates several important characteristics of legal fact finding. First, the default-logic model shows the continuity of reasoning from the authoritative, rule-based inferences in the upper levels of the implication tree to the case-specific, generalization-based inferences in the lower levels of the tree. The implications in the upper levels of the tree (which model the legal rules) are triggered directly by the implications in the lowest levels of the tree (which model the generalizations about the evidence). The ultimate conclusion at the top is warranted by a structured combination of legal rules and factual generalizations. The chain of reasoning as a whole constitutes default reasoning because it is practical, dynamic, defeasible, but presumptively valid.

Second, the default-logic model shows how the law evolves over time by extending the branches of the tree downward. While the SPS Agreement itself provides the rules represented in the very top levels, the subsequent caselaw of the fact-finding panels and the Appellate Body can add new legal rules that interpret and extend those upper levels. As the fact-finding panels explain their reasoning and their assessment of the evidence in particular

cases, they elaborate new levels of reasoning. The documented reasoning of the panels can then generate new legal rules (which would be reviewed by the Appellate Body if challenged), as well as new patterns of reasoning for later panels to use in assessing the probative value of evidence. A default-logic model capturing the changes in reasoning from case to case would show a single implication tree that is expanding downward and branching outward.

The capacity for extending the tree is provided in part by the uncertainties inherent in scientific reasoning about risk. As discussed previously, the default reasoning in the face of these uncertainties will be based on numerous generalizations. The reasoning about which generalizations to apply and about how to apply them will lead in turn to more generalizations. The reasoning in support of any finding is therefore complex, and often unstated. As principles of transparency operate to make explicit more of the implicit reasoning, and as fact-finding panels articulate additional layers of their reasoning, the implication tree expands downward.

Third, the model for the *Japan – Apples* reasoning suggests one mechanism by which new legal rules evolve. After the Appellate Body adds a new legal rule, fact-finding panels try to apply that new rule transparently to the evidence in new cases. When a panel articulates its reasoning under the new rule and the Appellate Body upholds that reasoning, this creates new lines of reasoning that panels are likely to follow in subsequent cases. Even if a panel does not declare a new rule of law as such, the panel's reasoning becomes a new "soft rule" because subsequent panels will think it unlikely that the Appellate Body will reverse a finding based on such reasoning. In some future case, the Appellate Body might even adopt such a pattern of reasoning itself, turning it into a new legal rule to be applied in all cases. Declaring a new legal rule is obviously not essential, however, if a reasoning pattern is de facto recognized as acceptable.

Through this dynamic process, for example, new legal rules (whether "hard" or "soft") may evolve in the future for proving that evidence is truly "scientific" or that an identified risk is merely "negligible." As mentioned earlier, the caselaw already requires finding that a risk is more than a "theoretical uncertainty."[24] The *Japan – Apples* Panel recited a variety of possible interpretations that some future panel might adopt in deciding

[24] Apples Panel Report, para. 8.144; Salmon Appellate Body Report, para. 125.

what constitutes a "negligible" risk – including the quantitative criterion of "a likelihood of between zero and one in one million."[25] When fact-finding panels adopt the reasoning of testifying experts whom they consider credible, the panels transform the generalizations of those experts into "soft" legal rules of reasoning, and perhaps eventually into "hard" rules of law. In effect, the scientists testifying before the panels are in a privileged position of influence, because their personal reasoning may gradually evolve into new legal rules under the SPS Agreement.

Transforming Science into Law

Within the expanding branches of the tree, there is a dynamic between rule-based reasoning and generalization-based reasoning that can have a politicizing effect on science. As we follow the reasoning down any particular branch of the tree, we reach some propositional node where rule-based reasoning ends and generalization-based reasoning begins. To state this point differently, and at some risk of oversimplification, there is a place in every branch of reasoning where authoritative law ends and scientific proof begins. One thesis of this chapter is that the pursuit of transparency and the rule of law creates a steady downward "pressure" at this interface between law and science – a steady pressure to convert more of the scientific, generalization-based reasoning into legal, rule-based reasoning. Moreover, when scientists become involved in legal fact finding, they have an incentive to transform the role of science into a more regulatory function. Scientists who wish to influence the fact finding may convert mere generalizations about uncertainty into authoritative rules about "correct" scientific method. When that fact finding happens to be about risk, a rule-oriented scientific "establishment" may overlook dangers to society that are very real, but unknown or poorly understood. In addition, the economic and political importance of what is at stake in international trade disputes ensures that scientific uncertainties will provide contentious political battlegrounds. This section of the chapter discusses the logic underlying these various developments.

25 Apples Panel Report, paras. 8.144, 8.149.

Transforming Scientific Generalizations into Legal Rules

From the perspective of transparency and the rule of law, rule-based reasoning has several desirable characteristics that generalization-based reasoning lacks, and these differences create a legal preference for rules over generalizations. First, rule-based inferences are more transparent than generalization-based inferences because rules apply universally. A rule applies in every situation where the triggering conditions are true. Rule-based reasoning is transparent because any refusal to follow the rule once it is triggered should be warranted by another rule that recognizes an explicit exception. The rule identifying the exception is also transparent, applying universally in all situations that satisfy its exceptional conditions. The warrant provided by universal rules is still defeasible, but the conditions of defeat are transparent and explicit. Rule-based reasoning is therefore "objective" in the sense that the criteria driving the fact finding are available for scrutiny by all interested parties. Figure 8.1 diagrams several rules that are transparent and universally applicable in SPS Agreement cases.

In contrast to rules, generalizations accurately describe less than all the cases to which they refer. For example, in Figures 8.2 and 8.3, the generalizations about what is "unlikely" do not claim to describe accurately every situation. It may be true that mature, symptomless apples are unlikely to be infested with *E. amylovora*, but this proposition is consistent with the proposition that a particular apple or shipment is infested with the bacteria. While a generalization claims that it will be accurate in some portion of the reference cases, it also implies that there may be cases where it is *not* accurate. The *Japan – Apples* Panel recognized that mature, symptomless apples have in fact been infested with *E. amylovora* from time to time.

Moreover, a generalization itself does not usually provide the criteria for deciding precisely *when* it is accurate, nor does it explain *why* it is accurate in some cases but not others. Variability among cases usually implies that there are explanatory factors that are unknown or unstated, but which would provide more accurate or complete explanations if they were taken into account. The generalization that most mature, symptomless apples are probably not infested does not itself disclose when or why the occasional infestation occurs, or how it can be detected. Reasoning that rests on mere

generalizations acknowledges that the scientific evidence relevant to the finding is not completely transparent.

Second, rule-based inferences generate more consistency in application than generalization-based inferences do. When universal rules of inference warrant the conclusions, then fact finders will reach the same conclusions in all cases with similar evidence. The rule structure increases the likelihood that fact finders will analyze similar evidence similarly. Generalization-based inferences, however, invite subjective judgment, and increase the likelihood that different fact finders will reach different conclusions on very similar evidence. When a particular fact finder decides to rest the ultimate finding on a generalization that "probably, most mature, symptomless apples are not infested," that fact finder is making a judgment that he or she finds the inherent uncertainties acceptable. Another fact finder might insist on more quantitative evidence to explain the word "most," or more convincing evidence than the word "probably" implies. Generalization-based reasoning therefore makes subjective judgments seem inevitable and reasonable, to an extent that legal rules do not. Generalizations suggest that transparent reasoning must end somewhere, and that subjective judgment must take over.

Third, rule-based reasoning is more efficient than generalization-based reasoning. Authoritative rules of law determine which evidence is relevant and irrelevant to the fact-finding process. Fact finders are obligated to ignore any irrelevant considerations, which not only slow down the fact-finding process, but can contaminate it by masking subjective bias or a hidden agenda. The confined process of inquiry produced by legal rules is far more efficient than the open-ended exploration in which scientists normally engage. Working scientists form hypotheses in order to design their studies, but basically conduct their research by following the evidence wherever it leads. For scientists, it might be the anomaly or the small percentage of cases *not* covered by a generalization that points the way to the next scientific discovery. Or it might be a rethinking of old evidence that allows a new theory to emerge. By contrast, the closed-ended efficiency of legal reasoning tends to assume that we can know at the outset which evidence is relevant and which concepts to use in our reasoning.

In a legal context, therefore, the values of transparency, consistency, and efficiency point in the same direction: toward an increase in rule-based reasoning and a decrease in generalization-based reasoning. For

reasons of principle (transparency and consistency) as well as practicality (efficient fact finding), legal practitioners prefer rule-based reasoning over generalization-based reasoning, to the extent that rule-based reasoning is achievable. The less transparent, more subjective, and less efficient reasoning based on mere generalizations is tolerated, to the extent necessary, but it is not the legal ideal. The legal mind prefers universal rules when it can get them.

This preference for rule-based reasoning over generalization-based reasoning creates a tendency for the legal fact-finding process to transform generalizations into rules. This natural tendency can easily operate through the mechanism previously discussed: Individual scientists testify before fact-finding panels about their scientific reasoning, fact-finding panels adopt some of that reasoning as their own, some of that reasoning becomes "soft rules" as the Appellate Body defers to it and later panels follow it, and some generalizations are explicitly converted into default rules of law. Perhaps the WTO has little need for an explicit rule of law about "mature, symptomless apples," but the reasoning patterns diagrammed in Figures 3 and 4 might make very useful rules if they are reformulated as rules about "apparently unaffected products." Once we focus on similarities and use them to classify cases together, we tend to produce legal rules for deciding these cases transparently and consistently.

Transforming Scientists into Regulators

This tendency to transform generalizations into rules also transforms the role that scientists play within a legal context. The area of risk regulation in international trade illustrates this transformation in role. Oddly enough, this change in role for scientists is mediated by an insistence on all sides that there should be a clear separation between legal, policy-driven reasoning and scientific, evidence-driven reasoning. To understand this change in role, therefore, it is first necessary to understand this insistence on a distinction between law and science.

Despite the tendency to create more legal rules, there is also a strong incentive for the political decision makers who create the initial legal rules (for example, those who negotiated the high-level rules in the SPS Agreement), as well as for the legal decision makers who elaborate the midlevel rules (such as the members the fact-finding panels and of the Appellate

Body), to insist that there is a "bright-line," fixed boundary between rule-based reasoning and generalization-based reasoning, between policy-driven laws and evidence-driven science. It is to their advantage to assert that scientists must independently determine "the facts" at the bottom of the chain of reasoning before legal decision makers can decide what management actions to take in response to those facts. We can appreciate this incentive by imagining a hypothetical scenario stemming from the *Japan – Apples* decision. If, as a result of the decision, Japan removes its protective measures on imported apples and then fire blight enters Japan by means of contaminated apples, the WTO would prefer to lay responsibility for this adverse outcome on scientists, who perhaps underestimated the likelihood of latent infestation in mature fruit or overlooked a pathway of transmission. To anyone who assumes that there is a clear, fixed boundary between political decision making and scientific fact-finding, such an explanation might even appear to be the only reasonable one. Thus, political risk managers can appear reasonable while blaming the scientific risk assessors for undesirable outcomes.

On the other hand, many scientists also insist that there is a bright, fixed line between legal policy and science. They do so in the hope of keeping politics out of science. Scientific reasoning about uncertain risks makes an inviting target for political manipulation. To the extent that there is uncertainty about how to conceptualize a problem, or about the validity of measurements, or about sample representativeness, or about how to model causal relationships, then good science keeps an open mind. It may be necessary to engage in default reasoning in order to extend scientific knowledge, but careful scientists are very candid about the inherent uncertainties. Indeed, the generalization-based reasoning of science is less transparent, more subjective, and less efficient than rule-based legal reasoning precisely because scientists refuse to oversimplify the phenomenon being studied, or to overstate their knowledge about that phenomenon. But the recognized need for professional judgments by individual scientists also makes those judgments and scientists inviting targets for those who want to exert political influence.

If there is a domain of science that is separate and distinct from that of law and politics, however, then perhaps science can better resist political pressure and keep legal decision makers from influencing the scientific

portion of fact finding. The European Union has gone so far, in the area of food safety, as to establish the European Food Safety Authority (EFSA) as a separate governmental agency to conduct scientific risk assessment. EFSA is expected to perform risk assessments independently, and the European Commission would then base its management decisions on the findings of those risk assessments.[26] Part of the motivation behind the establishment of EFSA was the public desire for sound, independent science – a desire heightened by the scares involving Bovine Spongiform Encephalopathy (BSE) in 1996 and dioxin-contaminated animal feed in 1999.[27]

Politicians, other legal decision makers, and many scientists, therefore, have a common goal of distinguishing legal reasoning from scientific reasoning. In terms of the default-logic model of fact finding, the upper levels of an implication tree, representing legal rules, are distinguishable from the lower levels, consisting of generalizations. As long as scientists can make their reasoning transparent and as rule-governed as possible, then such reasoning should satisfy legal ideals without the encroachment of the legal or political establishment. The regulatory approach of the United States Environmental Protection Agency (EPA) provides an example of a sustained effort to transform scientific reasoning into legal rules, explicitly and transparently.

EPA recognizes that within a scientific risk assessment, there are numerous places where reasoning must rest upon inadequate scientific evidence. For example, it may be uncertain whether a particular animal species is a good predictive model for humans, whether a dose-response curve extrapolated below the range of the observational data is accurate, or whether a particular margin of safety is likely to protect sensitive subpopulations (such as children or the elderly). In the absence of complete scientific evidence, decisions are necessary about how to assess the risks despite gaps

[26] European Parliament and Council Regulation 178/2002/EC, preamble paras. 33–66, arts. 22–3, 2002 OJ L31/1 (laying down the general principles and requirements of food law, establishing the European Food Safety Authority, and laying down procedures in matters of food safety); Health and Consumer Protection Directorate-General, "European Food Safety Authority (EFSA) – Introduction, European Food Safety Authority" (available at http://europa.eu.int/comm/food/efsa_en.htm); European Food Safety Authority, "EFSA Science, European Food Safety Authority" (available at http://www.efsa.eu.int/science/catindex_en.html).

[27] Raymond O'Rourke, *European Food Law* (Bembridge, UK: Palladian Law, 2nd ed., 2001), 7–8, 167–8, 216–28.

in scientific knowledge. For guidance in conducting risk assessments, EPA therefore adopts what it calls "science policies" or "default options," also sometimes called "inference guidelines."[28] Science policies establish the rules of default reasoning that risk assessment scientists are supposed to use. Such science policies create presumptions for fact finding, which are subject to defeat if there is sufficient evidence to overcome the presumption. By establishing authoritative default rules, science policies produce risk assessments that are more transparent, more consistent, and more predictable than would be the case if such decisions were left to individual scientists to decide on a case-by-case basis.

On the other hand, EPA recognizes that evaluating the "weight of the evidence" requires scientific judgment.[29] Integrating a multitude of evidence into a single judgment involves reasoning that is difficult to explain and not fully transparent.[30] The open-ended and not-completely-transparent nature of generalization-based reasoning is in conflict with the ideals of transparency and the rule of law.

Interestingly, emphasizing the nonrule nature of scientific reasoning can also be useful in shielding the agency's fact finding from attack, especially upon judicial review.[31] EPA can insist on deference to its expert judgment about when uncertainties are within acceptable bounds. So while the agency tries to satisfy the legal principles of transparency and the rule

28 U.S. Environmental Protection Agency, "Guidelines for Carcinogen Risk Assessment," (2005): appendix A (available at http://www.epa.gov/iris/cancer032505.pdf); U.S. Environmental Protection Agency, Science Policy Council, "Guidance for Risk Characterization," (1995) (available at http://www.epa.gov/osa/spc/htm/rcguide.htm); National Research Council, *Risk Assessment in the Federal Government: Managing the Process* (Washington, DC: National Academy Press, 1983) 51–85; National Research Council, *Science and Judgment in Risk Assessment* (Washington, DC: National Academy Press, 1994), 85–105; Walker, "Keeping the WTO from Becoming the 'World Trans-Science Organization'," 256–72.

29 National Research Council, *Science and Judgment*, 126–31; U.S. Environmental Protection Agency, "Guidelines for Carcinogen Risk Assessment," 1–11 to 1–12, 2–49 to 2–58.

30 National Research Council, *Understanding Risk: Informing Decisions in a Democratic Society* (Washington, DC: National Academy Press, 1996), 37–72; Vern R. Walker, "The Myth of Science as a 'Neutral Arbiter' for Triggering Precautions," *Boston College International and Comparative Law Review* 26, no. 2 (2003): 197; David Winickoff et al., "Adjudicating the GM Food Wars: Science, Risk, and Democracy in World Trade Law," *Yale Journal of International Law* 30, no. 1 (2005): 81, 93–9.

31 *Environmental Defense v. U.S. Environmental Protection Agency*, 369 F.3d 193 (2d Cir. 2004); *International Fabricare Institute v. U.S. Environmental Protection Agency*, 972 F.2d 384 (D.C. Cir. 1992).

of law, it also tries to shield its reasoning from external attack by its critics. As a result, the implication trees under the different statutes that EPA administers exhibit different degrees of elaboration, as the agency mixes administrative rule making and science-policy development (on the one hand) with case-by-case fact finding (on the other hand).

The agency's attempt to manage the interface between rule-based reasoning and generalization-based reasoning leads to a hybrid role for science within regulation – a role that many call "regulatory science."[32] The agency's regulatory programs also illustrate the inherent tension between rules and generalizations, the legal tendency to turn generalizations into rules, and the resulting tendency to turn scientists into regulators.

Transforming Science into Politics

The WTO fact-finding panels and the Appellate Body, however, do not have an institution like EPA to manage the interface between rules and generalizations. EPA has the statutory authority, resources, and expertise to conduct both risk assessment and risk management in well-defined areas, such as hazardous substances or pesticide products. The WTO disputes involve disparate products and risks, and panels are appointed to conduct the fact finding case by case. This institutional design might increase the probability that science will be politicized.

Scientists who influence fact finding using generalization-based reasoning wield significant power, whether in adopting generalizations as default rules or in subjectively applying generalizations to evidence in particular cases. Because scientific reasoning plays such an important role in WTO fact finding, and as political decision makers and scientists alike insist on a boundary between science (risk assessment) and political decision making (risk management), it becomes increasingly important to those interested in the outcomes to have the "right scientists" conducting the scientific reasoning. It is important to appoint scientists with the "right instincts" to sit on governmental advisory panels, to conduct the risk

[32] Wendy Wagner and David Michaels, "Equal Treatment for Regulatory Science: Extending the Controls Governing the Quality of Public Research to Private Research," *American Journal of Law and Medicine* 30, nos. 2–3 (2004): 11

assessments within administrative agencies, and to establish the default rules for such risk assessments. The uncertainties inherent in default reasoning make it rational to fight for the power to make the appointment decisions. Even if the scientific reasoning occurs in an institutional setting that is separate and independent from management decision making, this does not save it from the logic behind the politics of appointment. It becomes reasonable to reach even into those institutions of science that appear to be the most independent of politics – institutions such as university research centers, scientific journals, and prestigious scientific committees that can articulate and influence the very canons of sound scientific reasoning.

It is the logic of generalization-based reasoning itself that creates the opportunity and incentive for political influence. The analysis based on default logic shows that the problem lies not merely with individual scientists, but rather with scientific reasoning itself, and therefore with science itself. And that logic virtually ensures politicization.

The strategy of choice for those who happen not to possess the power of appointment at a particular time is usually to insist upon more transparency and more adherence to the rule of law. Parties adversely affected by the outcome of legal fact finding tend to attack the reasoning leading to that outcome. Opposing parties produce conflicting evidence and additional theories, fact finders provide more reasons for their findings, and appellate bodies convert more of those reasons into "soft" or even "hard" legal rules. This is the very dynamic, however, that pushes rule-based reasoning deeper into scientific reasoning, which turns scientists into regulators, and which in turn leads to more political influence over scientific institutions.

The advent of WTO fact finding in the last decade promises to globalize that chain of transformations. Even the short series of dispute settlement decisions under the SPS Agreement, culminating in the *Japan – Apples* case, shows the tendency to transform open-ended, scientific generalizations about risk into rules for identifying "non-theoretical" risks on the basis of evidence that is methodologically "scientific." When the causal situation is not well understood, however, as with genetically modified organisms (GMOs) or BSE, do scientists really understand the risks and uncertainties well enough to make findings that are transparently warranted? Even for the relatively well-understood risks of fire blight in apples, the Panel's

reasoning in finding that the risk is "negligible" that apple fruit will serve as a pathway for the entry of fire blight into Japan may appear to be too political to be reassuring, at least to the Japanese. If the ideal is to make the scientific reasoning completely transparent, then the price of doing so may be to make that reasoning more rule-based, to transform the role of scientists from advisors about uncertainty to regulators of default reasoning, and to politicize scientific reasoning.

Conclusion

This chapter argues that default reasoning combines law and science in legal fact finding, but that the ideals of transparency and the rule of law tend to transform scientific reasoning into legal reasoning. Scientists involved in legal fact finding have an incentive to turn the open-ended, generalization-based reasoning of science into the closed-ended, rule-based reasoning of law. Moreover, the fact-finding process itself provides a structure that can transform generalizations into rules, scientific reasoning into legal reasoning, research scientists into regulatory scientists, and scientific institutions into political institutions. If it is the logical nature of default reasoning that makes these transformations possible, does it also make them inevitable? Merely insisting on a bright, fixed boundary between those who make legal decisions and those who conduct scientific reasoning seems unlikely to solve the problem, because it is the logical nature of fact finding itself that underlies these transformations.

The place to begin the rescue of science is with the transparency principles that are part of the framework for this book. As applied to governmental fact finding, they require the fact finder to make clear to all interested parties the evidence relevant to a finding of fact, the fact finder's evaluation of that evidence, and the reasoning connecting the evidence to the finding. But the transparency principles also emphasize the need for honesty in representing that reasoning accurately, and in reporting the limitations of the evidence. The principles balance the ideal of complete transparency against the ideal of honest reporting. Legal rules may be more transparent than generalizations, but generalizations are often more faithful to the underlying uncertainties. Regulators should report all of the default patterns of reasoning upon which they rely, to the extent that they can do so. But they should also resist turning generalizations into rules if this

means misrepresenting the underlying uncertainties. In the bottom levels of the implication tree, generalizations honestly reflect the default reasoning about uncertainty.

Protecting the integrity of science means openly preserving its anti-authoritarian dimension – that is, openly reporting the methods, reasoning, and logic, so that all interested parties can judge for themselves the reasonableness of the conclusions. Although uncertainty creates a target of opportunity for those who wish to politicize regulatory science, adherence to the transparency principles and honest reporting of reasoning provide the best protections against distortion and manipulation. And when governmental fact finding is about the risk of harm, such as in international trade disputes, it is particularly important to rescue science from politics, and to do so in ways that respect not only the laws of nations, but also the laws of logic.